FEDERAL DEMOCRATIC REPUBLIC OF NEPAL
Nepal Electricity Authority (NEA)

# PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

## FINAL REPORT

MARCH 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIPPON KOEI CO., LTD.

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# PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to Nippon Koei Co., Ltd.

The survey team held a series of discussions with the officials concerned of the Government of Federal Democratic Republic of Nepal, and conducted a field investigation. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Federal Democratic Republic of Nepal for their close cooperation extended to the survey team.

March, 2014

Takumi UESHIMA
Director General
Industrial Development and Public Policy Department
Japan International Cooperation Agency

# SUMMARY

1. Overview of the Country

Federal Democratic Republic of Nepal (Nepal) is a small inland country which is narrow and long in an east-west direction and bounded by Chinese Tibet on the north and India on the other three sides. Its area is approximately 147,000 square kilometers. Its total population is approximately 26.49 million (census 2011). The topographic features are diverse with a mountainous region in the northern part which includes the Himalayas (altitude: 4,000 m or above), hilly land in the middle part which includes the capital city of Katmandu (altitude: 300 - 4,000m), and flatlands called Terai in the southern part (altitude: 300 m or less). The climate varies largely according to the altitude, an alpine climate being observed in the mountainous region, temperate climate in the hilly land, and subtropical high temperature and rainfall climate in the lowland. The southeast monsoon has a large impact in this area, and there is a rainy season from June to September, with a dry season from October to May.

Nepali GDP has continuously grown favorably, and its per capita GDP reached 735 US dollars in FY2011/2012*. The ratio of the primary industry to GDP in 2011 was 35.0%, which is the highest in the South Asian countries. The proportion of the secondary industry is as low as 15.0% and that of the tertiary industry such as tourism and information and communication shares half of the GDP.

The economy and the life of the people of Nepal are characterized by emigration and poverty. The number of overseas migrant workers has increased since the 1990s, and the number of new migrant workers was over 380,000 in FY2011/2012. Various countries are the destinations of emigration and approximately 70% of them are Middle Eastern countries and the others are Malaysia, Korea, etc. The proportion of the households which receive remittances from migrant workers to all households was 30% in FY2003/2004 and it increased to 56% in FY2010/2011.

Note *: Fiscal year (FY) starts around the middle of July.

2. Background of the Project

The three target micro-hydropower plants of the Project are located in the Mid-western and Far Western Region which lag behind in development. Each of the three target micro-hydropower plants has an independent power network, but there is no prospect of connection of the network to the main transmission system because of the domestic shortage of power supply and the delay in power source development. With a significant increase in power demand in the areas of three target sites, the average increase ratio in the number of customers exceeded 50% at the time of the preparatory survey in 2013 compared with the number in FY2011/2012. Therefore, the existing micro-hydropower plants have been increasingly indispensable for the society and economy, serving as the only power source, in each area.

The micro-hydropower plants of the target sites were constructed with assistance from Asian Development Bank and they have completed 23 years since the start of operation. Maintenance work such as overhauls and repairs have never been conducted for the three target micro-hydropower plants, and the generating equipment/facilities are aged and suffer failures and damage. Consequently, the reliability of stable power supply is almost completely lost in all the three micro-hydropower plants. Therefore, urgent rehabilitation is required for the three target micro-hydropower plants, which are the only power source in the respective areas, to restore their generation capacities and the reliability of the facilities.

If operation is continued with the damaged generating equipment without repairs, it will inevitably lead to complete destruction and eventually the entire power generation will come to a complete halt. It can be assumed that the long period without electricity until restoration of that power supply will cause a significant damage to the economy and livelihood of people in those areas. A long-term power failure is a matter of human life too as it brings even medical care services to a halt. In addition, a long term power failure at public facilities such as the military and the police may also affect public security.

In consideration of such a situation, the government of Nepal requested the government of Japan to improve the micro-hydropower plants as below.

| | | |
|---|---|---|
| 1) Bajhang Micro-hydropower Plant (Bajhang District) | Rehabilitation | 230 kW (115 kW x 2 units) |
| | Expansion | 230 kW (115 kW x 2 units) |
| 2) Bajura Micro-hydropower Plant (Bajura District) | Rehabilitation | 230 kW (115 kW x 2 units) |
| | Expansion | 230 kW (115 kW x 2 units) |
| 3) Syarpudaha Micro-hydropower Plant (Rukum District) | Rehabilitation | 240 kW (120 kW x 2 units) |
| | Expansion | 240 kW (120 kW x 2 units) |
| 4) Chaurjahari Micro-hydropower Plant (Rukum District) | Rehabilitation | 180 kW (90 kW x 2 units) |
| | Expansion | 180 kW (90 kW x 2 units) |

Note: The capacity of the existing facilities mentioned above indicates the output of the hydraulic turbines. The output of the generator is 200kW in all of Bajhang, Bajura and Syarpudaha micro-hydropower plants. It is 150kW in Chaurjahari Micro-hydropower plant.

The Chaurjahari micro-hydropower plant in Rukum District was included along with the three target sites when the request was made. However, since it was found out in the preliminary survey conducted in March 2013 that the supply area of the concerned power plant would be connected to the main transmission system in the near future and since the NEA had decided to cease operations in the power plant after the connection, this plant was excluded from the targets of the Project. In addition, although expansion of each micro-hydropower plant was requested, but since there is no existing hydrologic data which is sufficient to study the possibilities of expansion, it was decided not to consider the expansion plan in the Project.

When the micro-hydropower plants of the three target sites are improved by the implementation of the Project, the power plants will restore their original installed capacities which will be almost double the current capacities. Consequently, the electricity sales amount will also be doubled. Even though load shedding (power-cuts) will continue within each distribution network, load shedding at important public facilities such as hospitals will virtually end, and thus significantly contribute to medical care with power supply services and equipment running being able to run all day long.

With the doubling in the amount of supplied electricity, the power source for night-time illumination not only for the public facilities but also for general households is improved, and it is expected to help schoolchildren to study and learn as well as adults for their community activities.

3. Contents of the Project

The preparatory survey for the Project was carried out during the period from July 2013 to March 2014, and the survey team was dispatched to the sites three times in August 2013, October 2013 and December 2013.

Keeping in mind the contribution to implementation of the "Renewable Energy Policy" to supply power to village areas not connected to the main transmission system, the Project is planned for implementing the rehabilitation of the existing run-of-river type micro-hydropower plants having an installed capacity of 200kW each in Rukum District, Bajura District and Bajhang District based on the request by the government of Nepal and the results of the preparatory survey and discussions, as summarized below.

(1) Current state of Target Equipment/Facilities and Outline of Rehabilitation

Table Current State of the Equipment/Facilities and the Outline of Rehabilitation (1/4)

| Target site/equipment | Current state and outline of rehabilitation |
|---|---|
| Target site | Bajhang Micro-hydropower Plant (Bajhang District)<br>Bajura Micro-hydropower Plant (Bajura District)<br>Syarpudaha Micro-hydropower Plant (Rukum District) |
| 1. Hydraulic power generation equipment | The current state of the equipment and outline of rehabilitation are the same in the three target site. |
| Hydraulic turbines | The main units of the hydraulic turbines and the bearings are worn, and the accessory devices are also failing<br>The hydraulic turbines, on the whole, are in a state of failure<br>The entire set of hydraulic turbines will be renewed |
| Generators | The bearings are worn and the speed detectors are failing<br>Insulation failure has occurred in the generators a few times in the past, as the insulation has deteriorated<br>The generators are also being operated in a state of failure<br>The entire set of generators will be renewed |
| Control units and DC power supply units | The devices for frequency control and generator voltage are failing<br>Since the protective relays and each meter are broken or inaccurate, the generating equipment is being operated without protection or control<br>The DC power supply units are failing and not working<br>The entire set of control units and DC power supply units will be renewed |

Table Current State of the Equipment/Facilities and the Outline of Rehabilitation (2/4)

| Target site/equipment | Current state and outline of rehabilitation |
|---|---|
| Transformers | There is no burning or damage, but the thermometers and the moisture absorbers are failing, and there is leakage of insulation oil<br>By updating the transformers in accordance with update of the generating equipment, reliability of the restored micro-hydropower plant will be secured as a whole |
| 2. Hydraulic power generation facilities | The current state of the facilities and outline of rehabilitation are identical in the three target sites |
| Intake weirs and sand drain gates | The diversion weir and the intake were severely damaged during floods, and the plants have been forced to use an unstable withdrawal from the temporary intake consisting of the remaining existing headrace and some parts of the intake<br>The intake facilities will be reconstructed to satisfy the capacity of the renewed generating equipment |
| Headraces | Age-related deterioration has occurred over all the canals<br>The damages observed are as follows:<br>1) water leakage from the canals<br>2) scouring of the foundation<br>3) sedimentation of silt and sand<br>4) cracks and growth of algae on the bottom and the side walls<br>5) inflow of earth and sand from the slopes and/or streams along the canal<br>Repair will be carried out by restoration of the original state to improve efficiency and extend the life-time of the facilities<br>The damaged parts to be repaired will be selected according to priority as judged from factors such as<br>1) adverse impact to generating operation<br>2) danger to people in the area<br>3) disturbance of operation and maintenance management |

Table Current State of the Equipment/Facilities and the Outline of Rehabilitation (3/4)

| Target site/equipment | Current state and outline of rehabilitation |
|---|---|
| Water tanks | There are dangerous cracks in the bottom and the side walls of the water tank in the Bajhang plant<br>They will be repaired in order to prevent water leakage into the periphery<br>The capacity of the water tank has also been greatly reduced due to sedimentation of silt and sand<br>Consequently, the generating operation has hardly been carried out in two of the units. The deposited silt and sand will have to be removed, and the function of the water tank should be restored<br>There are cracks in the side walls of the water tanks at the Bajura and Syarpudaha plants, and they will have to be repaired.<br>There is no sedimentation of silt and sand, and there is no problem with the capacity of the water tanks.<br>Since the sand flushgates for the water tanks of the three sites are damaged or inoperable, all of them will be renewed |
| Steel penstock | There is a part which leaks water from a flange joint<br>The external surfaces of steel penstock are partially corroded, but coatings remain intact in general<br>There are cracks in some parts of the saddles and some foundations are collapsed<br>External surfaces of all the penstock will be repainted, and repair for some defects such as water leakage and defects in saddles will be carried out<br>For the areas where steel penstock are buried underneath village roads and farmland, the earth and sand around them will be removed, and the steel penstock will be protected with retaining walls |
| Buildings of the power house | There is no damage to the foundation, the pillars or beams, but the windows and the doors are damaged and cannot be closed, and there are gaps in the roofs<br>In order to protect the renewed equipment, the windows, the doors and the roofs will be repaired, and repainting of the walls will be carried out |

Table Current State of the Equipment/Facilities and the Outline of Rehabilitation (4/4)

| Target site/equipment | Current state and outline of rehabilitation |
|---|---|
| Tailrace channels | There are defects due to aging in the side walls and the bottom<br>In addition, the damages in the revetment at the exits of tailrace channels are progressing due to erosion by the rivers where water is discharged from the facilities<br>Repairs to restore them to their original forms will be carried out. The water tanks for cooling the resistors of the dummy load governors of the renewed generators will be newly constructed halfway down the tailrace channels |

(2) Soft component programme

The technical transfer of skills to the operators to conduct smooth operation and maintenance after restoration of the generating equipment and facilities will be carried out by means of Soft component programme for methods of;

1) recording and storing inspection records, failure records, repair records, etc.,

2) utilizing the data for the purpose of planning maintenance

3) managing financial data for planned procurement of spare parts

4. Implementation Schedule of the Project

The implementation of the Project will take 23 months from the conclusion of contract for consulting services to the completion of rehabilitation work after the Exchange of Notes (E/N) by both Governments. The implementation schedule will include approximately 2.5 months for the detailed design by consultant, and approximately 18 months for construction which includes design and manufacturing, transportation, on-site construction of the facilities and installation works, on-site testing and soft component.

5. Project Evaluation

The appropriateness of implementation of the Project will be evaluated as below.

1) The beneficiaries are the residents of Bajhang District, Bajura District and Rukum District, where the three target sites are located. With regards to the degree of poverty, Bajhang District, Bajura District and Rukum District were ranked 73rd place, 71st place and 58th place respectively in the ranking of the 75 districts of the country in the census of 2001.

2) The Project is implemented to respond to the increasing demand for electricity in the villages by repairing the existing aged micro-hydropower plants in the target areas which are not connected to the main transmission/distribution system, and thus contribute to development of the region’s economy and improvement of the people's livelihood. Both the importance and urgency of its implementation are very high.

3) It contributes to the policy of Nepal in the three-year plan, which is ranked at the top priority of the national development strategy (FY2013/2014 to FY2015/2016). The government of Nepal positions improvement of the economic infrastructure including electric power as the preferential area, and seeks to implement power supply development by generation of 15MW micro-hydropower to supply power to village areas in three years from now.

4) The government of Japan sets "Improvement of social infrastructures and systems for economic growth" including electricity as the priority area of the assistance policy per country for Nepal, and the Project matches the policy and the analysis above.

The following quantitative effects and qualitative effects are expected by implementing the Project.

(1) Quantitative effects

| Indicator name | Base (Actual values in 2012) | | | Target in 2019 (three years from completion of the Project) | | |
|---|---|---|---|---|---|---|
| | Bajhang | Bajura | Syarpudaha | Bajhang | Bajura | Syarpudaha |
| Average power output (kW) | 100 | 75 | 100 | 200 | 200 | 200 |
| Annual generated energy (kWh/ year) | 810,000 | 630,000 | 780,000 | 1,704,000 | 1,704,000 | 1,704,000 |
| Annual generating operation hours (h/ year) | 8,100 | 8,400 | 7,800 | 8,520 | 8,520 | 8,520 |

(2) Qualitative effects

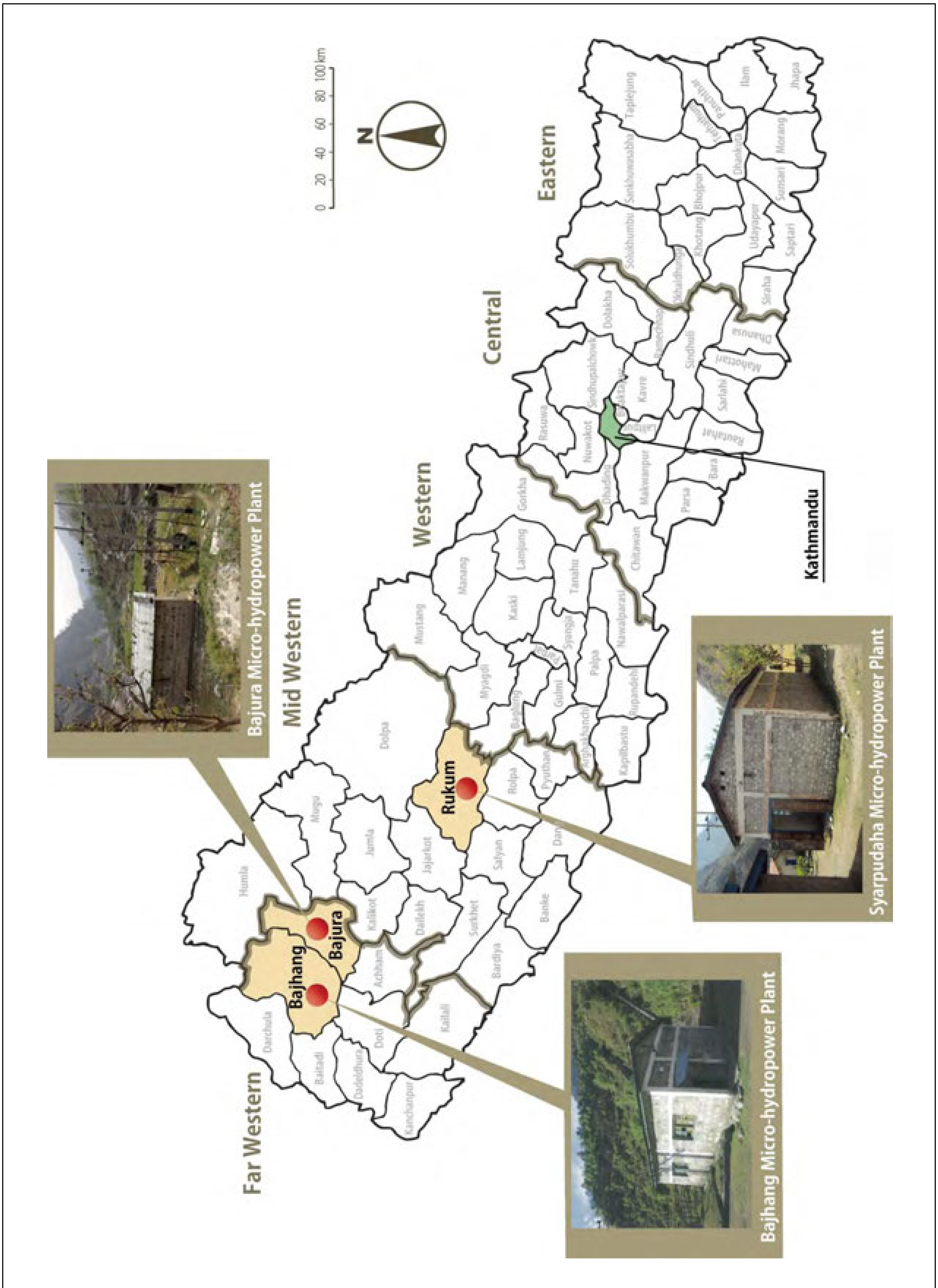
1) Power will be supplied stably to public facilities, and the public services will be improved

2) Nighttime illumination will be stable, and this will foster children's learning and adults' community activities

3) Stabilized voltage and frequency of the sources of electric power supply will reduce failures of electric motors

# CONTENTS

LOCATION MAP



PERSPECTIVE

Bajhang Micro-hydropower Plant Intake

Bajura Micro-hydropower Plant Intake

Syarpudaha Micro-hydropower Plant Intake

LIST OF FIGURES & TABLES

# ABBREVIATIONS

| | |
|---|---|
| A/P | Authorization to Pay |
| ADB | Asian Development Bank |
| AEPC | Alternative Energy Promotion Center |
| AIDS | Acquired Immune Deficiency Syndrome |
| ARP | Abbreviated Resettlement Action Plan |
| B/A | Banking Arrangement |
| CBS | Central Bureau of Statistics |
| CDO | Chief District Officer |
| CFC | Compensation Fixation Committee |
| CR | Critically Endangered |
| DCS | Distribution and Consumer Services |
| DDC | District Development Committee |
| DHM | Department of Hydrology and Meteorology |
| DoED | Department of Electricity Development |
| DOF | Department of Forest |
| EIA | Environmental Impact Assessment |
| EN | Endangered |
| EPA | Environmental Protection Act |
| EPR | Environmental Protection Rules |
| ETFC | Electricity Tariff Fixation Committee |
| FAO | Food and Agriculture Organization of the United Nations |
| FY | Fiscal Year |
| GDP | Gross Domestic Product |
| HIV | Human Immunodeficiency Virus |
| IEC | International Electrotechnical Commission |
| IEE | Initial Environmental Examination |
| IT | Information Technology |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| JEM | Japan Electric Machine Industry Association |
| JICA | Japan International Cooperation Agency |
| JIS | Japanese Industrial Standards |
| KfW | Kreditanstalt für Wiederaufbau |
| LACP | Land Acquisition and Compensation Plan |
| LDO | Local Development Officer |
| LPG | Liquefied Petroleum Gas |
| MoAC | Ministry of Agriculture and Cooperatives |
| MoE | Ministry of Energy |
| MoHA | Ministry of Home Affair |
| MoSTE | Ministry of Science, Technology and Environment |
| NEA | Nepal Electricity Authority |
| ODA | Official Development Assistance |
| PAPs | Project Affected Persons |
| PAUs | Project Affected Units |
| SLC | School Leaving Certificate |
| TOR | Terms of Reference |
| UNFCO | United Nations Field Coordination Office |
| USD | U.S. dollar |
| VDC | Village Development Committees |
| VU | Vulnerable |
| WB | World Bank |

# Chapter 1. Background of the Project

## 1-1 Background of Project

The micro-hydropower plants, which are the target sites of this Project, are located in the Mid-Western and Far-Western regions where development has lagged behind in Nepal. Each of the three target micro-hydropower plants has an independent power network; however, there is no possibility for the network to be connected to the main transmission system due to domestic shortage of electric power supply and delay in power source development. With a significant increase in demand in the areas of the three target sites, the average increase rate in the number of customers, as of the time of the preparatory survey in 2013, reached 50% compared with the number in FY2011/2012. Therefore, the existing micro-hydropower plants have been increasingly indispensable for the society and the economy, serving as the only power source in each area.

The micro-hydropower plants of the target sites were constructed with assistance from the Asian Development Bank (ADB), and 23 years have passed since the start of their operations. It is common to conduct overhaul maintenance of hydropower plant facilities every 10 to 15 years; however, maintenance works such as overhaul, has never been conducted for the target micro-hydropower plants since the start of their operations. The generating equipment and facilities are old and damaged, and have been experiencing failures. The current installed power output, as estimated from the annual average power output in FY2011/2012, has decreased by almost half of the originally installed 200 kW capacity. Consequently, the three target micro-hydropower plants have lost their reliability of providing stable electric power supply. Under such circumstances, rehabilitation of the micro-hydropower plants, which are the only power source in the areas, has become an urgent task for recovering their generation capacity and regaining their reliability.

If the current electric power generation equipment that is malfunctioning will be continuously used without rehabilitation, it is likely that such equipment would be destroyed and its power generation function would be completely lost. In such situation, the loss of electric power would continue for a long period of time until the power source is recovered, therefore cause damage to the economy and the people's livelihood in the communities in these areas. In particular, the municipal hospital, which is the only medical facilities in each area, does not have an alternative power source and only has emergency power source which is insufficient for ordinal activities. Likewise, a long-term power failure will stop medical activities which are critical to human life. Also, long-term power failure in the military, police, or other public facilities may affect public security.

In consideration of these situations, the Government of Nepal requested the Government of Japan to improve the following micro-hydropower plants.

| | | | |
|---|---|---|---|
| 1) | Bajhang Micro-hydropower Plant (Bajhang District) | Rehabilitation | 230 kW (115 kW x 2 units) |
| | | Expansion | 230 kW (115 kW x 2 units) |
| 2) | Bajura Micro-hydropower Plant (Bajura District) | Rehabilitation | 230 kW (115 kW x 2 units) |
| | | Expansion | 230 kW (115 kW x 2 units) |
| 3) | Syarpudaha Micro-hydropower Plant (Rukum District) | Rehabilitation | 240 kW (120 kW x 2 units) |
| | | Expansion | 240 kW (120 kW x 2 units) |
| 4) | Chaurjahari Micro-hydropower Plant (Rukum District) | Rehabilitation | 180 kW (90 kW x 2 units) |
| | | Expansion | 180 kW (90 kW x 2 units) |

Note: The capacity of the existing facilities mentioned above indicates the output of hydraulic turbines. The output of the generators in Bajhang, Bajura, and Syarpudaha micro-hydropower plants are 200 kW each while it is 150 kW in Chaurjahari Micro-hydropower Plant.

Chaurjahari Micro-hydropower Plant in Rukum District was included in the request by the Government of Nepal. However, since it was found out in the preliminary survey conducted in March 2013 that the supply area of the concerned power plant would be connected to the main transmission system in the near future and that the Nepal Electric Authority (NEA) has decided to cease operations of the power plant after the said connection, the Chaurjahari Micro-hydropower Plant was excluded from the targets of the Project. In addition, expansion of each micro-hydropower plant was included at the time of the request, but since there is no existing hydrologic data which is sufficient for the study on expansion, it was decided not to consider the expansion plan in the Project.

After the micro-hydropower plants of the three target sites are improved through implementation of the Project, the power plants would be able to recover their original installed capacity which is almost double the running capacity. Consequently, electricity sales would also be double. Even though load shedding will remain within each distribution network, load shedding in important public facilities such as hospitals will virtually be eliminated, and this would significantly contribute to medical care activities such as medical practices at nighttime.

With the twofold increase in amount of supplied electricity, a power source for nighttime illumination of public facilities and general households is secured, and it is expected to enhance learning of schoolchildren as well as community activities by adults.

## 1-2 Natural Conditions

### (1) Hydrometeorology

The climate in Nepal, which is divided into dry season from October to May and rainy season from June to September, is of subtropical monsoon climate for the most part. About 80% of the annual rainfall is concentrated in the rainy season. Most of the rainfall occurs mainly in July and August, while little rainfall is experienced in November and December. The Department of Hydrology and Meteorology (DHM) of the Ministry of Science and Technology of Nepal is conducting meteorological observations from the mid-20th century. Table 1-1 shows the rainfall observation data at locations in the vicinity of the respective micro-hydropower plants.

Table 1-1 Rainfall Observation Data near the Target Sites

Bajhang Micro-hydropower Plant (Observation period: 1953 to 2009)

| name | Evaluation | monthly rainfall (mm/m) | | | | | | | | | | | | annual rainfall (mm/y) | season (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | rainy | dry |
| Chainpur (Bajhang) | Maximum | 169 | 202 | 206 | 176 | 205 | 435 | 553 | 617 | 465 | 274 | 61 | 132 | 2,079 | 1,743 | 685 |
| | average | 52 | 60 | 63 | 46 | 60 | 177 | 372 | 386 | 216 | 54 | 9 | 25 | 1,518 | 1,151 | 368 |

Bajura Micro-hydropower Plant (Observation period: 1976 to 2009)

| name | Evaluation | monthly rainfall (mm/m) | | | | | | | | | | | | annual rainfall (mm/y) | season (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | rainy | dry |
| Bajura (Bajura) | Maximum | 175 | 240 | 309 | 163 | 263 | 509 | 1,277 | 770 | 570 | 186 | 79 | 175 | 2,792 | 2,403 | 864 |
| | average | 55 | 71 | 64 | 60 | 115 | 255 | 528 | 492 | 231 | 40 | 10 | 27 | 1,949 | 1,506 | 430 |

Syarpudaha Micro-hydropower Plant (Observation period: 1973 to 2009)

| name | Evaluation | monthly rainfall (mm/m) | | | | | | | | | | | | annual rainfall (mm/y) | season (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | rainy | dry |
| Musikot (Syarpudaha) | Maximum | 81 | 100 | 122 | 171 | 303 | 646 | 1,133 | 819 | 896 | 480 | 91 | 99 | 2,948 | 2,748 | 638 |
| | average | 23 | 31 | 37 | 46 | 116 | 291 | 545 | 548 | 311 | 69 | 14 | 17 | 2,050 | 1,695 | 354 |

Source: DHM

Since the Project is aimed at rehabilitation of the hydroelectric generation facilities including intake, weir, and headrace, the design flood discharge is required for designing the repair and reconstruction of facilities. According to the run-off model, the design flood discharge at each site is estimated as shown in Table 1-2 below. As for the run-off model, the discharge flow is calculated from a rational formula that is evaluated to be suitable for application for rivers in mountainous areas. The design conditions of facilities, such as intakes and weirs, are studied and decided based on the design flood discharge mentioned in the table.

Table 1-2 Design Flood Discharge at the Intake Weirs of the Three Target Sites

| Site | Catchment area ($km^2$) | Design flood discharge* ($m^3/s$) |
|---|---|---|
| Bajhang | 104.0 | 1,520 |
| Bajura | 27.3 | 560 |
| Syarpudaha | 40.8 | 830 |

* 50-year probability of flood is estimated from 50-year probability of rainfall at 204 mm/day (converted into rainfall intensity by the Mononobe formula) with the run-off model calculated using the rational formula.

Source: JICA survey team

(2) Topographic Survey

Preliminary topographic survey was conducted in the early stage of the 1st field survey by the study team for quick start of the design work, and then full-dress topographic survey was conducted by the local consultant to make detailed topographic maps.

Items and the final quantities of the topographic survey work entrusted to local consultant were shown in Table 1-3.

Table 1-3 Survey Items and Quantities

| Survey items | Bajhang | Bajura | Syarpudaha |
|---|---|---|---|
| Installation of control points | 4 | 6 | 3 |
| Topographic survey (ha) | 2.396 | 1.049 | 2.086 |
| Waterway profile survey (m) | 1,100 | 2,523 | 1,850 |
| Cross section survey for river, headrace, and penstock line(m) | 1,500 | 1,500 | 1,500 |
| Mapping | Topographic map ( 1/100~1/200)<br>Water way profile<br>River, waterway, and penstock line cross section | | |

Source: JICA survey team

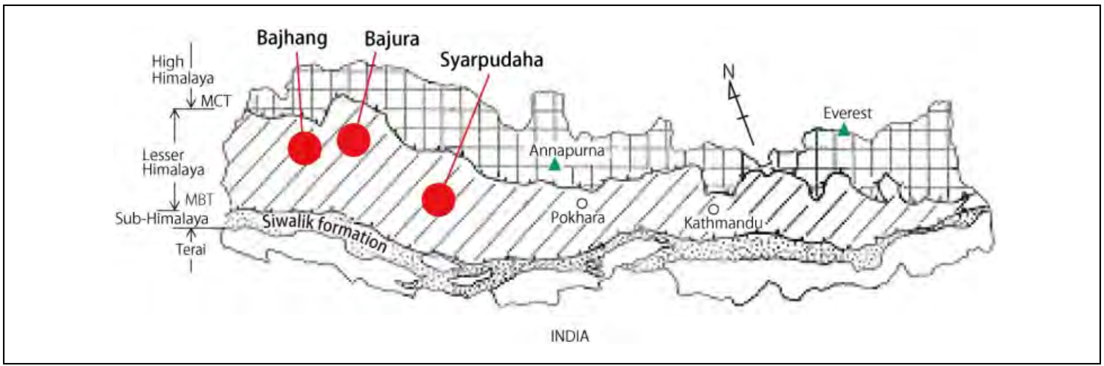
(3) Geological Reconnaissance

1) General view of the Project site

Nepal consists of four tectonic zones, the HIGHER HIMALAYA (EL.3000~8000m), LESSER HIMARAYA (EL.1000~3000m), SUB HIMALAYA (EL.300~1000m), and TERAI(EL.100~300m) from the northernmost. The project sites are located in Bajhang District (Bajhang Micro-hydropower Plant), Bajura District (Bajura Micro-hydropower Plant), and Rukum District (Syarpudaha Micro-hydropower Plant) on LESSER HIMARAYA zone shown in Figure 1-1.

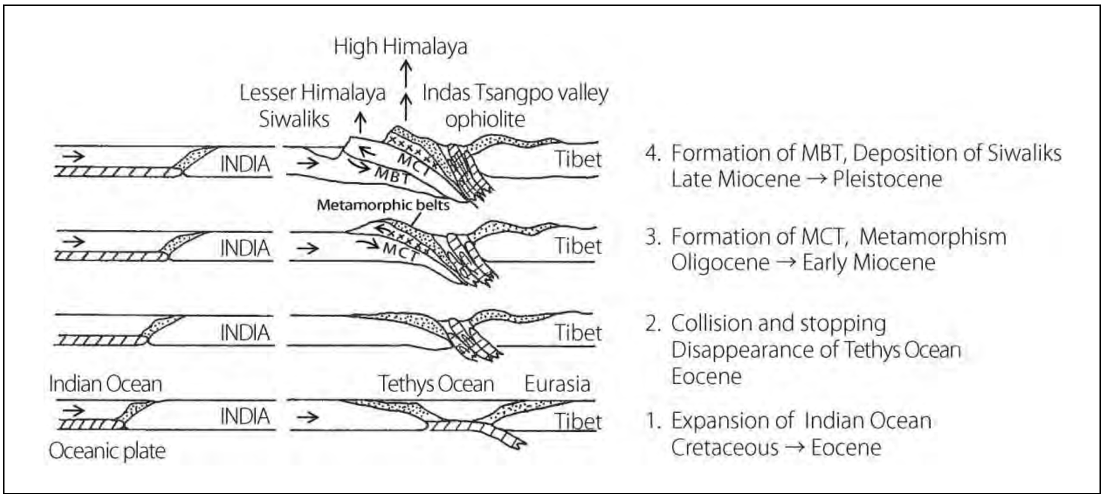
The MCT (Main Central Thrust), shown in Figure 1-1 and Figure 1-2 is a kind of fault which causes a rise of the Himalaya Mountains to altitude of 8000m. It is considered that the MBT (Main Boundary Thrust) shown in same figures is a reverse fault of steep angle which is still active.

LESSER HIMALAYA zone is composed of Pre-Cambrian to Neogene sedimentary rocks such as limestone, slate, phyllite, and sandstone.




Source: JICA survey team

Figure 1-1 Geological Classification of Terrain in Nepal




Source: JICA survey team

Figure 1-2 Himalayan Orogeny and Expansion of Indian Ocean

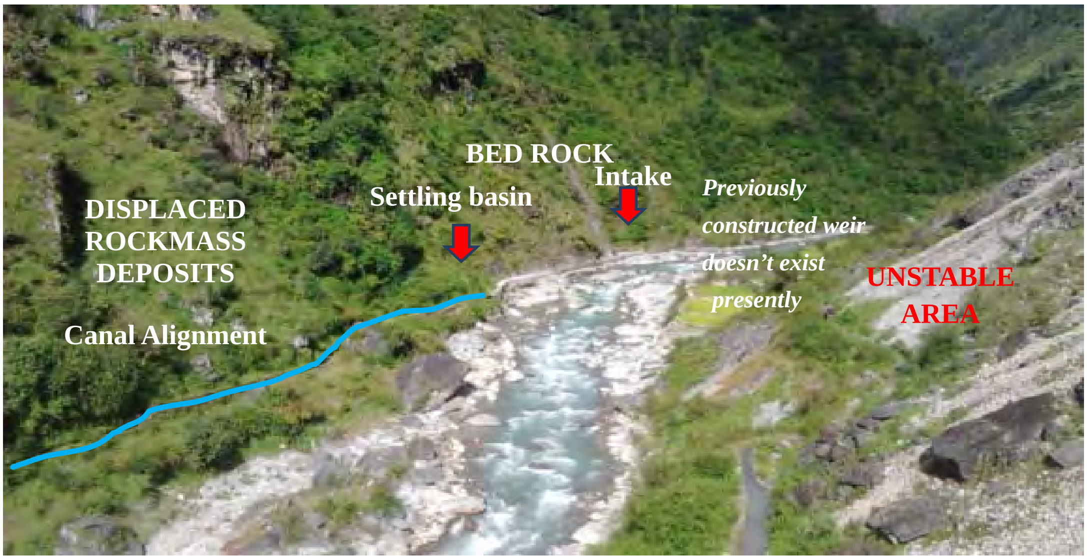
2) Geotechnical Features of the Scheme

(a) Bajhang

- The main rock type is composed of limestone, slate, sandstone, and phyllite.
- Intake
  - ✓ River bed slope; around 1/21
  - ✓ River bed; Boulders (5m < dia.) are scattered. Outcrop and fine materials in river bed deposit are not observed. Cobbles and boulders are found in 0.5m depth under ground level. River bed width is 30~40m.
  - ✓ Right bank; Outcrop of smoky grey to dirty white slightly weathered sandstone is observed.
  - ✓ Left bank; Collapsed slope is observed from the intake to upstream.
- Headrace Channel
  - ✓ Open channel, which is passing along cultivated field riverside, takes a half length of headrace channel. A mountain side slope along this channel is stable.
  - ✓ Open culvert with rids is passing along a collapsed slope which is composed of slate debris 250m width and 100m height. (See Figure 1-4)

- ✓ The channel, from collapsed slope to head pond, is passing along gentle slope, which is composed of alluvial terrace having more than 20m thickness.

- Head pond, Penstock line
  - ✓ The structures are constructed on alluvial terrace of medium hardness.
- Powerhouse, Tailrace
  - ✓ The structures are constructed on alluvial terrace.
  - ✓ The terrace is composed of boulders (1m > dia.), cobbles, gravels, and sandy clay.




Source: JICA survey team

Figure 1-3 Bajhang Intake Site

(View from downstream. Headrace channel is observed at right bank.)


Source: JICA survey team

Figure 1-4 Collapsed Slope along Headrace Channel (250m width, 100m height)

(b) Bajura

- The main rock type is composed of sandstone, and phyllite.
- Intake
  - ✓ River bed slope; around 1/12
  - ✓ River bed; Boulders (5m > diameter) are scattered. Outcrop and fine materials in river bed deposit are not observed. Cobbles and boulders are found in 0.2~0.4m depth under ground level. River bed width is 25~30m.
  - ✓ Right, and Left bank; Outcrop of dark green slightly weathered hard strength phyllite is observed. The outcrop is formed stable cliff at intake site. The dip strike is S/30~35°E/20~25°. ( See Figure 1-5 )
- Headrace channel
  - ✓ Mostly composed of open channel.
  - ✓ The channel is passing along stable residual soil with gentle slope.
  - ✓ Steep slopes of residual soil are observed along the channel. The slopes are stabilized by deep rooted grasses.
  - ✓ Open culvert with rids is passing along residential area which is composed of stable residual soil having more than 10m thickness.
- Head pond
  - ✓ The head pond is constructed on residual soil deposit of dark grey with medium hardness.
- Penstock line
  - ✓ The geological condition is the same as the head pond area for the upstream part of one third of the penstock line.
  - ✓ The penstock of the remaining part is passing along phyllite outcrop steep ridge.
- Powerhouse, Tailrace
  - ✓ The structures are constructed on relatively flat flood plain deposit, having 5m thickness formed by the Bauli Gad.
  - ✓ The deposit is composed of boulders (1m > dia.), cobbles, gravels, and sandy clay. The deposit contains 30% of fine materials and 70% of coarse materials.



Source: JICA survey team

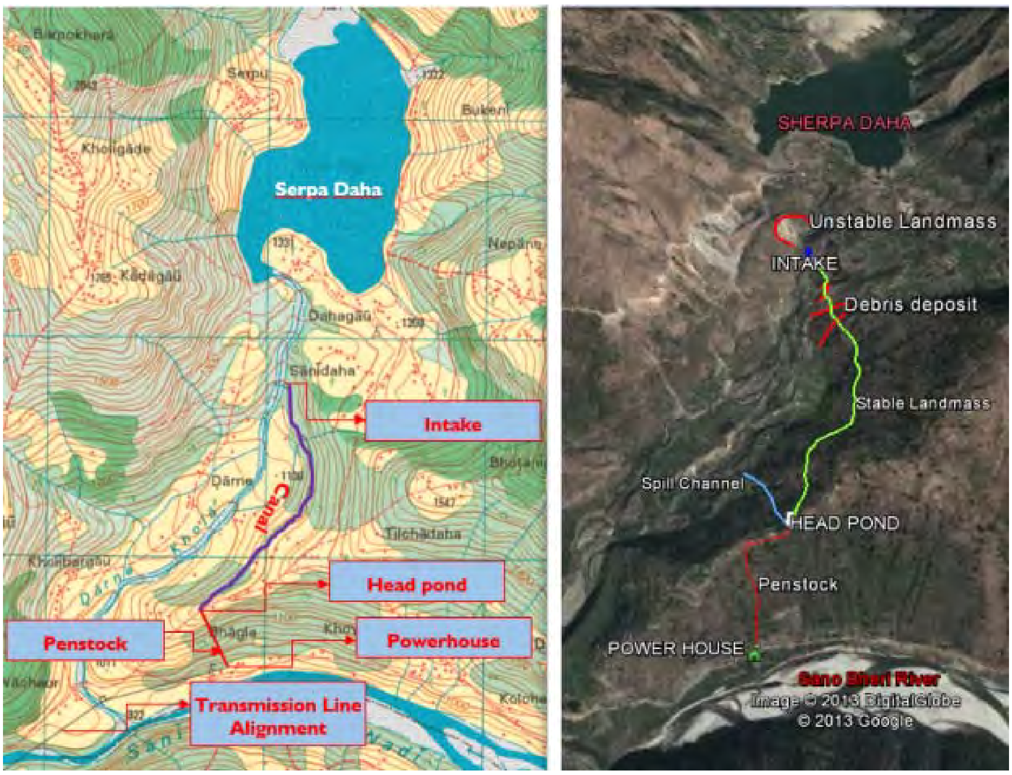
Figure 1-5 Bird's –Eye View of the Whole Bajura Area (Google Earth)


Source: JICA survey team

Figure 1-6　Bajura Intake Site (View from Bridge)

(c) Syarpudaha

- The main rock type is composed of limestone, sandstone, and phyllite.
- Intake
  - ✓ A lake formed by the natural damming of a river is observed 500m upstream of the intake site.
  - ✓ River bed water from a lake forms a few of surface water flow at intake site.
  - ✓ River bed slope; around 1/4.5
  - ✓ River bed; Boulders (5m > dia.) are scattered. Outcrop and fine materials in river bed deposit are not observed.
  - ✓ Right, and Left bank; Collapsed slope deposit is observed.
- Headrace channel
  - ✓ Channel is passing along collapsed slope area (S/70º, W/46º) in 380m, 30% of total length.
  - ✓ Channel is passing along stable residual soil, having 30º~40º slope, in 890m, 70% of total length.
  - ✓ Distance 160~210m from intake; Unstable slope is observed. The collapsed slope is composed of sandy silt, and debris having 60m height. Countermeasure is need.
- Head pond
  - ✓ The head pond is constructed on residual soil deposit of brown color with medium strength.
- Penstock line
  - ✓ The penstock is passing along stable residual soil deposit of brown color with medium to low hardness.
- Power house, Tailrace
  - ✓ The structures are constructed on relatively flat flood plain deposit having 5m ~7m thickness.
  - ✓ The deposit is composed of boulders (1m > diameter), cobbles, gravels, and sandy clay. The deposit contains 30% of fine materials and 70% of coarse materials.




Source: JICA survey team

Figure 1-7 Bird's –Eye View of the Whole Syarpudaha Area (Google Earth)


Source: JICA survey team

Figure 1-8 Syarpudaha Intake Site

## 1-3 Environmental and Social Consideration

### 1-3-1 Environmental Impact Assessment

(1) Environmental and social baselines

1) Natural environment

(a) Geographic features

The land of Nepal is geographically divided into the following three areas in the north-south direction: Upper Himalaya (mountainous regions where precipitous high mountains rise side by side), the hills and Lower Himalayan Range, and the Terai Valley (plains at lower altitudes above sea level). The hills and the middle mountain range are between the two extremes of the northern and southern areas. The Project sites exist in the hills and Lower Himalayan Range.

Since the mountain range and the hills where the Project sites are located consist of precipitous terrain, the sites suffer from damages by landslides, which result in blockage of traffic, and erosion of rivers caused by rainfall during the rainy season (monsoon season). On the other hand, the rainfall reduces during the dry season, and therefore affects cultivation of crops, causes reduction of hydropower generation, among others.

(b) Geological features

The geotectonic zones of Nepal are classified as the Upper Himalaya, the Lower Himalaya, Sub-Himalaya and Terai Plains. The boundaries of each range are separated by thrust faults with good continuity.

The Project sites are located on the southern side slopes of the western area of the Mahabharat Range in the Lower Himalayan Range.

The geological features of the Lower Himalayan Range are described below.

Mountains which relatively have summit-level accordance at 2,000 to 3,000 m levels stand in the range. They are composed of metamorphic rocks, sedimentary rocks from the Paleozoic and Mesozoic, and granites. The mountain ridges with summit-level accordance are rounded, and red weathering crusts remain well. The rivers formed steep V-shaped valleys due to downward erosion, and fresh bedrocks are exposed at the river beds. Landslide landforms and bulged landforms created by the creep of bedrocks are often formed on the slopes of the mountainsides, and they are utilized as terraced paddy fields.

(c) Riverine systems and rivers

The rivers where this Project is located belong to the following river systems:

- Bajhang micro-hydropower plant
  The water for power generation is taken from the Bauli River, which is a tributary that flows to the upper reaches of the Seti River near Chainpur, Bajhang District. The Seti River is a major tributary of the Karnali River.
- Bajura micro-hydropower plant
  There is the Any River at the upstream of the Budhiganga River, which is a tributary of the Seti River. The water for power generation is taken from the Bauly River, which flows into the Any River around Martadi, Bajura District.
- Syarpudaha micro-hydropower plant
  The Bheri River is a major tributary of the Karnali River. The Sani Bheri River is a

tributary of the Bheri River, and its upstream part flows to the northwestern side of Musikot, Rukum District. The Tilcha River flows out from the Sharpu Lake, which is located on the mountainside at the northern part of the Sani Bheri River, and flows into the Sani Bheri River. The water for power generation is taken from the Tilcha River.

(d) Climate and weather

The climate zones of the three districts where the Project sites are located consist mainly of temperate zone and cool-temperate zone.

The temperature and the rainfall of the three districts where the Project sites are located (hereinafter referred to as the three districts) are shown in Table 1-4.

Table 1-4 Temperature of the Three Districts

| | Bajhang District | Bajura District | Rukum District |
|---|---|---|---|
| Average temperature (°C) | 2-35 | 0-5 (winter season)<br>18-32 (summer season) | 0-43 |

Source: District Profile: BAJHANG, BAJURA and RUKUM,
United Nations Field Coordination Office (UNFCO) (2013)

Depending on the area, the representative rainy season of Nepal is from June to September, and the dry season is from October to May. In the Mid-Western and Far-Western area, the rainy season starts from the middle of June in normal years.

(e) Natural disaster

Nepal is easily affected by climate change because of its geographical features, and since it is located directly above the large faults which lift the Himalayas, the risk of earthquake is high.

Risks of flooding and landslides in target areas of the Project are high. Table 1-5 shows the situation of natural disasters in the three districts.

Table 1-5 Situation of Natural Disasters in the Three Districts

| Bajhang District | Bajura District | Rukum District |
|---|---|---|
| Natural disasters such as floods (mainly around the riverbanks of the Seti River), landslides, forest fires, damage from a hailstorm, and earthquakes easily occur.<br>The district has suffered from serious damage by landslides in the past. | Natural disasters such as flood, landslide, and forest fire easily occur.<br>Deforestation for the purpose of obtaining firewood occurs a lot.<br>The micro-hydropower generation facility was damaged and irrigation and water supply canals were destroyed due to landslide disaster in May 2012. | Landslides occur very easily because of the district's geographic features.<br>The rate of occurrence of landslides is increasing because of slope cutting for road construction.<br>There were as many as 26 deaths recorded due to landslide disaster in 2011. |

Source : District Profile: Bajhang, Bajura, and Rukum,
United Nations Field Coordination Office (UNFCO), 2013

(f) Biota and ecosystems

There are large differences in elevation within short distances in Nepal. It is a country with a large variety of ecosystems, having green forests, deserts in high mountains, and grasslands in lowlands.

a) Vegetation and forest

Distribution of vegetation in Nepal depends on the altitude of the land in general. Also, diverse and rich ecosystems are formed including meadows and humid forests where subalpine and alpine rhododendron and conifers grow, temperate deciduous and coniferous forests, subtropical evergreen forests and tropical rain forests.

Forests formed with rhododendron, various deciduous trees and evergreen oak family trees are distributed around the Mahabharat Range where the Project sites exist.

According to the Food and Agriculture Organization (FAO) of the United Nations, the forest area of Nepal was 3.64 million ha in 2010, which is 25% of Nepal's land area. However, the forest area is decreasing, and the rate of reduction of forest area from 2000 to 2005 due to changes in land use or natural factors was approximately 1.4% per year in average. There are a lot of non-electrified areas in Nepal, and such areas depend on forests for firewood, which is their energy source, therefore causing decrease of forests. Decrease of forests is one of the causes of soil erosion and sediment disasters.

b) Endemic species in Nepal

Endemic species in Nepal include 399 species of vascular plants, two species of mammals, two species of birds, 21 species of reptiles and amphibians, and six species of fish.

c) Threatened species

The numbers of threatened species in Nepal as reported by the International Union for Conservation of Nature (IUCN) released in February 2012 are listed in Table 1-6.

Table 1-6 Numbers of Threatened Species in Nepal

| | CR | EN | VU | Total |
|---|---|---|---|---|
| Animals | 12 | 23 | 51 | 86 |
| Plants | 0 | 4 | 5 | 9 |

Note: CR: Critically endangered
EN: Endangered
VU: Vulnerable
Source: IUCN (2012)

The numbers of threatened species, as given in Table 1-6, are listed by taxonomic classification in Table 1-7.

Table 1-7 Numbers of Species in Nepal by Taxonomic Classification

| Mammals | Birds | Reptiles | Amphibians | Fish | Mollusks | Other Invertebrates | Plants | Total |
|---|---|---|---|---|---|---|---|---|
| 31 | 33 | 9 | 3 | 7 | 1 | 2 | 9 | 95 |

Source: IUCN (2012)

A biological survey conducted to confirm the existence of species around the Project sites has never been implemented. Also, endemic and threatened species in Nepal described above have not been confirmed.

d) Protected areas

Management of protected areas in Nepal has been reinforced year by year since the 1970s.

Conservation areas make up 21.08% of the whole area of the country, which is 31,029.67 $km^2$ (as of 2012).

Ten national parks, three wildlife reserves, one hunting reserve, six conservation areas and 11 buffer zones have been identified as sanctuaries.

Among them, the Khaptad National Park (225 $km^2$) is close to the target areas of the Project, but is at least 20 km away from the Bajhang micro-hydropower plant.

2) Social environment

(a) Administrative divisions

Administrative units of Nepal are separated under five development regions, and further subdivided into 75 districts and the capital Kathmandu (Metropolitan). Under the districts, there are 3,915 villages (village development areas) and 58 municipalities (54 municipalities and 5 sub-metropolitans).

The districts correspond to prefectures of Japan's administrative units, and village development areas and municipalities are basic autonomous units.

The district council, district development committee (DDC) and village development committee (VDC) are established for each district. VDC administers village services under the village council.

There are 14 zones in Nepal. Each zone is composed of some districts. However, their political and administrative functions are lost now, and they are just the names which express the local areas.

Municipalities and villages have wards, but they are not strictly local autonomous bodies, but auxiliary units of municipalities and villages. Municipalities are composed of nine or more wards, and villages are composed of nine wards regardless of the size of population.

The administrative units where this Project is conducted are as follows:

| | |
|---|---|
| - Bajhang Micro-hydropower Plant: | Far West Development Region, Seti Zone<br>Bajhang District (District Office: Chainpur)<br>Daulichaur VDC |
| - Bajura Micro-hydropower Plant: | Far West Development Region, Seti Zone<br>Bajura District (District Office: Martadi)<br>Martadi VDC |
| - Syarpudaha Micro-hydropower Plant: | Mid West Development Region, Rapti Zone<br>Rukum District (District Office: Musikot)<br>Bafikot VDC |

(b) Population, households

According to the census of June 2011, the Nepali population was at 26.49 million, in which 17% are in urban areas and 83% in rural areas. The population in Tibetan culture areas in the mountain areas, where the living environment is severe, is only 6.7% of the total Nepali population, while most of the population resides in the southern Terai Valley (50.3%) and hill areas (43.0%).

The annual average population growth rate from 2001 to 2011 was 1.35%.

The population and the number of households of the three districts are listed in Table 1-8

The population and the number of households of the three VDC where the Project sites are located are shown in Table 1-9.

Table 1-8 Population and Number of Households in the Three Districts (2011)

| District | Population (Ratio to the Total Population, %) | | | Number of Households | Number of People per Household | Population Density (population/ km$^2$) |
|---|---|---|---|---|---|---|
| | Total | Male | Female | | | |
| Whole Country | 26,494,504 | 12,849,041 (48.5) | 13,645,463 (51.5) | 5,427,302 | 4.88 | 180.0 |
| Bajhang District | 195,159 | 92,794 (47.5) | 102,365 (52.5) | 33,773 | 5.64 | 57.0 |
| Bajura District | 134,912 | 65,806 (48.8) | 69,106 (51.2) | 24,888 | 5.45 | 61.6 |
| Rukum District | 208,567 | 99,159 (47.5) | 109,408 (52.5) | 41,837 | 4.98 | 72.5 |

Source: National Population and Housing Census 2011, CBS (Central Bureau of Statistics)

Table 1-9 Population and Number of Households in the Three VDC

| VDC | Population | | | Number of Households | Number of People per Household |
|---|---|---|---|---|---|
| | Total | Male | Female | | |
| Daulichaur VDC | 5,317 | 2,694 | 2,623 | 839 | 6.34 |
| Martadi VDC | 8,807 | 4,706 | 4,101 | 1,920 | 4.59 |
| Bafikot VDC | 5,164 | 2,424 | 2,740 | 1,075 | 4.80 |

Source: National Population and Housing Census 2011, CBS (Central Bureau of Statistics)

The youth population in the three districts is shown in Table 1-10.

Table 1-10 Youth Population in the Three Districts (2011)

| Age Levels | Population (Percentage with the District's Population, %) | | |
|---|---|---|---|
| | Bajhang District | Bajura District | Rukum District |
| 4 years old or younger | 27,161 (13.9) | 18,935 (14.0) | 24,316 (11.7) |
| 5-9 years old (corresponding to elementary school , 5 years) | 30,783 (15.8) | 20,662 (15.3) | 30,430 (14.6) |
| 10-14 years old (corresponding to junior high school , 3 years + high school students, 2 years) | 28,876 (14.8) | 19,,604(14.5) | 31,386 (15.0) |

Source: National Population and Housing Census2011, CBS (Central Bureau of Statistics)

(c) Language, religion, and races

According to the census of 2011, there are 123 languages in Nepal (the population of the people whose mother tongue is Nepali is 44.6%).

The main language used at the diet, public offices, etc., is Indo-European Nepali.

The main religions are Hinduism (81.3%), Buddhism (9.0%), and Islam (4.4%).

The main races are the Indo-Aryan (Indo-European) family (Bahun, Chhetri, etc.), Mongoloid (Gurung, Tamang, etc.) and Tibetan (Sherpa, etc.). There are 125 caste/ethnic. They adapt and live in land of various terrains, and each race forms a unique culture. Nepal is a nation where various and diverse cultures and customs coexist.

The caste system, which has lasted for more than 100 years, was abolished by the Constitution in 1963, but it is still incorporated into the social structure as a custom, and there is considerable disparity between the upper caste and the lower caste. Because of such social customs and traditions, the opportunities for education and work for women and for lower caste members are still limited.

Each race has become more adaptable when leaving their indigenous land and marriage among different races has also become more frequent.

The main religions, caste/ethnic and languages in the three districts are summarized in Table 1-11 .

Table 1-11 Main Religions (2010/2011) and Caste/Ethnic (2001) in the Three Districts

| Item | | Percentage with the District's Population (%) | | |
|---|---|---|---|---|
| | | Bajhang District | Bajura District | Rukum District |
| Religion | Hinduism | 99.74 | 98.68 | 96.51 |
| | Buddhism | 0.18 | 1.14 | 1.07 |
| | Christianity | 0.03 | 0.06 | 1.59 |
| | Islam | 0.00 | 0.07 | 0.06 |
| | Other religions | 0.04 | 0.05 | 0.76 |
| Caste/Ethnic | Chhetri* | 70 | 61 | 64 |
| | Dalit* | 16 | 23 | 7 |
| | Brahmin* | 12 | 10 | 5 |
| | Thakuri* | 0.5 | 6 | |
| | Janajati | | | 24 |
| | Sanyasi* | | 3 | |

Source: CBS

(Note) 1. * Caste group

2. Caste in Nepal has three lines by origin, unlike in India.

3. In Nepal, there are ethnic groups in the caste system and ethnic groups outside the caste system. Because the number of the former is larger, CBS is using the category of caste/ethnic group in taking the statistics concerning ethnicity.

Parude Hindu, which accounts more than half of the Nepalese population, is the biggest ethnic group and is divided into groups of name by caste system such as Chhetri in population statistics.

"Caste/Ethnic" in Table 1-11 is the names used and values in the census survey.

4. Chhetri and Thakuri: Warrior class traditionally on the caste system

Dalit: Generic name of the lowest group on caste system

Brahmin: Position of the priest traditionally on the caste system

Sanyasi: Meaning of fakir on the caste system

Janajati: Commercial ethnic group that has its origin from the western area of Nepal

(d) Poor people

The poverty conditions in Nepal are still severe, but improving. The poverty headcount ratio which indicates the percentage of the population living below the international poverty line (the minimum necessary level of income adjusted by purchasing power parity is USD 1.25/day) decreased from 41.8% in 1995/96 to 30.8% in 2003/2004 and down to 25.2% in 2010/2011. The main factor for such improvement is the increase in the number of households which receive remittances from immigrant workers.

Table 1-12 shows poverty headcount ratio (referred to as "ratio" in this section) in the region by category.

The ratio in the far-western area and the mid-western area where the three target sites of this Project are located was 36.8% in 2011/2012, and it is an outstanding ratio as compared with the mountainous area whose ratio is high.

The ratio also varies according to the level of education and the occupation of the head of the household. If the head of the household has never entered school, the ratio is 4.5 times higher than the case in which the head of the household has gone to school for 11 years. The ratio of a household where there is a woman who has gone to school for 11 years or more is only 5.15%, which is approximately one-sixth of the ratio of a household where there is a woman who cannot read or write. The ratio of households with heads who are wage-employed farmers is the highest at 47.0%, followed by self-employed farmers at 27.2%. On the other hand, households with the lowest ratios are those with heads that are professionals (5.6%), in trade (self-employed) (13.2%), and in services (self-employed) (19.6%).

Table 1-12　Poverty Headcount Ratio in the Region by Category (2010/2011)

| Region | | Poverty headcount ratio　% |
|---|---|---|
| Mountains | | 42.27 |
| Urban | Kathmandu | 11.47 |
| | Hill | 8.72 |
| | Terai | 22.04 |
| Rural Hills | Eastern | 15.93 |
| | Central | 29.37 |
| | Western | 28.01 |
| | Mid and Far Western | 36.83 |
| Rural Terai | Eastern | 20.97 |
| | Central | 23.13 |
| | Western | 22.31 |
| | Mid and Far Western | 31.09 |
| Nepal Total | | 25.16 |

Source：CBS

(e) Traffic situation

Public transportation in the three districts only consists of buses. There is no bus stop near the power plants; therefore, people need to go to a bus stop located at a considerable distance.

The bus stops which can be accessed from the power plants are as follows:

- For Bajhang micro-hydropower plant:
  Bus stop is in Chainpur wherein the district office is located (approximately three hours by foot from the power plant)
  Bus service: to Katmandu (1 service/day), and to Dhangarhi (4 services/day)
- For Bajura micro-hydropower plant:
  Bus stop is in Tipa-da bazaar (1.5 hours by truck, tractor, or other vehicle, or approximately three hours by foot from the power plant)
  Bus service: to Nepalgunj (1 service/day), and to Dhangarhi (4 services/day)
- Syarpudaha micro-hydropower plant
  Bus stop is near Musikot Airport (approximately two hours by four-wheel drive vehicle, or 3.5 hours by foot from the power plant)
  Bus service: to Katmandu (1 service/day), and to Nepalgunj (1 service/day)

(f) Domestic fuel

The percentage of households which use firewood remains at 10% in urban areas, but it is at least 80% in mountainous areas and rural areas.

The types of fuel used for cooking in the three districts are summarized in Table 1-13.

Table 1-13 Types of Fuel Used for Cooking in the Three Districts (2011)

| Item | Bajhang District | Bajura District | Rukum District |
|---|---|---|---|
| Fuel for cooking | | | |
| Number of cases | 33,209 | 24,622 | 40,889 |
| Wood/firewood | 57 | 13 | 43 |
| Kerosene oil | 121 | 6 | 602 |
| Liquefied petroleum gas | 5 | 2 | 113 |
| Cowpat | 50 | 42 | 49 |
| Biogas | 1 | 3 | 5 |
| Electricity | 330 | 200 | 136 |
| Others/unknown | 33,209 | 24,888 | 41,837 |
| Total (Household Data: Census 2011) | (33,786) | (24,908) | (41,856) |

Source: CBS (Central Bureau of Statistics)

(g) Education

Nepal implements a ten-year education system, which is composed of five years for primary education, three years for lower secondary education and two years for secondary education. When students graduate from secondary education, they take a nationwide qualification test called the School Leaving Certificate (SLC).

The ten-year education system of Nepal (primary education, lower secondary education, and secondary education) is two years shorter of the international standard. Therefore, as a provisional measure before being able to enter higher education (college/university), an additional two-year period of education is provided after secondary education. After this additional two-year period of education, students can then enter higher education (three years of education for a bachelor’s degree, or five years of education in medical school).

The literacy rates in the three districts are summarized in Table 1-14.

Table 1-14 Literacy Rates in the Three Districts

| | Bajhang District | Bajura District | Rukum District | National Average |
|---|---|---|---|---|
| Literacy Rate | | | | |
| Overall | 56 | 56 | 62 | 66 |
| Female | 40 | 43 | 54 | 57 |

Source: United Nations Field Coordination Office (UNFCO),
Far-Western Region/ Mid-Western Region, Nepal (2013)

The numbers of educational facilities in the three districts are given in Table 1-15.

Table 1-15 Numbers of Educational Facilities in the Three Districts (2011)

| Item | Bajhang District | Bajura District | Rukum District |
|---|---|---|---|
| School for primary education (corresponding to elementary school) | 454 | 259 | 383 |
| School for lower secondary education (corresponding to junior high school) | 153 | 108 | 136 |
| School for secondary education (corresponding to high school) | 73 | 52 | 69 |
| School for higher secondary education (Two years of education, so-called 10 + 2) | 35 | 16 | 29 |

Source: District and VDC Profile of Nepal-2013

The number of schools for primary education per ward (an administrative auxiliary unit under villages wherein there are nine units per village) is one in general, but there are two schools in some villages exceptionally.

(h) Health, medical care and sanitation

The situations on health, medical care, and sanitation in the three districts are summarized in Table 1-16.

Table 1-16 Situations on Health, Medical Care and Sanitation in the Three Districts (2010/2011)

| Item | Bajhang District | Bajura District | Rukum District |
|---|---|---|---|
| Health and Medical Care Facilities (2010/2011) | | | |
| District Hospital | 1 | 1 | 1 |
| Primary Health Centre | 2 | 1 | 2 |
| Health Posts | 10 | 11 | 7 |
| Sub-health Posts | 35 | 15 | 34 |
| Primary Health Care Outreach Clinics | 126 | 64 | 125 |
| Number of HIV-positive Persons (2011) | | | |
| Male (tested persons) | 2 (184) | 5 (254) | 4 (86) |
| Female (tested persons) | 0 (298) | 3 (226) | 3 (90) |
| Children (tested persons) | 0 (8) | 1 (9) | 0 (14) |
| Sanitation | | | |
| Percentage of households which drinking water is supplied by tap/pipeline (2011) (%) | 67 | 68 | 74 |
| Percentage of households without toilets (%) (2011) | 70 | 61 | 65 |

Source: Department of Health Services

In general, one sub-health post is established per VDC. However, some VDCs have two sub-health posts one exceptionally.

One primary health care outreach clinic is established per ward in general.

The number of toilets is not enough in local agricultural village areas in Nepal. In addition to unimproved water supply facilities, bad sanitary conditions including risks of water source pollution have been a problem. However, with the focused promotion of the plans and the policies related to improvement of water supply facilities and installation of toilets by the government, the supply of drinking water by pipelines from safe water sources and the installation of toilets in local agricultural villages have progressed, and the sanitary conditions are improving.

(i) Agriculture

The situation of agriculture in the three districts is summarized in Table 1-17. The irrigation rate of farmlands is very low in all of the three districts. Agrocultural technology is also at a low level.

Most of the residents of villages around the Project sites make a living by farming and raising livestock and their lives are close to being self-sufficient.

Table 1-17 Situation of Agriculture in the Three Districts (2010/2011)

| Item | Bajhang District | Bajura District | Rukum District |
|---|---|---|---|
| Area under cultivation (ha) | 29,257 | 20,156 | 35,470 |
| Number of agricultural households | 31,981 | 20,390 | 37,241 |
| Main crops | rice, maize, millet, wheat, barley, potatoes, pulse, vegetables, citrus fruits | wheat, potatoes, rice, sugar cane, millet, barley, maize, pulse, vegetables, citrus fruits | millet, wheat, potatoes, rice, green vegetables, citrus fruits |
| Main livestock | cattle, goat, buffaloes, sheep, fowl | cattle, goat, fowl, buffaloes | fowls, goat, cattle, buffaloes, sheep, pigs |

Source: Ministry of Agriculture and Cooperatives (MoAC)

(j) Forestry

The forests in Nepal are 100% owned by the government or public institutions. Administrative institutions or local community user groups have management rights and administrative authority over them.

The forest areas in the three districts are given in Table 1-18.

Table 1-18 Forest Areas in the Three Districts (2011/2012)

| | Bajhang District | Bajura District | Rukum District |
|---|---|---|---|
| Forest area (ha) | 102,443 | 94,150 | 171,255 |
| Area coverage rate (%) | 30 | 46 | 60 |

Source: United Nations Field Coordination Office (UNFCO)
Far-Western Region/ Mid-Western Region, Nepal (2013)

The situation of community forests in the three districts where the Project sites are located is summarized in Table 1-19.

Table 1-19 Situation of Community Forests in the Three Districts (2012)

| | Bajhang District | Bajura District | Rukum District |
|---|---|---|---|
| Number of community forest user groups | 275 | 218 | 412 |
| Number of households per user group | 20,017 | 24,302 | 41,000 |
| Area provided as community forest (ha) | 10,928 | 11,729 | 21,702 |

Source: Department of Forest

3) Environmental pollution

(a) Air pollution

There is no existing measurement data on air pollution in the areas around the Project sites.

There are no factories or workshops around the Project sites, and there only a small number of vehicles which use the roads. As there are only a few sources of pollution, it is assumed that there is virtually no air pollution, as of now.

(b) Water pollution

There is no existing measurement data on water pollution in the rivers around the Project sites.

There are no factories, workshops, or wastewater treatment plants around the Project sites. There is domestic wastewater, but the scale is small.

As there are only a few sources of pollution, it is assumed that there is virtually no water pollution in the rivers in the Project sites, as of now.

(c) Waste

Large containers or pits for waste collection are established at some places in a VDC where there is a district office or in a VDC of equivalent size. Some containers or pits are separated type. The residents can dispose their waste there.

However, there are no trash boxes to collect waste in the villages in the hill areas, and the people therein treat their waste by themselves. Leftovers and residues from cooking are fed to livestock, combustibles are burned, and other wastes are buried.

(2) Legal systems and organizations concerning environmental and social considerations of Nepal

1) Legal systems concerning environmental and social considerations

Major acts relevant to environmental and social considerations are listed in Table 1-20.

Table 1-20 Major Acts Relevant to Environmental and Social Considerations in Nepal

| Act | Description | Year of Enactment (Year of Amendment) |
|---|---|---|
| Environmental Protection Act (EPA) | Principles and basic policies on environmental protection | 1997 |
| Environmental Protection Rules (EPR) | Operation and enforcement rules of the EPA | 1997<br>(1999 and 2008) |
| Forest Act | Preservation, management, and use of forests | 1993 |
| Forest Rules | Operation and enforcement rules of the Forest Act | 1995 |
| Soil and Watershed Conservation Act | Preservation and management of soil and basins | 1982 |
| Plant Protection Act | Protection of plants | 1964 |
| Aquatic Animals Protection Act | Protection of aquatic animals | 1961 |
| National Parks and Wildlife Conservation Act | Preservation of national parks and wildlife | 1973 |
| National Trust for Nature Conservation Act | Regulations concerning national trust for conservation of nature | 1982 |
| Public Road Act | Planning, implementation, and management of public road projects | 1974 |
| Land Acquisition Act | Land acquisition-related regulations | 1977 |
| Labor Act | Regulations for appropriate working environment and labor conditions | 1993 |
| Buffer Zone Management Regulation | Buffer zone management rules | 1996 |
| Explosive Material Act | Control and management of explosives and dangerous goods | 1961 |
| Himalayan National Park Regulations | Preservation of the Himalayan National Park | 1979 |
| Local Self-Governance Act | Laws on municipalities | 1999 |
| Local Self-Governance Rules | Rules on municipalities | 1999 |
| Road Board Act | Roles of the road committee and details of activities are prescribed | 2002 |

Source: JICA survey team

Other than the above, there are a lot of acts and rules concerning protection and conservation of individual protected areas and targets of protection including national parks and wildlife.

2) Legal systems concerning environmental impact assessment

(a) Acts concerning environmental impact assessment

Among the acts listed in Table 1-20, environmental impact assessment (or environment assessment (EA) under Nepali laws) is legislatively based on the Environmental Protection Act (EPA) and Environmental Protection Rules (EPR) (both enacted in 1997 and the EPR was practically amended after).

The EPA prescribes that approval from the governing agency is required for implementation of any project. The EPR prescribes the processes, methods, details, approval procedures, etc., of surveys on environmental and social considerations implemented for projects per sector. Initial environmental examination (IEE) is examined and approved by the competent ministry, and environmental impact assessment (EIA) is examined and approved by the Ministry of Science, Technology and Environment (MoSTE).

Adding to the EPA and EPR, there are laws which regulate the development activities and rules for main sectors, as listed in Table 1-21, and implementation of environmental impact assessment is also regulated.

Table 1-21 Acts on Main Sector Including Regulations Concerning EIA

| Act | Sector (Development/project for which EIA is conducted) | Year of Enactment |
|---|---|---|
| Electricity Act | Electricity sector (power generation, power transmission) | 1992 |
| Electricity Rules | Electricity sector (particularly hydro-electricity) | 1993 |
| Forest Act | Forest sector (development projects implemented in forest areas or those which pass forest areas) | 1993 |
| Mines and Minerals Rules | Mining sector (development of mines and mineral resources) | 2000 |
| National Parks and Wildlife | National park and wildlife protection sector (use of specific areas or categories in the protected forest areas) | 1973 |
| Conservation Act | Tourism sector (acts which generate wastes or cause environmental pollution in the trekking areas) | 1978 |
| Tourism Act | Water resources sector (projects to develop and use water resources) | 1992 |

Source: JICA survey team

(b) Guidelines for environmental impact assessment

Three guidelines, i.e., EIA guideline (National Environmental Impact Guideline (1993)), Guideline for Forestry Sector (1995), and EIA Guideline for Industry Sector (1995), were prepared in the past but are now obsolete. The Nepal Office of IUCN has been preparing new versions of the guidelines above, reflecting the major amendments of the EPR in 2007.

(c) Examination and approval processes of environmental impact assessment (IEE and EIA)

According to the EPR, an EA report has to include the details of environmental impacts, environmental protection measures with an implementation plan, monitoring and evaluation. In addition, the EA procedure should also include public consultation processes.

Public participation takes place at least three times within the entire period of EIA preparation.

With regard to IEE, there is only one opportunity for public participation during the process.

(d) Disclosure of information

It used to be prescribed that the EIA report must disclose information to local institutions such as the local community institution, VDC or the municipality. However, such rule was abolished after the revision of the EPR in 2007, and is now an option.

However, as stipulated in Rule 10 of the EPR, the proponent of the project has to submit 15 copies of the report to the governmental authority concerned. The authority then sends ten copies of the report to MoSTE after checking the details of the report.

(e) Gaps between the legal system on environmental and social considerations in Nepal and the JICA guidelines and how to resolve the gaps

The JICA guidelines and the safeguard policies of the World Bank are generally more specific and stricter than the provisions being applied in Nepal. However, there are no contradictions with the basic points.

With regard to the social environment, the provisions in Nepal are laxer than the JICA guidelines and the safeguard policies of the World Bank. For example, the preparation of a resettlement action plan is not mandatory.

According to regulations in EPR, the governmental authority concerned or MoSTE, not the proponent, is responsible for activities on information disclosure related to EA, environmental monitoring and environmental audit. Moreover, the use of external resources, if the capacity of the proponent is inadequate, is not mentioned in the laws in Nepal.

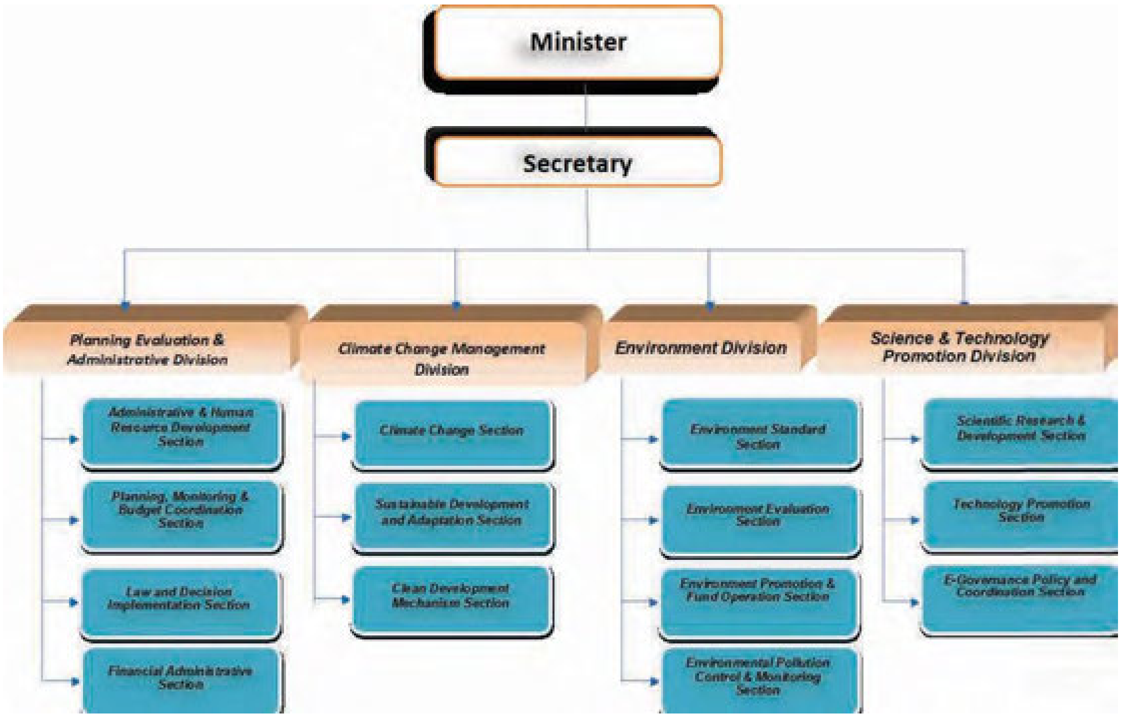
Taking into consideration the conditions above, IEE shall be implemented in according to both the processes and the details which are prescribed in relation to Category B projects in the JICA guidelines for this Project. Measures concerning the regulations prescribed by the acts in Nepal shall be taken within the scope which does not contradict with the JICA guidelines.

(f) Organization concerning Environmental Impact Assessment

The government organization which is responsible for the overall implementation of EA in Nepal is the MoSTE. The organizational chart of the MoSTE is shown in Figure 1-9.

The governmental authority concerned, such as the relevant ministry of the sector of the project, is decided according to the characteristics of the project. The authority is responsible for examination and approval of implementation of IEE.

This Project consists of hydraulic power generation, and it belongs to the electricity sector. Therefore, environmental impact assessment concerning project development shall be implemented under the responsibility of the Ministry of Energy (MoE), which is responsible for the sector, along with the MoSTE.




Source: Ministry of Science, Technology and Environment

Figure 1-9 Organizational Chart of the MoSTE

Major acts relevant to environmental and social considerations are listed in Table 1-22.

Table 1-22 Major Acts Relevant to Environmental and Social Considerations in Nepal

| Act | Description | Year of Enactment (Year of Amendment) |
|---|---|---|
| Environmental Protection Act (EPA) | Principles and basic policies on environmental protection | 1997 |
| Environmental Protection Rules (EPR) | Operation and enforcement rules of the EPA | 1997 (1999 and 2008) |
| Forest Act | Preservation, management, and use of forests | 1993 |
| Forest Rules | Operation and enforcement rules of the Forest Act | 1995 |
| Soil and Watershed Conservation Act | Preservation and management of soil and basins | 1982 |
| Plant Protection Act | Protection of plants | 1964 |
| Aquatic Animals Protection Act | Protection of aquatic animals | 1961 |
| National Parks and Wildlife Conservation Act | Preservation of national parks and wildlife | 1973 |
| National Trust for Nature Conservation Act | Regulations concerning national trust for conservation of nature | 1982 |
| Public Road Act | Planning, implementation, and management of public road projects | 1974 |
| Land Acquisition Act | Land acquisition-related regulations | 1977 |
| Labor Act | Regulations for appropriate working environment and labor conditions | 1993 |
| Buffer Zone Management Regulation | Buffer zone management rules | 1996 |
| Explosive Material Act | Control and management of explosives and dangerous goods | 1961 |
| Himalayan National Park Regulations | Preservation of the Himalayan National Park | 1979 |
| Local Self-Governance Act | Laws on municipalities | 1999 |
| Local Self-Governance Rules | Rules on municipalities | 1999 |
| Road Board Act | Roles of the road committee and details of activities are prescribed | 2002 |

Source: JICA survey team

Other than the above, there are a lot of laws and rules concerning protection and conservation of individual protected areas and targets of protection including national parks and wildlife.

(g) Project license and environmental impact assessment

With regard to hydraulic power generation projects, Provision 6 of the Electricity Act of 1992 of Nepal prescribes the following:

a) The licenses for conducting surveys, power generation, and power transmission/distribution are not required for projects which have electrical power plant capacity (referred to as “capacity” in this section) is 1,000 kW or less as implemented by the government or an institution.

b) It is necessary to submit information which explains the effects of the project to the Department of Electricity Development (DoED) of MoE before power generation, power transmission, or distribution for projects with capacity of 100 kW to 1,000 kW.

Note: Details and procedure on the preparation of information report mentioned above are stipulated in Clause 6 of the Directives for the Licensing of Hydropower Development (2011).

Because it is unnecessary for both a) and b) to apply for a license, the accompanying IEE/EIA is also unnecessary. On the other hand, DoED instructs that for a project intended to improve an already constructed power plant of installed capacity between 100 kW and 1,000 kW, but the installed capacity still remained between 100 kW to 1,000 kW after the improvement, the proponent shall submit the information to DoED to obtain its approval. Therefore, NEA has to submit the information report to DoED for approval.

(3) Comparison of alternatives (including Zero Option)

The following three alternatives considered for the Project as shown in the Table 1-23

The alternatives were compared from the view point of economic efficiency, engineering, and environmental and social considerations. Comprehensive evaluation was implemented and the current plan was selected as the project target.

Table 1-23 Comparison of Alternatives

| Alternative options | Overview | Influences |
|---|---|---|
| Alternative 1<br>(Zero Option)<br>Project for improving the existing power plant facilities is not conducted. | Intake of water is done by the temporary intake weirs. Failures of the control equipment remain under current conditions, and the operation of power generation is continued by manually operating the water-wheel generator. | ・ As the intake weirs are temporary structure, repair cost of 200,000 ~ 500,000 will be necessary every year.<br>・ The power plant capacity of 100 kW or less is not changed. That is half of the original capacity.<br>・ Because the amount of electricity generated decreases along with the aging of existing plant equipment, the problem of supply shortage will be further worsen.<br>・ As the power generation equipment is already fail, it is highly likely that mechanical accident of the water-wheel power generator would occur.<br>・ When an accident on power source occurs, power supply will be completely lost in the region because the network is not connected to the core grid.<br>・ There is no new impact on environmental and social conditions.<br>・ Load shedding due to construction work will not occur. |
| Alternative 2<br>Reconstruction of the current temporary intake structures is not conducted. | Although renewing of power generation facilities is conducted, reconstruction of the current temporary water intake structures is not conducted.<br>(Land to be newly required for the Project, excluding existing land currently used for the power plant will be used for reconstruction of the water intake structures. This alternative is set to reconsider land acquisition necessary in Bajhang.) | ・ As the temporary intake structures are not able to secure necessary amount of water intake and originally designed power output of 200kW is not achieved, the load restriction will not be reduced.<br>・ Even after improvement of the power generation equipment, the power output is not restored.<br>・ Every time flood occurs, the temporary structures are flown away and power generation is stopped until the recovery of the temporary structures.<br>・ Cost of construction work will be decreased significantly from the current plan.<br>・ Land acquisition is not required.<br>・ Muddy water rarely occurs in the river.<br>・ As the scale of civil engineering work becomes extremely small, there is little impact on the environment as caused by the noise and vibration generated by the operation of transportation vehicles and heavy machines.<br>・Period of load shedding during construction period is shorter than the current plan. |
| Alternative 3<br>(Current Plan) | Intake structures are reconstructed at the existing location.<br>While leaving the existing canals, water tank and hydraulic iron pipeline in original forms, renovation is conducted.<br>Power generation equipment is renewed. | ・ The power plant capacity will be recovered to 200 kW which is the original capacity.<br>・ The amount of power generation will double from the current amount, reaching approximately 1.6 GWh annually.<br>・ Amount of electricity supply will double, allowing reduction in load restriction.<br>・ Revenue from sales of electric power will increase and repair cost will decrease.<br>・ Generation of turbid water during construction period is unavoidable.<br>・ Temporary environmental impact will occur to some extent due to noise and vibration during operation of transportation vehicles and heavy construction machines.<br>・ Load shedding during construction period is unavoidable. |

(4) Scoping

35 items of Environmental and social impact were set, according to the items listed in JICA Guidelines for Environmental and Social Considerations (April 2010). The expected impacts were evaluated and summarized as scoping. Table 1-24 shows the results of scoping with the reason of assessment.

Table 1-24 Scoping (1/5)

| Category | | Environmental Item | Rating: Planning Stage / Construction Stage | Rating: Operation Stage | Scoping (Identified Impacts and Reasons) |
|---|---|---|---|---|---|
| Social Environment | 1 | Land acquisition and involuntary resettlement | B- | B- | There is no involuntary resettlement in this Project, but it is necessary to acquire agricultural land in Bajhang. There is no removal/relocation of properties such as private structures. The scale of the acquired land is small, and the owners are only two, so rating is assessed to be B-. |
| | 2 | Poor people | D | D | Many of the residents of the villages around the Project sites are poor people.<br>There is no factor in the implementation of this Project which particularly causes negative impacts on the economy or the lives of the poor people. |
| | 3 | Indigenous people or ethnic minority | C | C | Existence of minorities or indigenous people around the Project sites has not been confirmed. This will be confirmed by field surveys.<br>There is no factor in implementation of this Project which causes negative impacts on the economy, livelihood or culture of the minorities and the indigenous people. |
| | 4 | Local economy such as employment and livelihood | C+ | C+ | **Construction Stage:** Workers are required for construction works, though their employment is temporary, employment opportunities for workers, excluding skilled workers, are created in the areas.<br>**Operation Stage:** In terms of wide regional area, there is contribution to electrification of the areas and positive effects on the regional economy. |
| | 5 | Utilization of land and local resources | D | D | **Construction Stage:** Stone and gravel for civil works are taken from the riverbed, and most aggregates are taken from the existing borrow pit. Because the scope of the Project consists of improvement and repair of existing micro-hydropower plants, the scale of civil works is small. Therefore, the impact on regional resources is minor.<br>**Operation Stage:** No impact is expected. |
| | 6 | Water usage | B- | C | **Construction Stage:** If the water for construction and the water for worker's use are taken from the same water source of the residents, it may affect the water supply of the residents.<br>**Operation Stage:** The situation of water use for irrigation water and for fisheries in the rivers around the Project sites is unknown.<br>If there are such purposes of use, the detail including the impacts by the Project will be confirmed by field surveys. |
| | 7 | Existing social infrastructure and services | B- | B+ | **Construction Stage:** There may be inconvenience for the residents caused by load shedding for construction.<br>**Operation Stage:** In terms of wide regional area, because the advancement of regional electrification improves the bases of social infrastructure in the districts, there would be positive impacts on the villages where the Project sites are located. |

Table 1-24　Scoping (2/5)

| Category | | Environmental Item | Rating: Planning Stage / Construction Stage | Rating: Operation Stage | Scoping (Identified Impacts and Reasons) |
|---|---|---|---|---|---|
| Social Environment | 8 | Social institutions such as social infrastructure and local decision-making institutions | D | D | As the Project consists of improvement and repair of existing micro-hydropower plants, it is considered there would be little impact on social infrastructure, and to decision-making institutions in the regional areas. |
| | 9 | Misdistribution of benefits and damages | C- | C- | As improvement and repair of existing micro-hydropower plants are implemented in the Project, it is expected that the Project itself will not cause any misdistribution of benefits and damages to the peripheral areas. However, if appropriate consideration is not made for the residents and the local authorities with regard to the possibility of temporary negative impact on the life and the production activities during the construction stage, it may cause dissatisfaction to residents with regard to misdistribution of benefits and damages. |
| | 10 | Local conflicts of interest | D | D | Improvement and repair of existing micro-hydropower plants are implemented in the Project. The positive impacts, as a result of the increase in the amount of power supply, are distributed equally to the concerned areas. It is considered that these would not cause conflicts of interest within the areas. |
| | 11 | Cultural, historical, archaeological and religious heritage sites | D | D | **Construction Stage:** There are neither valuable nor cultural heritage sites to be protected. There is neither historically nor culturally high preservation value in and around the Project sites.<br>**Operation Stage:** No impact is expected. |
| | 12 | Water rights, fishing rights and rights of common | C | C | Whether water rights or fishery rights are set for the rivers around the Project sites and whether the forest common rights are set in the surrounding areas are unknown.<br>They will be confirmed by the field survey. |
| | 13 | Landscapes | D | D | **Construction Stage:** No impact is expected.<br>**Operation Stage:** The scale of the newly-installed structures, facilities, and equipment is small, and it does not particularly cause any negative impact on the landscapes. |
| | 14 | Gender | D | D | No particular negative effects on gender are expected with the Project. |
| | 15 | Rights of children | D | D | No particular negative impact on children's rights is expected with this Project. |
| | 16 | Public health and sanitation | B- | D | **Construction Stage:** There may be effects on health and sanitation of the residents around the Project sites because of the influx of construction workers from outside.<br>**Operation Stage:** No impact is expected. |
| | 17 | Infectious diseases such as HIV/AIDS | B- | D | **Construction Stage:** Although the possibility is not large, there are risks of occurrence of HIV/AIDS and other infectious diseases caused by construction workers migrating from outside the region and/or having contact with women.<br>**Operation Stage:** No impact is expected. |
| | 18 | Working conditions (including occupational health) | C- | D | **Construction Stage:** There are risks of impairment to the health and safety of construction workers, such as falling into rivers, or electric shocks. Depending on the construction works and the working conditions, it is necessary to pay attention to the working conditions of workers.<br>**Operation Stage:** It is expected that implementation of the Project would not cause any new negative impact on working conditions during operations of the power plants. |

Table 1-24 Scoping (3/5)

| Category | | Environmental Item | Rating | | Scoping (Identified Impacts and Reasons) |
|---|---|---|---|---|---|
| | | | Planning Stage / Construction Stage | Operation Stage | |
| Social Environment | 19 | Accidents and disasters | C- | D | **Construction Stage:**<br>1) Because no construction vehicle or heavy machine can go near the construction site, construction materials and installed equipment and tools will be carried into the construction site by manpower after transferring them by helicopter or land vehicle.<br>There are no materials or equipment that could be carried in to or out from the sites by vehicle, and there are no large-scale construction works, therefore it is expected that the possibility of an accident during construction is quite small.<br>2) There is no serious problem with the public safety around the Project sites in general, and cooperation between the security personnel of the construction sites and the residents in the areas is expected.<br>3) There are possibilities of occurrence of natural disasters such as earthquakes, landslides or slope failures, but they are not caused by the Project.<br>**Operation Stage:** No impact is expected. |
| | 20 | Global warming, climate change | D | D | **Construction Stage:** Because diesel generators are used for supplying power to the power sources and light sources, emission of greenhouse gases ($CO_2$, particulate matter, NOx, etc.) is expected. However, because the amount of emission into the atmosphere is small and the emitting area is limited, it is considered there is quite slight impact on global warming and climate change.<br>**Operation Stage:** Micro-hydropower produces renewable energy; therefore the Project would contribute to the reduction of $CO_2$. However, the effect is very small. |
| Natural environment | 21 | Protected area | D | D | There is no protected area, such as conservation zone, in and around the Project sites. |
| | 22 | Terrestrial fauna, flora and ecosystems | C | C | There are no endangered or rare animals and plants in and around the Project sites.<br>Land alteration which may affect terrestrial animals, plants and ecosystems will not be implemented in the Project.<br>In the preliminary plan, there is no cutting of trees for securing land or for construction works, but it will be confirmed when the final plan is decided. |
| | 23 | Aquatic fauna, flora and ecosystems | D/C- | D | There are no endangered or rare aquatic beings and benthos in the rivers in the Project sites.<br>Alteration of riverbank and riverbed that may affect aquatic animals, plants, and ecosystems will not be implemented in the Project.<br>The reduction of flow rate in the water recession area is small; therefore the impact on aquatic beings is minor.<br>Inhabitation of migratory fish is not confirmed. It will be confirmed in the field survey. |
| | 24 | Hydrological situation | C- | C- | Because there is no large increase in the amount of water intake for the Project, it is estimated that flow rate decrease in the recession area is little. It will be confirmed when the Project plan is finalized. |

Table 1-24 Scoping (4/5)

| Category | | Environmental Item | Rating: Planning Stage / Construction Stage | Rating: Operation Stage | Scoping (Identified Impacts and Reasons) |
|---|---|---|---|---|---|
| Natural environment | 25 | Topography and geology | D | D | **Construction Stage:** There are no important topographic or geological features around the Project sites.<br>The scale of all of the facilities of the project is small, and there are no development activities which may change the topographic or geological features of the land.<br>**Operation Stage:** No impact is expected. |
| | 26 | Soil erosion | D | D | **Construction Stage:** There is no cutting or filling activity; therefore there is no risk of soil erosion or destabilization of the construction works in this Project even in the rainy season.<br>**Operation Stage:** No impact is expected. |
| | 27 | Groundwater | C | D | **Construction Stage:** It is not planned to use groundwater for construction.<br>Presence of groundwater, existence of wells and the state of use around the Project sites are unknown.<br>**Operation Stage:** No impact is expected. |
| Environmental pollution | 28 | Air pollution | C- | D | **Construction Stage:** Because no construction vehicle or heavy machine can go near the construction site, construction materials and installed equipment and tools will be carried into the construction site by manpower after transferring them by helicopter or land vehicle. Therefore, there will be no air pollution due to construction vehicles or heavy machines in the Project sites.<br>Because diesel generators are used for supplying power as power source and light source, emission of air pollutants (particulate matter, NOx, etc.) is expected. However, the impact on the environment is minor because the scale of using the generators is not large and range of influence of the exhaust gas is limited; therefore the impact on the environment is minor.<br>**Operation Stage:** No impact is expected. |
| | 29 | Water pollution | B- | D | **Construction Stage:** Because works such as carrying materials and equipment in and out of the river areas and installation of an intake weir, turbid water may temporarily occur at some parts of the rivers.<br>There is a possibility that oil and other materials discharged from the construction sites may flow into the rivers, but their amount is small and the impact is minor.<br>If handling of daily waste by construction workers is inappropriate, there is a risk that water pollutants leak from such waste and temporarily flow into the rivers.<br>**Operation Stage:** No impact is expected. |
| | 30 | Soil contamination | C- | D | **Construction Stage:** There is a possibility of soil contamination by discharged matter, oil, and other materials from the construction site or from diesel generators. If such occurs, the amount is small and the impact is minor.<br>**Operation Stage:** No impact is expected. |
| | 31 | Bottom sediment | **C-** | D | **Operation Stage:** Any material which may cause water pollution will not be handled or will not be discharged into the rivers.<br>If handling of daily waste by construction workers is inappropriate, there is a possibility that such waste is discharged into the rivers and temporarily contaminates the bottom sediment.<br>**Operation Stage:** No impact is expected. |

Table 1-24 Scoping (5/5)

| Category | | Environmental Item | Rating: Planning Stage / Construction Stage | Rating: Operation Stage | Scoping (Identified Impacts and Reasons) |
|---|---|---|---|---|---|
| Environmental pollution | 32 | Waste | B- | D | **Construction Stage:** Construction wastes, such as construction debris and residual substances are generated from the construction sites. Generation of hazardous waste is not expected. Daily general waste from the activities and living of the workers is generated.<br>**Operation Stage:** No impact is expected. |
| | 33 | Noise and vibrations | C- | D | **Construction Stage:** Because no construction vehicle or heavy machines can enter near the construction site, construction materials and installed equipment and tools will be carried into the construction site by manpower after transferring them by helicopter or land vehicle. Therefore, there will almost be no noise or vibration produced by construction vehicle or heavy machine in the Project sites. Because diesel generators are used during construction, noise and vibration are generated. However, the scale of usage is not large, and the impact on the environment is local and minor.<br>**Operation Stage:** No impact is expected. |
| | 34 | Land subsidence | D | D | Pumping of groundwater in large quantities would not be carried out in the Project activities, therefore the occurrence of land subsidence is not expected. |
| | 35 | Offensive odor | C- | D | **Construction Stage:** If handling of daily waste of construction workers is inappropriate, there is a possibility for offensive odor to be generated from rotting or decaying waste.<br>**Operation Stage:** No impact is expected. |

<Rating>
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the study progresses.)
D: No impact is expected.

(5) TOR of surveys on environmental and social considerations

For the items selected from the results of scoping, details and methods were set as the TOR (Terms of Reference).

Table 1-25 shows the TOR of surveys on environmental and social considerations.

Table 1-25 TOR of Surveys on Environmental and Social Considerations (1/2)

| Environmental Item | | Survey Item | Details and Methods of the Survey |
|---|---|---|---|
| **Social environment** | | | |
| (1) | Land acquisition / resettlement | 1) -Conditions of residents, buildings and occupation of land in the areas affected by the Project.<br>-If there is any occupation, details of PAUs (Project Affected Units)/ PAPs (Project Affected Persons) based on the census, and the detailed numbers. | 1) -Confirmation on the conditions of habitation around the concerned area and conditions of occupation of buildings and land, based on the satellite photos of the concerned areas, field surveys, and local materials.<br>-Censuses and socioeconomic surveys of PAUs/ PAPs (commissioned to a local consultant). |
| | | 2) -Laws, regulations, policies and examples in Nepal concerning EIA and acquisition of land or resettlement.<br>-Comparison with the JICA guidelines. | 2) Collection of information/materials, and hearing with NEA and concerned government offices of the counterpart country. |
| | | 3) Request to NEA and support for preparation of abbreviated resettlement plan (ARP) or land acquisition and compensation plan (LACP), creation of system and implementation. | 3)-Request to NEA for formulation of ARP/LACP and creation of implementation system.<br>-Explanation about the details of ARP/LACP, and discussion with the leader on the side of NEA. |
| (2) | Indigenous people/ ethnic minority | 1) Conditions of minorities/indigenous people in and around the Project sites. | 1) Collection of existing materials (census), and hearing (district offices) |
| (3) | Water usage | 1) Conditions of water use in and around the Project sites. | 1) Collection of information concerning water use, and hearing (district office). |
| (4) | Existing social infrastructure and services | (1) The period for load shedding during construction and the affected areas. | 1) -Confirmation of the period for load shedding during construction in the construction plan.<br>-Confirmation of the countermeasures taken by NEA and Electricity Cooperatives. |
| (5) | Misdistribution of benefits and damages | 1) Expected damages and benefits. | 1) Consideration on the details of the benefits to the areas assumed in the Project plan, and the negative impacts to areas where residents live assumed in the environmental impact assessment.<br>-Hearing with the authorities concerned. |
| (6) | Water rights, fishing rights and rights of common | 1) Conditions of setting of water rights, fishing rights of the rivers in the Project sites, and the common rights of the forests in the peripheral areas. | 1) Collection of existing information and hearing (district office). |
| (7) | Public health and sanitation | 1) Conditions of medical care, health and sanitation facilities around the Project sites. | 1) Collection of existing materials (Department of Health Services) and hearing (district offices). |
| (8) | Infectious diseases such as HIV/AIDS | 1) Conditions of tested and positive persons with infectious diseases such as HIV/AIDS around the Project sites. | 1) Collection of existing materials (Department of Health Services) and hearing (district offices). |
| (9) | Working conditions (including occupational health) | 1) Laws and regulations in Nepal concerning working conditions/work safety. | 1) Collection of related laws and regulations and confirmation of their details. |
| (10) | Accidents and disasters | 1) Current state of traffic accidents in the areas around the Project sites.<br>2) State of occurrences of landslides, collapse of slopes, and other disasters. around the Project sites | 1) Collection of existing materials and hearing (district office).<br>2) Collection of existing materials and hearing (district office). |

Table 1-25 TOR of Surveys on Environmental and Social Considerations (2/2)

| Environmental Item | | Survey Item | Details and Methods of the Survey |
|---|---|---|---|
| **Natural environment** | | | |
| (11) | Terrestrial fauna, flora and ecosystems | 1) Current state of living things and ecosystems. | 1) -Collection of existing materials (IUCN and MoSTE), and hearing (district forest officers).<br>-Field surveys. |
| (12) | Aquatic fauna, flora and ecosystems | 1) Current state of the living things and ecosystems. | 1) Collection of existing materials (IUCN and MoSTE), and hearing (district forest officers).<br>-Field surveys. |
| (13) | Hydrological situation | 1) The amount of the water intake in the Project plan. | 1) Confirmation of the amount of the water intake in the Project plan (comparison with the amount before implementation of the Project). |
| (14) | Groundwater | 1) State of use of groundwater around the Project sites. | 1) Hearing (the district offices). |
| **Environmental pollution** | | | |
| (15) | Air pollution | 1) Estimation of emission levels of diesel generators. | 1) Confirmation of the extent of use of diesel generators during construction in the Project plan. |
| (16) | Water pollution | 1) Estimation of the occurrence level of muddy water during construction. | 1) Confirmation of the period, the time and the scale of works in the riverbed and riverside areas during construction in the Project plan. |
| (17) | Soil contamination | 1) Consideration of the possibility of soil contamination caused by oil, and other materials discharged from heavy machinery used for construction and diesel generators. | 1) Confirmation of the measures to control discharge assuming the possibility of soil contamination. |
| (18) | Bottom sediment | 1) Current state of bottom sediment of the rivers.<br>2) Methods of treatment and disposal of general waste, earth and sand which may contaminate the bottom sediment of rivers during construction. | 1) Field surveys.<br>2) Confirmation of the method of treatment and disposal of general waste, earth and sand in the construction plan. |
| (19) | Waste | 1) Current state of treatment and disposal of waste.<br>2) Methods of treatment and disposal of construction waste, general waste and industrial waste during construction works. | 1) Collection of information related to treatment and disposal of waste in the districts where the Project sites are located.<br>2) Confirmation of methods of treatment and disposal of construction waste, industrial waste and general waste in the construction plan. |
| (20) | Noise and vibration | 1) Understanding the current state of traffic and noise sources.<br>2) Understanding the scale and the period of use of transportation vehicles and heavy machinery in the construction plan. | 1) Field surveys and hearing with the district office.<br>2) Understanding the construction plan |
| (21) | Offensive odor | 1) Consideration of the possibility of occurrence of offensive odor from rotting or decaying general waste during construction. | 1) -Confirmation of the treatment method of general waste in the construction plan.<br>-Research of existing cases. |

(6) Results of the survey on environmental and social considerations

1) Natural environment

Major tree species in the forests around the Project sites are listed in Table 1-26.

Table 1-26 Major Tree Species in the Forests of the Three District

| | Scientific Name | English Name |
|---|---|---|
| Bajhang District | Quercus spp.<br>Texus baccata<br>Pinus wallichiana<br>Cinnamomum tamala<br>Alnus nepalensis<br>Rhododendron spp.<br>Abies pindrow<br>Hippophae salicifolia | Oak<br>English yew<br>Indian Bay Leaf<br>Nepalese Alder<br>Indian Red Kapok Tree<br>Rhododendron<br>West Himalayan Fir<br>Sea-buckthorn |
| Bajura District | Quercus spp.<br>Texus baccata<br>Pinus roxburghii<br>Pinus wallichiana<br>Cinnamomum tamala<br>Alnus nepalensis<br>Rhododendron spp.<br>Bombax ceiba<br>Abies pindrow<br>Hippophae salicifolia | Oak<br>English Yew<br>Chir Pine<br>Indian Bay Leaf<br>Nepalese Alder<br>Indian Red Kapok Tree<br>Rhododendron<br>West Himalayan Fir<br>West Himalayan Fir<br>Sea-buckthorn |
| Rukum District | Pinus roxburghii<br>Bassia butyracea | Chir Pine<br>Indian Butter |

Source: JICA survey team (hearing with the district forest officers of the three districts)

According to a hearing with the district forest officers of the three districts, there are no rare birds living around the Project sites.

The district forest officer of Bajura District said that kingfishers and Blue Whistling thrushs have been observed around the Project site, and pheasants, mynas, and vultures have been observed in the mountainous region away from the Project sites.

According to a hearing with the district forest officers of the three districts, a lot of cyprinid fish called *asla* in Nepali or snow trout in English live in the rivers around the Project sites. They live in cold-water areas, and are observed widely in Nepal. They move within short distances, and are not migratory fishes (species which travel between a river and the sea to lay eggs). They are fished as a hobby or as food at home, using angling, nests, nets, etc. They are not targets of fishery around the Project sites.

According to a hearing with the Rukum District Office, there are no fishes live in Sharpu Lake, which is the water source taken in at the power plant.

As described above, there is no threatened and rare species in the continental and aquatic areas.

There is no protected area in or around the Project sites.

Since the scale of transporting of materials and equipment and construction works is small and the works are temporary, there is no special risk to damage the natural environment in the continental and aquatic areas.

2) Environmental pollution

Residences are away from the construction sites, and since the scale of construction is not large; therefore there is no significant impact on each item concerning environmental pollution.

The impact of air pollution is minor.

Although temporary and partly, turbid water occurs to some extent as caused by transportation and construction activities on the riverbed. Qualitative levels of turbidity should be monitored and mitigation measures should be implemented by the contractor, if necessary.

With regard to noise and vibrations produced by vehicles and heavy machinery during construction, it is assumed that the overall environmental impact is small because the scale of construction is not large and residences are away from the sites. However, there is a possibility that it would temporarily affect the living conditions of residents depending on the extent of construction activities. Therefore, noise and vibration levels should be monitored qualitatively during the construction period, and mitigation measures should be taken, if necessary.

With regard to construction waste, general waste and effluents generated by the construction workers, the construction supervisors and the staff who manage plant operations should take actions according to the rules on treatment and disposal of each district.

3) Social environment

There is no involuntary resettlement with this Project, but it is necessary to acquire some land for the water intake structures, stockyard of construction materials, and construction work space in Bajhang. The details are discussed in “1-3-2 Land Acquisition”.

Water is not taken for forestry, agriculture, or drinking water purposes in the recession area between the water intake point and the water discharge point for power generation. Fishery is not conducted either.

The results of hearing with the three district offices about water usage around the Project sites are described below.

(a) Drinking water

The water of the rivers in the three project sites is not used as a source of drinking water.

Drinking water in the villages around the power plants is supplied as follows:

- Bajhang District

  Water is taken from water sources in the hills far up the riverbanks near the power plant, and distributed to the village through pipelines.

- Bajura District

  Water is taken from springs and hill streams (two places), and via water storages (five places), and distributed to the village through pipelines.

- Syarpudaha

  Water is taken from water sources in the mountain upstream of Sharpu Lake, which is the water source of the Tilcha River where the power plant takes water, and distributed to the village through pipelines.

(b) Agricultural water

Water is not taken for use of farmlands from the rivers in the Project sites.

In Bajhang and Bajura farmers use overflow water from waterway (canal) by cutting some small paths of canal wall. However, use is limited to the vicinity of agricultural land, the amount of used water does not affect the power generation.

No water rights are clearly established with regard to the rivers and canals in the Project sites.

(c) Use for fishery

No fishing rights are clearly established with regard to the rivers in and around the Project sites. There are no professional fishermen either.

The number of community forest user groups in the three VDCs in the Project sites is shown in Table 1-27.

Table 1-27 Number of Community Forest User Groups in the Three VDCs in the Project Sites (2013)

| | Daulichaur VDC, Bajhang District | Martadi VDC, Bajura District | Bafikot VDC, Rukum District |
|---|---|---|---|
| Number of community forest user groups | 8 | 27 | 11 |

Source: Hearing with the district forest officers of the three districts

The communities in each VDC of the districts have authority to administer the community forests. It is according to the right of common. The communities pay taxes and apply for use and management to the government.

Firewood for fuel and logs for lumber are the major products taken from the community forests. Next to firewood and logs, the other products taken are various plants for medicinal use, food, etc. The amount of collection is limited per species.

There is no community forest in and around the Project sites.

Species of medicinal herbs, among others, in the community forests in the three districts are listed in Table 1-28 to Table 1-30.

Table 1-28 Species of Medicinal Herbs, etc. in Daulichaur VDC (Bajhang District) (2013)

| Scientific Name | English Name (Nepali) | Purpose of Use |
|---|---|---|
| Cordyceps sinensis | Cordyceps mushroom | Herbal medicine, herbal medicinal cooking |
| Zanthonylum armatum | Prickly ash (Timur) | Various medicinal properties (fruits) |
| Allium sativum | Garlic | For food |
| Naredoshychus grandiflora | Spikenard | Medicinal herbs (various medicinal properties) |
| Local mushroom | Local mushroom | For food |
| Paris polyphylla | Herb Paris (Satuwa) | Medicinal herbs (anticancer effects) |
| Berginia ciliata | (Pakhanbhed) | For Ayurveda (immunomodulation), paper |
| Daphne spp. | Daphne | Cloth |

Source: Hearing with the district forest officers of the three districts

Table 1-29 Species of Medicinal Herbs, etc. in Martadi VDC (Bajura District) (2013)

| Scientific Name | English Name (Nepali) | Purpose of Use |
| --- | --- | --- |
| Cordyceps sinensis | Cordyceps mushroom | Herbal medicines, herbal medicinal cooking |
| Zanthonylum armatum | Prickly ash (Timur) | Various medicinal properties (fruits) |
| Paris polyphylla | Herb Paris (Satuwa) | Medicinal herbs (anticancer effects) |
| Naredoshychus grandiflora | Spikenard | Medicinal herbs (various medicinal properties) |
| Local mushroom | Local mushroom | For food |
| Berginia ciliata | (Pakhanbhed) | For Ayurveda (immunomodulation) |
| Genus: Swertia | (Chiraito) | For removal of fever, cold, Ayurveda |
| Daphne spp. | Daphne | Paper, cloth |
| Genus: Boraginaceae/Euphorbiaceae | Himalayan Giant Nettle (Allo) | Hats |

Source: Hearing with the district forest officers of the three districts

Table 1-30 Species of Medicinal Herbs, etc. in Bafikot VDC (Rukum District) (2013)

| Scientific Name | English Name (Nepali) | Purpose of Use |
| --- | --- | --- |
| Zanthonylum armatum | Prickly ash (Timur) | For Ayurveda (immunomodulation) |
| Berginia ciliata | (Pakhanbhed) | |

Source: Hearing with the district forest officers of the three districts

(7) Environmental impact assessment

Based on the results of surveys on environmental and social considerations and scoping, the environmental impacts of the Project are assessed. Table 1-31 shows the results of assessment with the reason of assessment.

Table 1-31 Results of Environmental Impact Assessment (1/6)

| Category | Environmental Item | | Assessment Rating of Impacts in the Scoping | | Assessment Rating of Impacts Based on the Results of the Study | | Reason of Assessment (Identified Impacts and Reasons) |
|---|---|---|---|---|---|---|---|
| | | | Planning Stage / Construction Stage | Operation Stage | Planning Stage / Construction Stage | Operation Stage | |
| **Social Environment** | 1 | Land acquisition and involuntary resettlement | B- | B- | B- | D | **Planning Stage / Construction Stage:** It is necessary to permanently acquire some farmland. (One of them is not being used now.) There is neither involuntary resettlement nor removal/relocation of properties such as private structures.<br>The land to be acquired has a small area, and owned by only two owners; so rating is assessed to be B-. |
| | 3 | Indigenous people or ethnic minority | C | C | D | B+ | **Construction stage:** The owners of the land to be acquired are not ethnic minority or indigenous people.<br>There is no factor which particularly causes negative impact on the economy, and lives and culture of ethnic minorities and indigenous people.<br>**Operation stage:** Because advancement of regional electrification would improve social services and social infrastructure in the region, there would be positive impacts on ethnic minorities and indigenous people. |

Table 1-31 Results of Environmental Impact Assessment (2/6)

| Category | Environmental Item | | Assessment Rating of Impacts in the Scoping | | Assessment Rating of Impacts Based on the Results of the Study | | Reason of Assessment (Identified Impacts and Reasons) |
|---|---|---|---|---|---|---|---|
| | | | Planning Stage / Construction Stage | Operation Stage | Planning Stage / Construction Stage | Operation Stage | |
| **Social Environment** | 4 | Local economy such as employment and livelihood | C+ | C+ | D | B+ | **Construction Stage:** Workers are required for construction works, though their employment is temporary, employment opportunities for workers, excluding skilled workers, are created in the areas.<br>**Operation Stage:** In terms of wide regional area, there are positive impacts on the regional economies with the advancement of electrification. |
| | 6 | Water usage | B- | C | D | D | **Construction Stage:** Drinking water for construction workers is brought in, and service water for the administrative houses of the power plants is used as water for daily life. River water is used for construction. Therefore, it will not affect the water use of residents around the Project sites.<br>**Operation Stage:** Water for agricultural and drinking water purposes is not taken from the recession zones of the rivers in the Project sites. Fishery is not conducted in the rivers. |
| | 7 | Existing social infrastructure and services | B- | B+ | B- | B+ | **Construction Stage:** Two-month period of load shedding during construction would cause temporary inconvenience of residents in the areas.<br>**Operation Stage:** As advancement of regional electrification improves social services and social infrastructure in the region, there would be positive impacts to the peripheral areas where power is distributed. |

Table 1-31 Results of Environmental Impact Assessment (3/6)

| Category | Environmental Item | | Assessment Rating of Impacts in the Scoping | | Assessment Rating of Impacts Based on the Results of the Study | | Reason of Assessment (Identified Impacts and Reasons) |
|---|---|---|---|---|---|---|---|
| | | | Planning Stage / Construction Stage | Operation Stage | Planning Stage / Construction Stage | Operation Stage | |
| **Social Environment** | 9 | Misdistribution of benefits and damages | C- | C- | D | D | **Construction Stage:** Improvement, repair and updating of existing micro-hydropower plants are implemented in the Project, and it is considered that the Project itself would not cause any unfair misdistribution of damages and benefits to the peripheral areas.<br>With regard to the possibility of temporary negative impacts on living conditions and production activities during construction, understanding from the residents and the local authorities shall be obtained at the stakeholders meeting by appropriate explanation of consideration for the impacts. |
| | 12 | Water rights, fishing rights and rights of common | C | C | D | D | No fishing rights of the rivers around the Project sites have been established. No clear water rights have been established either.<br>With regard to common rights of forests in the peripheral areas, community forests are established, and the rights to use them are given to the community forest user groups. However, there are no community forests in the Project sites. |
| | 16 | Public health and sanitation | B- | D | B- | D | **Construction Stage:** There may be effects on health and sanitation of the residents around the Project sites because of the influx of construction workers from outside. |
| | 17 | Infectious diseases such as HIV/AIDS | B- | D | B- | D | **Construction Stage:** Although the possibility is not large, there is risk of occurrence of HIV/AIDS and other infectious diseases caused by construction workers migrating from outside the region and having contact with women. |
| | 18 | Working environment (including work safety) | C- | D | B- | D | **Construction Stage:** It is expected that there are risks of impairment to the health and safety of construction workers, such as falling into rivers, or electric shocks. |

Table 1-31 Results of Environmental Impact Assessment (4/6)

| Category | Environmental Item | | Assessment Rating of Impacts in the Scoping | | Assessment Rating of Impacts Based on the Results of the Study | | Reason of Assessment (Identified Impacts and Reasons) |
|---|---|---|---|---|---|---|---|
| | | | Planning Stage / Construction Stage | Operation Stage | Planning Stage / Construction Stage | Operation Stage | |
| **Social Environment** | 19 | Accidents and disasters | C- | D | B- | D | **Construction Stage:** The construction sites are away from residences, therefore the possibility of residents getting into accidents is very low.<br>The roads which residents use are also used by vehicles and heavy machines for construction. The scale of construction activities is small, but there is a possibility for occurrence of traffic accidents. |
| **Natural Environment** | 22 | Terrestrial fauna, flora and ecosystems | C | C | D | D | There are no endangered or rare animals and plants in and around the Project sites.<br>Land alteration which may affect terrestrial animals, plants and ecosystem will not be implemented in the Project.<br>Trees will not be cut for construction activities. |
| | 23 | Aquatic fauna, flora and ecosystems | D/C- | D | D | D | There are no endangered or rare aquatic beings and benthos in the rivers in the Project sites.<br>Alteration of riverbank and riverbed that may affect aquatic animals, plants and ecosystems will not be implemented in the Project.<br>Because the amount of reduction of flow rate in the water recession area is small, the impact on aquatic beings is minor.<br>Cyprinidae (called asla in Nepali), which thrive in the rivers around the Project sites, moves within short distances, and are not migratory fishes.<br>The Project will not significantly increase the amount of water taken as compared to the amount taken before implementation of the Project, and the maintenance flow and the routes of rivers are also maintained. Therefore, the Project would not result to negative impact on the inhabitation of fish. |
| | 24 | Hydrological situation | C- | C- | D | D | **Construction Stage:** The increase in the amount of water taken by this Project is quite little, and changes in the flow rate in the recession zones of rivers are small.<br>Therefore, there is no impact on the hydrological situation of the rivers in the Project sites. |

Table 1-31 Results of Environmental Impact Assessment (5/6)

| Category | Environmental Item | | Assessment Rating of Impacts in the Scoping | | Assessment Rating of Impacts Based on the Results of the Study | | Reason of Assessment (Identified Impacts and Reasons) |
|---|---|---|---|---|---|---|---|
| | | | Planning Stage / Construction Stage | Operation Stage | Planning Stage / Construction Stage | Operation Stage | |
| **Natural Environment** | 27 | Groundwater | C | D | D | D | **Construction Stage:** Groundwater is not planned to be used for construction.<br>Groundwater around the Project sites is not used for agriculture or drinking purposes. |
| **Environmental Pollution** | 28 | Air pollution | C- | D | D | D | **Construction Stage:** There will be quite small amount of air pollution coming from exhaust gas produced by transportation vehicles and heavy machinery used in the Project sites.<br>Diesel generators, as power and lighting source, are used only temporarily and locally. Therefore environmental impact caused by exhaust gas is very minor. |
| | 29 | Water pollution | B- | D | B- | D | **Construction Stage:** Because works such as carrying materials and equipment in and out of the river areas and installation of an intake weir, turbid water may temporarily occur at some parts of the rivers.<br>The amount of oil and other materials that may leak from the temporarily and locally used diesel generators on the land surface is very small and the possibility of such to flow into the rivers is very low, therefore the impact is minor.<br>If handling of general waste by construction workers is inappropriate, there is a risk that water pollutants which may leak from such waste would temporarily flow into the rivers. |
| | 30 | Soil contamination | C- | D | D | D | **Construction Stage:** The amount of waste fluid, oil, and other waste materials from construction sites or diesel generators is very small, and such amount is not a level that would cause soil contamination. |
| | 31 | Bottom sediment | C- | D | D | D | **Construction Stage:** Water pollutants which may contaminate the bottom material of rivers are not discharged into the rivers by the construction activities.<br>With regard to general waste of workers, there is no possibility that it would be handled inappropriately, such as throwing waste into the rivers and contaminating the bottom material. |

Table 1-31 Results of Environmental Impact Assessment (6/6)

| Category | Environmental Item | | Assessment Rating of Impacts in the Scoping | | Assessment Rating of Impacts Based on the Results of the Study | | Reason of Assessment (Identified Impacts and Reasons) |
|---|---|---|---|---|---|---|---|
| | | | Planning Stage / Construction Stage | Operation Stage | Planning Stage / Construction Stage | Operation Stage | |
| **Environmental Pollution** | 32 | Waste | B- | D | B- | D | **Construction Stage:** Wastes, such as construction debris, residual substances related to equipment and tools and general waste from activities and daily living of workers, are generated from the construction sites.<br>Generation of hazardous waste is not expected. |
| | 33 | Noise and vibration | C- | D | B- | D | **Construction Stage:** The improvement of roads toward the Project sites is insufficient, therefore the scale of transportation of vehicles and heavy machines is limited to use of helicopters, manpower, among other means. The area where heavy machines and diesel generators are used is not large, therefore the extent of environmental impact is local. However, they occur to some degree for a short term. |
| | 35 | Offensive odor | C- | D | D | D | **Construction Stage:** There is no inappropriate handling of general waste, such as leaving waste to rot by construction workers. |

<Rating of assessment of impacts>

A+/- : Significant positive effects/negative effects are expected.

B+/- : Positive effects/negative effects to some degree are expected.

C+/- : The degree of positive/ negative effects is unknown. (Further surveys are required to clarify the degree of the effects.)

D : No effects are expected.

(8) Mitigation measures

Table 1-32 shows the mitigation measures and cost of implementation of such items classified as “B-” or “C” in the environmental impact assessment. From the results of assessment, there is no item classified as “C”.

Table 1-32 Mitigation Measures (1/3)

| Category | | Environmental Item | Environmental Impact | Mitigation Measure | Implementing Organization | Responsible Organization | Cost (Unit) |
|---|---|---|---|---|---|---|---|
| Planning Stage | | | | | | | |
| Social Environment | 1 | Land acquisition | Land for water intake structure, stockyard of construction materials and construction work space is required in Bajhang. | Land will be acquired with appropriate compensation according to the legal system in Nepal and the JICA guidelines. | NEA | NEA | Compensation cost Burden of NEA<br><br>As shown in Table 1-47 |
| Construction Stage | | | | | | | |
| Social Environment | 2 | Load shedding for construction | There will be a two-month period of load shedding during works for electromechanical systems. | The period of load shedding will be fixed as early as possible, and notified to the users of electricity in advance to get their cooperation. It will be requested to the Electricity Cooperatives to comprehend the problems caused by load shedding. In case of any problem occurs which need to be dealt with urgently, appropriate measures such as enhancement of emergency power supply should be taken. | NEA<br>Electricity Cooperatives<br>Contractor | NEA | (Cost of measures when necessary) (amount is according to situation)<br>Burden of NEA |
| | 3 | Impact on the local public health and sanitation | There may be impacts on the local public health in relation to the living conditions of construction workers coming in from outside. | On-site treatment-type or portable toilets are installed for the construction workers.<br>Local residents are hired as construction workers as much as possible. | Contractor | NEA | Cost for installation of temporary toilets<br>Burden of the contractor<br>300,000Rs |
| | 4 | Occurrence of infectious diseases | There is a possibility for HIV and other infectious diseases to occur or spread out as caused by activities of construction workers migrating from outside of the region. | Educate the construction workers and residents about HIV and other infectious diseases.<br>Local residents are hired as construction workers as much as possible. | NEA<br>Contractor | NEA | Cost for educational materials<br>Burden of the contractor)<br>15,000Rs |

Table 1-32 Mitigation Measures (2/3)

| Category | | Environmental Item | Environmental Impact | Mitigation Measures | Implementing Organization | Responsible Organization | Cost (Unit) |
|---|---|---|---|---|---|---|---|
| Social Environment | 5 | Work safety | There is a possibility that safety of workers is impaired during transportation and construction works (e.g., contact with heavy machines, bruising from rocks in the riverside areas, falling into river, being caught in river flow (especially when the river is swollen), and electric shock during electrical works). | NEA and contractors shall comply with the Labor Act (1992) of Nepal when hiring workers for the Project and engaging them for the works.<br>-The contractors should prepare a construction safety plan.<br>-Instructions to perform daily safety check and instructions to confirm safety during the works by the construction supervisor.<br>-Confirmation of the procedures to follow in case any safety-related problem occurs.<br>-Putting up placard of safety check items at the powerhouse.<br>-Clarification of the procedures to follow in case any safety-related problem occurs.<br>-Thorough education of construction workers about safety. | NEA<br>Contractor | NEA | Burden of the contractor (within construction management cost) |
| | 6 | Accidents | There is a possibility of accidents if residents come close to places where materials and equipment are carried in/out of the construction sites. | Notify the construction plan (details of construction works, schedule and place) to the residents of the areas around the construction sites twice.<br>Putting up a notice about the details above on the roadsides of the villages, at the construction sites, among other locations.<br>Clarification of the boundaries of the construction areas with rope, fences, among other means. | Contractor | NEA | Burden of the contractor |

Table 1-32 Mitigation Measures (3/3)

| Category | | Environmental Item | Environmental Impact | Mitigation Measures | Implementing Organization | Responsible Organization | Cost (Unit) |
|---|---|---|---|---|---|---|---|
| Environmental Pollution | 1 | Water pollution --Occurrence of turbid water in rivers | Turbid water occurs in some parts of the rivers for works such as transportation and installation of the intake weirs. | Perform the construction works by controlling occurrence of turbid water as much as possible. If turbid water occurs frequently, set up a temporary setting basin in the river to control the flow of turbid water if necessary. | Contractor | NEA<br>Contractor | Burden of the contractor<br>180,000Rs |
| | 2 | Construction waste | Generation of debris from civil engineering works, residual substances related to equipment and tools and residual substances after various construction works. | Construction waste should be treated and disposed appropriately such as separating and placing waste in the local waste pits according to the district's regulations and rules on treatment and disposal of waste. Waste which are not prescribed in the regulations and rules and cannot be treated or disposed in the areas should be brought back by the contractor and treated and disposed appropriately. | Contractor | NEA<br>Contractor | Burden of the contractor<br>30,000Rs |
| | 3 | Daily waste of construction workers | Organic waste such as dregs of cooking and meals are generated. | If the waste is paper, cloth, or of similar material, and can be disposed at the local waste pits, they should be placed according to the regulations and rules of the districts.<br>Other waste such as dregs of cooking and meals should be incinerated or buried around the Project sites within the extent of the materials and the location as the district government approves.<br>Thorough education of construction workers not to throw their waste into the river. | Contractor | NEA<br>Contractor | Burden of the contractor<br>30,000Rs |
| | 4 | Noise and vibration | Noise and vibration are generated by transportation vehicles and heavy machines. | Vehicles should be driven at low noise and low vibration conditions.<br>Limit construction work time in the morning and at night.<br>Improvement of construction activity corresponding to complaints. | Contractor | NEA<br>Contractor | Burden of the contractor (within construction management cost) |
| | | | | | | Total Cost | 600,000Rs |

(9) Environmental Management Plan and Monitoring plan

1) Environmental management plan

This Project is aimed at reconstruction of water intake structures, renovation of existing water canals and renewal of power generation equipment for the power plants with power capacity of 200 kW. Considering this scope and scale of the Project, there is no serious impact identified in the evaluation of environmental and social conditions. However, the evaluation results showed that some items have negative environmental impact to some extent in the construction stage. The mitigation measures to be taken for the items with negative impact to some extent are described in Table 1-33. The monitoring plan for the items to be monitored during the construction stage is described in 2) the monitoring plan below.

In consideration of the scale of impacts on environmental and social conditions by the Project, the environmental management plan consists of the following two aspects: mitigation measures and environmental monitoring plan. Other environmental management issues for the Project are not included.

Table 1-33 Environmental Management Plan

| Plan Items | Important Items in the Environmental Management Plan |
|---|---|
| Implementation of the monitoring plan | • Monitoring shall be implemented according to the plan.<br>• Response/action to a comment and instruction from the local government and inhabitants shall be made according to the plan.<br>• The report on the monitoring result shall be made according to the monitoring form, and reporting shall be conducted at a designated frequency. |
| Implementation of the mitigation measures | • NEA, electric cooperatives, and contractors shall securely implement the responsible mitigation measures.<br>• When a problem on environmental and social conditions still remains after implementing the mitigation measures, more effective and feasible mitigation measures shall be examined and applied to mitigate the impact with the responsibility of NEA. |

2) Monitoring plan

Table 1-34 shows the monitoring plan.

Table 1-35 shows the responses/actions to comments and guidance from the government of the district and the public.

Table 1-36 shows quantitative and qualitative measurement method of level of livelihood of PAPs.

Table 1-37 and Table 1-38 show qualitative measurement method of noise/vibrations and turbidity.

Table 1-39 shows the monitoring form.

Table 1-34 Monitoring plan

| Environmental Item | Item | Measurement Point | Monitoring Method | Frequency (Period) | Implementing Organization | Responsible Organization |
|---|---|---|---|---|---|---|
| Construction Phase | | | | | | |
| Level of livelihood | Livelihood of the PAPs (Project Affected Persons) | Residences of the PAPs | Hearing from the PAPs | twice/year (Jun.2014–Mar.2016) | Electricity Cooperatives | NEA |
| Noise and Vibration | Noise and Vibration | Near the construction site | Hearing from inhabitants | twice /month (Sep.2014–Mar. 2016) | Electricity Cooperatives | NEA |
| Water quality | Turbidity | a. river near the intake<br>b. canal near the power plant<br>c. river immediately downstream of the power plant | Visual monitoring | twice /month (Sep.2014–Mar. 2016) | Electricity Cooperatives | NEA |

Table 1-35 Responses/Actions to Comments and Guidance from the Government of the District and the Public

| Monitoring Item | | Monitoring Results during Report Period |
|---|---|---|
| Level of Livelihood of PAPs (Construction Phase) | Quantitative and qualitative level of livelihood | Improvement action needs to be taken if living conditions of PAPs get worsened due to the land acquisition. |
| Noise and Vibration (Construction Phase) | Qualitative level of noise and vibration | Improvement action needs to be taken by the proponent when the impact is expected to be considerable (“Level 4: There is impact to the life of inhabitants.” in the Table of Turbidity Qualitative Measurement)<br>With the associated data of frequency, date and result of improvement action |
| Turbidity (Construction Phase) | Qualitative level of turbidity | Improvement action needs to be taken by the proponent when the turbidity level is high (“Level 3: There is significant turbidity in the water” in the Table of Turbidity Qualitative Measurement)<br>With the associated data of frequency, date and result of improvement action |

Table 1-36 Quantitative and Qualitative Measurement Method of Level of Livelihood of PAPs

| Item | Monitor the situation of the level of livelihood by hearing from PAPs | | Measurement Point, Frequency, etc |
|---|---|---|---|
| | Quantitative Item | Qualitative Item | |
| Level of Livelihood of PAPs | -Monthly income (all sources)<br>–Area of owned land address,<br>-House owned / borrowing - and<br>–Household expenditure and spending (approximate)<br>-Address, household, family structure | -Feeling of change in level of livelihood and it’s reason<br>-Problems on livelihood and relation to the land acquisition<br>-Requirement to be supported for improvement of livelihood | Measurement Point, Frequency, etc. are shown In Table 1-34 |

Table 1-37 Qualitative Measurement Method of Noise and Vibrations

| Item | Method of rating for level of noise and vibration in the monitoring (by comments from inhabitants) | Measurement Point, Frequency, etc |
|---|---|---|
| Noise and Vibration | Level 4: There is impact to the life of inhabitants.<br>Level 3: There is tolerable temporary impact.<br>Level 2: There is tolerable slight impact.<br>Level 1: There is no impact, or there is negligible impact. | Measurement Point, Frequency, etc. are shown In Table 1-34 |

Table 1-38 Qualitative Measurement Method of Turbidity

| Item | Method of rating for level of turbidity measured by visual monitoring | Measurement Point, Frequency, etc |
|---|---|---|
| Turbidity | Level 3: There is significant turbidity in the water<br>Level 2: There is turbidity to some extent in the water<br>Level 1: Water is clear and includes no turbidity | Measurement Point, Frequency, etc. are shown In Table 1-34 |

Table 1-39 Monitoring Form

| Environmental Item | Measurement Point | Period<br><br>(from dd/mm/yyyy to dd/mm/yyyy) | Frequency | Results<br><br>Qualitative Data | Results Comments<br><br>Responses/Actions to Comments and Guidance from the Public (with date) |
|---|---|---|---|---|---|
| Construction Phase | | | | | |
| Level of Livelihood of PAPs | | | | | |
| Noise and Vibration | | | | | |
| Water Quality<br><br>-Turbidity | | | | | |

(10) Stakeholders meeting

The stakeholders meeting was held in Kathmandu on December 18, 2013 (11:30 to 13:30).

(Venue: Managing Director Meeting Room, NEA)

There are 21 participants, as follows:

| | |
|---|---|
| NEA | : six people |
| Electricity Cooperatives | : four people |
| Land owner | : one person |
| JICA | : five people |
| The consultant team | : five people |

The minutes of the meeting are provided below.

<<Explanation>>

(1) The outline, basic design, and the implementation schedule of the Project.
(The leader of the consultant team.)

(2) About the results of surveys on environmental and social considerations.
(The person in charge of the task of the consultant team.)

First, land acquisition was explained emphasizing the following points.

- Necessity of land acquisition in the Project.
- Land acquisition and compensation are implemented under NEA's responsibility.
- Policies of the JICA guidelines on land acquisition and compensation processes, the amount of compensation and livelihood support to PAPs after land acquisition.
- The amount of compensation is decided based on the replacement cost, and it is paid in cash just after completion of the negotiation.
- If PAPs are cultivating the acquired land, the amount equivalent to the market price of the crops produced in a year should be compensated by NEA as livelihood support to PAPs in addition to the amount of compensation for the land.
- After completion of compensation, the conditions of living of PAPs should be monitored for at least about one and a half years, and if the level of living has deteriorated, NEA should provide livelihood support.

Next, the results of the study on environmental and social considerations other than land acquisition was explained as follows:

- About implementation of IEE

  According to the regulations in Nepal, as the power plant capacity after the Project is less than the prescribed level, implementation of environmental impact assessment is not necessary for this Project. However, according to the policy of JICA on this Project, IEE was implemented as part of the study.

- About the procedures of IEE and the results of environmental impact assessment

  The scale of the Project is small and the scope consists of improvement of existing facilities, therefore there is generally no significant negative environmental impact. However, with regard to the environmental items of which impacts are expected to some extent, necessary mitigation measures are taken to alleviate such impacts.

<<Question and answer>>

(Note) 1. Q : question, A : answer, C : comment/ request/ proposal
2. The items without notes are questions or comments to the consultant.

Q It is mentioned that the total load shedding time for construction will be two months. Does the consultant or JICA plan to provide some alternative measure to supply power during this period? If JICA can provide a generator for each site, NEA can manage the necessary fuel.

A At present there is no plan to provide power through diesel generator or other alternative measures. If required, NEA or the lease owners should manage them individually.

C If possible please make the load shedding period shorter.

A Because of the necessity of cooperation between the electromechanical system and civil engineering works, load shedding is planned to be implemented in the dry season of 2015. If work period includes rainy season, load shedding will be required two times. Therefore, construction period shall be planned so that load shedding requires one time.

C The machines, especially the governor, should not be too complicated. If it is designed simply, even the local technicians can manage simple repair and maintenance works.

A The machines would be simple and based on dummy load governor. In addition, the operators will be trained on how to make simple repairs when necessary. Soft components are also provided so that local technicians can make effective maintenance works.

Q If it becomes possible to use the national grid in the future, do the power plants have the capability to synchronize with the national grid?

A Yes, it is a facility which has the ability to synchronize.

Q Is it planned to increase the power plant's capacity? Or does this Project only improve the facility?

A NEA's original request for this Project was to increase the power plant's capacity. However, since there was no flow rate data of rivers, it is difficult to quantify the benefits of increasing the plant's capacity. According to the results of surveys conducted so far, the existing canals of Bajhang (headrace canal and penstocks) do not have sufficient capacity to carry the increased amount of water. The results of surveys imply that the canals of Bajura and Syarpudaha have capacity to carry the increased amount of water if available. The study on the availability of running water is also underway.
If a study on increasing capacity is conducted, it will be separated from this phase of the Project, and it is not covered by this Project phase. However, as a consultant, the findings obtained by the study on increasing capacity should be included in the final report.

Q There is a risk of flooding in the powerhouse. Are there some plans to maintain the riverbanks so that the powerhouse will be protected?

A Necessary measures to protect the powerhouse from flood will be taken.

Q Syarpudaha Plant is in danger from flooding of the Sani Bheri River. Is there any plan to conduct river training works in the Sani Bheri River?

A There are some works for protecting the tailrace. However, protecting the entire area is beyond the present scope.

Q Will adequate spare parts be provided within the contract of this Project? It is commonly observed that a project is hindered due to the unavailability of spare parts of machines when broken. Because it is difficult to find spare parts for Japanese machines in the Nepalese market, incidents such as long-term power outage may occur.

A A few necessary spare parts can be provided within the contract. Parts which are expected to last more than five years (e.g., bearings) cannot be considered as spare parts and will not be provided.

It is expected that the lease owners will make reserve funds for buying necessary parts in the future. It is also anticipated that the lease owners will inspect and maintain the plant in good order assuming at least the main failure factors in order to prevent sudden failure of power generation.

Q (From consultant to the land owners)
Do you have any questions or requests on land acquisition, compensation policy, etc.?

A We understood the explanation, and we have no special question or request.

Q (From consultant to NEA)
We would like to know the procedure of land acquisition complying with the Land Acquisition Act of Nepal. Does it take a very long time?

A As NEA is a government agency, it has to comply with the policy of land acquisition laws.
In the case of NEA, we first submit the land acquisition request to MoE, which is the responsible ministry. The ministry appoints an officer in charge for the purpose. A district level CFC, whose members are composed of the chief district officer (CDO), the representative of the District Development Committee (DDC), Village Development Committee (VDC), NEA, Survey Department and other organizations, is formed. The Compensation Fixation Committee decides the amount of compensation based on the base data and negotiation with the land owners. When the decided amount of compensation is paid, the land ownership is transferred to NEA.
In the past, NEA has experienced land acquisition within 30 days. Because the land to be acquired has already been identified, it is expected that the procedure will complete within 30 to 45 days at the longest.

Q (From consultant to NEA)
Is there any possibility that there are differences with the policy of the JICA guidelines about compensation for land acquisition if the Compensation Fixation Committee decides the amount of compensation?

A The committee decides the amount of compensation at a meeting where the land owners attend, and the amount is decided based on the market prices and the dealing prices in the area. NEA provides fair compensation that land owners expect.

### 1-3-2 Land Acquisition

(1) Necessity of land acquisition

1) Necessity of land acquisition

There is no involuntary resettlement with this Project. However, it is necessary to acquire some land for the water intake structure, stockyard of construction materials, and construction work space in Bajhang.

The Project site is located in a narrow valley with very small flatland, and it is difficult to secure the construction areas only with the land owned by NEA and the electric cooperatives.

2) Consideration of alternatives

The following two alternatives have been examined. Both options were not selected because conditions such as of geography are worse than the current plan.

<Current plan>

Reconstruction of current temporary water intake structures with new ones at the location of the existing intake structures.

Alternative 1)

Place without farmland on the upstream side, far from the current intake weir.

This alternative was not selected due to poor location conditions as described below:

- The land is narrower and it is difficult to secure necessary land area.
- Access to the construction site is bad and the transportation cost will increase.
- There is collapsed land and there is risk of landslide in the area near the location.

Alternative 2)

Place without farmland on the downstream, far from the current intake weir.

This alternative option was not selected due to the following reasons:

- It is impossible to secure the necessary drop in water level and the flow rate required for power generation.
- Due to bad geographic conditions, the construction costs will nearly double the estimated cost in the current plan.

3) Effort to reduce the necessary area as much as possible

Necessary land was designed to be minimized and as a continuous integrated land with the land for construction materials stockyard, intake structures and construction work space.

In addition, the construction materials storage stockyard and construction work space were designed to be minimized as much as possible within a tolerance of topographical conditions.

By the measures described above, the entire required area was reduced than what was originally expected.

(2) Legal framework concerning land acquisition

1) Legal framework of Nepal concerning acquisition of land and assets

The core law concerning the acquisition of land/assets and involuntary resettlement in Nepal is the Land Acquisition Act (1977). According to the framework of this act, land acquisition and compensation for public purposes are implemented.

Besides, any institution seeking land acquisition may also request the Government of Nepal

(GON) to acquire land under the regulatory provisions subject to compensation by such institution's resources.

The Land Acquisition Act stipulates a series of procedures for land acquisition and compensation, as follows:

Preliminary action relating to acquire land (the proponent)

↓

The proponent submits findings of preliminary action to the concerned GON

↓

Order of initiation of the land acquisition process from GON to the district government

↓

Public notification of land acquisition (CDO)

↓

Right of landowner to file complaint

↓

District government forms Fixation of compensation (CFC)

↓

Criteria to be considered while determining compensation

↓

Fixation of compensation (CFC) and notice from CDO to GON

↓

Devolution of ownership

↓

Procedure for lawsuit in the case the land owner does not agree to land acquisition (Ministry of Home Affair, CFC)

In the case that details of the land and the owner are clearly identified, the procedure for land acquisition can start by forming CFC after approval of land acquisition by GON. Therefore, the time required for the process of land acquisition will be completed in a considerably short time.

As per the regulatory provision, while acquiring land, GON orders district government to form CFC at the district level (Clause 13). CDO plays a central role in the process of land acquisition, including the activities of CFC.

The main members to be included in the committee are as follows (Clause 13):

- CDO
- Land Administrator or Chief of the Land Revenue Office
- An officer assigned by CDO
- A representative of VDC
- The project officer of the proponent

CFC acts for actual verification of land to be acquired, reviewing and fixing compensation rate, identification of proper owners, distribution of compensation, and providing necessary administrative support addressing related issues.

Formally, the implementation process of CFC begins by formal approval of GON for land acquisition. After the approval, CFC shall issue a "Notification of Land Acquisition". This notification contains details or particulars of the land to be acquired.

If the land has to be acquired for institutions fully owned by the government, the committee has to consider the following in fixing the compensation amount:

- Price of land prevailing at the time of the publication of the notice of land acquisition.
- The value of crops, houses, walls, sheds, etc., if any, acquired along with the land.
- The losses which PAPs will suffer as a result of shifting the residence or place of the business by reason of land acquisition.

2) Policy of JICA

(a) Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

(b) People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

(c) Compensation must be based on the full replacement cost*as much as possible.

(d) Compensation and other kinds of assistance must be provided prior to displacement.

(e) In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

(f) Appropriate participation of affected people must be promoted in planning, implementation, and monitoring

(g) Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies".

(h) Additional key principle based on World Bank OP 4.12 is as follows. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the Project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

(i) Provide support for the transition period (between displacement and livelihood restoration).

(j) Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

3) Comparison of laws of Nepal and the JICA guidelines

Table 1-40 Comparison between the JICA Guidelines and Nepal Legislation (1/3)

| No. | JICA Guidelines/World Bank | Laws of Nepal | Gaps between the JICA Guidelines or the World Bank and the Laws of Nepal | Resolution Measures of Gaps |
|---|---|---|---|---|
| 1 | Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives (JICA GL) | None | No law was identified. | There is no law on such in Nepal, including corresponding provisions.<br><br>In the land acquisition policy of the Project (the Project Policy), it is described that land acquisition is to be avoided when feasible by exploring all viable alternatives. |
| 2 | People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)<br><br>Compensation must be based on the full replacement cost as much as possible. (JICA GL) | Land Acquisition Act (1977) (Clause 16) | Clause 16:<br>While determining the amount of compensation for land to be acquired, CFC shall take the following criteria into consideration:<br>(a) The price of the land at the time of the publication of “Notification of Land Acquisition”.<br>(b) The value of the crops, houses, walls, sheds, etc., if any, acquired along with the land.<br>(c) Losses which the concerned person will suffer as a result of shifting his/her residence, or the place of his/her business, by reason of the acquisition of his/her land. | Because there is little difference, the "policy on improvement or at least restoration of means of livelihood of PAPs" is described in the Project Policy according to JICA’s policy. |
| 3 | Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL) | Land Acquisition Act (Clause 19) | Clause 19:<br>After CFC has determined the amount of compensation, the CDO shall notify GON accordingly. | Since the results of determination of compensation are notified to GON before the payment of compensation and transfer of land ownership, there is no difference. |
| 4 | In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL) | None | No law specifically mentions the requirement of resettlement action plan for involuntary resettlement. | It is said in the Project Policy that "making land acquisition and compensation plan is to be requested." |

Table 1-40 Comparison between the JICA Guidelines and Nepal Legislation (2/3)

| No. | JICA Guidelines/World Bank | Laws of Nepal | Gaps between the JICA Guidelines or the World Bank and the Laws of Nepal | Resolution Measures of Gaps |
|---|---|---|---|---|
| 5 | Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.<br>(JICA GL) | None | Same as above. | It is said in the Project Policy that "PAPs should be involved in the process of land acquisition and compensation." |
| 6 | Appropriate and accessible grievance mechanism must be established for the affected people and their communities.<br>(JICA GL) | Land Acquisition Act (Clause 10, 11) | Clause 10:<br>After the “Notification of Land Acquisition”, the concerned person can submit an application for claiming compensation within a minimum period of 15 days, along with documentary evidence of his/her title to the land.<br>Clause 11:<br>Within a period of seven days from the date of the publication the “Notification of Land Acquisition”, plus the time required for the journey involved, the concerned landowner may file a complaint with the Ministry of Home Affairs, GON through the local officer, explaining the reasons, if any, why his/her land should not be acquired. | There is no fundamental difference. |
| 7 | Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits<br>(WBOP4.12 Para.6) | Land Acquisition Act (Clause 8) | Clause 8:<br>The officer (of the proponent) responsible for preliminary action shall complete such action within 15 days from its start, determinate whether the land is suitable for acquisition, and then submit a report containing necessary information in respect to such action to the local office as early as possible. | There is no fundamental difference. |

Table 1-40 Comparison between the JICA Guidelines and Nepal Legislation (3/3)

| No. | JICA Guidelines/World Bank | Laws of Nepal | Gaps between the JICA Guidelines or the World Bank and the Laws of Nepal | Resolution Measures of Gaps |
|---|---|---|---|---|
| 8 | Eligibility of benefits includes the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal right to the land they are occupying. (WB OP4.12 Para.15) | Land Acquisition Act (Clause 2) | The act stipulates that a "concerned person" means the person who is entitled to the compensation payable for lands acquired under this act. However, the eligibility of PAPs other than what is described above is not clearly prescribed in the act. | It is not clearly prescribed that eligibility of benefits includes PAPs who do not have formal legal rights to land. In the Project Policy it is said that "those who do Not have a legal rights are also regarded as PAPs." |
| 9 | Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4.12 Para.6) | None | No law on the provision of support for the transition period was identified. | In the Project Policy it is said that "support to PAPs for the transition period is to be provided." |
| 10 | Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc. (WB OP4.12 Para.8) | None | No law with particular attention to vulnerable groups was identified. | In the Project Policy it is described that "particular attention must be paid to the needs of the vulnerable groups among PAPs." |

Source: Land related laws of Nepal, JICA Guidelines and World Bank OP 4.12.

4) Policy on land acquisition for the Project

The policy of land acquisition by NEA in this Project (the Project Policy) is basically due legal and policy framework of Nepal.

Existing laws and regulations of Nepal have been designed to basically address according to international practice including JICA’s policy, however, some gaps exist between them. Accordingly, the Project Policy is supplemented by JICA’s policy.

(a) Land acquisition will be avoided or minimized where feasible, by identifying possible alternative project designs

(b) Where land acquisition is unavoidable, all PAPs losing land will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions

(c) Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which on account of project implementation would have his, her or their.

- Standard of living adversely affected;
- Right, title or interest in any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently.
- Income earning opportunities, work adversely affected temporarily or permanently.

(d) All PAPs residing, working, doing business and/or cultivating land within the Project impacted areas as of the date of the latest census and inventory of lost assets, are entitled to compensation for their lost assets (land and/or non-land assets), at replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.

(e) PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the land acquisition process.

(f) After receiving the detailed preliminary report relating land to be acquired and the landowners, CDO shall issue the "Notification of land acquisition" with particulars in respect to the land. The Notification shall be affixed at concerned offices and public places.

(g) LACP will be disclosed for the reference of PAPs as well as other interested groups.

(h) Payment for land will be based on the principle of replacement cost.

(i) Land acquisition assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs.

(j) LACP must consider the needs of those most vulnerable to the adverse impacts of land acquisition (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled). Assistance should be provided to help them improve their socio-economic status.

(k) PAPs and their communities will be consulted about the Project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the decisions that are made concerning their loss of land.

(l) Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition within the agreed implementation period. The funds for all replacement activities will come from NEA.

(m) Acquisition of land, payment of compensation will be completed prior to any construction activities, except when a court of law orders so in expropriation cases.

(n) Organization and administrative arrangements for the effective preparation and implementation of the LACP will be identified and in place prior to the commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities.

(o) Appropriate reporting (including redress functions and monitoring) will be identified and set in place as part of the LACP system.

(3) Scope of land acquisition

1) Occupants of the Project affected land

Table 1-41 Occupancy of land the Project will require

| Site | Location | Area | Purpose of land use for the Project | Owner or jurisdiction |
|---|---|---|---|---|
| Bajhang | Left bank paddy field at intake weir | 1,394 $m^2$ | Construction for intake weir | Left bank paddy field owned by two different individuals |
| | River bed and river terrace at intake weir | 6,517 $m^2$ | Construction for intake weir | Almost land is owned by NEA, the remaining land owned by government) |
| Bajura | River bed at intake weir | 2,153 $m^2$ | Construction for intake weir | The land is owned by NEA. |
| | Left bank area just downstream of intake weir | 390 $m^2$ | Temporary stock yard for construction of intake weir | The land is owned by the local government. |
| Syarpudaha | River bed at intake weir | 5,117 $m^2$ | Construction for intake weir and temporary stock yard | The land for intake is owned by NEA. Land for temporary stockyard is owned by government. |
| | Land purchased by Electricity Cooperatives for the power station | 3,000 $m^2$ | Temporary office for contractor during the construction | The land is owned by the lease holding company. |

2) Scope of land acquisition

Table 1-42 Scope of Land Acquisition

| Site | Usage in the Project | Necessary Area | Land Owner | Current Use | Policy for Compensation |
|---|---|---|---|---|---|
| Bajhang | Stockyard of construction materials | 230 $m^2$ * | Two individual owners<br>A：975 $m^2$<br>B：145 $m^2$ | A: paddy field<br>B: farmland currently not cultivated | As written in (4) Specific measures of compensation and support. |
| | Construction work space | 487 $m^2$ * | | | |
| | Water intake structure | 677 $m^2$ * | | | |
| | Total | 1,394 $m^2$ | 1,120 $m^2$ | | |
| Bajura | It is not necessary to acquire land. | | | | |
| Syarpudaha | It is not necessary to acquire land. | | | | |

Note*: The area above is the area of required land. The actual acquired area may change during the process of land acquisition.

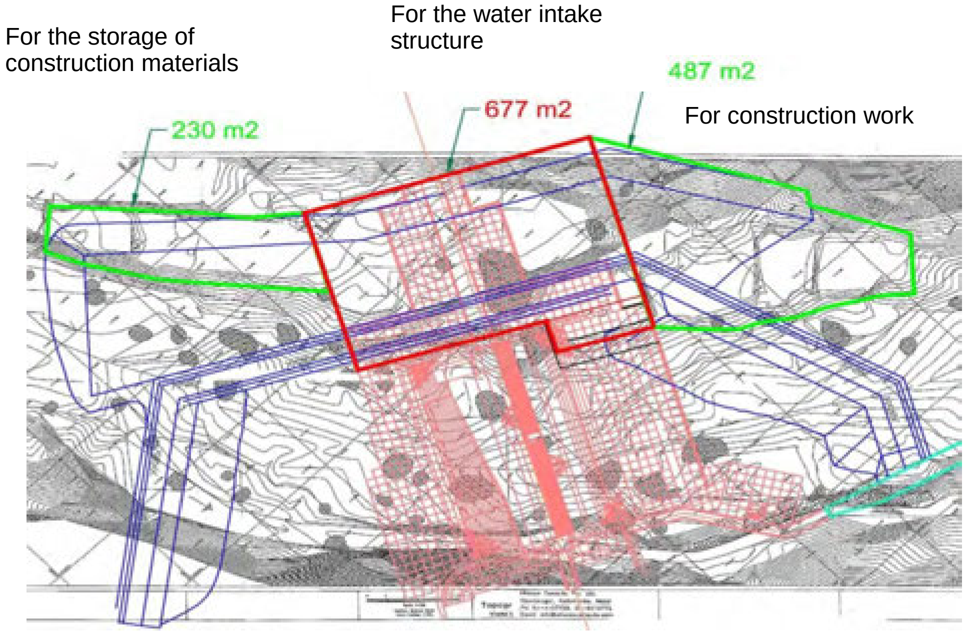



Figure 1-10 Required Area for Land Acquisition

3) Result of the census survey

Table 1-43 Results of the Census Survey of the Land Owners

| Item | | Land Owner (1) | Land Owner (2) |
|---|---|---|---|
| Land owner | | Person A, male<br>Age: Hidden (personal information) | Person B, male<br>Age: Hidden (personal information) |
| Address | | Daulichaur VDC, Bajhang | Daulichaur VDC, Bajhang |
| Household, family | Living together with | Hidden (personal information) | Hidden (personal information) |
| | Not living together with | Hidden (personal information) | Hidden (personal information) |
| Caste/Ethnic | | Chhetri | Chhetri |
| Religion | | Hinduism | Hinduism |
| Household income (except for different household) | Working away from home | Hidden (personal information) | |
| | Farming | Self-consumption | Self-consumption |
| Status of land to be acquired | Area to be acquired | 975 $m^2$ * | 145 $m^2$ * |
| Purpose of use | Agricultural land | Cultivated<br>Rice, wheat | Not cultivated |
| Trees | | None | None |

(4) Specific measures for compensation and support

1) Requirements for compensation entitlements

Copies of legal certificate (land registration document) of each land owner have been already received.

The letters prepared by the land owners addressed to NEA have been already received. It is written in the letters that they agree to comply with the procedures of land acquisition.

2) Procedure and policy of land acquisition

The Project specifies the following procedure for land acquisition and compensation based on the Land Acquisition Act.

Table 1-44 Procedures of Land Acquisition and Compensation for the Project

| Steps of the Land Acquisition Procedure | Status |
|---|---|
| NEA has finalized the plan of the Project. | NEA based on feasibility studies has finalized the designs, including the layout for the Project. |
| NEA requests MoE to acquire land, specifying objectives and committing payments of compensation and other expenses. | NEA will submit the request to MoE seeking approval for acquiring land.<br>Provisions for land acquisition and compensation are made within NEA budget. |
| MoE approves and orders the initiation process to the Bajhang District government. | To be approved once the commitment for funding of the Project is obtained. |
| The Chief District Officer (CDO) of Bajhang District forms CFC (usually within seven days). | |
| Land revenue officer confirms the area and location of land to be acquired including likely compensation and amount of loss. | To be carried out once the approval from MoE to initiate the process of land acquisition is obtained. |
| CDO issues “Notification of Land Acquisition” including purpose of acquisition and details of land to be acquired.<br>Land transactions are banned within the notified area. | |
| Owner can file complaints through the CDO within seven days.<br>Resolution of grievance within 15 days of complaint. | |
| CFC determines the amount of compensation. | |
| Compensation payment/disbursement | NEA will disburse the compensation amount to the district administration office (DAO).<br>The money will be deposited to DAO account.<br>The PAPs can receive money immediately.<br>The PAPs can claim their compensation using their legal title documents at any time. |
| Devolution of ownership | After the payment, land ownership devolves to NEA. |

Members of the CFC will be as follows:

- CDO
- Local Development Officer (LDO)
- Member of VDC
- Representative of District Survey Office
- Representative of District Account and Audit Office
- Representative of District Land Administration Office
- Land owners
- Officer of the proponent

For the Project the detail of land to be acquired ant land owners are identified clearly, and land owners are only two. Accordingly, the procedure of land acquisition is possible to initiate the procedure from the stage of forming CFC, and it is possible to skip the previous stage.

The committee members include all officers that are familiar and related to the practice of land acquisition.

As described above, it is possible that the procedure is processed smoothly and the procedure of land acquisition can be completed in a short period of time.

The committee includes land owners and an officer of NEA. The committee decides the amount of compensation where the land owner and NEA are attending. Therefore, the committee is also involved in some aspect of negotiation.

The committee figures out the amount of compensation based on the concept of replacement price with reference to the market prices and transaction prices in the region where the Project site is located.

As described above, there is no particular difference between this process to determine the compensation and the policy in the JICA guidelines.

The latest projects wherein NEA acquired land following the process above are as follows:
Dipayal – Sanfebagar 33 kV T/L Project
(2013, land acquisition for substation construction)

Khodpe – Chainpur 33 kV T/L Project
(2013, land acquisition at Khodpe for switching station construction)

3) Compensation to support livelihood of PAPs

In addition to the compensation for land itself, in the case the land for acquisition is being cultivated by the land owner, NEA shall compensate the amount equivalent to the market price for annual production of crops in order to support the livelihood of the owner. One of the two land owners is currently cultivating his land, in which the products are for self-consumption.

(5) Grievance redressal mechanism

1) Constitutional grievance redressal mechanism

The constitutional basis of activities related to grievance is the Land Acquisition Act of 1977. This act stipulates that CDO is the overall responsible person that will manage land acquisition activities and address the grievances related to land acquisition activities. According to the legal provision mentioned in the act, the basic process of grievance redressal to be undertaken is as follows:

- The various queries, complaints, and problems that are likely to be generated among the PAPs shall be resolved through constitutional mechanism.
- Decisions should be made within 15 days after receiving the complaints.
- Processing of complaints or any decision should be taken only after consultation with CDO and also with the NEA officer, if deemed necessary.
- The Ministry of Home Affairs can exercise legal authority as the District Court, and consults with CDO and NEA on the complaints by PAPs occurred in the process of land acquisition.
- Decision on complaints (including final decision of the court) shall be made within the prescribed number of days.

2) NEA-side grievance redressal mechanism

In addition to the constitutional mechanism, NEA will maintain interaction with PAPs to identify problems and undertake appropriate remedial measures. For this aim, NEA will assign a person in charge of grievance redressal (i.e., grievance redressal officer).

The grievance redressal mechanism shall be easily accessible for PAPs, and oral or verbal grievance can be made.

It is important that the grievance redressal officer is always present at the NEA Office during the process of land acquisition with land owners and addresses any queries, disputes, and complaints that may arise.

- Determination in correspondence should be given as soon as possible after receiving any grievance.
- For issues that cannot be addressed by the grievance redressal officer, the officer shall request the correspondence and resolution to CDO in CFC, in accordance with the Land Acquisition Act.
- The officer must record all complaints and respective actions and report to CDO in CFC.
- The expenses related to the grievance redressal activities mentioned above shall be burdened to NEA.

(6) Framework for implementation

Organizations with responsibility and duty for land acquisition in the Project are shown in Table 1-45.

Table 1-45 Organizations with Responsibility and Duty for Land Acquisition

| Organization | Role | Description of Responsibility and Duty |
|---|---|---|
| MoE | Has jurisdiction over land acquisition in the energy sector, and the line ministry of NEA | -Approval of application of land acquisition.<br>-Order of the initiation process to the Bajhang District government. |
| NEA | As the proponent | -Submission of data identifying the land to be acquired and land owners.<br>-Close communication with landowners, CDO, MoE and MoHA<br>-Adequate response for grievance from PAPs with constant interaction<br>-Payment of compensation<br>-Support to livelihood of PAPs after completion of the process of CFC |
| Government of Bajhang District | Has jurisdiction over land acquisition in the district | -Forming of CFC |
| CFC | Handles the procedure and all issues related to land acquisition and compensation | -Confirmation of data identifying the land and land owners affected by the Project.<br>-Decision of compensation amounts<br>-Grievance redress<br>-Support for district administrative practical work of the payment of compensation and devolution of ownership |
| Ministry of Home Affairs (MoHA) | Legal authority as the District Court | -For complaint filed by landowners, MoHA shall consult with CDO and NEA<br>-Decision on complaints (including final decision of the court) shall be made within prescribed number of days |
| Consultants | Support to and consultation with NEA | -Preliminary survey of land to be acquired and preliminary survey of PAPs<br>-Preliminary survey of replacement cost of land to be acquired<br>-Preliminary survey of the amount equivalent to market prices of annual production of the crops |
| NGOs, and mass media | Appropriate activities are expected in line with the purpose of their activities | |

(7) Implementation schedule of land acquisition

Implementation schedule of land acquisition is shown in Table 1-46.

Table 1-46 Implementation Schedule of Land Acquisition

| Item | January, 2014 | | | February | | | March | | | April | | | May | | | June | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Setting up LACP Implementation Framework, Initiation of Action | | | | △ | | | | | | | | | | | | | | |
| Date of Grant Aid Agreement* | | | | | | | | △ | | | | | | | | | | |
| Appointment of acquisition office | | | | | | | | ▬ | ▬ | ▬ | | | | | | | | |
| Finalization of process, compensation amount | | | | | | | | | | ▬ | ▬ | ▬ | ▬ | ▬ | | | | |
| Compensation, ownership transfer, and demarcation | | | | | | | | | | | | | | ▬ | ▬ | ▬ | | |
| Grievances redress | | | | | | | | | | | | | | | | ▬ | ▬ | |
| Compensation Payment Devolution of ownership | | | | | | | | | | | | | | | | △ | | |
| Completion of Procedure f or Land Acquisition | | | | | | | | | | | | | | | | | △ | |
| Completion of Preparation of LACP by NEA | | | | △ | | | | | | | | | | | | | | |
| Monitoring of Livelihood of PAPs | | | | | | | | | | | | | | | | | ▬ | ▬ |

>> to March, 2016

* The procedure for land acquisition will be started upon the date of Grant Aid Agreement

(8) Estimated cost and source of funds

The cost for implementation of LACP including compensation is shown in Table 1-47.

Table 1-47 Estimated Cost of Compensation, Source of Funds and LACP Implementation Budget

| No. | Description | Unit | Quantity | Rate (Rs/Unit) | Amount (Rs) |
|---|---|---|---|---|---|
| 1. | Land acquisition | $m^2$ | 1,300 (necessary area 1,120 $m^2$ +allowance) | 80 | 104,000 |
| 2 | Support for Livelihood | Area : $m^2$<br><br>Land Productivity : kg/ $m^2$/year<br><br>Crop Price: Rs/kg | 975 $m^2$ | Rice: 0.29 kg/$m^2$/year*<br>Wheat: 0.17 kg/$m^2$/year*<br><br>Rice : Rs 63/kg**<br>Wheat : Rs 50/kg** | 26,100<br><br>Rice: 17,800<br>Wheat: 8,300 |
| 3. | Cost related to CFC<br>Burden of operating costs of CFC, various commission fees, transportation, among others | Lump sum | | | 100,000 |
| 4. | Office supplies, etc. | Lump sum | | | 20,000 |
| | Subtotal (A) | | | | 250,100 |
| 5 | General and administrative costs and contingency cost (B) 20% of (A) | | | | 50,020 |
| | Total | | | | 300,120 |

Note * : Set as 1.25 times of statistical values in Bajhang District. The reason for using 1.25 times is consideration of fluctuations in productivity.

** : The higher of values obtained from hearing in the Bajhang area

Compensation amounts in the table above are estimated values, as actual amounts will be determined by CFC.

CFC will be formed in early April 2014 or later as anticipated by NEA. It is assumed that the amount of compensation will be determined approximately 1.5 months after the CFC is formed.

The total cost for implementation of LACP including compensation is estimated at 300,000 Rs.

(9) Monitoring framework and monitoring form developed by the proponent

Table 1-48 shows the monitoring plan.

Table 1-49 shows the responses/actions to comments and guidance from the government of the district and the public.

Table 1-50 shows quantitative and qualitative measurement method of level of livelihood of PAPs.

Table 1-51 shows the monitoring form.

Table 1-48 Monitoring Plan

| Environmental Item | Item | Measurement Point | Monitoring Method | Frequency (Period) | Implementing Organization | Responsible Organization |
|---|---|---|---|---|---|---|
| Construction Phase | | | | | | |
| Level of livelihood | Livelihood of the PAPs (Project Affected Persons) | Residences of the PAPs | Hearing from the PAPs | twice/year (Jun.2014–Mar.2016) | Electricity Cooperatives | NEA |

Table 1-49 Responses/Actions to Comments and Guidance from the Government of the District and the Public

| Monitoring Item | | Monitoring Results during Report Period |
|---|---|---|
| Level of Livelihood of PAPs (Construction Phase) | Quantitative and qualitative level of livelihood | Improvement action needs to be taken if living conditions of PAPs get worsened due to the land acquisition. |

Table 1-50 Quantitative and Qualitative Measurement Method of Level of Livelihood of PAPs

| Item | Monitor the situation of the level of livelihood by hearing from PAPs | | Measurement Point, Frequency, etc. |
|---|---|---|---|
| | Quantitative Item | Qualitative Item | |
| Level of Livelihood of PAPs | -Monthly income (all sources)<br>–Area of owned land address,<br>-House owned / borrowing - and<br>–Household expenditure and spending (approximate)<br>-Address, household, family structure | -Feeling of change in level of livelihood and it's reason<br>-Problems on livelihood and relation to the land acquisition<br>-Requirement to be supported for improvement of livelihood | Measurement Point, Frequency, etc. are shown In Table 1-48 |

Table 1-51 Monitoring Form

| Environmental Item | Measurement Point | Period (from dd/mm/yyyy to dd/mm/yyyy) | Frequency | Results Qualitative Data | Results Comments Responses/Actions to Comments and Guidance from the Public (with date) |
|---|---|---|---|---|---|
| Construction Phase | | | | | |
| Level of Livelihood of PAPs | | | | | |

(10) Consultation with PAPs

1) Direct consultation with PAPs

Before the stakeholders meeting, NEA and the electricity cooperatives explained to the land owners about the policy and measures of land acquisition. The land owners understood well about the explanation.

2) Stakeholders meeting

At the stakeholders meeting held on December 18, 2013, the explanation and consultation about land acquisition were made.

In the meeting, the following question had been asked: “The procedure of land acquisition for the Project complies with the Land Acquisition Act of Nepal. Does it take very long time?”

The answer and explanation by an officer of NEA was as follows:

NEA prepares detailed data concerning specified land to be acquired and land owners, and MoE then applies land acquisition. After approval of the application, MoE orders the initiation of land acquisition procedure to Bajhang District. CFC is formed with central role of CDO at the district level, and the procedure of land acquisition is advanced. NEA and land owners are also included in the committee. Negotiations with the land owners are also done in the committee, and the amounts of compensation are determined. Because owners and land to be acquired have already been identified in the present case, the procedure does not take a long time.

Another question had been asked, as follows: “Is there any possibility that there are differences with the policy of JICA guidelines concerning compensation for land acquisition if CFC decides the amount of compensation?”

The answer and explanation by an officer of NEA was as follows:

CFC will decide the compensation rate for the land in the presence of the land owner and the basis of rate will be the market prices of land and the transaction prices in the area. NEA will also try to provide fair compensation to the land owner as per their expectation. Therefore a large difference with the policy of the JICA guidelines does not occur.

One of the two land owners attended the meeting. He said that he understood the policy of land acquisition and compensation of the Project and thought there is no any particular problem or question with the explanation.

A letter of another land owner agreeing to accept the procedure of land acquisition has also been obtained.

There was no dissent against the Project made in this meeting.

## 1-3-3 Others

< Environmental Checklist >

(for Hydropower Stations, Dams and Reservoirs) **MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL**

(1/9)

| Category | Environmental Item | Main Check Items | Yes: Y No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 1 Permits and Explanation | (1) EIA and Environmental Permits | (a) Have EIA reports been already prepared in official process?<br>(b) Have EIA reports been approved by authorities of the host country's government?<br>(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?<br>(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government? | (a) N/A<br>(b) N/A<br>(c) N/A<br>(d) Y | (a) Article 3 of the Electricity Act, 1992 of Nepal states that hydropower project with the power plant capacity up to 1,000 kW does not require any license for survey, construction and operation. Therefore, It does not require any IEE/EIA in association with the application for license.<br>(b) Not applicable<br>(c) Not applicable<br>(d) The project with the installed capacity between 100 and 1,000 kW requires the report on investigations and plans to be submitted to the Department of Electricity Development (DoED). Accordingly, NEA will submit the report (unnecessary with IEE) to DoED for approval. The details and procedures of the report are stated in Article 6 of "Directives on licensing of hydropower projects, 2011". |
| | (2) Explanation to the Local Stakeholders | (a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders?<br>(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design? | (a) Y<br>(b) Y | (a) The stakeholders meeting was conducted on 18th December, 2013. Local stakeholders well understood the project and environmental and social considerations for the project.<br>(b) The comments from the stakeholders have been reflected to the project design such as the construction process. |
| | (3) Examination of Alternatives | (a) Have alternative plans of the project been examined with social and environmental considerations? | (a) Y | (a) Following alternative plans were examined.<br>- The land for stock yard and intake structure with no farmland located far upstream from the intake (Bajhang)<br>This alternative could not be selected since the topographical condition and the accessibility are poorer.<br>- Creation of new access roads (Bajhang, Syarpudaha)<br>This alternative could not be selected by the reason of construction period and environmental impact that the construction of the new road causes. |

| Category | Environmental Item | Main Check Items | Yes: Y No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 2 Pollution Control | (1) Water Quality | (a) Does the water quality of dam pond/reservoir comply with the country's ambient water quality standards? Is there a possibility that proliferation of phytoplankton and zooplankton will occur?<br>(b) Does the quality of water discharged from the dam pond/reservoir comply with the country's ambient water quality standards?<br>(c) Are adequate measures, such as clearance of woody vegetation from the inundation zone prior to flooding planned to prevent water quality degradation in the dam pond/reservoir?<br>(d) Is there a possibility that reduced the river flow downstream will cause water quality degradation resulting in areas that do not comply with the country's ambient water quality standards?<br>(e) Is the discharge of water from the lower portion of the dam pond/reservoir (the water temperature of the lower portion is generally lower than the water temperature of the upper portion) planned by considering the impacts to downstream areas? | (a) N/A<br>(b)N/A<br>(c) N/A<br>(d) N<br>(e) N/A | (a) Since the scheme of the project is "run of the river generation", it does not include dam or pond/reservoir.<br>(b) Not applicable<br>(c) Not applicable<br>(d) Since the amount of water intake is almost same as that of before the project, the river flow downstream will not be reduced any more. Accordingly, water quality degradation does not occur.<br>(e) Not applicable |
| 2 Pollution Control | (2) Wastes | (a) Are earth and sand generated by excavation properly treated and disposed of in accordance with the country's regulations? | (a) Y | (a) Stones and gravels for the civil work are taken from the river bed, and most aggregates are taken from the existing borrow-pit. Sand to be insufficient is taken from water bed (Bajhang). Residue of sand and gravels should be backfilled in accordance with the District's rule. |
| 3 Natural Environment | (1) Protected Areas | (a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas? | (a) N | (a) There is no protected area in and around the project site. |

| Category | Environmental Item | Main Check Items | Yes: Y No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| | (2) Ecosystem | (a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?<br>(b) Does the project site encompass the primeval forests, tropical rain forests, ecologically valuable habitats designated by the country's laws or international treaties and conventions?<br>(c) Is there a possibility that the project will adversely affect downstream aquatic organisms, animals, plants, and ecosystems? Are adequate protection measures taken to reduce the impacts on the ecosystem?<br>(d) Is there a possibility that installation of structures, such as dams will block the movement of the migratory fish species (such as salmon, trout and eel those move between rivers and sea for spawning)? Are adequate measures taken to reduce the impacts on these species? | (a) N<br>(b) N<br>(c) N<br>(d) N | (a) There are no primeval forests, tropical rain forests, ecologically valuable habitats forests that the project site encompasses.<br>(b) There is no valuable habitat or endangered species that the project site encompasses.<br>(c) Since the amount of water intake is almost same as that of before the project, there is no possibility that the project will adversely affect downstream aquatic organisms.<br>(d) There are no migratory fish such as salmon, trout and eel in the river within the project site. |
| | (3) Hydrology | (a) Is there a possibility that hydrologic changes due to the installation of structures, such as weirs will adversely affect the surface and groundwater flows (especially in "run of the river generation" projects)? | (a) N | (a) The old intake weirs were washed away by flood. Current temporary weirs are re-constructed by the project. However, since flow rates of downstream from intakes are almost unchanged by the replacement, there will be no change of surface and groundwater flows. |
| | (4) Topography and Geology | (a) Is there a possibility that reductions in sediment loads downstream due to settling of suspended particles in the reservoir will cause impacts, such as scouring of the downstream riverbeds and soil erosion? Is there a possibility that sedimentation of the reservoir will cause loss of the storage capacity, water logging upstream, and formation of sediment deposits at the reservoir entrance? Are the possibilities of the impacts studied, and adequate prevention measures taken?<br>(b) Is there a possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas (especially in run of the river generation projects and geothermal power generation projects)? | (a) N/A<br>(b) N | (a) Not applicable<br>(b) There is no possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas. Though current temporary weirs are replaced by new ones, the scale of the alteration of the river bed is small. |

| Category | Environmental Item | Main Check Items | Yes: Y No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 4 SocialEnvironment | (1) Resettlement | (a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? | (a) Y | (a) No involuntary resettlement is caused by project implementation. However, land acquisition is necessary (Bajhang).<br>Necessary land was designed to be minimized and as a continuous integrated land with the land for construction materials stockyard, intake structures and construction work space.<br>In addition, the construction materials stockyard and construction work space were designed to be minimized as much as possible within a tolerance of topographical conditions.<br>By the measures described above, the entire required area was reduced than what was originally expected. |
| | | (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? | (b) Y | (b) Explanation on land acquisition and compensation was given to landowners on stakeholder meeting and direct communication. |
| | | (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? | (c) Y | (c) NEA shall develop “Land Acquisition and Compensation Plan (LACP)" that includes compensations with full costs based on socioeconomic studies on land acquisition. |
| | | (d) Are the compensations going to be paid prior to the resettlement? | (d) Y | (d) The compensations shall be paid prior to the land acquisition in cash by NEA. |
| | | (e) Are the compensation policies prepared in document? | (e) Y | (e) The compensation policies are written on the explanation document of the stakeholder meeting. |
| | | (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? | (f) Y | (f) LACP will pay particular attention to vulnerable groups or people and indigenous peoples. |
| | | (g) Are agreements with the affected people obtained prior to resettlement? | (g) Y | (g) The letters prepared by the land owners addressed to NEA have been already received. It is written in the letters that they agree to comply with the procedures of land acquisition.<br>Agreements with the land owners were obtained prior to land acquisition. |
| | | (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? | (h) Y | (h) NEA will establish the team with necessary capacity and budget secured to implement LACP. |
| | | (i) Are any plans developed to monitor the impacts of resettlement? | (i) Y | (i) NEA will develop the monitoring plan to monitor the impact of land acquisition. |
| | | (j) Is the grievance redress mechanism established? | (j) Y | (j) NEA will create the position of the grievance redress and decide the person in charge of the grievance redress (grievance redress officer). |

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations<br>(Reasons, Mitigation Measures) |
|---|---|---|---|---|
| | (2) Living and Livelihood | (a) Is there any possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?<br>(b) Is there any possibility that the project causes the change of land uses in the neighboring areas to affect adversely livelihood of local people?<br>(c) Is there any possibility that the project facilities adversely affect the traffic systems?<br>(d) Is there any possibility that diseases, including infectious diseases, such as HIV, will be brought due to the immigration of workers associated with the project? Are adequate considerations given to public health, if necessary?<br>(e) Is the minimum flow required for maintaining downstream water uses secured?<br>(f) Is there any possibility that reductions in water flow downstream or seawater intrusion will have impacts on downstream water and land uses?<br>(g) Is there any possibility that water-borne or water-related diseases (e.g., schistosomiasis, malaria, and filariasis) will be introduced?<br>(h) Is there any possibility that fishery rights, water usage rights, and common usage rights, etc. would be restricted? | (a) Y<br>(b) Y<br>(c) N<br>(d) Y<br>(e) Y<br>(f) N<br>(g) N<br>(h) N | (a) There is the possibility that infectious diseases, such as HIV, will be brought due to the immigration of construction workers. Details are shown in "5 Others-(1) Impacts during Construction-(c).<br>(b) There is no impact on land use in the neighboring areas except the agricultural land to be acquired (Bajhang).<br>(c) There is no possibility that the project adversely affects the traffic systems in the region. The project site is located in rural mountainous region area wherein there are only few vehicles passing by on community roads.<br>(d) Details are shown in "5 Others-(1) Impacts during Construction-(c)".<br>(e) Since the amount of water intake is almost same as that of before the project, there is no change in the river maintenance flow.<br>(f) There is no possibility that reductions in water flow downstream or seawater intrusion.<br>(g) There is no possibility that water-borne or water-related diseases will be introduced, since the project does not increase water stagnant zone or spot.<br>(h) Since the amount of water intake is almost same as that of before the project, there is no possibility that water intake by the project is restricted. There is no fishery right in and around the project site. The project does not use the land of "community forest". |
| 4 Social Environment | (3) Heritage | (a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws? | (a) N | (a) In and around the project site, there is no spot that is significant for local archeological, historical, cultural, and religious heritage. |
| | (4) Landscape | (a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken? | (a) N | (a) There is no activity in the project such as installation of structures or modification of environment that affect the local landscape. |

| Category | Environmental Item | Main Check Items | Yes: Y No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| | (5) Ethnic Minorities and Indigenous Peoples | (a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?<br>(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources to be respected? | (a) Y<br><br>(b) Y | (a) There is no activity within the project that particularly affects the culture and lifestyle of ethnic minorities and indigenous peoples. Power supply will be stabilized by the project that leads to the improvement of social services in the region. That is a slight but effective benefit for ethnic minorities and indigenous peoples in the region.<br>(b) The project will be executed such that all the rights of ethnic minorities and indigenous peoples in relation to land and resources are to be respected. |
| | (6) Working Conditions | (a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?<br>(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?<br>(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?<br>(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents? | (a) Y<br><br>(b) Y<br><br>(c) Y<br><br>(d) Y | (a) NEA and the contractor shall be not violating the Labour Act (1992) that covers working conditions, the welfare of workers and safety and health.<br><br>(b)<br>- Around the charging unit should be set partition with ropes or nets to prevent danger.<br>- Work around high-voltage power line and charging unit and transportation of heavy machines should be done under monitoring by safety management supervisor of the contractor.<br>- In the construction site where heavy machines for construction are operated, intrusiveness except concerned parties should be banned.<br>(c)<br>- The contractor should prepare safety and health management plan, including traffic safety, accident prevention and public sanitation, etc. according to the Labour Act.<br>- The contractor should conduct educational training of safety, health and public sanitation to workers and staffs.<br>- The construction site manager must collect every morning all the workers and staffs and conduct instructions to them on health and safety through control over the construction site.<br>(d) The contractor should implement proper and strict management and education of guards no to infringe safety and security of residents and staffs/ workers. |

| Category | Environmental Item | Main Check Items | Yes: Y No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 5 Others | (1) Impacts during Construction | (a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? | (a ) Y | (a)<br>a1) Noise and vibrations, air pollution<br>Housings are located a substantial distance from the project site, and the construction activities will be temporary on a small scale. Any impact as regards air pollution, noise and vibrations will consequently be negligible. Additionally, good-quality fuel and oil are used for construction machines and vehicles.<br>a2) Turbid water occurs by transportation and construction activities on the river bed though temporary and quite partly. Therefore, following mitigation measures shall be taken.<br>- The contractor will work to reduce the occurrence of turbid water wherever possible.<br>a3) Wastes<br>- Wastes generated during construction (construction wastes and worker's wastes shall be properly treated and disposed by the contractor in accordance with District's rules.<br>- The contractor shall reduce the quantity of construction waste as much as possible by effective recycling, reuse, etc., and shall provide education and enlightenment for above activities by workers.<br>- By use effectively separation trash bin, proper waste disposal shall be carried out by corresponding to the difference of wastes.<br>- Wastes that cannot be treated and disposed in the district shall be taken away and be treated and disposed according to the rule of the government at the place where the wastes are carried in. |
| | | (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts? | (b) N/A | (b) Adverse Impacts to the natural environment in land or water areas in construction stage are expected to be negligible. |
| | | (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts? | (c) Y | (c) There is the possibility that infectious diseases, such as HIV, will be brought due to the immigration of construction workers. Mitigation measures are as follows.<br>- HIV education for construction workers and residents<br>- Regional workers will be hired preferentially as much as possible. |

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations<br>(Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 5 Others | (2) Accident Prevention Measures | (a) Is a warning system established to alert the inhabitants to water discharge from the dam? | (a)<br>(N/A) | (a) Not applicable<br>(Accident Prevention Measures in construction works are as follows.)<br>In order to ensure the safety of people in working, acting or moving in and around the project site, The contractor shall prepare following measures.<br>- To inform the construction work plan (description of work, time, location) to local residents by posting on village road or public bulletin board<br>- To zone the construction area including stock yard explicitly by rope, fence, or nets, etc.<br>- To set the danger notice of the plate for particularly dangerous construction area |
| | (3) Monitoring | (a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?<br>(b) What are the items, methods and frequencies of the monitoring program?<br>(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?<br>(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities? | (a) Y<br>(b) Y<br>(c) Y<br>(d) Y | (a) NEA developed the monitoring program (draft). NEA will implement the program run from the start of the construction works.Environmental items of monitoring are as follows.<br>- livelihood of land owners after land acquisition (method: hearing from land owners)<br>- noise and vibration (method: hearing from inhabitants)<br>- water turbidity (method: visual monitoring)<br>(b) The monitoring program developed by NEA includes the items, methods and frequencies, etc.<br>(c) NEA is establishing the monitoring framework (team, responsible person, equipment, budget, etc.)<br>(d) According to the Environment Protection Rules (EPR, 1997), for a project that requires IEE/EIA, the proponent should formulate monitoring procedures, including the monitoring agency, time-schedule, monitoring and evaluation indicators, etc. However, for a project that doesn't require IEE/EIA, there is no regulation concerning environmental monitoring. |

| Category | Environmental Item | Main Check Items | Yes: Y No: N | Confirmation of Environmental Considerations (Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 6 Note | Reference to Checklist of Other Sectors | (a) Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects in the mountains including large areas of deforestation).<br>(b) In the case of dams and reservoirs, such as irrigation, water supply, and industrial water purposes, where necessary, pertinent items described in the Agriculture and Water Supply checklists should also be checked.<br>(c) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities). | (a) N/A<br>(b) N/A<br>(c) N/A | (a) Not applicable<br>(b) Not applicable<br>(c) The scope of the project is the improvement of the existing hydropower system and don't include installation of electric transmission lines and/or electric distribution facilities. |
| | Note on Using Environmental Checklist | (a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming). | (a) N | (a) Since emission of greenhouse gases such as CO2 from transportation vehicles and heavy machines in construction works are quite little and temporary, the impacts to transboundary or global issues are estimated to be negligible. |

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are requested to be made.
   In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

# Chapter 2. Contents of the Project

## 2-1 Basic Concept of the Project

### (1) High-level Goals and Project Goals

In the three-year plan (from FY2013/2014 to FY2015/2016), which is placed at the top of the national development strategy, the Nepali government intends to identify the improvement of electric power and other economic infrastructures as a priority area and achieve electric power development of 15 MW by means of micro-hydropower generation in the next three years to supply electricity in the village areas. In 2009, the government also developed a renewable energy policy, which states the necessity of micro-hydropower generation to supply electricity in the village areas not connected to the main transmission system.

Based on the policy and plan, this Project seeks to improve the existing micro-hydropower plants and sustain electric power supply in the village areas not connected to the main transmission system with the view of improving electric power infrastructure on a constant basis.

### (2) Project Outline

The three target micro-hydropower plants belong to the Distribution and Consumer Services (DCS) of Nepal Electricity Authority (NEA), and are controlled by the DCS regional offices. The locations of target sites and DCS regional offices are shown in Table 2-1.

Table 2-1 Target Sites and DCS Regional Offices

| Target Sites | NEA's DCS Regional Offices |
|---|---|
| 1. Bajhang Micro-hydropower Plant:<br>Dogadi, Daulichaur VDC, Ward No. 7,<br>Bajhang District | Attaria Regional Office<br>Attaria, Geta VDC, Ward No. 3, Kailali District |
| 2. Bajura Micro-hydropower Plant:<br>Salaghat, Martadi VDC, Ward No. 9, Bajura District | |
| 3. Syarpudaha Micro-hydropower Plant:<br>Bhagle, Bafikot VDC, Ward No. 6, Rukum District | Nepalgunj Regional Office<br>Buspark, Nepalgunj Municipality Ward No. 5,<br>Banke District |

VDC: Village Development Committee

These sites are not connected to the main transmission system but are supplied with electric power from an independent distribution network of each micro-hydropower plant as the only power source. In the three target sites, the respective electricity operators carry out power supply operation using the power generation and distribution equipment leased from NEA. The respective electricity operators are hereinafter referred to as electric cooperative (Ec), though the Bajhang electricity operator runs as a company while the remaining operators run as cooperatives.

After around 23 years from the start of operations, the equipment have significantly degraded and the operating power generation machines have been left without overhaul or replacement of equipment. Ec has only repeated partial and minimum repairs within its operations budget. Thus, the village areas lose electricity, and it is only a matter of time before the equipment fully break down.

The Project intends to repair the existing degraded or damaged equipment, restore the reliability of power generation functions and power supply, and extend the life of the equipment for the purpose of maintaining electric power development through micro-hydropower generation and sustaining power supply in the village areas of the three target sites. Stable and sustained power supply is expected to contribute significantly to a better and improved life that the people in the areas desire.

This Project which consists of three target sites includes civil work and equipment procurement for the reconstruction of intake works, repair of the existing headraces, and replacement of the generating equipment for each site.

## 2-2 Outline Design of the Japanese Assistance

### 2-2-1 Design Policy

(1) Basic Policy

The original request of Nepali Government was made regarding the repair and expansion of the existing micro-hydropower plants including Chaurjahari Micro-hydropower Plant located in Rukum District as well as the target three sites. However, the Chaurjahari Micro-hydropower Plant was excluded from the targets of the Project as the preliminary survey indicated that the area supplied by the power plant will soon be connected to the national grid system, and the power plant will be terminated after the connection. In addition, although the request included the expansion of the four micro-hydropower plants, the expansion plan was eliminated from the Project due to the lack of available hydrological data relevant to the expansion.

The Project therefore sets the basic policy to restore the existing three micro-hydropower plants to their original form in principle. The design data of three target sites are shown in Table 2-2 below:

Table 2-2 Design Data of Existing Micro-hydropower Plant

| | | Bajhang | Bajura | Syarpudaha |
|---|---|---|---|---|
| Turbine | Type | Cross flow | Pelton | Pelton |
| | Quantity | 2 | 2 | 2 |
| | Net head | 37.043 m | 248.99 m | 265.6 m |
| | Rated flow | 0.415 $m^3/s$ | 0.0542 $m^3/s$ | 0.0535 $m^3/s$ |
| | Rated output | 115 kW | 114 kW | 120 kW |
| | Rated speed | 750 rpm | 1500 rpm | 1500 rpm |
| Generator | Type | Synchronous | Synchronous | Synchronous |
| | Quantity | 2 | 2 | 2 |
| | Rated capacity | 125 kVA | 125 kVA | 125 kVA |
| | Rated voltage | 415 V | 415 V | 415 V |
| | Power factor | 0.8 | 0.8 | 0.8 |
| | Rated frequency | 50 Hz | 50 Hz | 50 Hz |
| Year of completion | | 1986 | 1986 | 1986 |

While it was decided not to consider the expansion program, the Project will still consider whether the amount of usable water may be increased and whether expansion is feasible, taking into account the flow data collected during the survey period through the water level gauge installed at the intake weir of each power plant, the record of electricity generated in the past, the water flow capacity of the existing waterways, and other impacts on intake.

(2) Policy for Natural Conditions

The three target sites are located between the upper Himalayan area and Terai Plain area and belong to the temperate zone from 1,000 to 1,800m elevation. With the rainy and dry seasons, the temperature of the areas fluctuates between 0 °C and 30 °C and the annual mean precipitation is about 1,500 mm. Although varying by areas, the rainy season of Nepal is from June to September, while the dry season is from October to May. In general, the rainy season in the west area starts in mid-June.

During rainy season, the three target sites have extremely poor road conditions. In particular, roads are cut off by frequent falling rocks or landslides and transport is blocked by unpaved roads or due to crossing of swollen rivers. The transportation of equipment/materials during rainy season has the risk of not only being involved in landslides but also facing the difficulty of planning the processes including uncertain restoration from such obstructions to traffic. Taking into account the road conditions during the rainy season, the Project will therefore not plan any transportation or construction work from June to September.

The equipment/materials to be procured are subjected to processing necessary for shipment, storage, installation, and operation under high temperature, high humidity, heavy rainfall or other conditions near the subtropical climate.

(3) Policy for Socioeconomic Conditions

Dasain, the largest annual festival in Nepal, is widely celebrated nationwide for 14 days. The official holidays, which vary each year, last about seven days in September or October. During the holidays, a number of people go back home to spend time with their family, which means any operation must stop for at least ten consecutive days including the days before and after the holidays. Construction work also stops in most cases as workers go back home, which has a significant impact on the schedule. In November, following Dasain, the nation celebrates a three-day long festival called Tihar during which every operation is also suspended for nearly a week including the days before and after the holidays. For the period from Dasain to Tihar festivals, it must be assumed that construction work will be suspended or stagnated.

(4) Policy for Construction/Procurement Conditions

1) Applicable Standards

Japanese standards shall basically apply to the equipment procured for the Project, considering the grant aid scheme. The standards to be applied to the main equipment to be procured will be the International Electrotechnical Commission (IEC) standards as the equipment contains electrical goods. In addition, the standards of the Japanese Industrial Standards (JIS) and the Japan Electrical Manufacturers' Association (JEMA) will be applied and shall supplement the IEC for detailed items which are not set forth in the IEC and for which NEA does not have any specifications, such as the items on steel plate thickness for the control panel.

2) Level of Local Workforce and Locally Procured Equipment/materials

Cases from the past similar projects indicate that local workforce sufficiently reaches the required level with instructions from Japanese engineers. Taking this into account, the construction plan calculates the portion of local currency to construction costs on the basis of local work. The equipment/materials that may be locally procured shall be procured to the extent that quality and reliability permit. They mainly are materials for civil works and buildings.

(5) Policy Related to Utilization of Local Contractor

The past records of Japan's grant aids for Nepal indicate that some civil engineers and construction workers have reached the technically reliable level with appropriate instructions and supervision. The Project intends to take advantage of these workers as much as possible. Civil work at each site under the Project shall therefore be planned to be carried out by local contractors under the control of a Japanese main contractor.

With regard to equipment installation, such important work as the installation of water turbines and generators, cable connection, checks for wiring control cables on generator control panels, inspection, testing, and trial run shall be performed by Japanese engineers while the actual manual labor is to be done by local workers under the guidance of Japanese engineers.

The local civil engineers shall also be procured in the consultant's construction supervisions of civil work under the supervision of Japanese civil engineering consultants.

(6) Policy for Operation and Maintenance Management Capability of Implementing Organizations

The responsible organizations for the Project implementation are the NEA headquarters and the Planning and Technical Service Department of DCS. One personnel for civil engineering and one for electricity shall be assigned as NEA's contacts personnel to engage in external affairs and make negotiations. A number of staff who are presently playing central roles in DCS experienced different opportunities in terms of the transfer of skills on the side of engineers, counterparts, etc. during the improvement plan for the transmission lines, substations and distribution system at the Kathmandu Valley through grant aids from Japan, which were continuously offered after the end of the 1970s.

After completion of the Project, each Ec shall be responsible for the operation and maintenance management under a control by the Nepalgunj Regional Office (Rukum District) or the Attaria Regional Office (Bajhang and Bajura districts). Regional offices with technical departments composed of civil and electrical engineers provide the technical support for the micro-hydropower plants.

Though the purpose of the Project is to recover the original performance of the existing micro-hydropower plant, some instructions and training will be required for operators to operate the replaced new generating equipment. Accordingly, manufacturers' instructors will teach the preliminary technique of operation to Ec's operators together with the responsible engineers of the respective NEA Regional Offices.

As for the electrical operators, Bajhang and Syarpudaha Ecs have sufficient track record and years of experience. Though operation experience in Bajura Ec is only for three years, previous management by NEA has been taken over by Bajura Ec. Considering the actual experience, Bajura Ec is expected to have the ability to operate the plant. However, the financial statements prepared by each Ec is found to be improved because the financial statement was not correctly prepared, namely incorrect categorization of expense items, improper financial analysis, etc. Further, the improvement of Ecs operators' capacity is also required for the technique of operation and maintenance management of the generating equipment, because there is no record for inspections, failures and repairs.

The continuous impact after the implementation of the Project requires proper administration and management skills, which shall be provided by means of Soft-component programme.

(7) Policy Related to Rating Facilities, Equipment, etc.

With the general rule of restoration to the original form, the grades of the rehabilitated generating equipment such as water turbines, generators, and control panels shall be equal to or better than those of the existing equipment, while the materials, models, or design methods that are no longer used after technical advancement shall be replaced with those currently available. For example, devices that were analog controlled turned into digital controlled, therefore the manufactures do not make the same products any more or, even if they do, it has been a kind of specially ordered product which is nearly unavailable. Considering the future maintenance management, the materials and components used shall be locally available as much as possible, and control systems in particular shall employ the design that leaves some room for manual operation.

The existing civil works and buildings have been constructed with a method generally available in Nepal. At this stage, although they have some components that need immediate repair or replacement, the facility still maintains its minimum function with no components requiring a special repair method. Therefore, the use of a construction method generally available in Nepal for the repair and replacement of the existing waterways does not seem to affect the maintenance management of the completed generating equipment.

On the other hand, it is confirmed through the interviews at target sites that the existing intake structures have flown out as a result of floods after completion. Such collapse of intake structures by flood is possibly due to the limited construction method applied with the manpower available at the time of construction. The proposed plan is to consider the local natural conditions and to construct water intakes that will mitigate flood damage and allow water to be stably withdrawn through mobilization of construction equipment thereby.

(8) Policy Related to Construction/Procurement Method and Construction Period

Since all the three sites are located on the southern slope in the western lower Himalayan area, the land transportation route goes through the intermountain road that runs north from the trunk road stretching from east to west on the Terai Plain. On the steep land, landslide or river erosion takes place during the rainy season which frequently interrupts traffic even on paved roads. On dirt roads, roughness on road surface in addition to landslide significantly worsens the road conditions and almost blocks the traffic. In the sites where the road ends before the power plant or intake structure, material transportation may have to rely on manpower, or even helicopters to transport the equipment. Transportation would be sufficient to determine that the construction period should not include the rainy season.

The construction areas for intake structures in all the three sites are located in narrow valleys. Although gravel may be procured around or near the construction areas, sand is hardly obtainable. Thus, sand used as concrete aggregate shall be procured from a downstream sand pit and partially transported by manpower.

The project intends to use backhoe as the construction machine for intake works, which must be self-propelled for a substantial distance considering road conditions along the way and access near the site. Because the actual work of backhoes was observed during the preparatory site survey, it might be judged that there was no obstruction to the self-propelled transport of backhoe. But enough time for transportation is taken into consideration.

In addition to the transfer of the construction machine, the fortnight Dasain period from September to October when construction is suspended shall also be taken into account in setting the construction period.

### 2-2-2 Basic Plan

(1) Overall Planning

Table 2-3 shows the present conditions and modification details of the facilities and equipment to be implemented in the target sites of the Project.

Table 2-3 Conditions and Modification Details of Target Facilities and Equipment (1/3)

| Target Sites, Facilities or Equipment | Conditions and Modification Details |
|---|---|
| Target sites | Bajhang Micro-hydropower Plant (Bajhang District)<br>Bajura Micro-hydropower Plant (Bajura District)<br>Syarpudaha Micro-hydropower Plant (Rukum District) |
| 1. Hydroelectric power equipment | The conditions of target facilities are the same in all the three sites requiring the same modification |
| Water turbine | The water turbine itself and the bearing are worn out, and the accessory equipments are damaged<br>The water turbine as a whole is broken and thus needs to be replaced |
| Generator | The bearing is worn out and the rotation speed detector damaged<br>Due to insulation failure in the past, insulation deterioration has taken place<br>Similar to the water turbine, the generator runs in a faulty state and therefore needs to be totally replaced |
| Generator control panel and direct current (DC) power supply | The equipment for controlling frequency and generator voltage has broken down and disabled<br>With the protection relay and measuring instruments that are either damaged or inaccurate, the equipment has been running unprotected and uncontrolled<br>The DC power supply has been broken down and disabled<br>Both the controller and DC power supply need to be totally replaced |
| Main transformer | Although no burnout or damage is seen, the thermometer and hydroscopic equipment have been broken down with leakage of insulation oil<br>Renewal of the main transformer needs to ensure the reliability of the entire hydroelectric power equipment being recovered in coordination with the replacement of the water turbine and generator. |

Table 2-3　Conditions and Modification Details of Target Facilities and Equipment (2/3)

| Target Sites, Facilities or Equipment | Conditions and Modification Details |
|---|---|
| 2. Hydroelectric facilities | The conditions of target facilities are nearly the same in all the three sites basically requiring the same modification. |
| Intake weir and intake | As the intake weir and intake flowed out after a flood, unstable water intake has been forced from the temporary intake using part of the residual existing headrace and intake<br>The intake structure that satisfies the capacity of the renewed generating equipment needs to be reconstructed |
| Headrace | Deterioration of the entire waterways has progressed<br>The abnormalities seen include water leakage from waterways, scouring of the foundation ground, soil sedimentation, damage to foundations or side walls, cracks, algae growth, and sediment inflow from a slope along the way or torrent<br>The part of abnormality affecting power generation, maintenance management duties, and people's livelihood in the region shall be repaired so that the waterways recover the original function and extend its life time. |
| Tank | The tank installed in the Bajhang Micro-hydropower Plant has harmful cracks on the foundation and side walls, which shall be repaired to prevent water from leaking out<br>Sediment deposition has resulted in insufficient tank capacity, making it difficult to generate power with two units<br>Deposited sediment shall be eliminated to recover the function of the tank<br>The tanks of the Bajura and Syarpudaha plants have cracks and damages on the side walls, accordingly such defects/damages shall be repaired<br>There is no sediment deposition that reduces the tank capacity<br>The drain gates installed in the tank have been either damaged or disabled in all the three sites and thus need to be renewed. |
| Penstock | Water leakage from part of the flange joints has been observed<br>There is some corrosion seen partly on the outer surface of steel pipes, but the coat still remains all over the surface. Some saddles have cracks or collapsed foundations<br>The outer surface of all the pipes shall be coated again along with eliminating water leakage and repairing the saddles<br>Where steel pipes are buried to secure village roads or farmland, peripheral sediment shall be eliminated and steel pipes shall be protected by retaining walls or other means. |

Table 2-3 Conditions and Modification Details of Target Facilities and Equipment (3/3)

| Target Sites, Facilities or Equipment | Conditions and Modification Details |
| --- | --- |
| Power House | The foundations, columns or beams have not been damaged<br>Windows and entrance doors have been damaged and cannot be closed<br>Some gaps have been found on roofs<br>The windows, doors and roofs shall be repaired and walls shall be recoated to protect the conditions of the devices which will be renewed |
| Tailrace | Side walls and foundations have been damaged due to aging<br>The damage to the revetment of the tailrace outlet has progressed as a result of erosion by the effluent stream<br>These shall be repaired and restored to the original form<br>A new tank shall be constructed in the middle of the tailrace to cool the dummy load governor resistor for the renewed generator |

(2) Equipment/Materials Planning

Table 2-4 shows the outline specifications of the main devices to be used for renewing the existing devices under the Project.

Table 2-4 Outline Specifications of the Main Devices (1/4)

| No. | Equipment | Quantity | Outline Specifications | Purpose |
|---|---|---|---|---|
| 1 | Water turbine | | | To convert water energy into rotational power by runner |
| 1-1 | Water turbine A (Bajhang Micro-hydropower Plant) | 2 units | 1) Type : Horizontal shaft, single runner, single guide vane type cross flow turbine<br>2) Net head : 37.043 m<br>3) Discharge : 0.415 $m^3/s$<br>4) Output : 114 kW or more<br>5) Rotational speed : 750 rpm<br>6) Quality of the material :<br>Runner：<br>S25C+STPG38S<br>Guide vane：<br>SS400＋SUS304<br>Casing：<br>SS400＋S25C | |
| 1-2 | Water turbine B (Bajura Micro-hydropower Plant) | 2 units | 1) Type : Horizontal shaft, single runner, single jet type Pelton turbine<br>2) Net head : 248.99 m<br>3) Discharge : 0.0542 $m^3/s$<br>4) Output : 108 kW or more<br>5) Rotational speed : 1,500 rpm<br>6) Quality of the material :<br>Runner : SCS5<br>Needle : SUS420J2<br>Housing : SS400 | |
| 1-3 | Water turbine C (Syarpudaha Micro-hydropower Plant) | 2units | 1) Type : Horizontal shaft, single runner, single jet type Pelton turbine<br>2) Net head : 265.6 m<br>3) Discharge : 0.0535 $m^3/s$<br>4) Output : 113 kW or more<br>5) Rotational speed : 1,500 rpm<br>6) Quality of the material :<br>Runner : SCS5<br>Needle : SUS420J2<br>Housing : SS400 | |

Table 2-4　Outline Specifications of the Main Devices (2/4)

| No. | Equipment | Quantity | Outline　Specifications | Purpose |
|---|---|---|---|---|
| 2 | Generator | | | To convert kinetic energy of water to electrical energy. Mainly composed of the rotor and stator |
| 2-1 | Generator A<br><br>(Bajhang Micro-hydropower Plant) | 2 units | 1) Type: Horizontal shaft, three phase synchronous generator<br>2) Rated Capacity: 125 kVA<br>3) Rated voltage: 415 V<br>4) Power factor: Lag 80%<br>5) Rated speed: 750 rpm<br>6) Frequency: 50 Hz<br>7) Exciter: AC exciter and rotary rectifier | |
| 2-2 | Generator B<br><br>(Bajura and Syarpudaha Micro-hydropower Plants) | 4 units | 1) Type: Horizontal shaft, three phase synchronous generator<br>2) Rated Capacity: 125 kVA<br>3) Rated voltage: 415 V<br>4) Power factor: Lag 80%<br>5) Rated speed: 1,500 rpm<br>6) Frequency: 50 Hz<br>7) Exciter: AC exciter and rotary rectifier | |
| 3 | Inlet valve | | | To stop water from penstock during stoppage or maintenance of turbine generator |
| 3-1 | Inlet valve A (Bajhang Micro-hydropower Plant) | 2 units | 1) Type: Butterfly valve<br>2) Diameter: φ400 mm<br>3) Operation: Motorized operation<br>4) Operation power: DC 110 V<br>5) Opening detector: Limit switch (2 sets : full closed, full open)<br>6) Others: Manual operation is possible | |
| 3-2 | Inlet valve B (Bajura and Syarpudaha Micro-hydropower Plants) | 4 units | 1) Type: Gate valve<br>2) Diameter: φ125 mm<br>3) Operation: Motorized operation<br>4) Operation power: DC 110 V<br>5) Opening detector: Limit switch　(2 sets : full closed, full open)<br>6) Others: Manual operation is possible | |
| 4 | Driven equipment | 6 units | 1) Type: Motor-driven<br>2) Power source: DC 110 V<br>3) Position detector: Limit switch 5 sets, Opening position indicator<br>4) Others: Manual operation is possible | Devices to control the flow of water |

Table 2-4 Outline Specifications of the Main Devices (3/4)

| No. | Equipment | Quantity | Outline Specifications | Purpose |
|---|---|---|---|---|
| 5 | Rotating speed detector | | | Devices to detect the rotational speed of water turbine/generator used in speed relays and speed control |
| 5-1 | Permanent magnet generator A (Bajhang Micro-hydropower Plant) | 2 units | 1) Type: Permanent magnet generator<br>2) Voltage: 110 V / 750 rpm | |
| 5-2 | Permanent magnet generator B (Bajura and Syarpudaha Micro-hydropower Plants) | 4 units | 1) Type: Permanent magnet generator<br>2)Voltage: 110 V / 1500 rpm | |
| 6 | Generator control panel | 6 panels | 1) Type:<br>Steel indoor, self-standing type cubicle<br>2) Dimensions:<br>Width 700<br>Depth 1,150<br>Height 2,350 | For water turbine generator control |
| 7 | Low voltage panel | 3 panels | 1) Type:<br>Steel indoor, self-standing type cubicle<br>2) Dimensions:<br>Width 700<br>Depth 1,150<br>Height 2,350 | For the switch panel and configuration of the 415V bus bars, and auxiliary power supply |
| 8 | Speed regulator panel | 6 panels | 1) Type:<br>Steel indoor, self-standing type cubicle<br>2) Dimensions:<br>Width 600<br>Depth 800<br>Height 2,350<br>3) Control system: Dummy load<br>4) Dummy load capacity: 100 kW<br>5) Cooling system:<br>Water cooling<br>Tailrace installation | To keep the constant rotation of the turbine and generator varies depending on the load equipment to control the dummy load adjustment |

Table 2-4 Outline Specifications of the Main Devices (4/4)

| No. | Equipment | Quantity | Outline Specifications | Purpose |
|---|---|---|---|---|
| 9 | DC power supply | 3 panels | 1) Type:<br>Steel indoor, self-standing type cubicle with batteries<br>2) Dimensions:<br>Width 800<br>Depth 1,300<br>Height 1,950<br>3) Internal equipment:<br>Thyristor rectifier<br>Silicon dropper<br>MCCB AC 3P 1 piece<br>DC 2P 6 pieces<br>4) Batteries:<br>Battery capacity corresponding to the load<br>5) Protection relay: 80, 64 D (JEM) | To make DC power supply for control of turbine and generator or inlet valve, guide vane or needle-driving device |
| 10 | Main transformer | 3 units | 1) Type: Outdoor oil-immersed three-phase transformer<br>2) Rated voltage: 11,000 V/415 V<br>3) Rated Capacity: 300 kVA<br>4) Frequency: 50 Hz<br>5) Cooling system: ONAN<br>6) Conection: Yy-O | A device to convert voltage from 415 V to 11,000 V |
| 11 | Head pond sand flush gate | | | Equipment for draining sand on the bottom of the head pond |
| 11-1 | Slide gate A (Bajhang Micro-hydropower Plant) | 1 set | 1)Type: Manually driven, rack gear type, steel plate girder construction, slide gate<br>2)Dimensions:<br>Clear span: 0.8 m<br>Clear height: 0.7 m | |
| 11-2 | Slide gate B (Bajura and Syarpudaha Micro-hydropower Plants) | 2 sets | 1)Type: Manually driven, rack gear type, steel plate girder construction, slide gate<br>2)Dimensions:<br>Clear span: 0.7 m<br>Clear height: 0.8 m | |
| 12 | Intake sand flush gate | 5 sets | 1)Type : Manually driven<br>2)Dimensions<br>Clear span : 1.0 m<br>Clear height : 1.0 m | |

(3) Facility Planning

1) Tank

The head tank made of stone masonry and mortar is located as a head pond at the connection point between the headrace and penstock. The tank has the function to adjust fluctuations in the water surface resulting from changes in the water turbine flow. A spillway is provided to overflow the excessive water to the spillway channel when the water turbine flow is reduced or stopped.

The tank for the Bajhang plant has several vertical cracks normal to the effluent direction from the bottom to the side walls. When the water level is somewhat lowered, sediment exposed above the water surface is observed. Sediment is found all over the tank resulting in a reduced tank capacity. Although the maximum rated flow is 0.83 $m^3/s$, the actual operation of the two water turbines requires the power of one water turbine to be set to 100% or the other to be less than 25% since the water level in the tank cannot be kept at the required level to operate properly the generation.

The tanks of the Bajura and Syarpudaha plants, which have fractures and cracks, shall be repaired. Although no sediment in the tanks is seen, there is much waste deposited which is also caught on the screen resulting in head loss.

For the continuous use of the tanks of Bajhang, Bajura and Syarpudaha plants, cracks shall be filled and the damage repaired. The existing sand flush gates are inoperable and thus need to be renewed.

2) Penstock

The steel penstock is installed to supply water for power generation from head tank to the water turbine. A single penstock stretching from the tank to the power plant is installed along a slope, branched into two just before the power plant, and connected to two water turbines. The penstock was constructed using flange connection.

The coating on the steel pipes still remains without significant corrosion. The result of measuring plate thickness to the possible extent indicates that the plate is sound with no reduction in thickness. Some abnormalities such as open cracks and level differences were found on saddles. The conditions of the penstocks for all the three sites are almost the same, and these penstocks shall continue to be used after the following repairs:

i) The entire outer surface of the steel pipes is recoated;
ii) Seals are replaced or repaired for water leakage spots at the flange joints and expansion joints;
iii) Lost bolts are supplied;
iv) Where steel pipes are buried to secure village roads or farmland, peripheral sediment is eliminated and steel pipes are protected by retaining walls or other means;
v) Open cracks of saddles are repaired. The saddles of unequal settlement are replaced.

3) Power House

The power house had no fissures or other defects on the columns, beams and walls, and no cracks or fractures on the floors and machine foundations. Although the appearance is not satisfactory, the roof shows evidence of renewal in the past with no leak or other defects at this stage. Wood doors and window frames have been aging. Since the buildings at all the three sites show no structural defect, the columns, beams, floors, foundations and walls of the buildings should continue to be used with no modification.

i) Aging and damaged window frames and doors are renewed focusing on equipment protection;
ii) Roofs are renewed in conjunction with the improved endurance of the overall facilities although they have no leak or other defects at this stage;
iii) Lost connection bolts of beams are supplied;
iv) Floors are repaired by breaking them for the renewal of equipment;
v) Light bulbs are broken or missing. Whole the indoor and outdoor lighting equipment are renewed.

4) Tailrace

The tailrace returns the pass water, through water turbine to generate electric power, to the river. The independent waterways running from each water turbine join together once and they run out of the power plant.

The tailrace has been aging with some fractures to the side walls and bottoms. The damage to the revetment of the tailrace outlet has progressed as a result of erosion by the effluent stream. These shall be repaired by restoration to the original form. Also, a new water tank, to cool the dummy load governor resistor, shall be mounted by modifying part of the tailrace.

### 2-2-3 Outline Design Drawing

Table 2-5 shows the general drawings for the Project.

Table 2-5 List of General Drawings

| No. | Drawing No. | Title | |
|---|---|---|---|
| 1 | MHI-001 | BAJHANG POWER STATION | INTAKE GENERAL PLAN |
| 2 | MHI-002 | BAJHANG POWER STATION | INTAKE WEIR (1) |
| 3 | MHI-003 | BAJHANG POWER STATION | INTAKE WEIR (2) |
| 4 | MHI-004 | BAJHANG POWER STATION | INTAKE SAND FLUSH GATE |
| 5 | MHI-005 | BAJHANG POWER STATION | INTAKE BAR SCREEN |
| 6 | MHI-006 | BAJHANG POWER STATION | GENERAL LAYOUT |
| 7 | MHI-007 | BAJHANG POWER STATION | POWER HOUSE (1) |
| 8 | MHI-008 | BAJHANG POWER STATION | POWER HOUSE (2) |
| 9 | MHI-009 | BAJHANG POWER STATION | SINGLE LINE DIAGRAM |
| 10 | MHI-010 | BAJURA POWER STATION | INTAKE GENERAL PLAN |
| 11 | MHI-011 | BAJURA POWER STATION | INTAKE WEIR (1) |
| 12 | MHI-012 | BAJURA POWER STATION | INTAKE WEIR (2) |
| 13 | MHI-013 | BAJURA POWER STATION | INTAKE LEFT ABUTMENT |
| 14 | MHI-014 | BAJURA POWER STATION | INTAKE SAND FLUSH GATE |
| 15 | MHI-015 | BAJURA POWER STATION | INTAKE BAR SCREEN |
| 16 | MHI-016 | BAJURA POWER STATION | GENERAL LAYOUT |
| 17 | MHI-017 | BAJURA POWER STATION | POWER HOUSE (1) |
| 18 | MHI-018 | BAJURA POWER STATION | POWER HOUSE (2) |
| 19 | MHI-019 | BAJURA POWER STATION | SINGLE LINE DIAGRAM |
| 20 | MHI-020 | SYARPUDAHA POWER STATION | INTAKE GENERAL PLAN |
| 21 | MHI-021 | SYARPUDAHA POWER STATION | INTAKE WEIR (1) |
| 22 | MHI-022 | SYARPUDAHA POWER STATION | INTAKE WEIR (2) |
| 23 | MHI-023 | SYARPUDAHA POWER STATION | INTAKE LEFT ABUTMENT |
| 24 | MHI-024 | SYARPUDAHA POWER STATION | INTAKE SAND FLUSH GATE |
| 25 | MHI-025 | SYARPUDAHA POWER STATION | INTAKE BAR SCREEN |
| 26 | MHI-026 | SYARPUDAHA POWER STATION | GENERAL LAYOUT |
| 27 | MHI-027 | SYARPUDAHA POWER STATION | POWER HOUSE (1) |
| 28 | MHI-028 | SYARPUDAHA POWER STATION | POWER HOUSE (2) |
| 29 | MHI-029 | SYARPUDAHA POWER STATION | SINGLE LINE DIAGRAM |

## 2-2-4 Implementation Plan

### 2-2-4-1 Procurement Policy

(1) Equipment/Materials

The main equipment including water turbines, generators, controllers, protective relay panels, and any other equipment used for the Project will basically be procured from Japan.

Ideally, transformers, control panels, low voltage panels, or any equipment other than the main equipment could be procured from a supplier in Nepal, which must be capable of completing the design, manufacturing, and shipment within 12 months after the contract. However, the use of Nepali suppliers shall not be considered as it is very likely to delay the process and fail to meet the short deadline of the Project. As for the transformers, it is the standard and commercially available capacity and grades, and it therefore could be procured in Nepal. In the procurement plan, however, all the equipment including transformers is considered to be procured from Japan. Table 2-6 shows the procurement plan for the Project.

Table 2-6 Procurement Plan

| No. | Equipment | Nepal | Japan | Other Countries |
|---|---|---|---|---|
| 1 | Water turbine | | | |
| 1-1 | Water turbine A (Bajhang Micro-hydropower Plant) | | ○ | |
| 1-2 | Water turbine B (Bajura Micro-hydropower Plant) | | ○ | |
| 1-3 | Water turbine C (Syarpudaha Micro-hydropower Plant) | | ○ | |
| 2 | Generator | | | |
| 2-1 | Generator A (Bajhang Micro-hydropower Plant) | | ○ | |
| 2-2 | Generator B (Bajura and Syarpudaha Micro-hydropower Plants) | | ○ | |
| 3 | Inlet valve | | | |
| 3-1 | Inlet valve A (Bajhang Micro-hydropower Plant) | | ○ | |
| 3-2 | Inlet valve B (Bajura and Syarpudaha Micro-hydropower Plants) | | ○ | |
| 4 | Guide vane, Needle-driven equipment | | ○ | |
| 5 | Generator control panel | | ○ | |
| 6 | Low voltage panel | | ○ | |
| 7 | Generator control panel | | ○ | |
| 8 | DC power supply | | ○ | |
| 9 | Main transformer | | ○ | |
| 10 | Head pond sand flush gate | | | |
| 10-1 | Slide gate A (Bajhang Micro-hydropower Plant) | | ○ | |
| 10-2 | Slide gate B(Bajura Micro hydropower Plant) | | ○ | |
| 11 | Intake sand flush gate | | ○ | |
| 12 | Steel penstock | | ○ | |

(2) Civil Work

1) Materials for Construction

General materials for construction including reinforcing bars, cement, and form materials are available in Nepalgunj.

With respect to concrete aggregates, while coarse aggregates may be collected on-site, fine aggregates, little of which may be collected on-site, shall be procured from a nearby location.

In Syarpudaha, however, both coarse and fine aggregates, which are nearly unavailable on-site, will be procured from a nearby location.

2) Machines for Construction

General machines for construction including backhoes and dump trucks will be leased on-site.

Table 2-7 Classification of Procurement of Machines for Construction

| Machines for Construction | Specification | Lease or Purchase | Procurement Source | | |
|---|---|---|---|---|---|
| | | | Nepal | Japan | Other Countries |
| Hydraulic backhoe | 0.6 $m^3$ | Lease | ○ | | |
| Heavyweight breaker | 1300 kg | 〃 | ○ | | |
| Bulldozer | 3 t | 〃 | ○ | | |
| Crawler dump | 10 t | 〃 | ○ | | |
| Dump truck | 10 t | 〃 | ○ | | |
| Boom truck | 4 t | 〃 | ○ | | |
| Truck trailer | 20 t | 〃 | ○ | | |
| Air compressor | 2.5 $m^3$/min | 〃 | ○ | | |
| Generator | 100 kVA | 〃 | ○ | | |
| Welder | 250 A | 〃 | ○ | | |
| Plate compactor | 60-80 kg | 〃 | ○ | | |
| Concrete mixer | 1.0 $m^3$ | 〃 | ○ | | |
| Submersible pump | φ100 | 〃 | ○ | | |
| Portable vibrator | φ40 mm | 〃 | ○ | | |
| Floodlight | 100 V | 〃 | ○ | | |

(3) Contract Type

The contractor shall ideally be responsible for coordinating all construction work, developing construction plans, and managing processes to implement an integrated project such as the Project within a short construction period. Therefore, the procurement of all equipment/materials installation, and civil work and building shall be carried out in one contract.

(4) Contractor Organization

The contractor shall procure necessary equipment and installation/construction work from water turbine manufacturers, manufacturers of electric appliances, machine builders, and civil work contractors to deal with a series of implementation work.

The contractor shall send lead civil engineers in charge of comprehensive management and instructions to each site where civil work is mainly carried out during the site work. It shall also send instructors from each manufacturer responsible for installation, quality control, and process control, as well as dispatching specialized coordination experts for field tests. The contractor shall send certified assemblers for the on-site assembly of water turbines and generators requiring special skills and sophisticated work quality.

### 2-2-4-2 Implementation Policy

(1) Equipment/Materials

The following shows the basic matters and particular points to remember in implementing the project:

1) Implementing Organization

The responsible organizations for the Project include the NEA and the Planning and Engineering Department of DCS Office. One personnel for civil engineering and one for electricity shall be assigned as the NEA's contact personnel to engage in external affairs and make negotiations. Administration and management after completion shall be carried out by the Nepalgunj Regional Office in Rukum District for Syarpudaha power plant and Attaria Regional Office for Bajhang and Bajura powerplants.

2) Consultant

As a grant aid project, a Japanese consultant will enter into a procurement and management agreement with the Government of Nepal to prepare the bidding documents for the procurement of equipment/materials and repair work as well as to manage the repair work for the Project.

The following shows the major tasks of the consultant:

Before construction (tasks to be done in Japan)

- i) Prepare bidding documents for the procurement of equipment/materials and repair work;
- ii) Assist and evaluate bidding;
- iii) Negotiate a contract;
- iv) Review and approve the drawings and documents of equipment/materials;
- v) Witness factory inspections before shipment;
- vi) Issue inspection and test certificates; and
- vii) Make explanations and reports to related organizations

Construction stage (tasks to be done on-site)

- i) Progress control for transportation, repair work, and field tests;
- ii) Coordination among the respective works;
- iii) Safety control of on-site work;
- iv) Witness field tests;
- v) Evaluate field test results;

vi) Prepare monthly reports on transportation, repair work, and field tests;
vii) Issue certificates for performance and payment;
viii) Prepare completion records of transportation, repair work, and field tests;
ix) Conduct defects inspection a year after delivery; and
x) Make periodic reports to related organizations.

3) Equipment/Materials Supplier

Two months are required to shut down each micro-hydropower plant, during which all the required repair and renewal work except civil facilities and field tests are planned to be completed.

The equipment/materials supplier shall, according to the specifications prepared by the consultant: i) design, fabricate, supply, test at a factory, pack for exporting, and transport equipment/materials; ii) instruct on-site installation work and field tests; and iii) verify the repair state of the equipment and their performances after repair work. The supplier shall also transfer relevant skills to the organizations of Nepal during a series of on-site repair work and field tests.

From the perspectives of quality assurance, performance guarantee, defects liability, and schedule management, the material supplier shall be required to submit the construction plan, installation manual, and work schedule before commencing the repair work.

The equipment/materials supplier shall send the engineers with the following expertise:

(a) Technical advisers (for installation)

Nine engineers: Water turbine/ inlet valve/ generator / control panel / control cable / transformer

(b) Technical advisers (for testing operation and adjustment)

Nine engineers: Water turbine / generator / inlet valve / control panel / general coordination

(2) Civil Work

The following shows the basic policies for civil work:

1) Existing Structures

The existing structures must be connected to new structures to set up a new intake. The removal of the existing structures shall be minimized in order to use as many existing structures as possible.

2) Materials

Concrete aggregates and materials used for gabions, mortar masonry or stone pitching shall be collected on-site and other materials available on-site shall be used in order to reduce costs.

3) Method

Considering the fact that the structure to be constructed for the Project is larger than the original intake facilities, construction shall be done using construction machines. The repair and replacement of the existing waterways shall employ the conventional construction methods in Nepal in order to facilitate maintenance management.

### 2-2-4-3 Implementation Conditions

#### (1) Equipment/Materials

1) Ensuring Communication Means

A prompt action against possible problems during the implementation period essentially requires prior information gathering and establishment of a means of communication.

The villages closest to the micro-hydropower plants have no fixed international communication line available for receiving international communication. Mobile phones shall therefore be provided during the implementation period to ensure a means of communications within Nepal and between Japan.

2) Safety Work

This work might require the transportation of materials to rely on manpower. It will often involve transferring heavy objects and working in small spaces, and therefore shall consider safety as an important issue.

All possible measures must be taken to secure safety before each on-site work.

3) Advance Preparation

Two months are required to shut down each micro-hydropower plant, during which all the required repair and renewal work except civil work facilities and field tests are to be completed. In order to smoothly execute the work for the equipment, the consultant, equipment/materials supplier, and workers must mutually confirm the work procedure and the route for carrying equipment/materials in before stopping the generators.

4) Plan to Stop the Water Turbine and Generator for Repair

Considering the design and production period of 12 months, it is impossible to complete the installation within the construction period if executed one by one. The installation work shall therefore be executed concurrently at all the three sites, and the period required for removing the existing equipment from each site and installing the newly introduced equipment shall be a month and a half. After the installation work is completed, the commissioning hall be conducted at each micro-hydropower plant, followed by guidance on equipment operation. The estimate period required for these tasks shall be about half a month. Following guidance on operation, inspections shall be made for delivery. Approximately two months are required for the removal, installation, and commissioning for the equipment and guidance on its operation. Accordingly, each micro-hydropower plant should stop generating for about two months.

#### (2) Civil Work

1) Transportation Planning

The conditions of the roads used to access each site are extremely poor. In Bajhang and Syarpudaha sites, in particular, the intake cannot be accessed by vehicles so far. Helicopters, trucks, tractors, manpower (or donkeys) or other appropriate means of transportation must be selected for the transportation of equipment/materials at each site. Since the Project uses a large amount of concrete, transportation planning must be carefully considered and established in order to avoid insufficient supply of materials during the construction period.

2) Safety Work

The majority of the construction work involves both machine operation and manual work. With small spaces for working, each work must be clearly classified in order to avoid any physical contact between heavy equipment and workers or prevent workers from being caught in.

For work in headrace which partially passes through landslide zone with scattered culverts, it is important to ensure clear operation paths and sufficient ventilation.

3) Advance Preparation

As the areas for construction are distributed into three sites, camps must be set up at each construction site before the commencement of work. In the camps, a yard for materials/machinery necessary for construction work and temporary buildings as site offices or for other purposes must be provided. Moreover, some measures must be considered for preventing intrusion of suspicious individuals or unexpected entry of the general public into the construction areas.

4) Period for Micro-hydropower Plant Shutdown

Construction must be planned to be executed while operating the micro-hydropower plants as much as possible in order to shorten the whole outage period. From this point of view, the temporary headrace shall be installed first at all points to allow taking water during construction work. The temporary headrace will be removed during the whole outage period when removal/installation work for water turbines and generators are implemented simultaneously, which obviously means that the civil work is to be executed at the three locations concurrently.

Even though the duration of whole outage is minimized by the construction method, total shutdown of micro-hydropower plant will be required to remove the existing and install new equipment for around two months on each site. During such total shutdown, the minimum power should be provided for the important facilities such as hospital, police station, governmental office, etc. As for alternative power sources, diesel engine generators will be most feasible. In case facilities have some alternative power sources such as diesel engine generators, the consumption of diesel fuel will increase because of longer outage. NEA should be requested to consider some fuel subsidy for such facilities.

### 2-2-4-4 Scope of Works

Table 2-8 shows the classification of construction, procurement, and installation between Japan and Nepal.

Table 2-8 Construction and Procurement and Installation Classification between Japan and Nepal

| Item of Work and Procurement | | Division |
|---|---|---|
| 1. Procurement of devices and materials | | |
| | 1. Water turbine | Japan |
| | 2. Generator | Japan |
| | 3. Inlet valve | Japan |
| | 4. Guide vane, needle-driven equipment | Japan |
| | 5. Rotating speed detector | Japan |
| | 6. Generator control panel | Japan |
| | 7. Low voltage panel | Japan |
| | 8. Speed regulator panel | Japan |
| | 9. DC power supply | Japan |
| | 10. Main transformer | Japan |
| | 11. Head pond sand flush gate | Japan |
| | 12. Intake sand flush gate | Japan |
| | 13. Cable | Japan |
| 2. Construction and installation | | |
| | 1. Installation and commissioning | Japan |
| | 2. Power house renewal work | Japan |
| | 3. Cabling work | Japan |
| | 4. Connection to existing power line | Japan |

Responsibility boundary point for the Project between Japan and Nepal is the existing fuse switch installed on the secondary side of the main transformer. Nepal shall be responsible for the load side of the existing transmission and distribution lines from the point of existing fuse switch. The NEA as the implementing organization is well experienced in maintenance and management operations and thus should successfully fulfill these duties.

### 2-2-4-5 Consultant Supervision

On the basis of Japan's grant aid, the consultant will develop a consistent project team for the procurement/construction management in order to carry out smooth operations, keeping in mind the intention of the basic design.

(1) Basic Policy for Procurement/Construction Management

The consultant must supervise and instruct the contractor throughout the construction work such that the construction work is executed within the required construction period in a stable and safe manner and that the repair work achieves the required effects. The basic policies for the procurement/construction management work are as follows:

1) Progress Control

i) The progress of fabrication, transportation, and construction of equipment/materials shall be confirmed for each set of equipment. Also, the progress of tasks assigned to Nepal shall be confirmed.

ii) The procedures of the repair work by the contractor and the tasks assigned to Nepal shall be confirmed for efficient coordination.

iii) The schedule adjustment meeting shall be held on a timely basis for the progress control and schedule adjustment of the overall project. The meeting will be held weekly during the on-site repair work period or on daily basis during the field test.

2) Safety Control

i) Safety confirmation shall be encouraged before operation.

ii) If several operations are executed at a single location, the contractors shall be informed of the details and processes of their work to prevent accidents.

iii) The work for carrying in and installing the equipment shall be executed under the supervision of the personnel responsible for safety control.

iv) The opening shall be sectioned with ropes to draw operators' attention.

v) Safety patrol shall be conducted to prevent accidents.

vi) A thorough emergency network shall be established.

3) Quality Control

i) The contractor shall be obliged to submit drawings on equipment/materials to confirm that the specifications and quality are consistent with the contract specifications.

ii) The results of the repair work shall be verified by field tests. All tests required to verify functional recovery shall be conducted.

(2) Procurement/Construction Management System

In order to carry out smooth procurement/construction management, the personnel who is well experienced in similar operations and fully understands the details of the Project shall be appointed to be the operation leader. Also, each personnel responsible for bidding, drawing examinations, construction management, and field tests shall develop the procurement/construction management system.

1) Operation Leader (One Person)

The Operation Leader shall manage the overall operation. He/she shall also provide the policy for each operation and give advice to each responsible personnel as required.

During the on-site construction stage, he/she shall confirm the work method and safety of the equipment, adjust the overall processes, instruct the procurement and management system, and witness the water test to verify the planning targets.

2) Personnel Responsible for Detailed Design (Six Persons)

They shall conduct a final inspection of the planning details, field survey, review of the equipment specifications, and the analysis or design work in Japan. Experts shall intensively be involved in this operation to complete detailed designs within a short period. Six experts shall address this operation. The six experts consist of one person responsible for the electrical equipment, one person for the mechanical equipment, three persons for the civil work facilities, and one person for construction/procurement planning and quantity/cost estimation.

3) Personnel Responsible for Bidding (Seven Persons)

They shall prepare and approve the bidding documents for planning, make public announcement, deliver drawings and explain their details, receive bids and evaluate the bidding. Activities related to bidding shall be addressed by a total of seven persons, which consist of one person in charge of bidding documents and the other six persons responsible for detailed designs.

4) Personnel Responsible for Equipment Drawing Examinations (Two Persons)

They shall examine the documents and other materials submitted by the contractor for the purpose of quality control of equipment/materials. With the expertise required, this operation shall involve a total of two persons, which consist of one person responsible for electrical equipment and the other for machines.

5) Personnel Responsible for Construction Management (Four Persons)

A full-time supervising engineer (civil engineer) shall coordinate the entire civil work of the three micro-hydropower plants for review of construction drawings, progress control and safety management. As the construction work will be executed concurrently at the three sites, a construction supervising engineer shall be added for managing civil work during the busy period.

Also, two procurement supervising engineers shall manage the progress, quality, and safety of the equipment procured.

6) Personnel Responsible for Soft-component (One Person)

He/she shall engage in the transfer of skills for proper and efficient operation and maintenance management. With the expertise required, this task shall be addressed by a person in charge of operation and maintenance management.

### 2-2-4-6 Quality Control Plan

The following shows the items and test methods of main construction items that should be kept in mind for quality control:

(1) Quality Control Test

The reinforcing bars and cement procured on-site shall come with a certificate of quality or other quality verification documents provided by the supplier. For aggregates collected on-site, concrete strength shall be verified with trial mix once before construction and once every mixture of 150 $m^3$ during construction.

The following Table 2-9 shows the necessary tests:

Table 2-9 Quality Control Tests for Concrete Aggregates

| Test | Number of Times | Notes |
|---|---|---|
| Test for concrete compressive strength | Once before construction and once every 150 $m^3$ during construction | The test shall be executed at a testing station in Nepalgunj |
| Slump test | 〃 | The test shall be executed at the sites |
| Air content test | 〃 | 〃 |

### 2-2-4-7 Procurement Plan

(1) Equipment/Materials

1) Equipment/materials Supplier

In Nepal, several local suppliers design, produce, and install electrical equipment, including transformers, switchboards and cables. With the relatively short construction period, the Project requires equipment/materials to be delivered within 12 months from the supplier contract, and could therefore take advantage of these suppliers as long as they strictly keep the deadline. The main equipment like water turbines and generators will be supplied from Japan.

2) Spare Parts Supplier

The spare parts and maintenance and repair tools essential for keeping the repair planning effective on a continuous basis shall be supplied. Spare parts are categorized into consumable parts and replacement parts according to their nature. The Project will involve lamps, fuses, and other consumable parts required for operation.

3) Guarantee Policy

All equipment/materials procured for the Project shall require defects liability. Any portion of the equipment/materials which is not subjected to repair but where defect has been caused by the repair for the Project shall be included in the scope of the defects liability. The period for defects liability shall be exactly/strictly one year. Also, performance guarantee shall be required for the fully renewed machines or the repair parts whose performance can be measured separately.

(2) Civil Work

For civil work, concrete aggregates and materials to be used for gabions, mortar masonry or stone pitching shall be collected on-site, while other materials may be locally procured.

### 2-2-4-8 Initial Manipulation/Operation Instruction Plan

The manipulation and operation instructions for the equipment renewed by the Project shall be provided by the suppliers during the field test. The operation and maintenance manuals required for the manipulation and operation instructions shall be created by the suppliers under the contract agreement.

### 2-2-4-9 Soft-Component (Technical Assistance) Plan

(1) Goals

To sustain the project's impact, it is expected that accurate knowledge about the equipment and civil work facilities should be acquired for maintenance management in accordance with drawings, instruction manuals, and operation and maintenance manuals.

The Soft-component programme intends to acquire operation and maintenance management skills as well as maintenance management skills for the purpose of enabling the long-term operation of the micro-hydropower plant and continuing and maintaining the effect of the repair by enhancing the operation and maintenance management capability of the staff of the NEA regional offices, which are responsible for the micro-hydropower plant of the target site, and the power plant operators/personnel.

(2) Activities

In the NEA Attaria and Nepalgunj regional offices, which currently control the micro-hydropower plants at the three sites, the technical division consisting of electrical and civil engineers provides technical support to the micro-hydropower plants.

In the respective micro-hydropower plants, the Ecs' operators perform the operation of generating equipment. However, insufficient management are found on operation of the respective Ecs for the maintenance management of generating equipment, such as no record of accident and/or repair, no record of inspection. It is also assumed that the assistance and instruction by the respective Regional Offices had been insufficient for the Ecs with regard to the operation and maintenance technology.

Therefore the technical capabilities of both parties of Regional Offices and Ecs should be improved and the execution of cooperative maintenance is required for the target three micro-hydropower plants to be sustainably operated and maintained. For that purpose, it is further necessary to procure timely the required parts for maintenance. But past parts procurement had not been made properly, because the budget was not planned based on the financial management. Thus, the activities of guidance will be included for financial management personnel of Ecs.

The following personnel of NEA and the operators of Ecs shall be the candidates for the training:

| | |
|---|---|
| NEA Attaria Regional Office: | Two civil engineers, and two electrical engineers |
| Bajhang Ec: | Six operators and one accountant |
| Bajura Ec: | Four operators and one accountant |
| NEA Nepalgunj Regional Office: | Two civil engineers, and two electrical engineers |
| Syarpudaha Ec: | Seven operators and one accountant |

The following activities shall be carried out at each micro-hydropower plant. Instructions at each site shall be required to effectively implement the Soft-component programme based on the actual equipment in order to acquire operation and maintenance management skills properly.

1) Acquisition of Operation Skills

The following activities for transferring skills shall be carried out focusing on on-the-job training in operation and maintenance activities:

- Operating procedures for start/stop and confirmations
- Response in case of an accident and resuming procedures

With respect to the equipment delivered for the Project, individual equipment suppliers shall provide instructions regarding operations and inspections to the electricity operator members. This Soft-component shall allow the NEA managing the electricity operators to acquire the maintenance management skills by allowing them to acquire the basic knowledge necessary for operating the micro-hydropower plant and creating an integrated operation and maintenance management manual on the equipment of the entire micro-hydropower plant, from the perspective of maintaining the function of the entire micro-hydropower plant. Therefore, instructions shall be provided while fully understanding the instructions by individual equipment suppliers for ensuring consistency.

2) Acquisition of Maintenance Management Skills

The following activities for transferring skills shall be carried out focusing on on-the-job training in maintenance management:

- Inspection types (periodic inspection and detailed inspection), inspection items and schedule
- Method to maintain the operation and accident record sheet
- Method to maintain the registers and/or inventories for replacement parts
- Method to maintain drawings and instruction manuals

3) Acquisition of Financial Statement Preparation Skills

Based on the actual sample of financial statement, the activities for transferring skills shall be carried out on preparation of suitable financial statement and analysis of financial conditions.

(3) Input Plan

In implementing the Soft-component, three members including one Japanese electrical engineer, one locally-employed electrical engineer, one locally-employed civil engineer and one locally-employed person in charge of finance shall be provided as the Soft-component personnel.

In the Project, the generating equipment removal and installation work in the Bajura Micro-hydropower Plant, among the three sites, are planned to be completed after February 2016 when the construction period will nearly end as referred to Table 2-10. This means that there is not sufficient time for implementing the Soft-component programme after introducing the generating equipment in Bajura power plant. The Bajura power plant shall therefore have a plan to implement the Soft-component programme before the generating equipment removal and installation work are completed. The Soft-component programme for the entire power generation facilities, except the equipment, shall be implemented at the actual facilities in Bajura power Plant, while with respect to the equipment, on-site instructions in addition to desk instructions shall be provided at the Bajhang Micro-hydropower Plant after the completion of the installation work to make necessary supplement.

### 2-2-4-10 Implementation Schedule

About 23 months shall be planned from the conclusion of the contract for consulting services to the completion of the Project implementation. Also, the actual period from the execution of the supplier contract to the commissioning is expected to be 18 months.

Table 2-10 shows the planned implementation schedule.

A total of 16 months shall be required for the construction time, including 12 months allocated for designing and fabricating the generating equipment, two months for transportation, 1.5 months for removal and installation work, and 0.5 month for the field tests and operation guidance.

Regarding the assignment of manufacturers' supervisors in the installation period of the Project, it is reported that simultaneous dispatch of supervisors to the three sites is difficult for them. Taking account of such assignment situation, the installation work for Bajhang and Syarpudaha will be commenced ahead and the Bajura work will follow the completion of the other two sites.

Table 2-10 Implementation Schedule

| | | 2014 | | | | | | | | | 2015 | | | | | | | | | | | | 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 |
| Tendering and Contract | Contract with consultant | ▼ | | | | | | | | | | | | | | | | | | | | | | | | |
| | Detailed design | ■ | ■□ | | | | | | | | | | | | | | | | | | | | | | | |
| | Bidding | | | □■ | □ | □ | ■ | | | | | | | | | | | | | | | | | | | |
| | Contract with suppliers | | | | | | ▼ | | | | | | | | | | | | | | | | | | | |
| Bajhang Micro-hydropower Plant | Preparatory work | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | |
| | Intake works | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ | ■ | ■ | ■ | |
| | Canal and settling basin work | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | |
| | Head tank work | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | |
| | Penstock work | | | | | | | | | | ■ | ■ | | | | | | | | | ■ | ■ | | | | |
| | Power house renewal work | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | |
| | Equipment installation work | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | |
| Bajura Micro-hydropower Plant | Preparatory work | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | |
| | Intake works | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ | ■ | ■ | | |
| | Canal and settling basin work | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | | |
| | Head tank work | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | | |
| | Penstock work | | | | | | | | | | ■ | ■ | | | | | | | | | | | ■ | ■ | | |
| | Power house renewal work | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | |
| | Equipment installation work | | | | | | | | | | | | | | | | | | | | | | ■ | ■ | | |
| Syarpudaha Micro-hydropower Plant | Preparatory work | | | | | | | ■ | ■ | | | | | | | | | | | | | | | | | |
| | Intake works | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | ■ | ■ | ■ | ■ | ■ | |
| | Canal and settling basin work | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | |
| | Head tank work | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | |
| | Penstock work | | | | | | | | | | ■ | ■ | | | | | | | | | ■ | ■ | | | | |
| | Power house renewal work | | | | | | | | | | ■ | ■ | | | | | | | | | | | | | | |
| | Equipment installation work | | | | | | | | | | | | | | | | | | | | ■ | ■ | | | | |
| Soft component programme | | | | | | | | | | | | | | | | | | | | | □ | □■ | ■ | | | |

□ Activity in Japan
■ Activity in Nepal

## 2-3 Obligations of Recipient Country

In the Project, while Japan shall consistently execute all the construction and installation work for the required rehabilitation, Nepal shall be responsible for the following:

### (1) Coordination in Relation to the Full Stop of Power Supply Services

The renewal work for the generating equipment shall require both of the two generators to fully stop at each micro-hydropower plant. Two months are expected for the whole outage period. Nepal shall be in charge of coordination with concerned parties in relation to the power outage.

### (2) On-site Work

1) Provision and/or acquisition of land for construction including provision of land for temporary work
2) Suspension of the generating equipment when it is required for the construction
3) Provision of storage for disposal of removed items (the removal and transportation of such items to the assigned storage area shall be burdened by Japan)

### (3) Storage and Disposal of Removed Equipment/Materials

Nepal shall be responsible for the storage and disposal of the removed items during construction.

Any flammable items that can be incinerated on-site shall be safely incinerated according to the district rules/regulations. Other items shall be buried, treated or disposed through means that would not affect the environment according to the district rules/regulations.

### (4) Land Acquisition

Compensation costs shall be paid upon consultation between the NEA regional offices and the landowners concerning the scope of acquisition and the amount to be paid. Part of the land for intake works for Bajhang hydropower plant must be acquired.

### (5) Monitoring

Vibration/noise caused by the construction work shall be monitored with interview and water turbidity shall be monitored during the construction period at the respective work sites. As for the water turbidity, the monitoring should be continued for one year after the completion of the Project.

Table 2-11 Classification of Operations between Japan and Nepal

| No. | Item | Japan | Nepal |
|---|---|---|---|
| 1 | Land acquisition and preparation necessary for construction work | | 〇*1 |
| 2 | Temporary work | | |
| | 1) Storage area for equipment/materials | 〇 | |
| | 2) Roads in land | 〇 | |
| | 3) Bridge strengthening in land | 〇 | |
| | 4) Transportation/storage of removed items and civil work waste*2 | | 〇 |
| 3 | Receipt of goods and customs clearance at ports | | |
| | a. Marine/air transport | 〇 | |
| | b. Tax exemption and customs clearance | | 〇 |
| | c. Inland transport (from landing port to site) | 〇 | |
| 4 | Tax exemption on locally purchased items and services | | 〇 |
| 5 | Assistance in immigration and accommodation for Japanese engineers and related persons | | 〇 |
| 6 | Management of installed equipment | | 〇 |
| 7 | Expense other than grant aid | | 〇 |
| 8 | Payment of commission charges for B/A*3 | | |
| | 1) Advice to A/P | | 〇 |
| | 2) Payment of commission charges | | 〇 |
| 9 | Consideration for environment and society | | 〇 |

*1: Arrangement of budget will be required for land acquisition for the construction of intake weir at Bajhang Micro-hydropower Plant.

*2: The cost for removal of existing equipment/facilities shall be borne by Japan side including transportation of such wastes to the location specified by NEA.

*3: B/A: Banking arrangement, A/P: Authorization to pay
Bank charge shall be borne by Nepal side, accordingly the arrangement of budget will be required.

## 2-4 Project Operation Plan

(1) Operation and Maintenance Management System

The target micro-hydropower plants, operated by the respective Ecs, supply electricity by leasing power generation and power distribution equipment from the respective NEA regional offices that control the target sites to each corresponding Ec.

After the completion of the Project, the present O&M management system will be kept as it is. An outline of the leasing agreements is shown in Table 2-12 as below.

Table 2-12 Outline of Leasing Agreement between NEA and Each Ec

| Item | Bajhang | Bajura | Syarpudaha |
| --- | --- | --- | --- |
| Year of agreement | 1993 | 2009 | 2005 |
| Period of leasing | 20 years<br>(After renewal of agreement in January 2014, leasing period will come 10 years, subject to necessary amendment in January of each year.) | 20 years | 10 years |
| Rental revenue | Rs.200,000<br>(After renewal of agreement in January 2014, the conditions will be the same as the case of Bajura and Syarpudaha.) | Rs.200,000<br>Providing a deposit of Rs.200,000 per year shall be made as the un-operative fund between NEA and Ec. | |
| Extent of leasing | All generating equipment/facilities including 11,000V and 400V distribution lines. | | |
| Others | After renewal of agreement in January 2014, the conditions will be the same as the case of Bajura and Syarpudaha. | Subject to NEA approval on the application of use of fund submitted by Ec, Ec can withdraw the fund but the use is limited to the purpose of repair/maintenance of equipment. | |

The agreement between NEA and each Ec stipulates that Ec is responsible for operating and maintaining the generating equipment. In case of Bajura and Syarpudaha Ecs, Rs.200,000 shall be deposited annually as the non-operative cooperative fund between NEA and Ec. This fund can be used for large-scale repair/rehabilitation upon the approval of NEA, provided the additional costs beyond the amount of the fund shall be borne by the Ec. In the case of Bajhang Ec until December 2013, the cost of repair up to Rs.20,000 in one case was borne by Ec, but the amount above Rs.20,000 was borne by NEA according to the current agreement. None of the Ecs has a large-scale upgrading plan for the equipment or has accumulated private fund for such a plan.

The Ecs of Bajhang, Bajura and Syarpudaha have experience of operation and maintenance of micro-hydropower plants for 20 years, 3 years and 8 years, respectively. The present number of employees in each Ec is shown in Table 2-13 as below.

Table 2-13 Present Number of Employees in Ec

| Item | Bajhang | Bajura | Syarpudaha |
|---|---|---|---|
| Total Employees | 24 | 13 | 21 |
| Administration | 12<br>(incl. 6 meter readers) | 4<br>(incl. 2 meter readers) | 6 |
| Operators | 6 | 4 | 7 |
| Maintenance staff | 6 | 5 | 8<br>(working as maintenance and meter reader) |

Each micro-hydropower plant has witnessed failure of power generation equipment, despite that, the operators of each plant have been continuing operation of equipment with the help of the manuals provided by the machine fabricators. Based on the past performance of operators, it is judged that they have sufficient skill to operate the generation equipment under such conditions. After the completion of the Project, if knowledge about new equipment is properly transferred to the operators, the present organization and staff of each Ec will have adequate ability to continue the generating operation. As for the collection of electricity tariff, the numbers of meter readers are sufficient under the present organization, taking account of the respective collection ratios, reportedly 95% at Bajura and Syarpudaha and 85 to 90% at Bajhang.

On the other hand, the Ecs reported that the technical support by the NEA Regional Offices had been insufficient with regard to the maintenance management. As described in the clause of Soft Component Plan (See 2-2-4-9), the technical support by the NEA Regional Offices is essential for Ecs to establish the organization and systems for maintenance management so as to properly operate the respective micro-hydropower plants. The co-operation between NEA Regional Offices and Ecs is required for such a maintenance management system. Accordingly, the Soft Component Plan was scheduled in the Project to expedite the maintenance management for Ecs, specially the implementation of inspection and the proper documentation of inspection or repair results.

(2) Operation and Maintenance Record

Upon examination of operation and maintenance records, it was found that the daily operation status has been recorded in a scheduled manner. Faults, accidents or maintenance works, however, have not been recorded. No periodic parts replacement seems to have taken place, or no replacement record of even consumable or worn items was found. These records are essential to manage the equipment status and must be organized for developing and evaluating the maintenance management and plann. To maintain these records, the Project shall ask the NEA regional offices to provide the electricity operator with instructions and advice on how to maintain and organize operation and maintenance records.

In addition to the maintenance of machines, civil engineering facilities such as the intake port or headrace shall be maintained as important components of the operation of power supply. For example, cleaning the headrace can keep the flow capacity at an appropriate level and ensure the requisite flow for power generation on a constant basis and consequently increase electric power production. The record of maintenance activities for these facilities shall also be used for developing and evaluating the maintenance management plan.

(3) Maintenance and Inspection

1) Periodic Inspection

Each micro-hydropower plant shall establish an operation system for carrying out periodic inspections, the purpose of which is for verifying and maintaining the functions of the generating equipment.

2) Detailed Inspection

Detailed inspections of the micro-hydropower plants for the purpose of performance recovery were never conducted as the plants have been in almost continual operation since they were first installed. The Project shall plan on transferring the skills for assembling and disassembling the water turbines/generators through the actual rehabilitation work during the removal and installation work of the generating equipment so that Ecs will be able to independently carry out detailed or special inspections.

3) Inspection Record

Similar to the operation and maintenance record a means for organizing and maintaining the records of periodic and detailed inspections shall be established. This record will be very helpful for developing and evaluating the maintenance management plan.

## 2-5 Project Cost Estimation

### 2-5-1 Initial Cost

The expenses borne by Nepal may be estimated as follows in order to perform the Nepal side obligations under the calculation conditions shown in (2) below:

(1) Expenses to be covered by Nepal

1) Land acquisition cost: NPR 0.3 million (about JPY 0.3 million)
2) Bank fee for A/P: NPR 2 million (about JPY 2 million)

(2) Conditions for Estimation

(a) Estimation time: August 2013

(b) Exchange rates: USD 1 = JPY 100.47
NPR 1 = JPY 1.082

(c) Period for construction and procurement: The periods for detailed design, construction, and equipment procurement shall be as shown in the implementation schedule (Table 2-10).

(d) Others: Calculation shall be based on the grant aid system of the Government of Japan.

### 2-5-2 Operation and Maintenance Cost

(1) Operation and Maintenance Management Costs

The operation and maintenance management of the micro-hydropower plants are independently implemented by each Ec under the jurisdiction of the NEA. Based on the past performance, it is clear that the concerned Ecs seem to have experience of operation of the micro-hydropower plants. Table 2-14 and Table 2-15 show "Profit and Loss Statement" and "Balance Sheet" over the past two years respectively. Ec of Syarpudaha has not prepared the balance sheet.

Table 2-14 Income and Expenditures of Micro-hydropower Plants (Unit: Rs.1,000)

| Item | Bajhang | | Bajura | | Syarpudaha | |
|---|---|---|---|---|---|---|
| | 2012/2013# | 2011/2012 | 2012/2013 | 2011/2012 | 2012/2013 | 2011/2012 |
| Electrical power sales | 2,390 | 2,431 | 3,717 | 4,003 | 6,144 | 5,563 |
| Other sales | 124 | 201 | 1,099 | 811 | 2,106 | 1,530 |
| **Gross Sales*** | **2,513** | **2,632** | **4,816** | **4,814** | **8,250** | **7,093** |
| Labor cost | 1,575 | 1,633 | 1,947 | 1,433 | 2,902 | 3,297 |
| Repair cost | 435 | 355 | 135 | 303 | 2,796 | 1,693 |
| Others | 377 | 465 | 917 | 458 | 1,114 | 2,119 |
| **Total Cost*** | **2,386** | **2,453** | **2,999** | **2,195** | **6,811** | **7,110** |
| **Operating Profit or Loss** | **127** | **178** | **1,817** | **2,620** | **1,439** | **-17** |

* Some totals may not match due to the effect of rounding
# Fiscal year starts around the mid July.
Source: Ecs of Bajhang, Bajura and Syarpudaha

Table 2-15　Balance Sheet of Ecs (Unit: Rs.1,000)

| Item | Bajhang | | Bajura | |
|---|---|---|---|---|
| | 2012/2013# | 2011/2012 | 2012/2013 | 2011/2012 |
| Cash & bank balance | 151 | 177 | 1,060 | 347 |
| Accounts receivable | 83 | 96 | 3,546 | 2,581 |
| Other current assets | 1,093 | 964 | 2 | 634 |
| Fixed assets | 1,399 | 1,509 | 1,657 | 738 |
| **Total Assets** | **2,726** | **2,746** | **6,265** | **4,300** |
| Accounts payable | 83 | 119 | 365 | 103 |
| Other current liabilities | 1 | 1 | 1,886 | 1,353 |
| Fixed liabilities | - | - | - | 224 |
| Capital stock and retained earnings | 2,642 | 2,626 | 4,014 | 2,620 |
| **Total Liabilities and Capital** | **2,726** | **2,746** | **6,265** | **4,300** |

# Fiscal year starts around the mid July.
Source: Ecs of Bajhang and Bajura

In the case of Bajhang Ec, the revenue from electricity sales is low compared with the other two Ecs. It is assumed that low generating power was mainly caused by deduction of water withdrawal due to insufficient function of the existing temporary intake. On the other hand, the other costs such as repairs was kept low because according to the leasing agreement which states that the NEA Regional Office is responsible for the additional cost of repair which exceeded Rs.20,000 per case. From the past experience, it is expected that the Bajhang Ec will sustain its cost by the revenue generated from the sale of generated energy. Based on the available data from the balance sheet of Bajhang Ec, the account receivable of Rs.13,000 decreased and the account payable of Rs.36,000 decreased in fiscal year of 2012/2013.　The operating cash flow is assumed as shown in Table 2-16.

Table 2-16　Operating Cash Flow of Bajhang Ec (Unit: Rs.1,000)

| Item | 2011/2012# | 2012/2013 | Increase/ decrease | Remarks |
|---|---|---|---|---|
| **Operating Profit or Loss** | | | 127 | |
| **Asset** | | | | |
| Accounts receivable | 96 | 83 | +13 | Decrease to be assessed as plus |
| Other current assets | 964 | 1,093 | -129 | |
| **Liabilities and Capital** | | | | |
| Accounts payable | 119 | 83 | -36 | Increase to be assessed as minus |
| Other current liabilities + Fixed liabilities | 1 | 1 | 0 | |
| **Operating Cash Flow** | | | -25 | |

# Fiscal year starts around the mid July.
Source: Bajhang Ec

After renewal of leasing agreement in 2014, the repair cost shall be borne by Bajhang Ec according to the same conditions as stipulated in the leasing agreement with the other two Ecs. The total operating cost budget will need to be around Rs.3,500,000 considering the renewal of leasing agreement and the additional costs of removal of sedimentation in waterway for increasing the power generation.

In the case of Bajura Ec, no large scale repair was made on the equipment/facilities in last two years and the repair costs were kept low. Accordingly, the income from the operation came mainly from the sales of electricity. Based on the available data from the balance sheet of Bajura Ec, the account receivable is Rs. 965,000 and the account payable is Rs. 262,000 in fiscal year of 2011/2012. The operating cash flow is assumed as shown in Table 2-17.

Table 2-17 Operating Cash Flow of Bajura Ec (Unit: Rs.1,000)

| Item | 2011/2012# | 2012/2013 | Increase/ decrease | Remarks |
|---|---|---|---|---|
| **Operating Profit or Loss** | | | 1,817 | |
| **Asset** | | | | Decrease to be assessed as plus |
| Accounts receivable | 2,581 | 3,546 | -965 | |
| Other current assets | 634 | 2 | +632 | |
| **Liabilities and Capital** | | | | Increase to be assessed as minus |
| Accounts payable | 103 | 365 | +262 | |
| Other current liabilities + Fixed liabilities | 1,577 | 1,886 | +309 | |
| **Operating Cash Flow** | | | +2,055 | |

# Fiscal year starts around the mid July.
Source: Bajura Ec

The total operating cost budget will be around Rs. 3,000,000 after the completion of the Project.

In the case of Syarpudaha Ec, the income from operation was a negative Rs.17,000 in the fiscal year of 2011/2012, because an unexpected cost arose in 2012 for repairing the headrace which had collapsed due to landslide and accordingly the operating cost increased in fiscal year of 2012/2013. This operating loss was appropriated from Rs. 2,549,000 carried forward from the previous years. Syarpudaha Ec is doing a run so that total cost and total sales are balanced. In a normal year, the total cost of power generation will be around Rs. 4,500,000 to 5,000,000. Based on the past results, Rs.5, 000,000 has been considered as the current operating budget.

Each Ec has no sales other than operating sales, and it is not expected for the power generation to be significantly improved under the current situation. However, the power generation will increase almost two-fold after the completion of the Project, and even low estimates put the consequent increase in the sales at Rs. 3,000,000 or more. The sales of electricity is estimated to be Rs. 5,000,000 to Rs.8,000,000 and will cover the scheduled operating budget and produce enough income from operations. The renewal of generator will decrease yearly repair costs by Rs. 200,000 to Rs. 300,000 which can be appropriated to the maintenance of other equipment. From the above, it is clear that the maintenance will be carried out by the current operating budget without problems.

Since Bajura and Syarpudaha Ecs have retained about Rs. 2,000,000 and Rs. 3,000,000, respectively, and credited the profit to the Ec fund, the Ecs are able to make a necessary budgetary arrangement against sudden expense for unexpected events such as restoration of waterway. Bajhang Ec has also credited even its small profit to the operating capital. Overall, it is expected that the balance brought forward will increase because of increase of electricity sales.

If the periodic inspections and overhaul of equipment necessary every ten years are adequately performed after the completion of the Project, the lifetime of the replaced generating equipment will be extended by 25 to 30 years. Although Rs.500,000 will be required for hiring specialists and purchasing the necessary parts to perform the overhaul, each Ec can keep reserves for those expenses from the profit out of electricity sales.

(2) Replacement Parts

The consumables quickly required for operating the power generation equipment and the replacement parts in case failure will be supplied to the project.

The detailed inspection of the water turbine, which is generally planned for every ten years following the completion of the Project, shall require the replacement parts listed in Table 2-18 for disassembling and assembling the machine.

Table 2-18 Replacement Parts to be Newly Purchased for Overhaul (Unit: JPY1,000)

| Replacement Parts | Estimated Budget |
|---|---|
| 1. Water turbine packing | 120 |
| 2. Inlet valve packing | 30 |
| 3. Drive unit packing | 5 |
| **Total** | **155** |

# Chapter 3. Project Evaluation

## 3-1 Preconditions

The preconditions for implementing the Project are as described below:

(1) Construction Work Permission, Land Acquisition and Environmental and Social Consideration

As the Project is for rehabilitation of existing power plants of less than 1,000 kW capacity, construction permission is not required. As to the land for construction, land acquisition is necessary for building the intake in Bajhang site. NEA has already started the procedures for acquisition abiding by the requirements of the LACP.

Under Nepalese Law, projects for the rehabilitation work of existing power plants of less than 1,000 kW capacity need not be subject to environmental impact assessment, permission and authorization.

(2) Shutdown of Water Turbine and Generator due to Rehabilitation Work

The rehabilitation work for the Project requires renewing the water turbine and generator. This requires stopping of the water turbine and generator and the power plant should be shut down for certain duration of time. The schedule of rehabilitation work should be organized to minimize the period of power stoppage. The construction of intake and rehabilitation of headrace channel, water tank and steel penstock should also be conducted at the same time that the shutdown is in place.

(3) Budget and Tax Exemption Measures Required for the Project

The Government of Nepal is been requested to implement procedures for bank arrangement, necessary budget measures, and tax exemption measures for the import of equipment and materials related to the Project.

## 3-2 Necessary Inputs by Recipient Country

(1) Inputs by NEA

NEA needs to enhance monitoring and technical support for the operation and management of the three sites to sustain the effect of rehabilitation after the completion of the Project. The relevant Attaria Regional Office and Nepalgunj Regional Office have been in charge of the operation so far. However, it is necessary to enhance the organization and securely implement the following technical support in the future.

1) Monitoring of the micro-hydropower plants by periodic patrol
2) Evaluation of the monitoring and recommendation for improvements in maintenance and management
3) Periodic education of the micro-hydropower plant operators to secure appropriate operation and manipulation
4) Implementation of annual joint inspection with the operators of the respective Ecs
5) Lease of necessary equipment and materials for inspection of the micro-hydropower plants

(2) Inputs by the Ecs

The Ecs are responsible for the maintenance and management of power plants after the completion of the Project. Therefore, they are required to implement the following maintenance and management activities to sustain the effect of rehabilitation.

1) Reporting the operation record
2) Establishing the inspection and maintenance plan
3) Reporting the inspection and maintenance record
4) Reporting the accident and repair record
5) Reporting the analysis of the appropriate financial statements
6) Establishing the procurement plan for consumable/replacement parts and the reserve plan for the budget

## 3-3 Important Assumptions

The following matters are assumed to be the factors that inhibit the sustainable effects of the Project.

1) There is a precedent that the existing intakes in the three sites have been washed out by flood.

The type and shape of the weir has been selected as a countermeasure against washout by flood; however, there still remains a possibility of washout by a flood whose magnitude is beyond that anticipated in the design. Loss of weir disrupts the necessary flow rate at the intake, leading to a decline in the amount of power generation.

2) All sites have collapsed land near the intake and/or on the way to the headrace channel.

Any large-scale collapse of land can stop the flow of the river or cause blockage of the intake due to soil and sand deposit. This can stop power generation. All the three sites have collapsed land upstream of the intake. A large-scale collapse exists on the way to the headrace channels in Bajhang and Syarpudaha. While the headrace channel in Bajhang is partially buried, a part of the headrace channel in Syarpudaha has also collapsed with a landslide and has been reconstructed on a detour. There is still a possibility of collapse which includes the headrace channels.

3) The headrace channel/steel penstock crosses the farmland or the road crosses the steel penstock.

The steel penstock crossing the farmland in Bajura has some parts that are buried with soil and sand and also cause an obstacle to farming. Two sections of the pipeline cross the road and act as speed-humps, this can cause injury to passengers if a driver is caught unawares.

The factors as described above, excluding 3), are natural and external conditions and it is impossible to avoid them even though voluntary efforts will be carried out to sustain the effectiveness of the Project. The factor 3) is avoidable by protection of steel penstock passing through farmland and implementing awareness campaign for vehicle users.

## 3-4 Project Evaluation

The evaluation of the Project is as described below. The Project is highly valid and effective.

### 3-4-1 Relevance

- The beneficiaries of the Project are the residents of Bajhang District, Bajura District and Rukum District, where the target three sites are located. All of these three districts are very poor and development is delayed. Bajhang, Bajura and Rukum districts were ranked 73rd, 71st and 58th respectively in poverty measures out of 75 districts of the country in the census of 2001.

- The Project is implemented to respond to the increasing demand for electricity in the villages by repairing the existing aged micro-hydropower plants in the target areas which are not connected to the main transmission/distribution system, and thus contribute to development of regional economy and improvement of the people's livelihood. Both of the importance and the urgency of its implementation are very high.
- It contributes to the policy of Nepal in the three-year plan, which is ranked at the top of the national development strategy (FY2013/2014 to FY2015/2016). The Government of Nepal positions improvement of the economic infrastructure including electric power as the preferential area, and seeks to implement power supply development by the generation of 15MW micro-hydropower to supply power to village areas in three years from now. Also, in the "Renewable Energy Policy" set out by the government in 2009, the government stated that micro-hydropower generation is necessary to supply electric power to the villages without connection to the major transmission system.
- The Government of Japan sets "Improvement of social infrastructures and systems for economic growth" including electricity as the priority area of the assistance policy per country for Nepal, and the Project matches the policy and the analysis as above.

### 3-4-2 Effectiveness

(1) Quantitative effects

Table 3-1 Quantitative Effect

| Indicator name | Base (Actual values in 2012) | | | Target in 2019 (three years from completion of the Project) | | |
|---|---|---|---|---|---|---|
| | Bajhang | Bajura | Syarpudaha | Bajhang | Bajura | Syarpudaha |
| Average power output (kW) | 100 | 75 | 100 | 200 | 200 | 200 |
| Annual generated energy (kWh/ year) | 810,000 | 630,000 | 780,000 | 1,704,000 | 1,704,000 | 1,704,000 |
| Annual generating operation hours (h/ year) | 8,100 | 8,400 | 7,800 | 8,520 | 8,520 | 8,520 |

(2) Qualitative effects

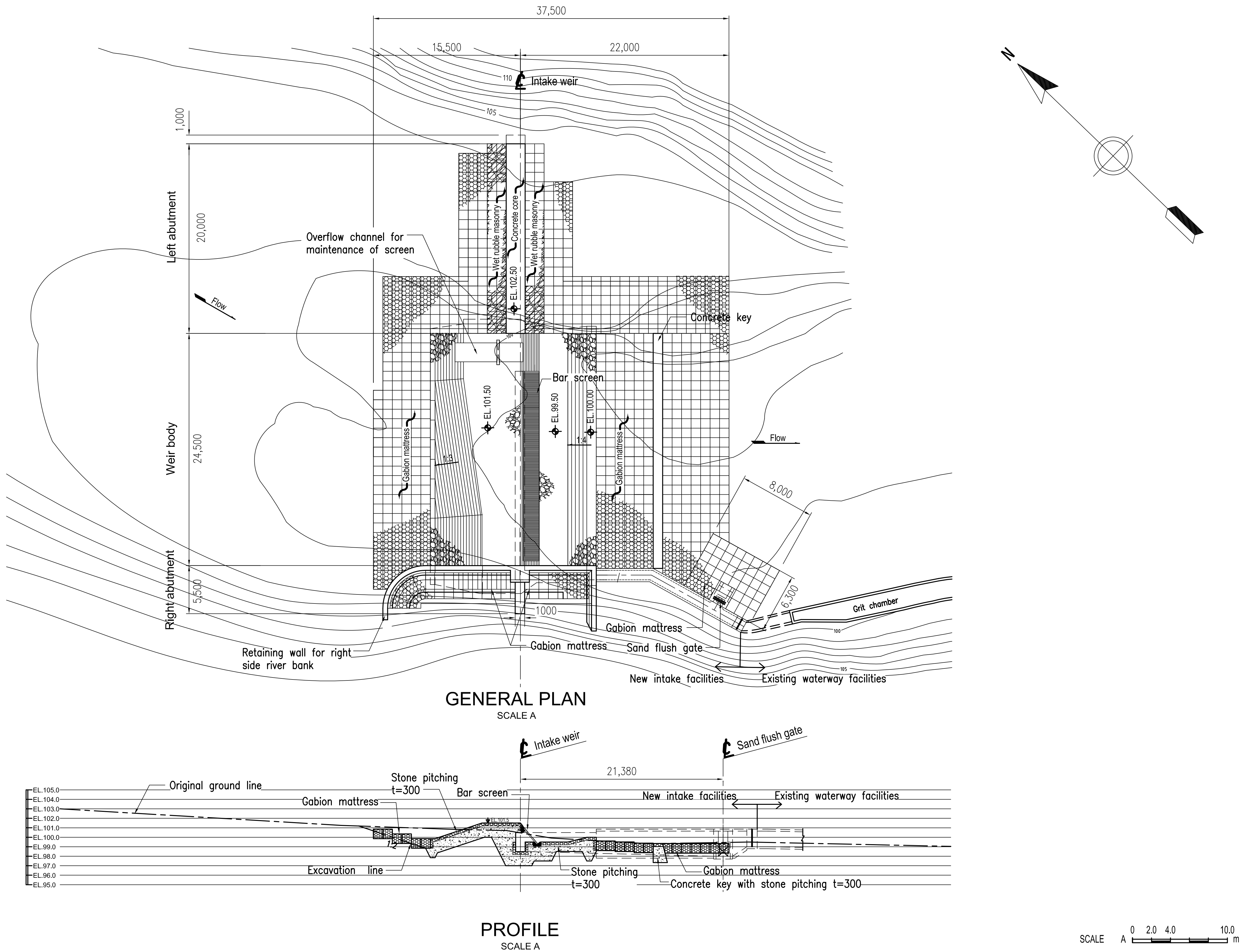
The anticipated qualitative effects are as described below.

1) Power will be supplied stably to public facilities, and the public service will be improved.
2) Nighttime illumination becomes stable, and fosters children's learning and adults' community activities.
3) Stabilized voltage and frequency of the sources of electric power supply will reduce failures of electric motors.

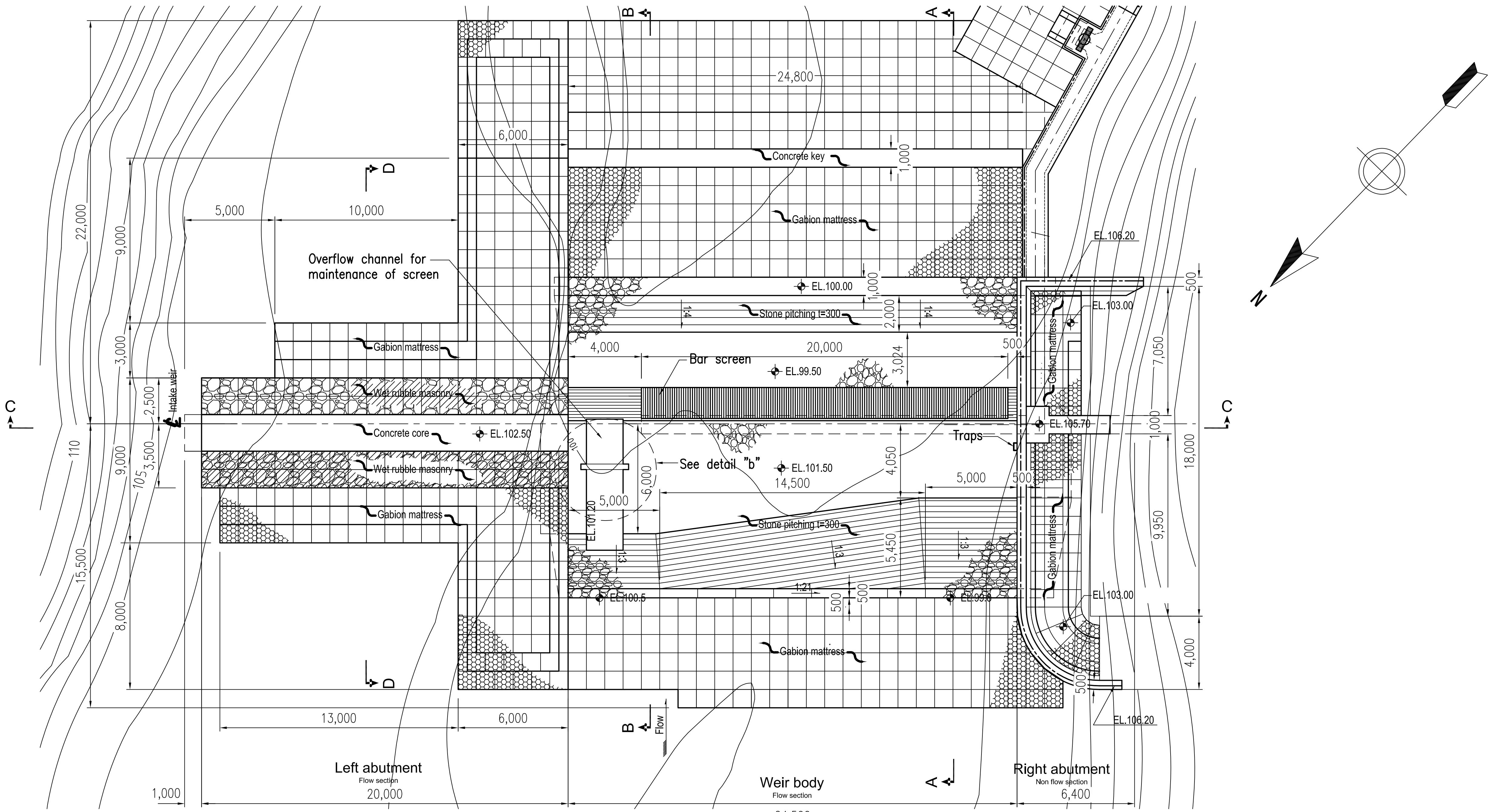
# Outline Design Drawings

List of Outline Design Drawings

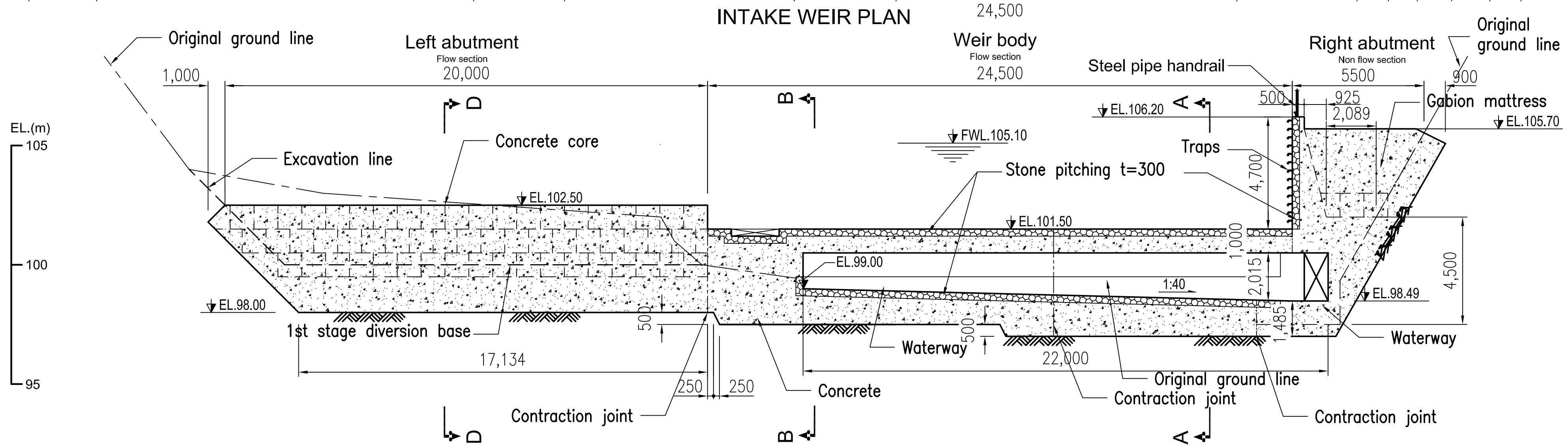
| No. | Drawing No. | Title |
|---|---|---|
| 1 | MHI-001 | BAJHANG POWER STATION INTAKE GENERAL PLAN |
| 2 | MHI-002 | BAJHANG POWER STATION INTAKE WEIR (1) |
| 3 | MHI-003 | BAJHANG POWER STATION INTAKE WEIR (2) |
| 4 | MHI-004 | BAJHANG POWER STATION INTAKE SAND FLUSH GATE |
| 5 | MHI-005 | BAJHANG POWER STATION INTAKE BAR SCREEN |
| 6 | MHI-006 | BAJHANG POWER STATION GENERAL LAYOUT |
| 7 | MHI-007 | BAJHANG POWER STATION POWER HOUSE (1) |
| 8 | MHI-008 | BAJHANG POWER STATION POWER HOUSE (2) |
| 9 | MHI-009 | BAJHANG POWER STATION SINGLE LINE DIAGRAM |
| 10 | MHI-010 | BAJURA POWER STATION INTAKE GENERAL PLAN |
| 11 | MHI-011 | BAJURA POWER STATION INTAKE WEIR (1) |
| 12 | MHI-012 | BAJURA POWER STATION INTAKE WEIR (2) |
| 13 | MHI-013 | BAJURA POWER STATION INTAKE LEFT ABUTMENT |
| 14 | MHI-014 | BAJURA POWER STATION INTAKE SAND FLUSH GATE |
| 15 | MHI-015 | BAJURA POWER STATION INTAKE BAR SCREEN |
| 16 | MHI-016 | BAJURA POWER STATION GENERAL LAYOUT |
| 17 | MHI-017 | BAJURA POWER STATION POWER HOUSE (1) |
| 18 | MHI-018 | BAJURA POWER STATION POWER HOUSE (2) |
| 19 | MHI-019 | BAJURA POWER STATION SINGLE LINE DIAGRAM |
| 20 | MHI-020 | SYARPUDAHA POWER STATION INTAKE GENERAL PLAN |
| 21 | MHI-021 | SYARPUDAHA POWER STATION INTAKE WEIR (1) |
| 22 | MHI-022 | SYARPUDAHA POWER STATION INTAKE WEIR (2) |
| 23 | MHI-023 | SYARPUDAHA POWER STATION INTAKE LEFT ABUTMENT |
| 24 | MHI-024 | SYARPUDAHA POWER STATION INTAKE SAND FLUSH GATE |
| 25 | MHI-025 | SYARPUDAHA POWER STATION INTAKE BAR SCREEN |
| 26 | MHI-026 | SYARPUDAHA POWER STATION GENERAL LAYOUT |
| 27 | MHI-027 | SYARPUDAHA POWER STATION POWER HOUSE (1) |
| 28 | MHI-028 | SYARPUDAHA POWER STATION POWER HOUSE (2) |
| 29 | MHI-029 | SYARPUDAHA POWER STATION SINGLE LINE DIAGRAM |




| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJHANG POWER STATION INTAKE GENERAL PLAN | DRAW. NO.: MHI-001 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|



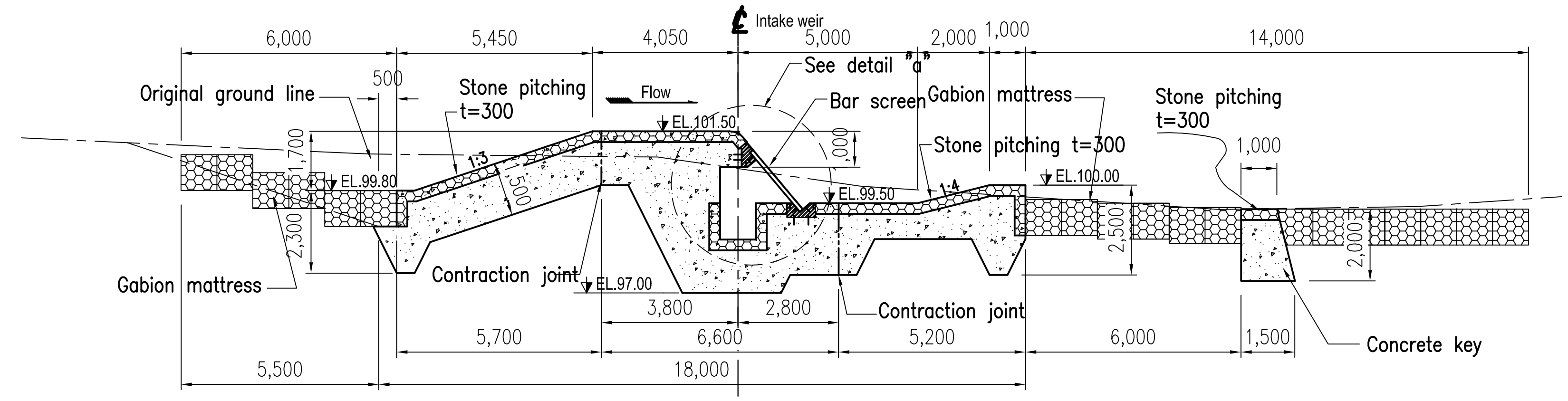

INTAKE WEIR PLAN




SECTION C-C

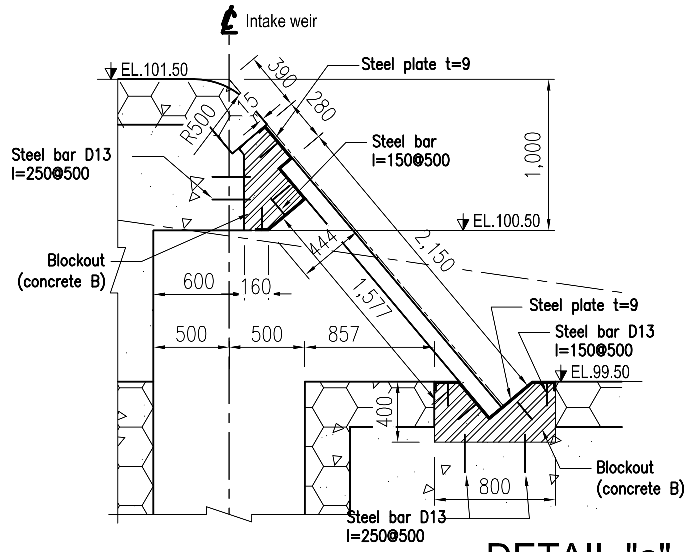
SCALE A 0 1.25 2.5 6.25 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJHANG POWER STATION INTAKE WEIR (1) | DRAW. NO.: MHI-002 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|



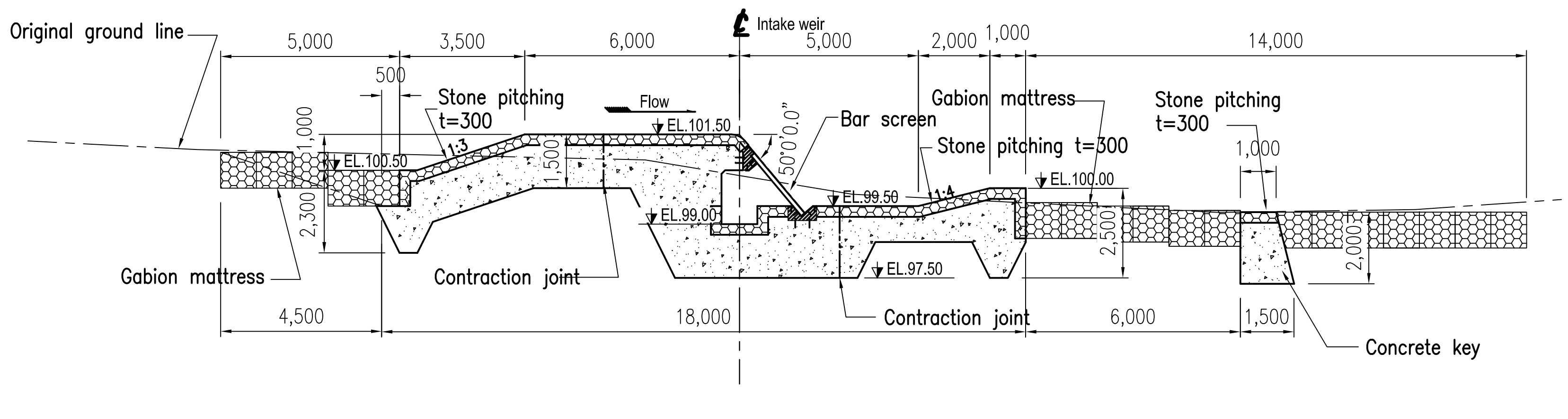

## SECTION A-A

SCALE A



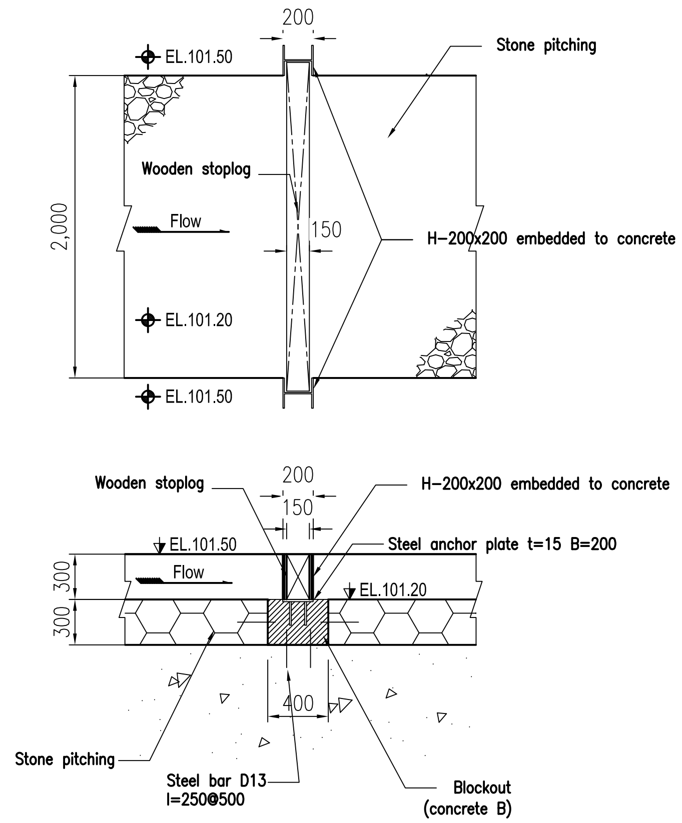

## DETAIL "a"

SCALE B




## SECTION B-B

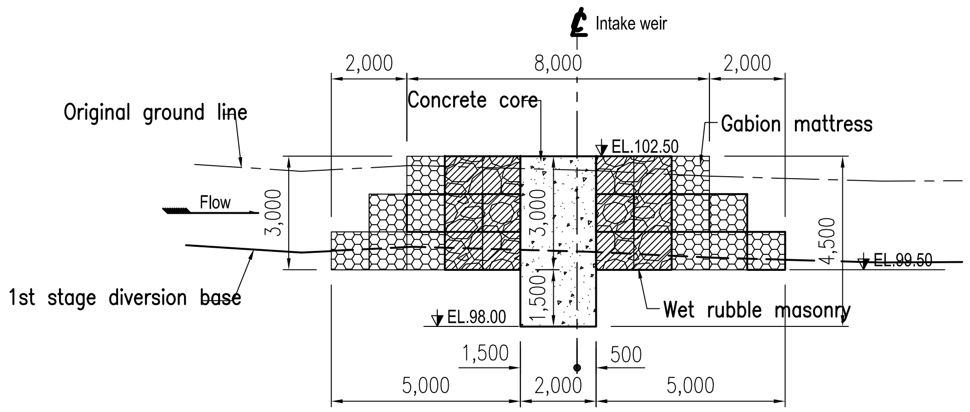
SCALE A




## OVERFLOW CHANNEL FOR MAINTENANCE OF SCREEN

## DETAIL "b"

SCALE B



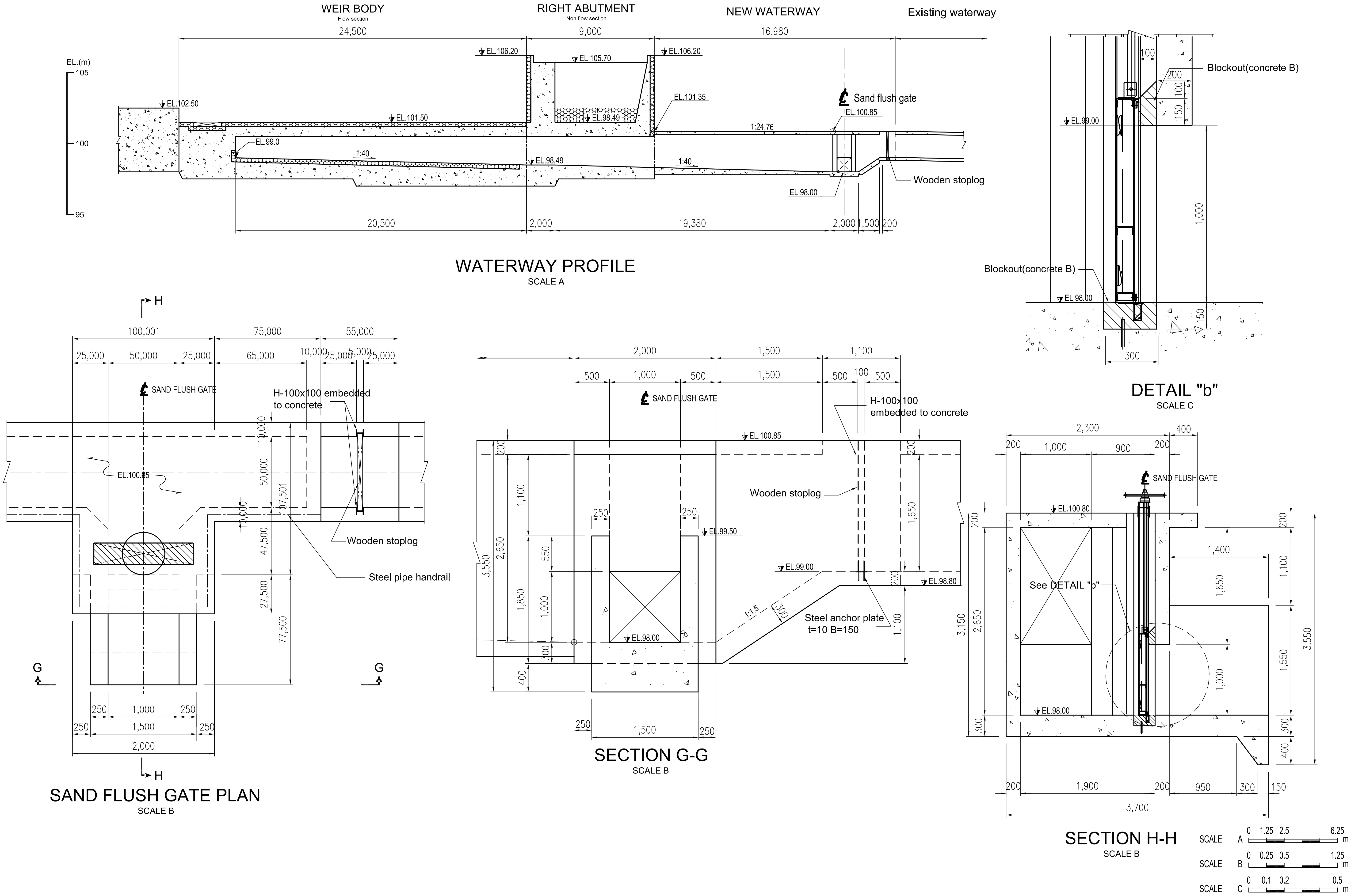

## SECTION D-D

SCALE A

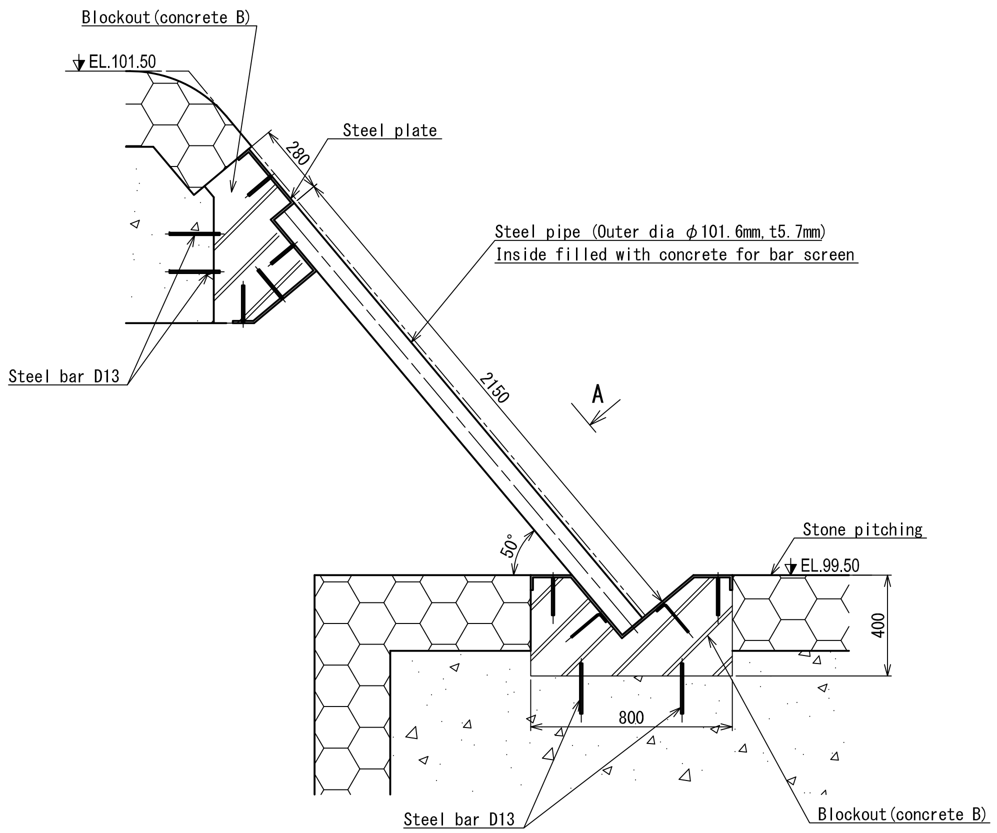
SCALE A 0 1.0 2.0 5.0 m

SCALE B 0 0.25 0.5 1.25 m

| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | BAJHANG POWER STATION INTAKE WEIR (2) | MHI-003 | NIPPON KOEI CO.,LTD. |

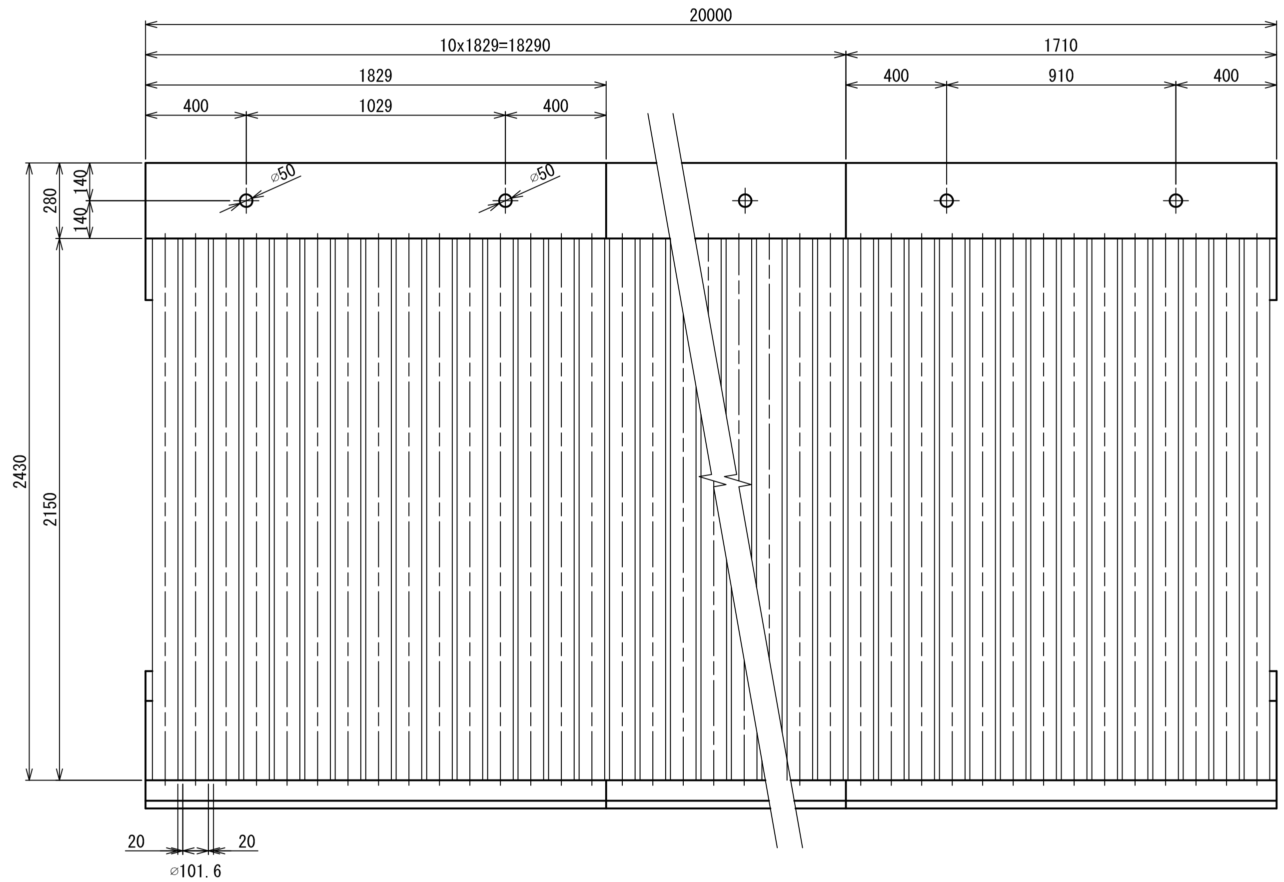



| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJHANG POWER STATION INTAKE SAND FLUSH GATE | DRAW. NO.: MHI-004 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|




FITTING DETAIL PLAN OF BAR SCREEN

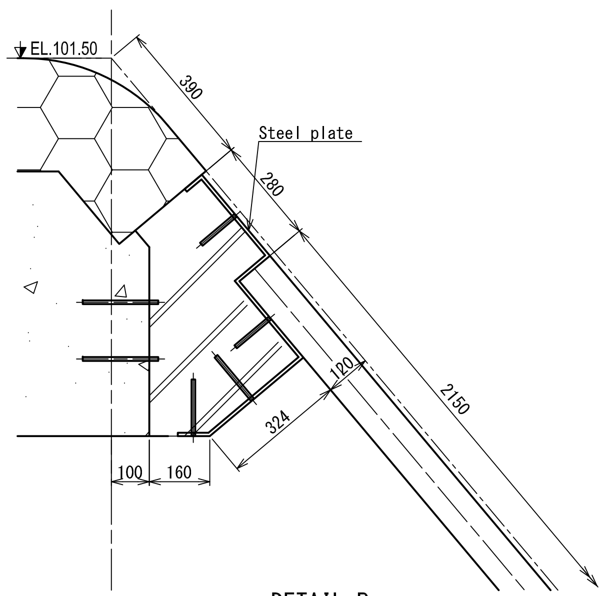
SCALE A




VIEW A

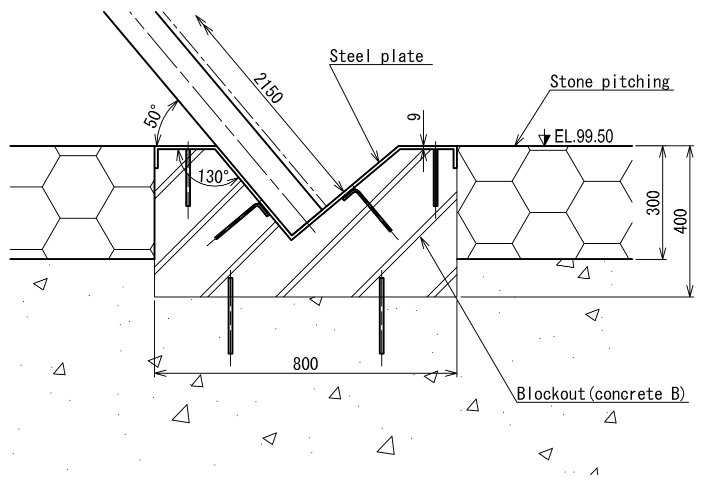
SCALE A

Note:Steel pipe for bar screen
JIS G 3454 Carbon steel pipes for pressure service
STPG410 90A Outer dia 101.6mm, Thickness 5.7mm




DETAIL B

SCALE B



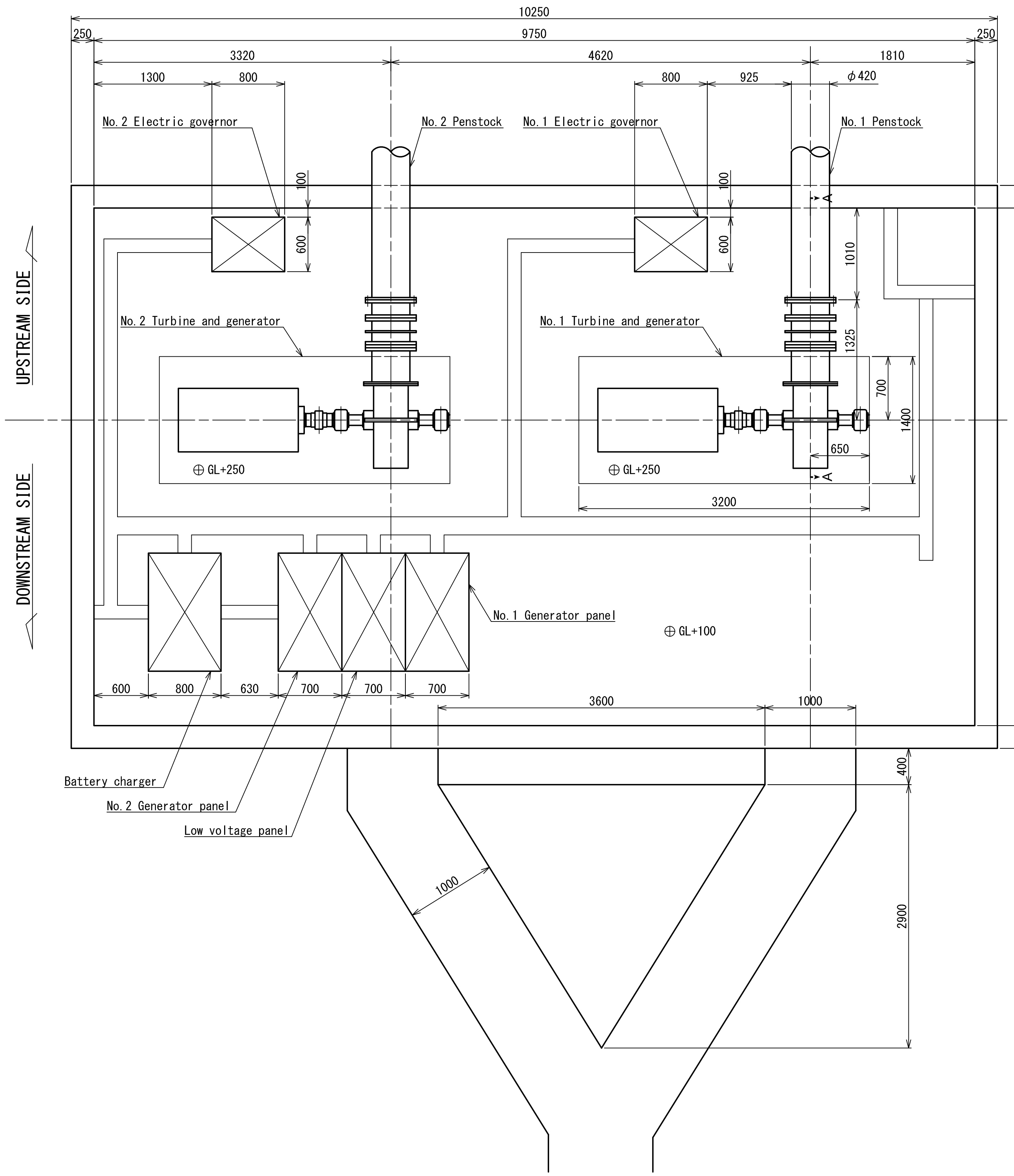

DETAIL C

SCALE B

SCALE A 0 0.15 0.3 0.75 m

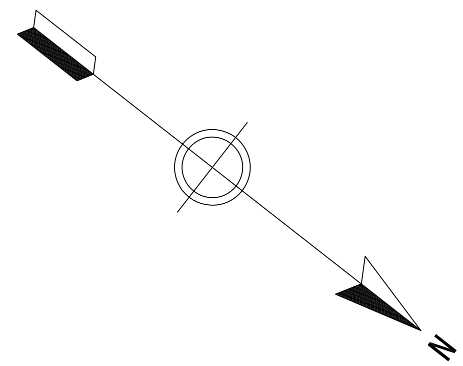
SCALE B 0 0.1 0.2 0.5 m

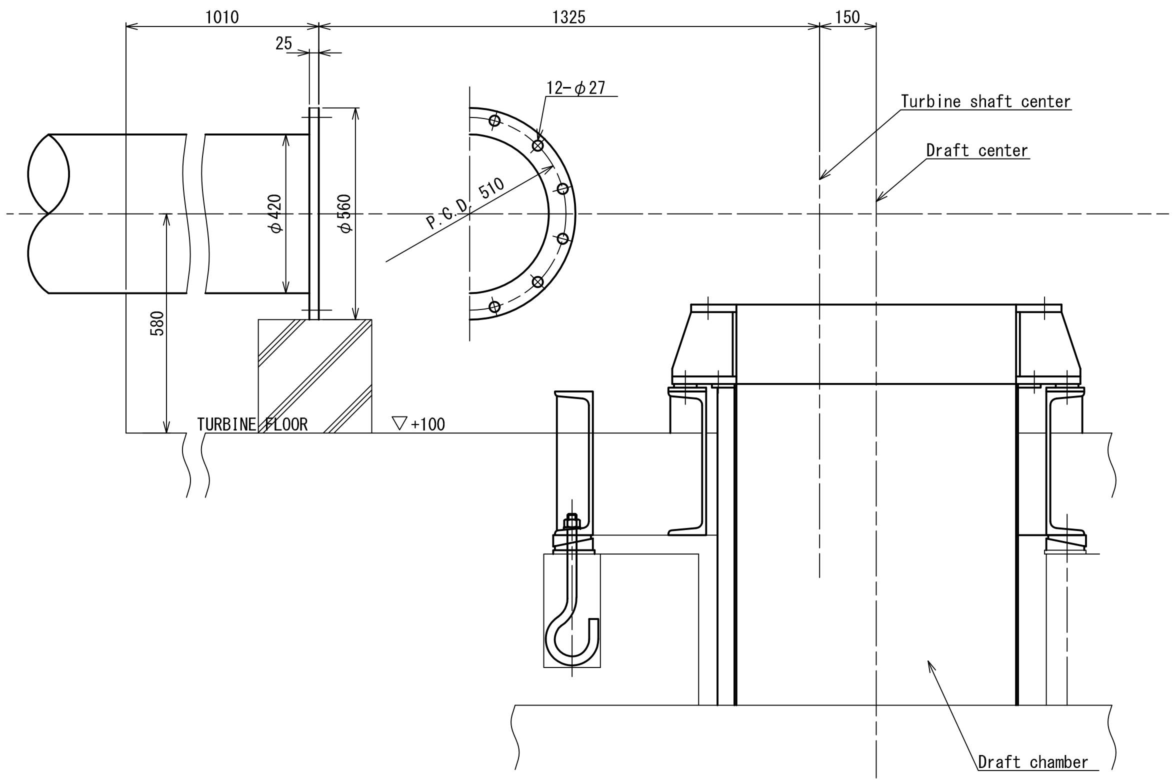
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO−HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJHANG POWER STATION INTAKE BAR SCREEN | DRAW. NO.: MHI-005 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|




GENERAL LAYOUT OF POWER HOUSE

SCALE A



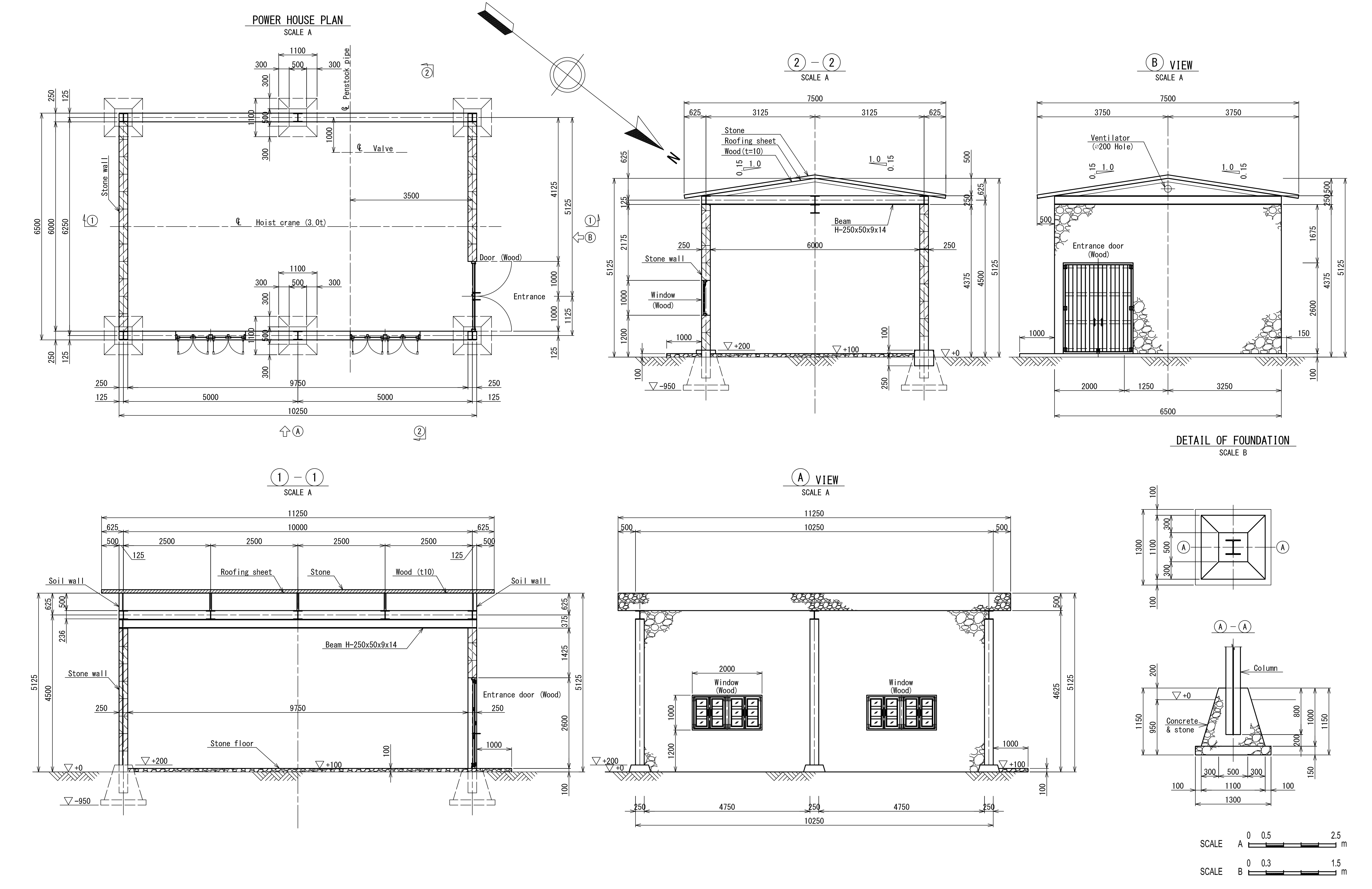

SECTION A-A

SCALE B

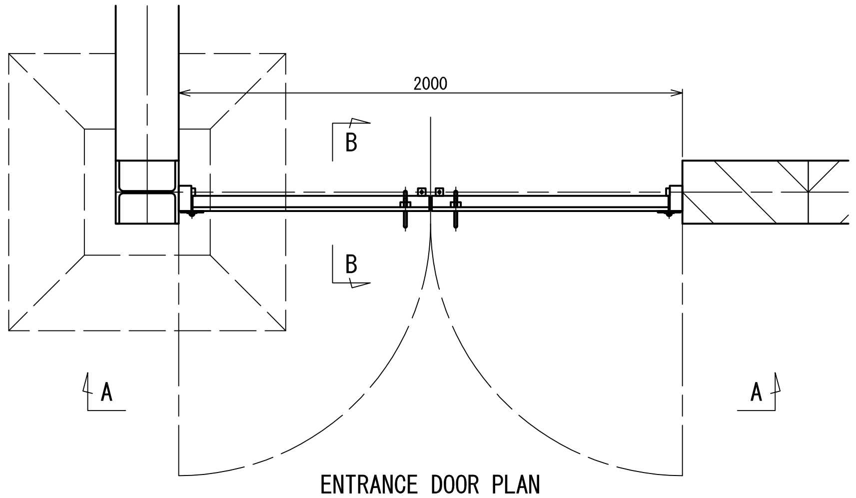
SCALE A 0 0.3 1.5 m

SCALE B 0 0.1 0.5 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO—HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJHANG POWER STATION GENERAL LAYOUT | DRAW. NO.: MHI-006 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|

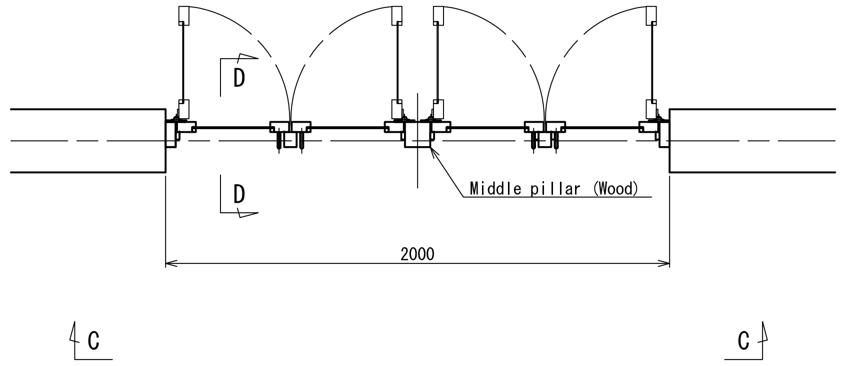



| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO−HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJHANG POWER STATION POWER HOUSE(1) | DRAW. NO.: MHI-007 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|



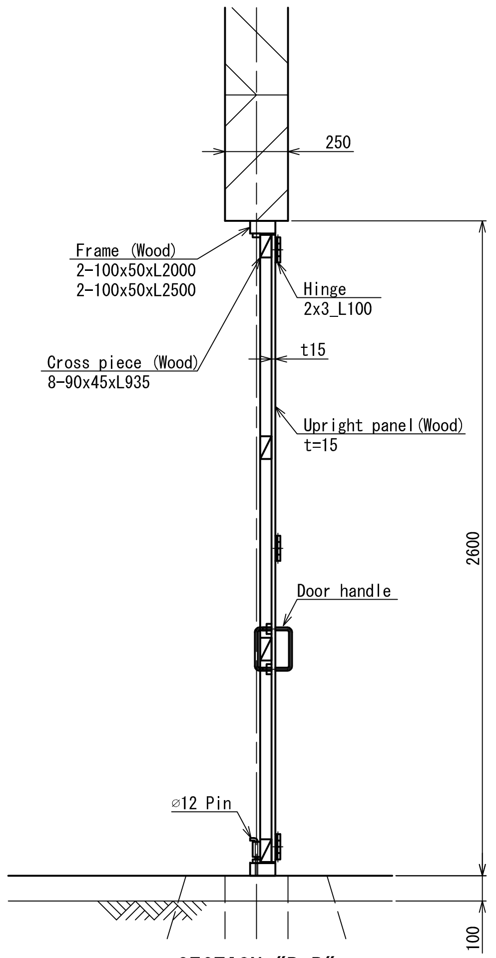

ENTRANCE DOOR PLAN

SCALE A



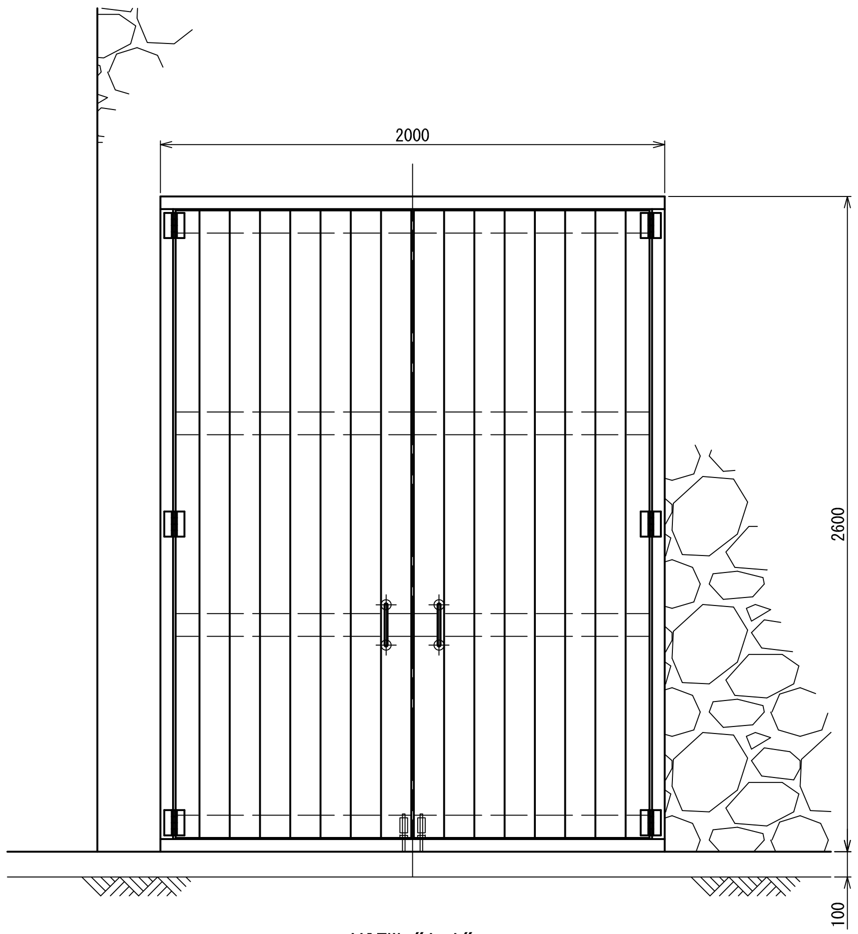

WINDOW PLAN

SCALE A



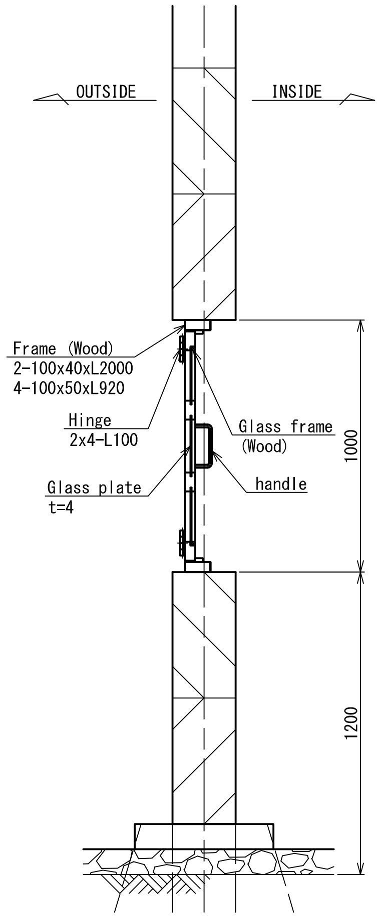

SECTION "B-B"

SCALE A



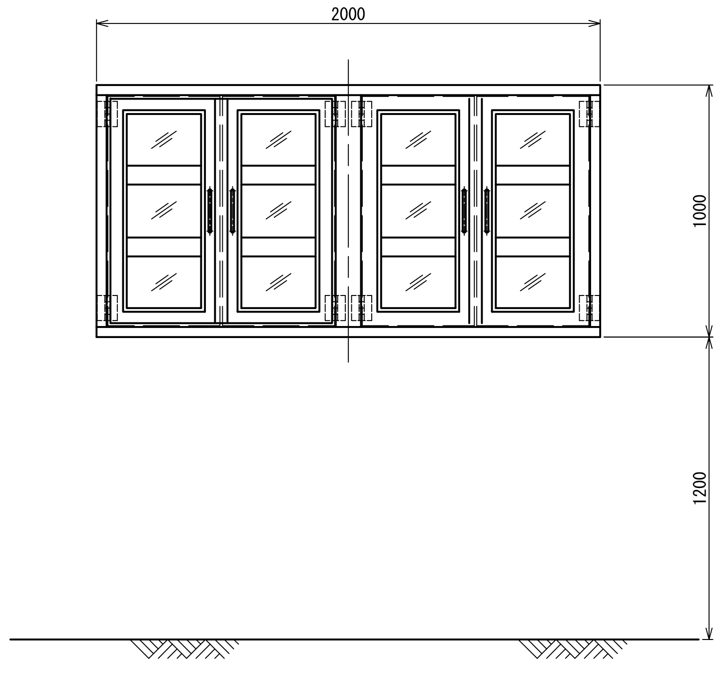

VIEW "A-A"

SCALE A




SECTION "D-D"

SCALE A

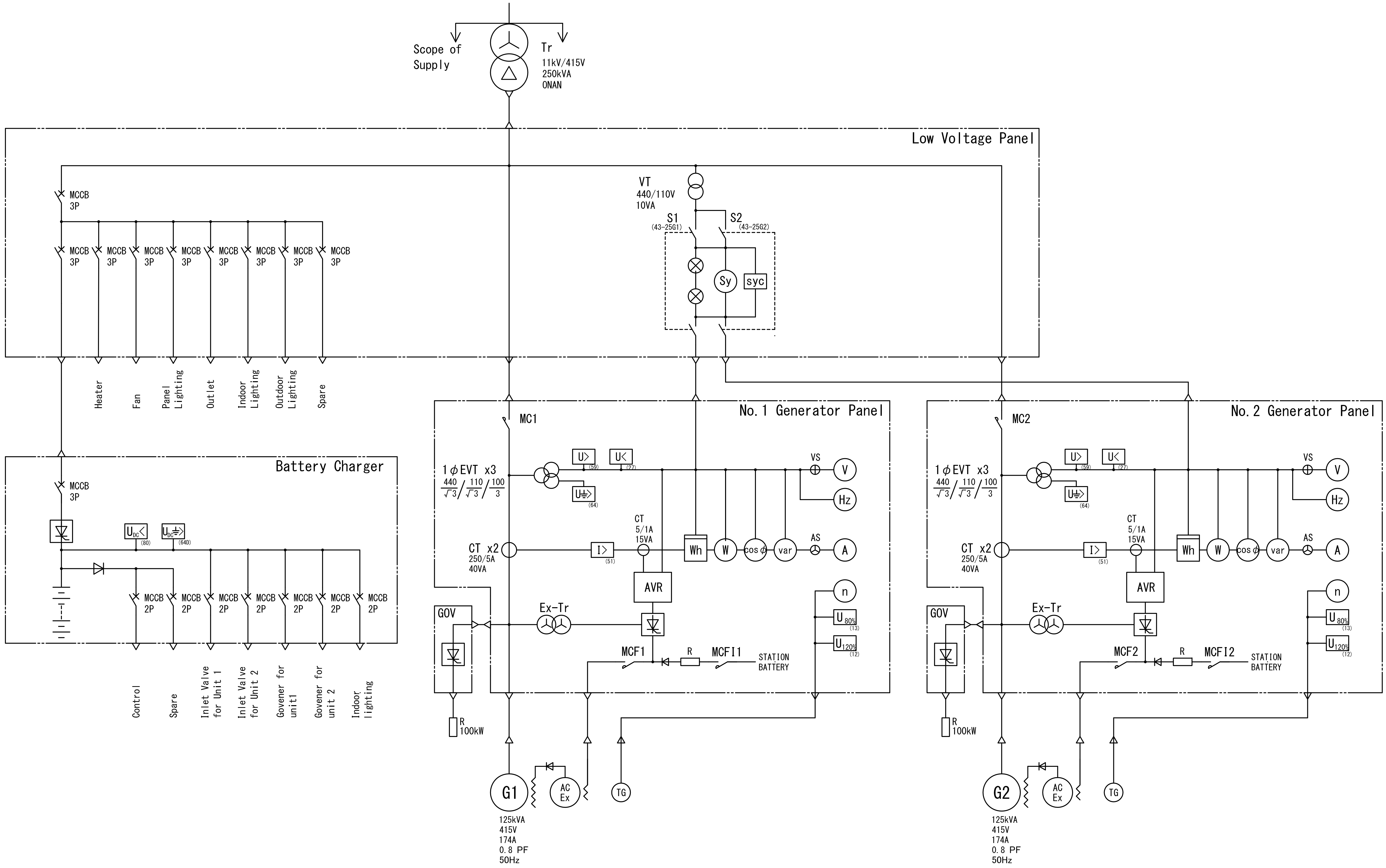



VIEW "C-C"

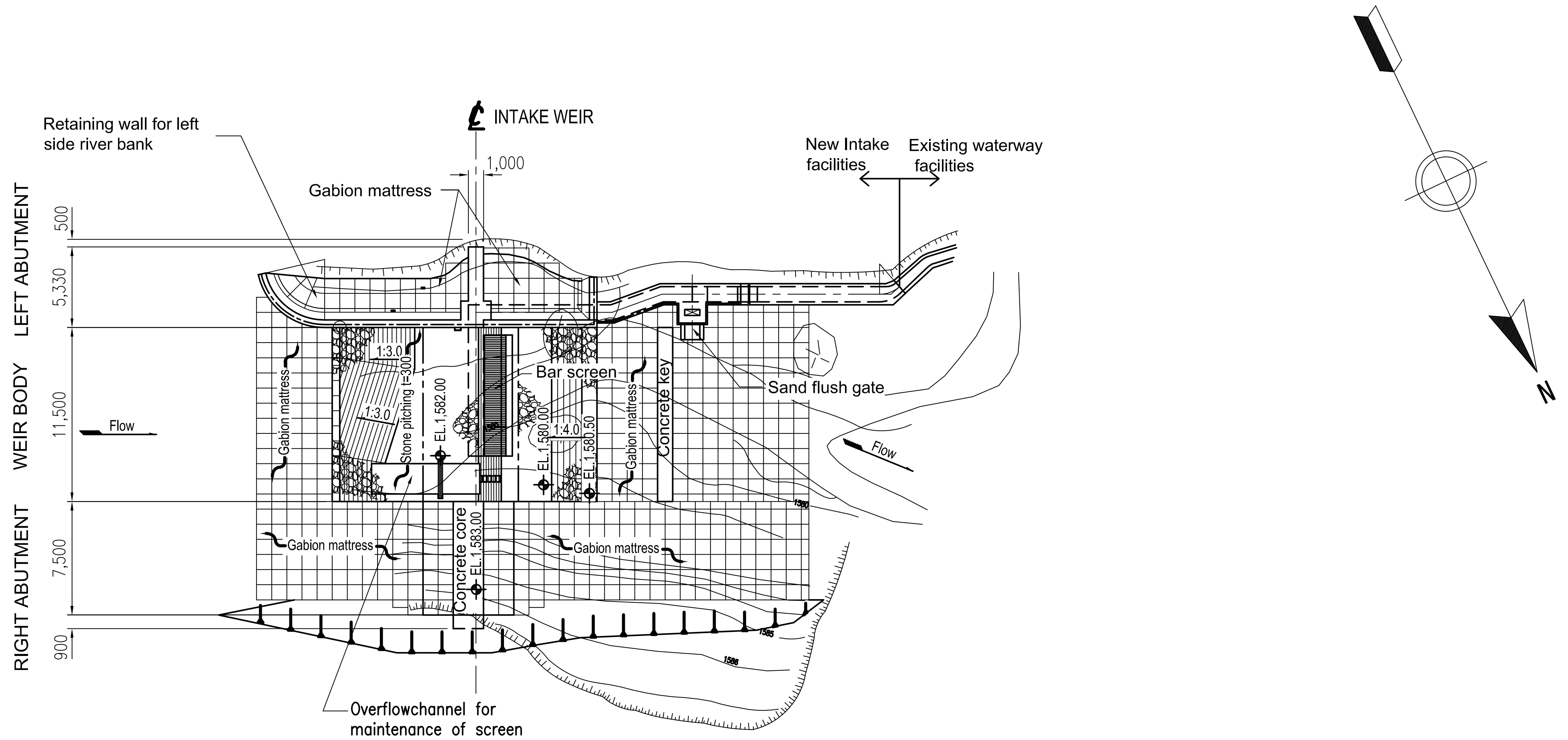
SCALE A

SCALE A 0 0.15 7.5 m

| | | | | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO−HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE<br>BAJHANG POWER STATION POWER HOUSE(2) | DRAW. NO.<br>MHI-008 | NIPPON KOEI CO.,LTD. |

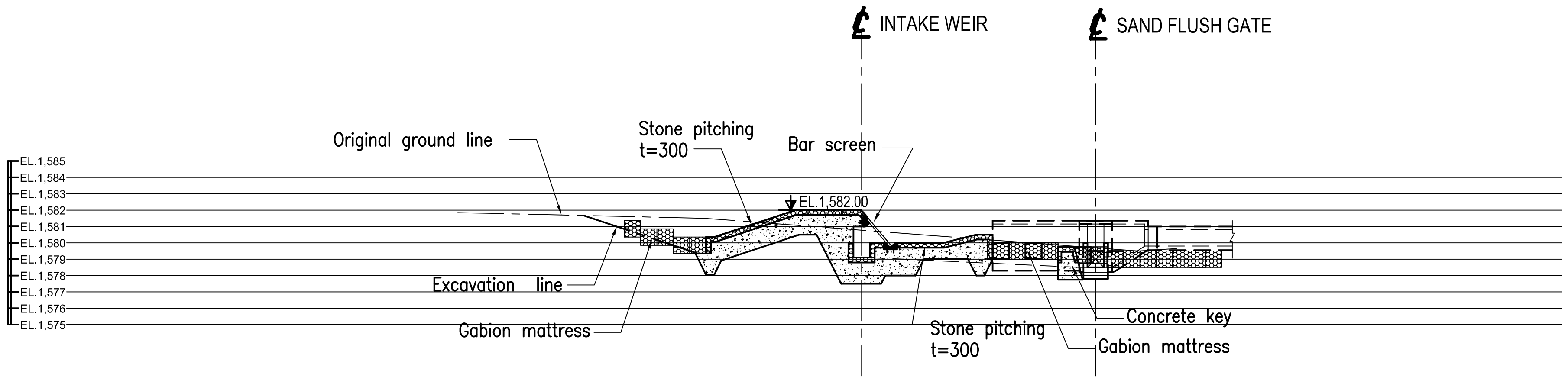



| | | | | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO－HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE<br>BAJHANG POWER STATION SINGLE LINE DIAGRAM | DRAW. NO.<br>MHI-009 | NIPPON KOEI CO.,LTD. |




GENERAL PLAN

SCALE A

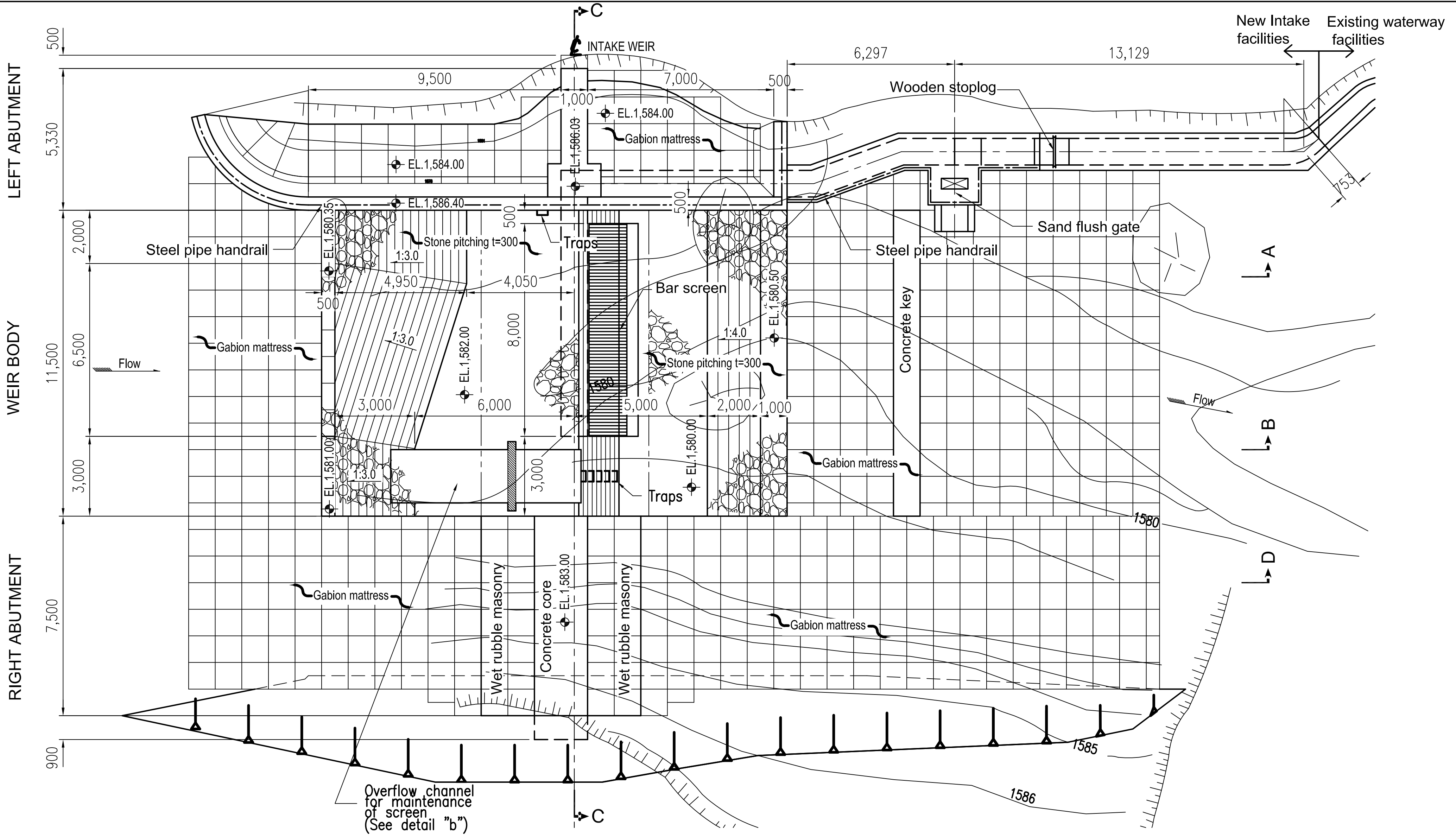



PROFILE

SCALE A

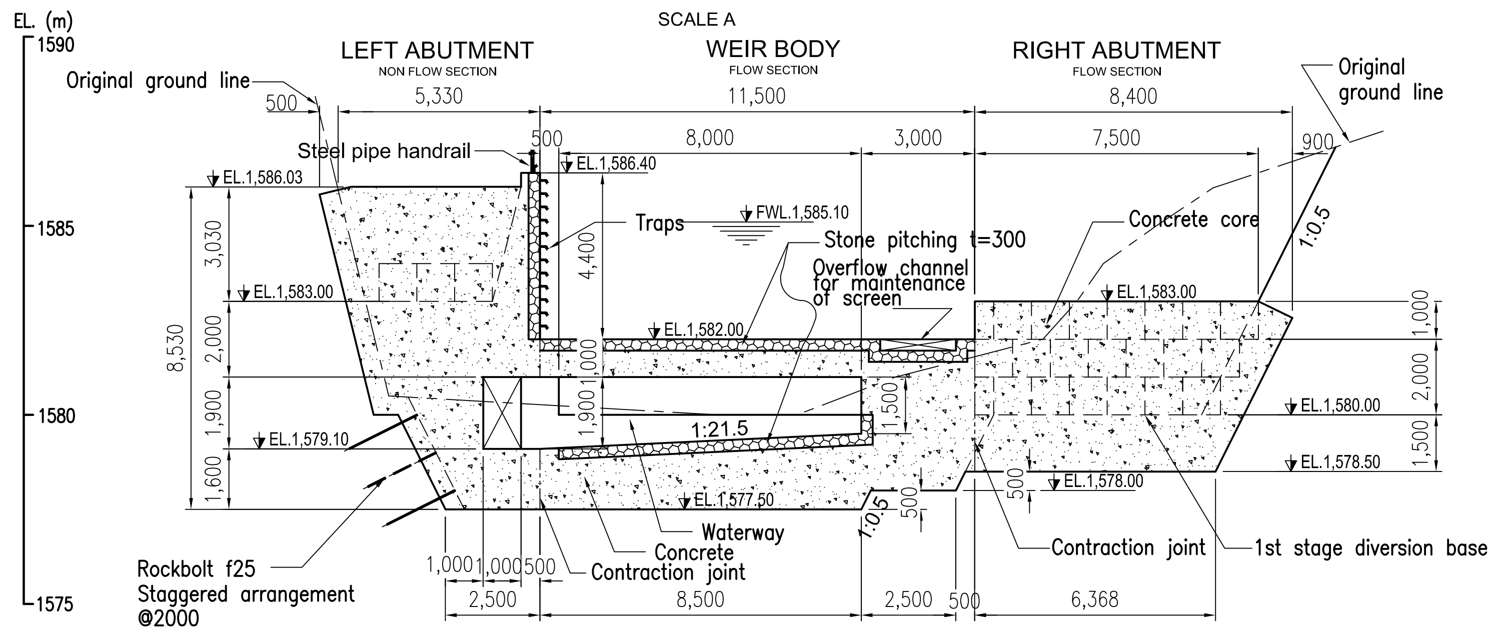
SCALE A 0 2.0 4.0 10.0 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJURA POWER STATION INTAKE GENERAL PLAN | DRAW. NO.: MHI-010 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|




## INTAKE WEIR PLAN

SCALE A

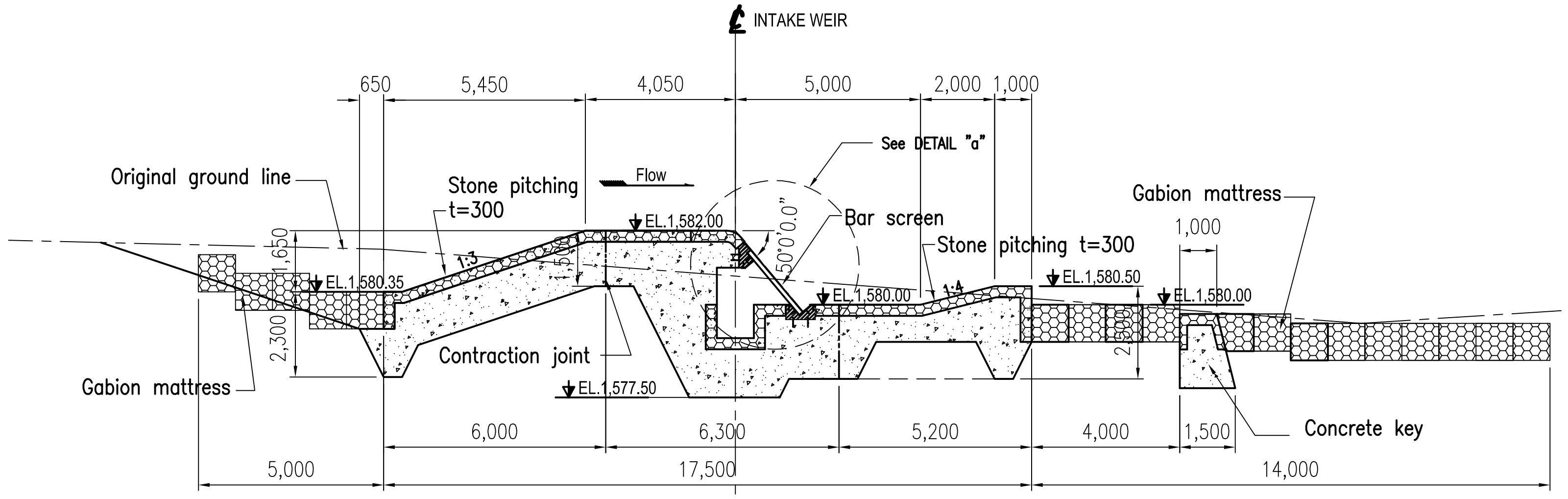



## SECTION C-C

SCALE A

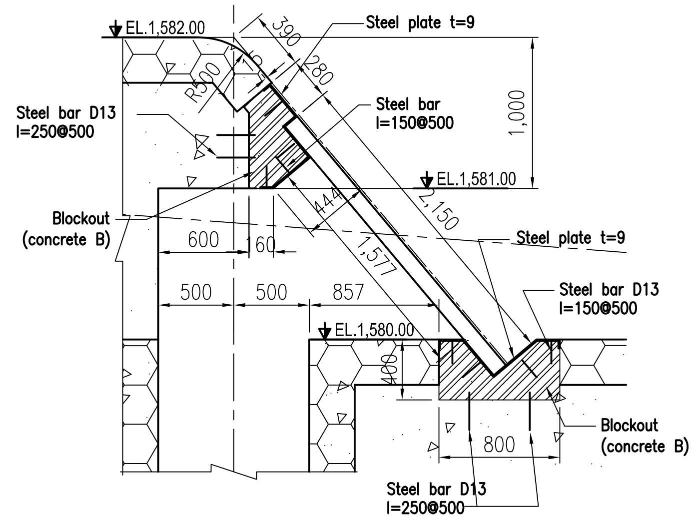
SCALE A 0 1.0 2.0 5.0 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJURA POWER STATION INTAKE WEIR (1) | DRAW. NO. MHI-011 | NIPPON KOEI CO.,LTD. |
| --- | --- | --- | --- | --- |



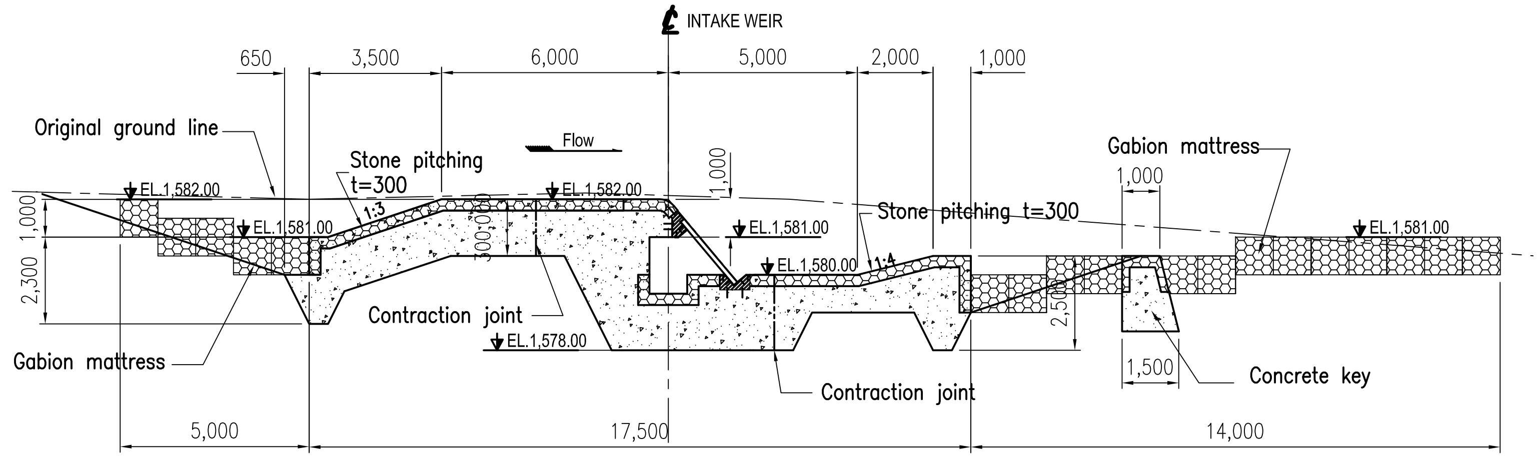

## SECTION A-A

SCALE A



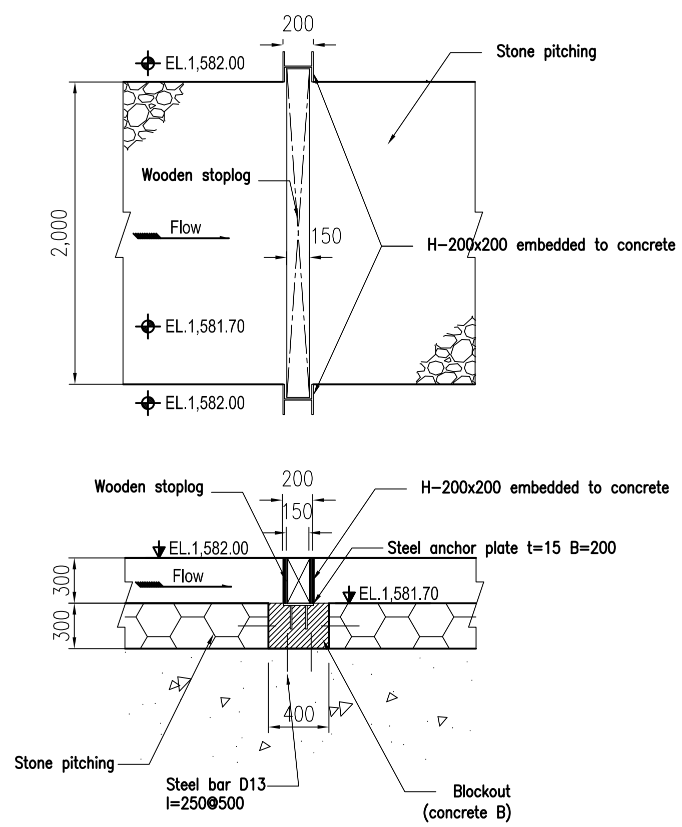

## DETAIL "a"

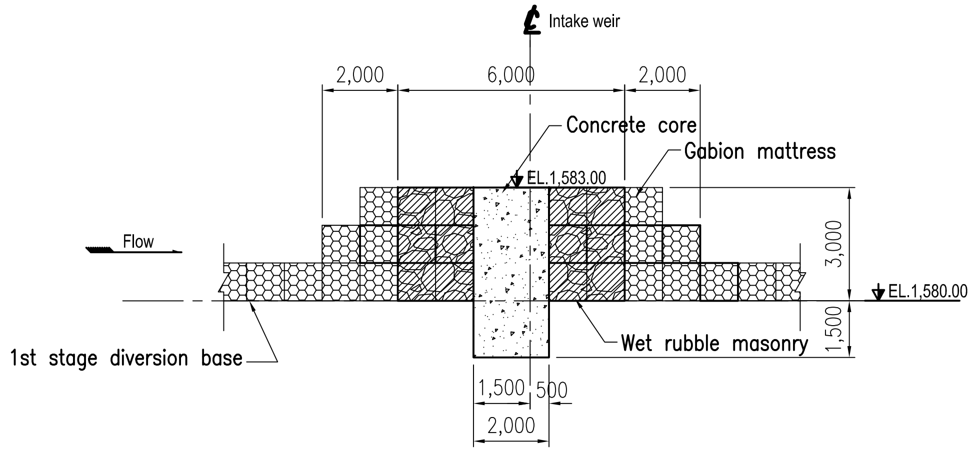
SCALE B




## SECTION B-B

SCALE A



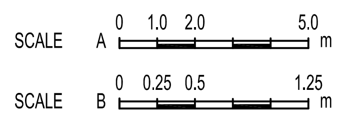

## SECTION D-D

SCALE A

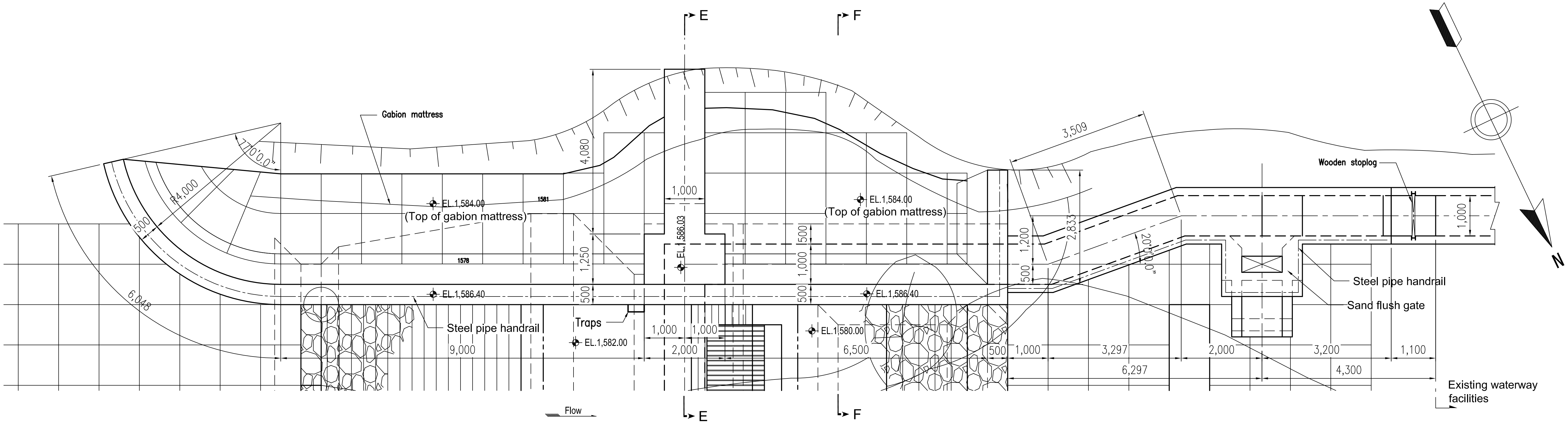
## OVERFLOW CHANNEL FOR MAINTENANCE OF SCREEN

## DETAIL "b"

SCALE B

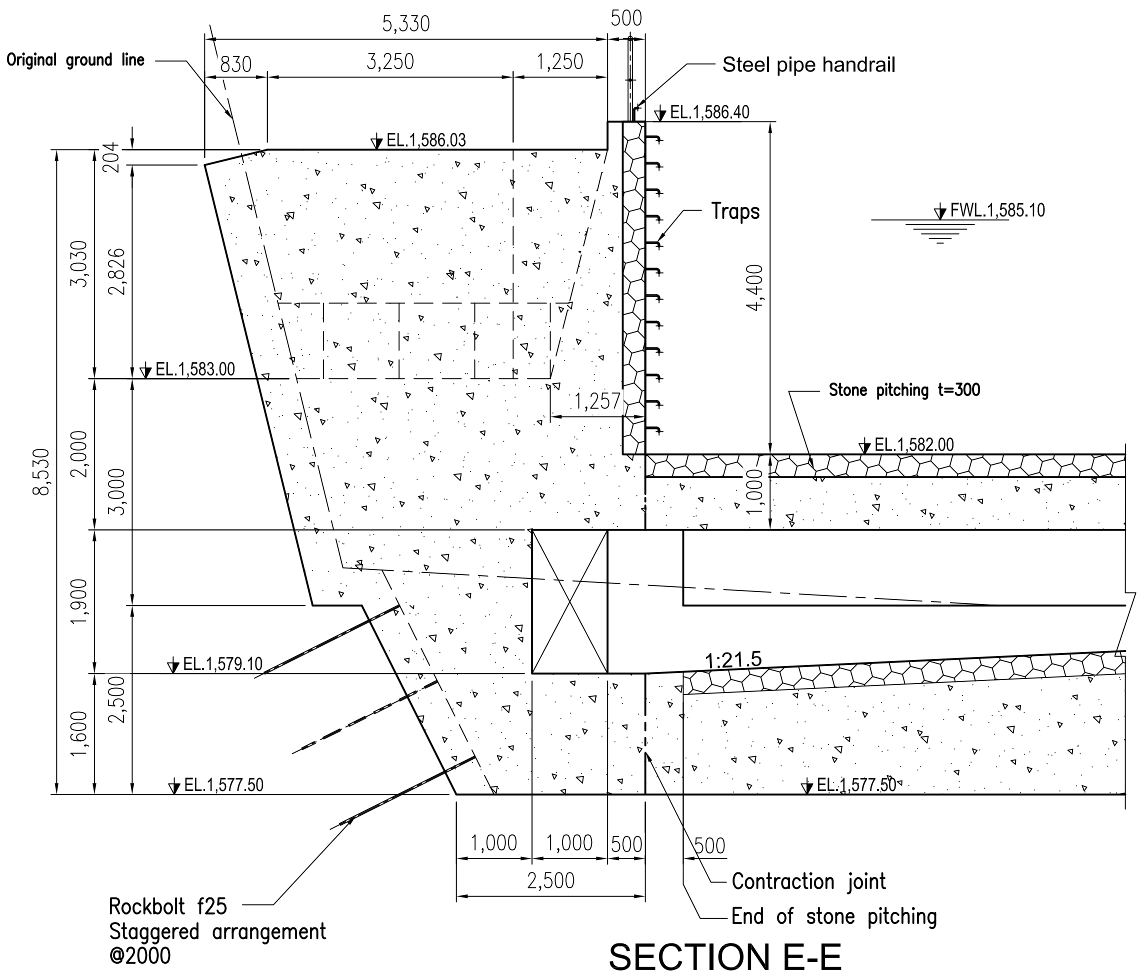



| | | | | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE<br>BAJURA POWER STATION<br>INTAKE WEIR (2) | DRAW. NO.<br>MHI-012 | NIPPON KOEI CO.,LTD. |



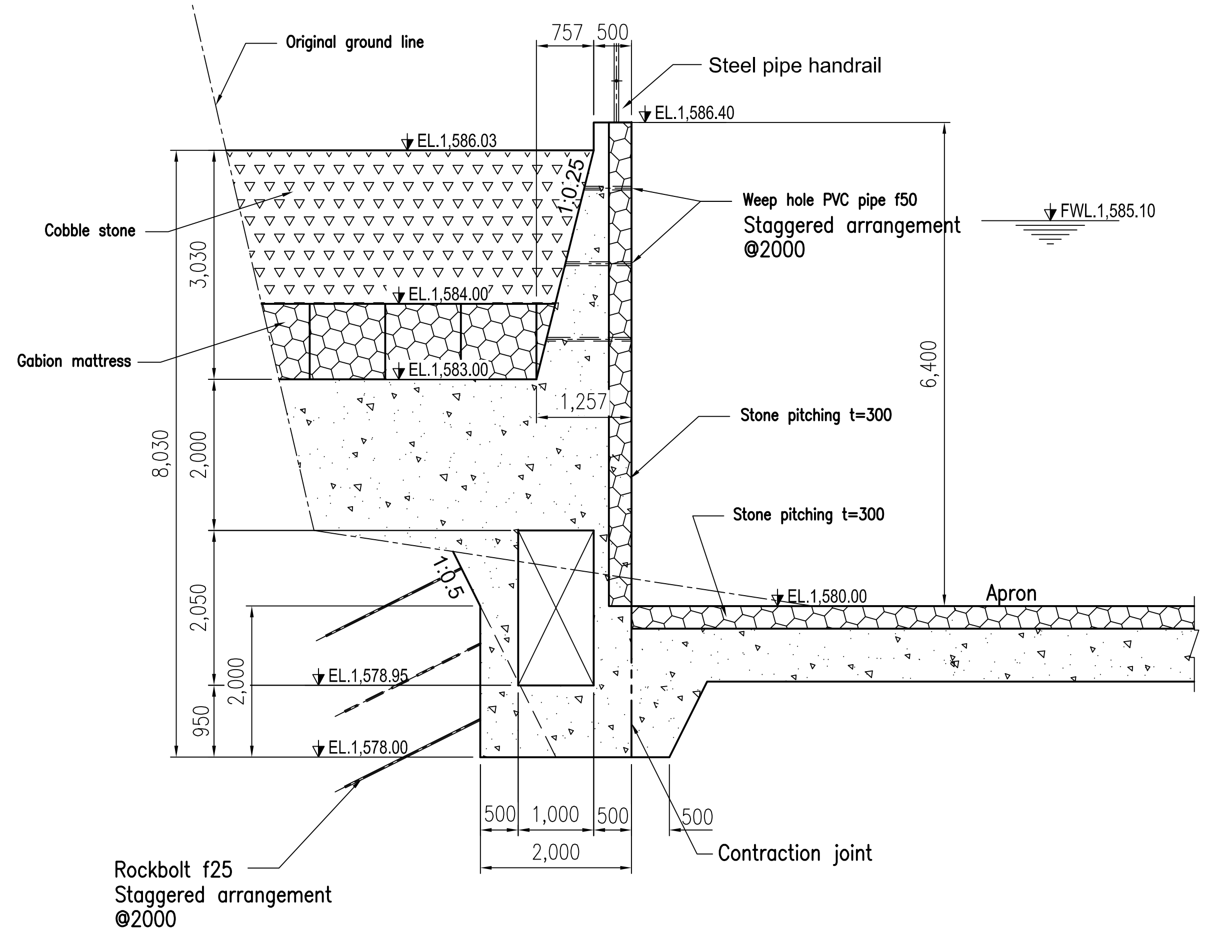

# LEFT ABUTMENT PLAN

SCALE A




## SECTION E-E

SCALE A

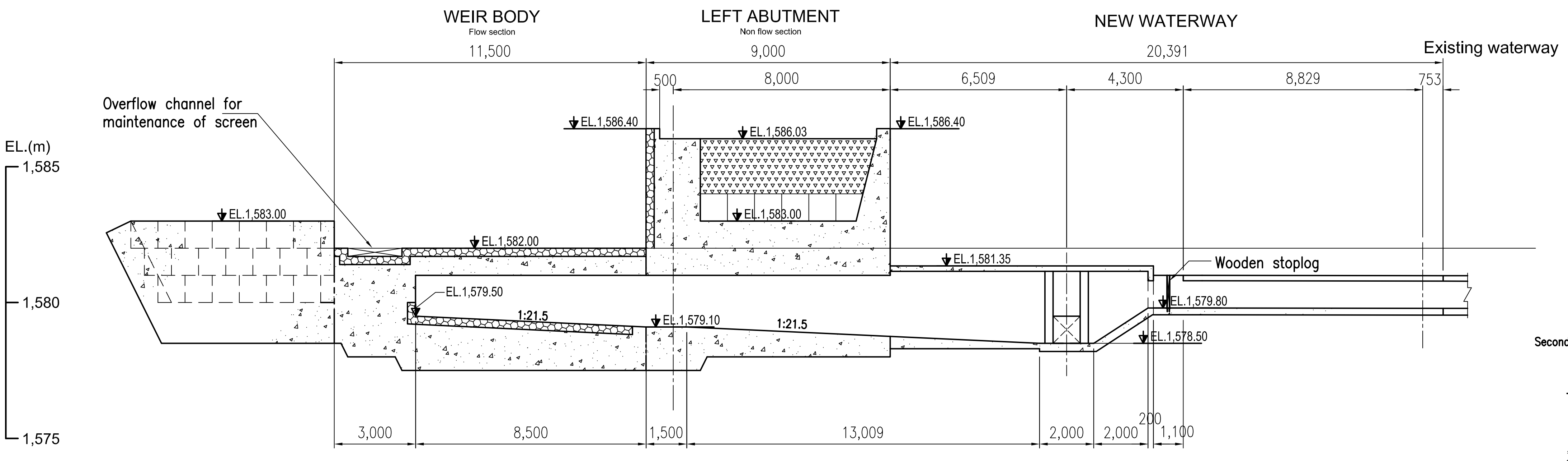



## SECTION F-F

SCALE A

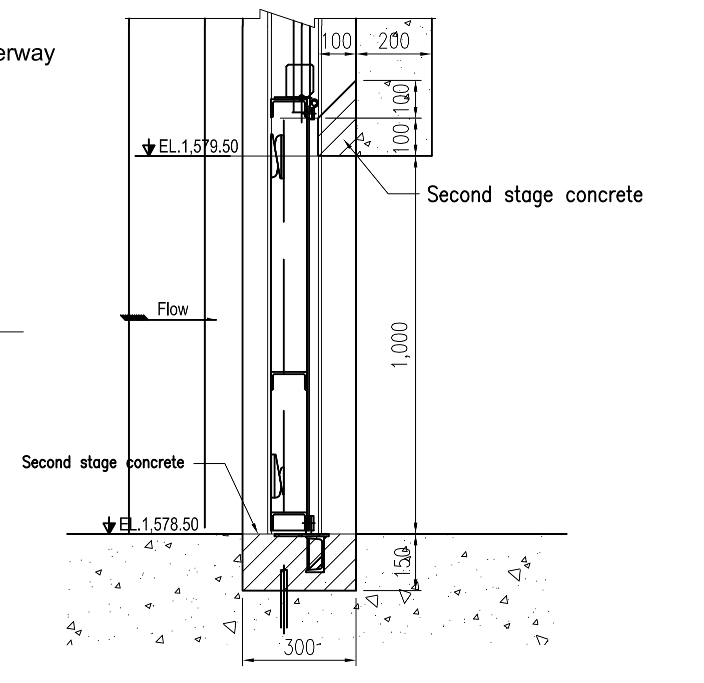
SCALE A 0 0.5 1.0 2.5 m

| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | BAJURA POWER STATION INTAKE LEFT ABUTMENT | MHI-013 | NIPPON KOEI CO.,LTD. |



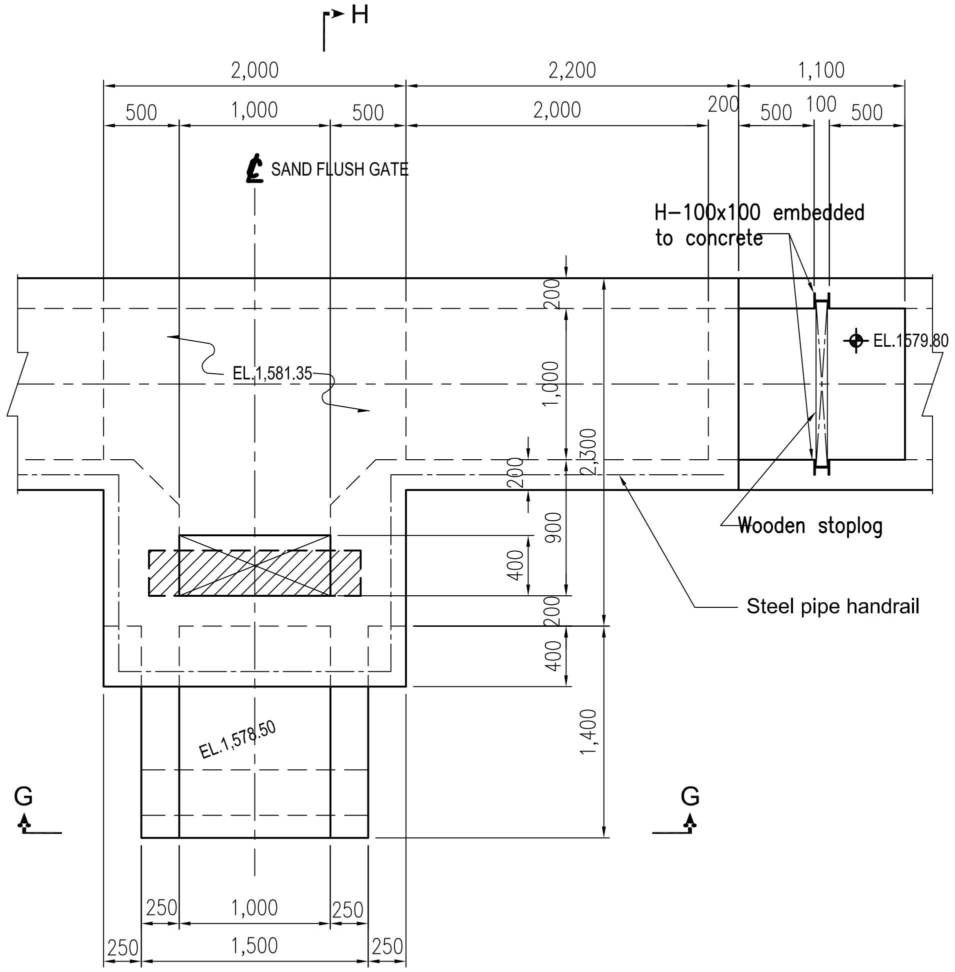

## WATERWAY PROFILE

SCALE A



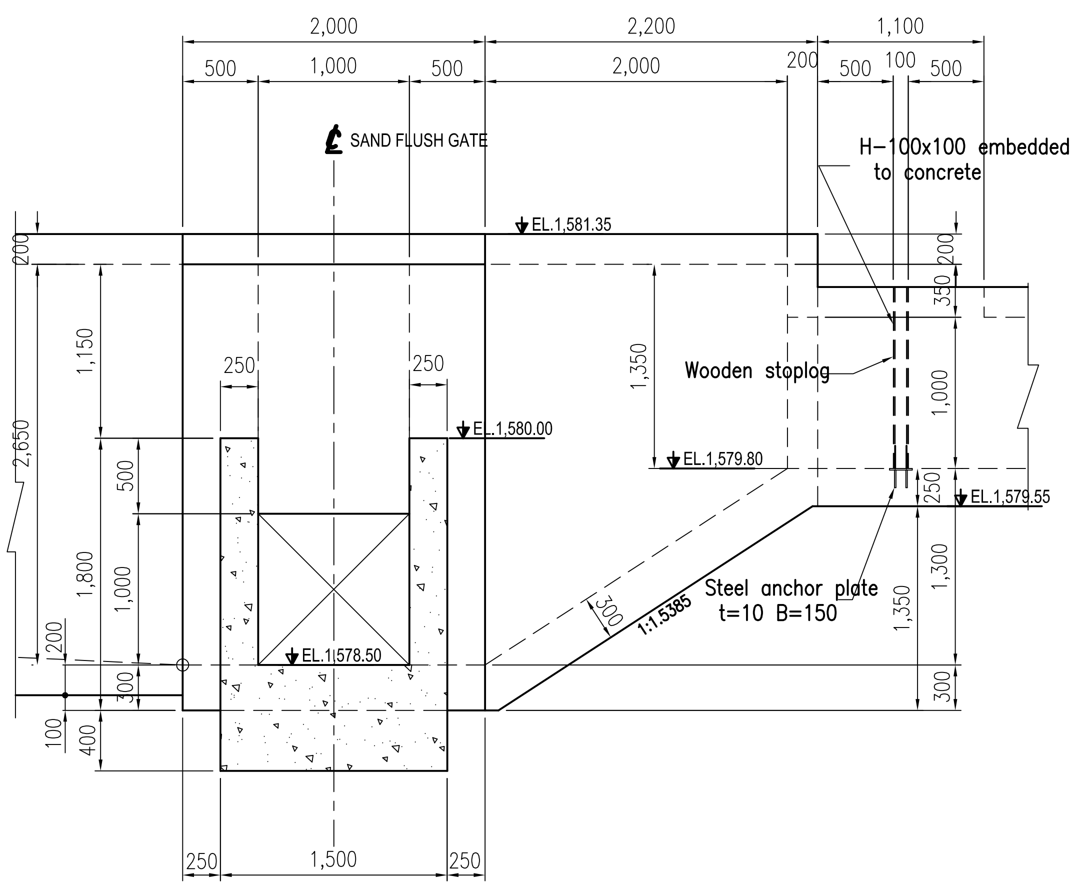

## DETAIL "b"

SCALE C



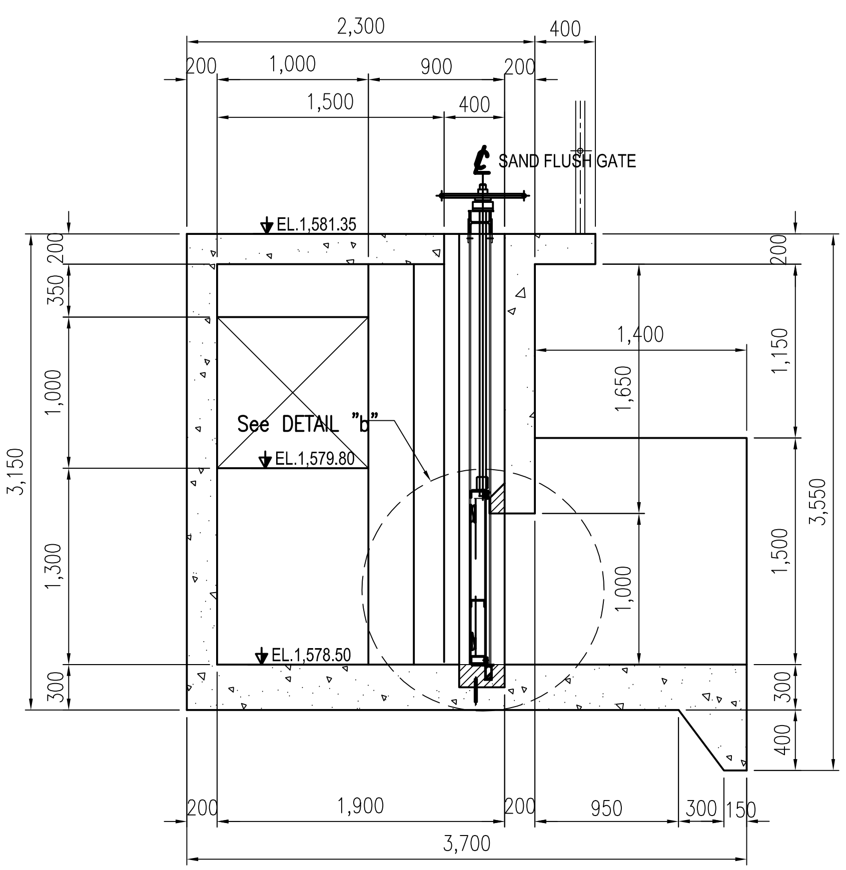

## SAND FLUSH GATE PLAN

SCALE B




## SECTION G-G

SCALE B




## SECTION H-H

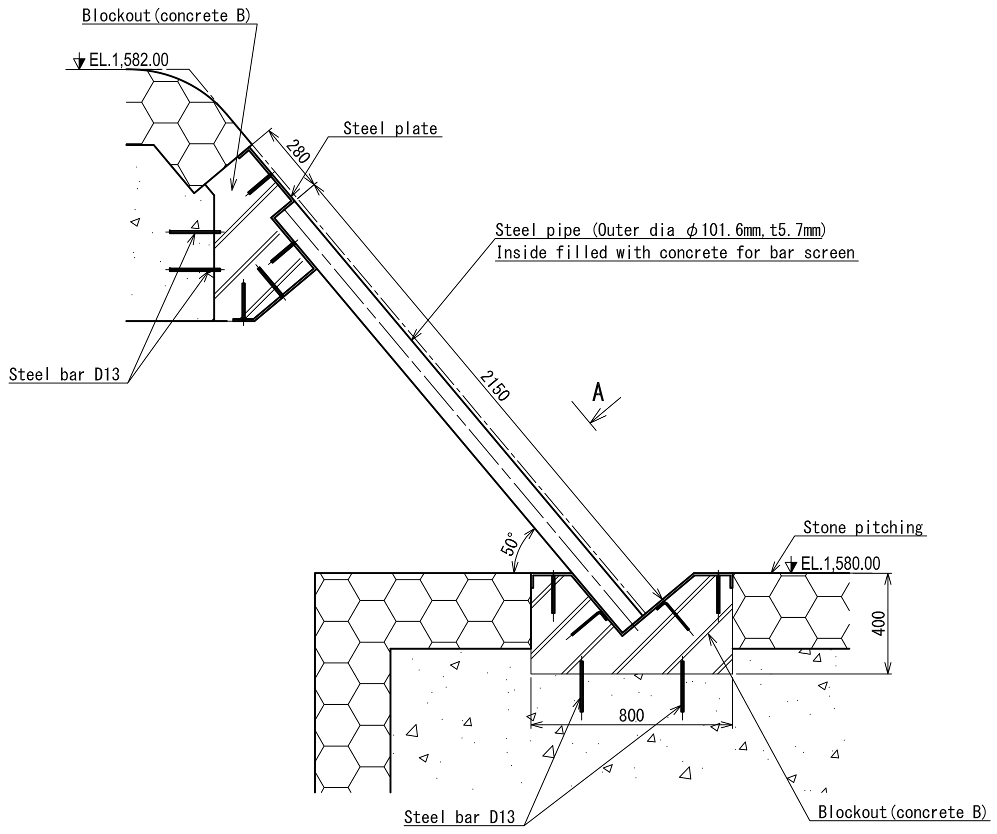
SCALE B

SCALE A 0 1.0 2.0 5.0 m

SCALE B 0 0.25 0.5 1.25 m

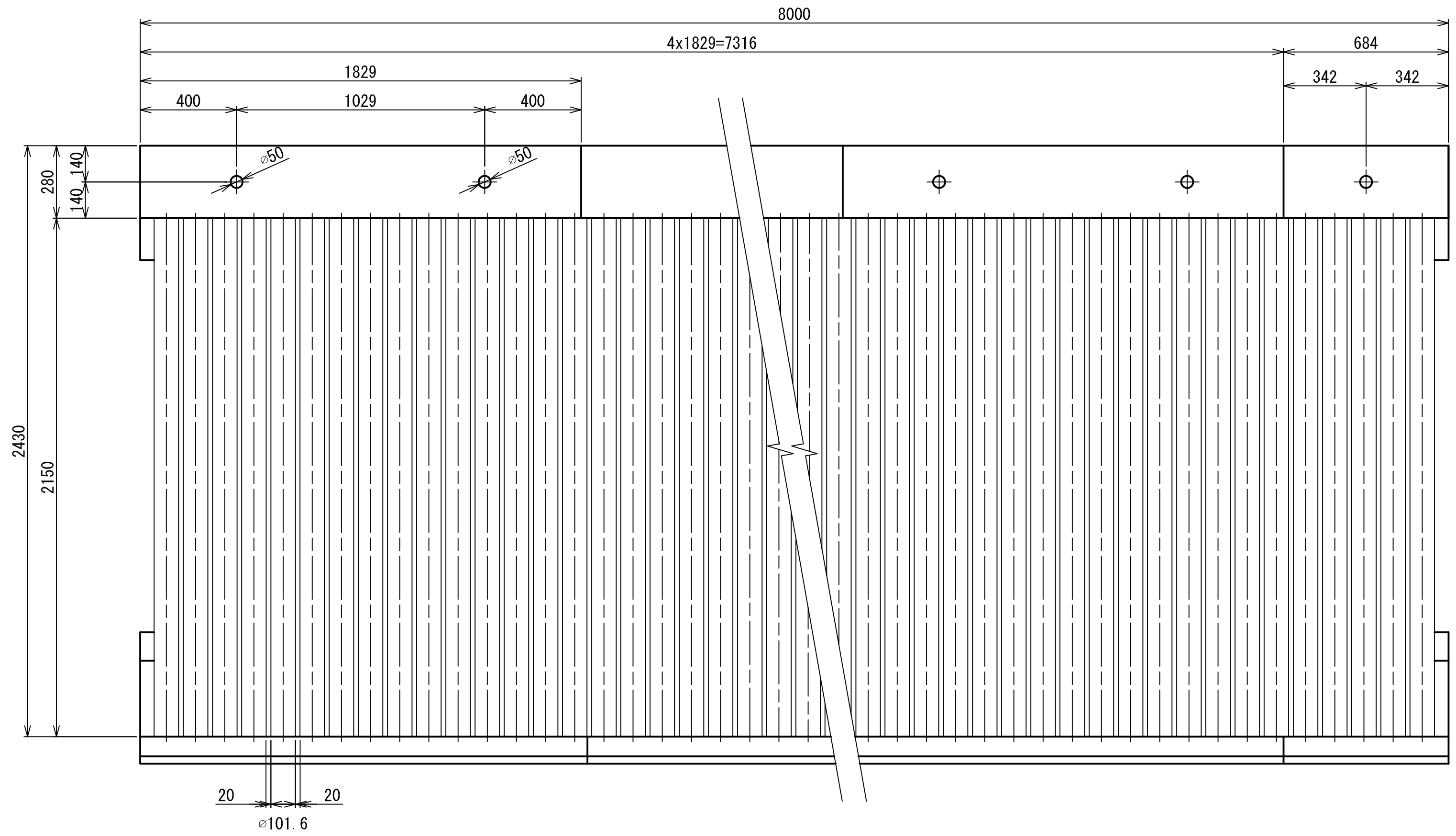
SCALE C 0 0.1 0.2 0.5 m

| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | BAJURA POWER STATION INTAKE SAND FLUSH GATE | MHI-014 | NIPPON KOEI CO.,LTD. |




FITTING DETAIL PLAN OF BAR SCREEN

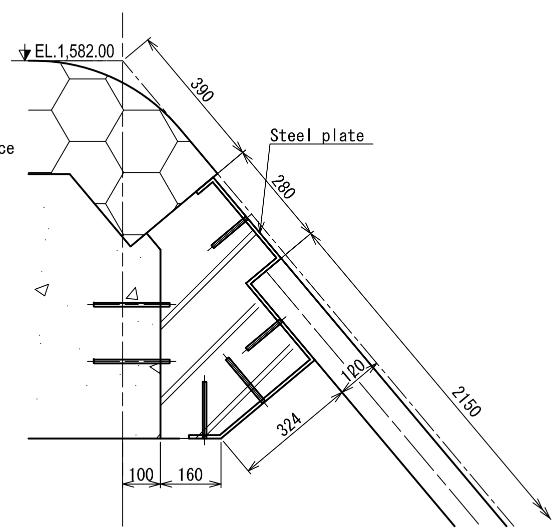
SCALE A




VIEW A

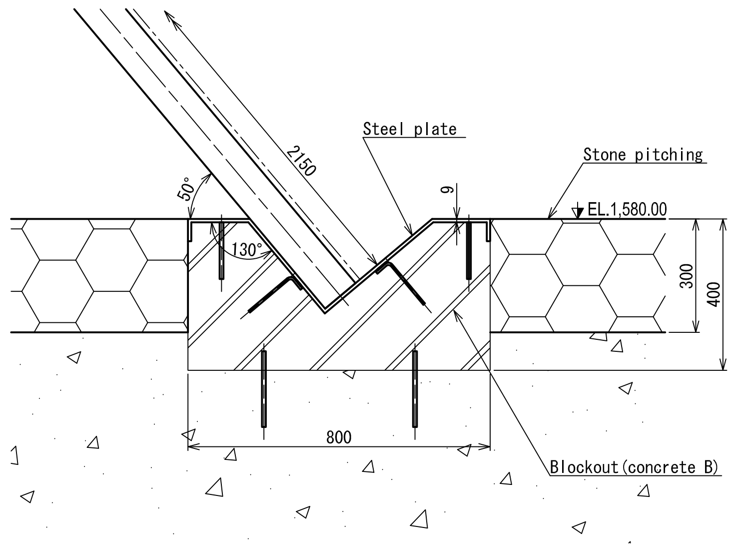
SCALE A

Note:Steel pipe for bar screen
JIS G 3454 Carbon steel pipes for pressure service
STPG410 90A Outer dia 101.6mm, Thickness 5.7mm




DETAIL B

SCALE B



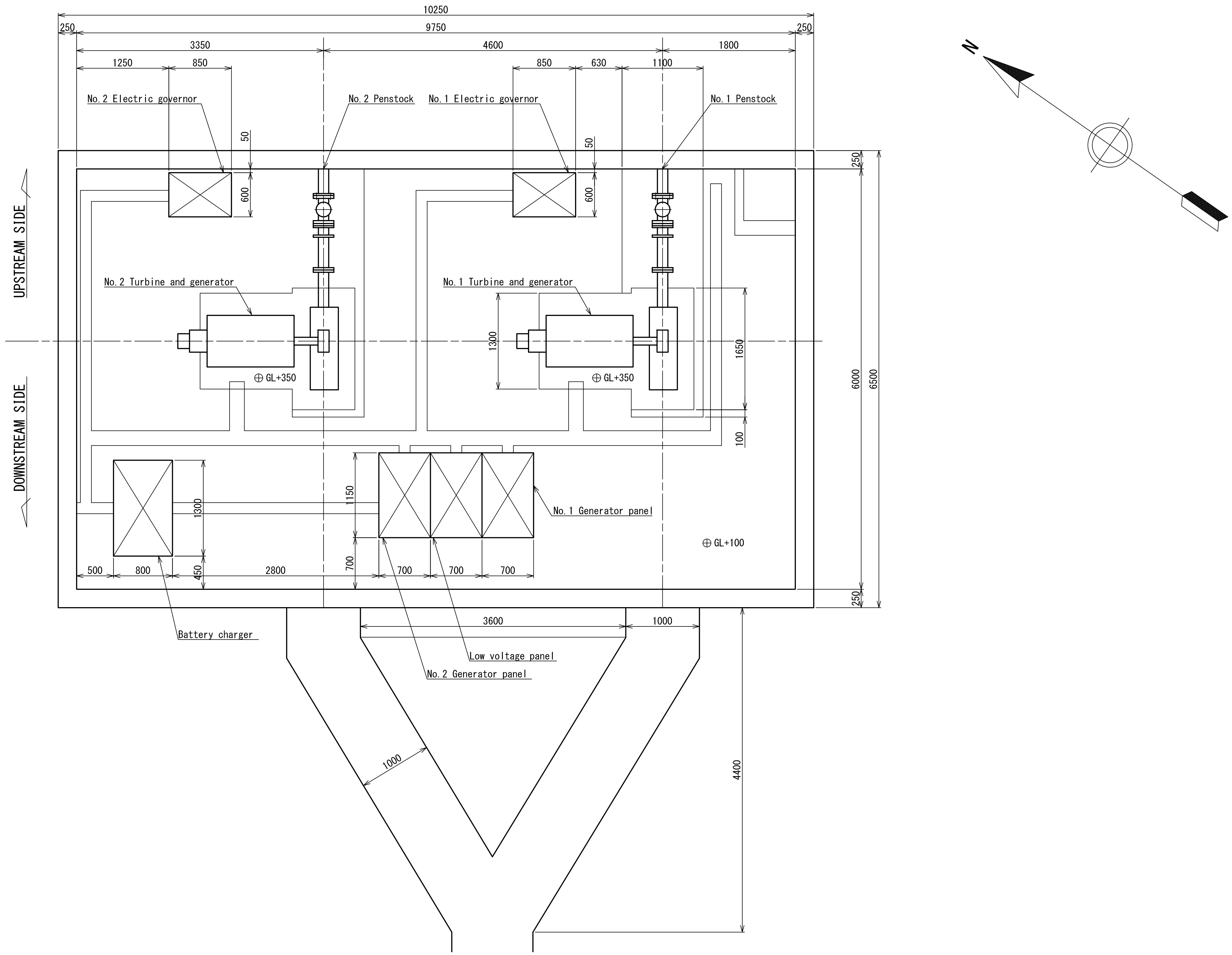

DETAIL C

SCALE B

SCALE A 0 0.15 0.3 0.75 m

SCALE B 0 0.1 0.2 0.5 m

| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO—HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | BAJURA POWER STATION INTAKE BAR SCREEN | MHI-015 | NIPPON KOEI CO.,LTD. |

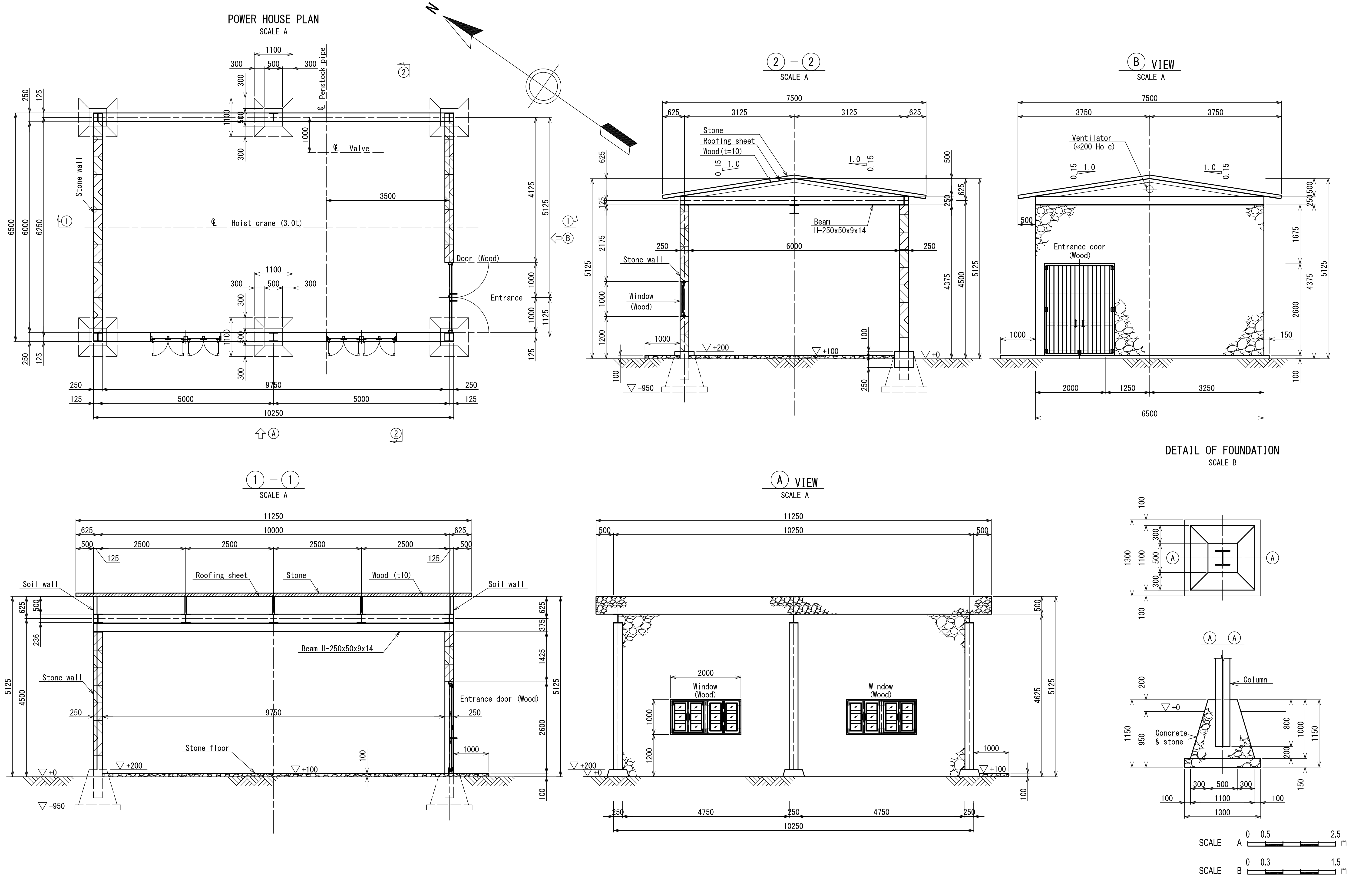



GENERAL LAYOUT OF POWER HOUSE

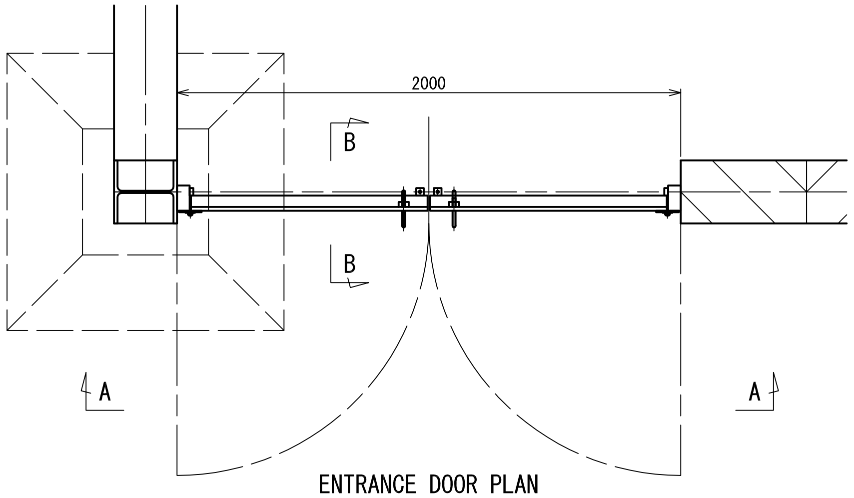
SCALE A

SCALE A 0 0.3 1.5 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO−HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: BAJURA POWER STATION GENERAL LAYOUT | DRAW. NO.: MHI-016 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|

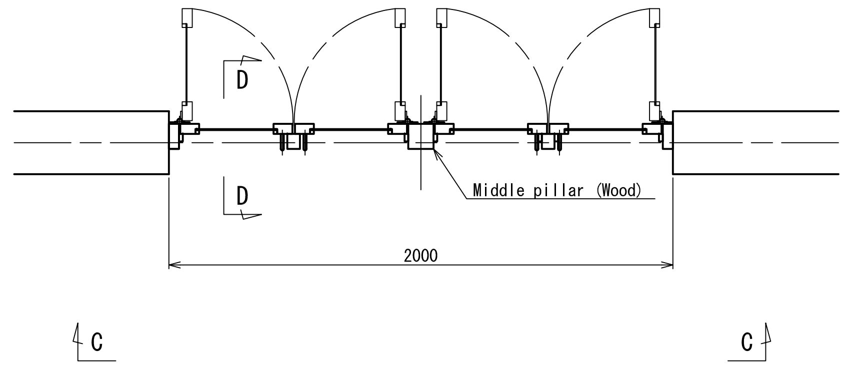



| | | | | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE<br>BAJURA POWER STATION<br>POWER HOUSE(1) | DRAW. NO.<br>MHI-017 | NIPPON KOEI CO.,LTD. |



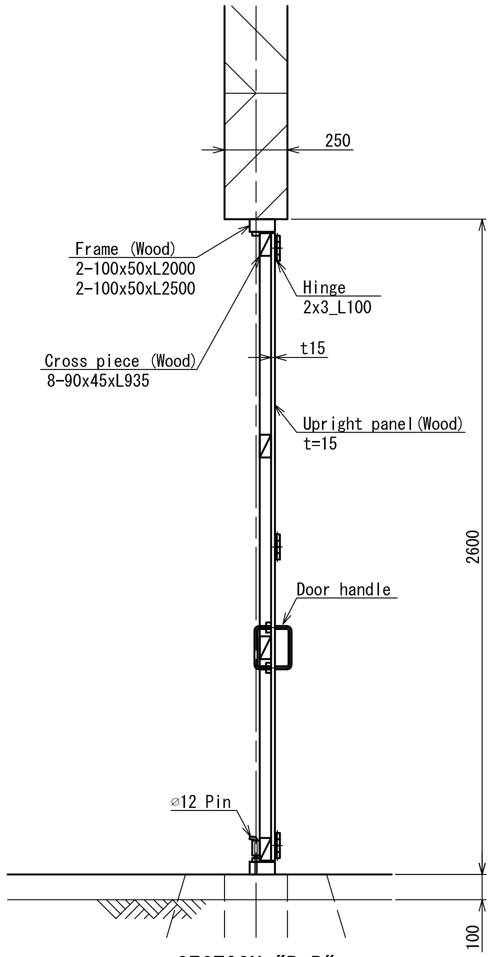

ENTRANCE DOOR PLAN

SCALE A



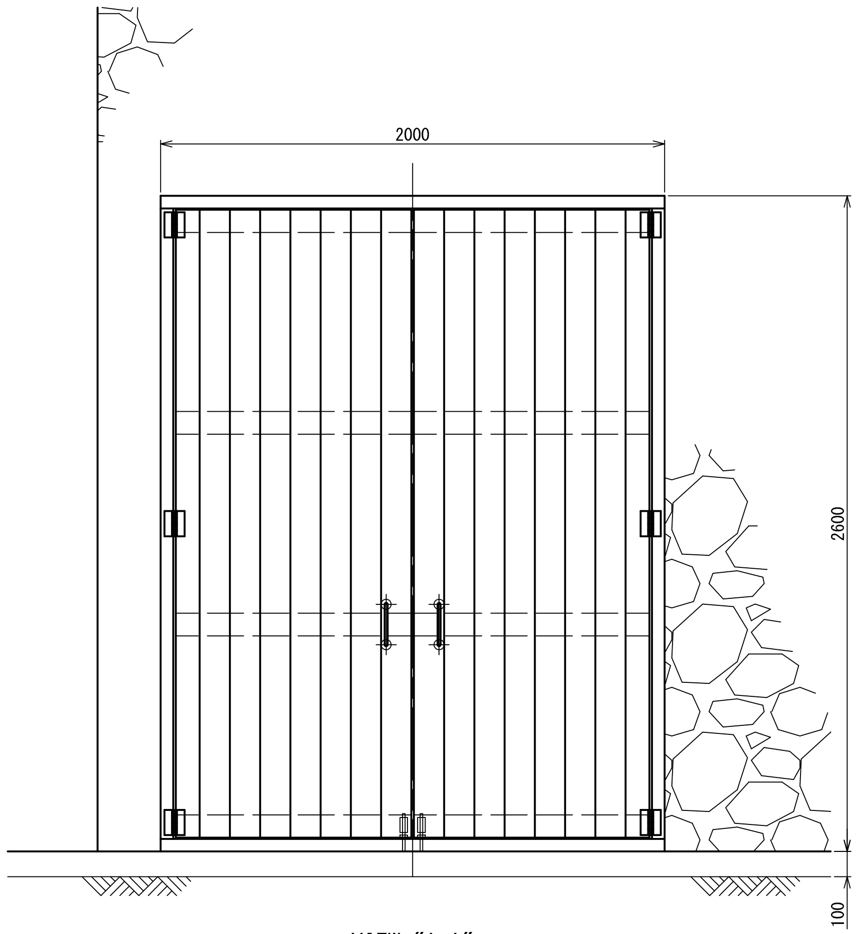

WINDOW PLAN

SCALE A



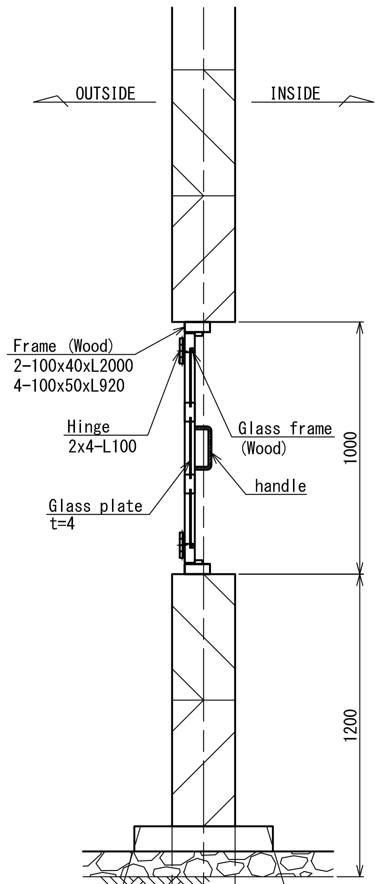

SECTION "B-B"

SCALE A



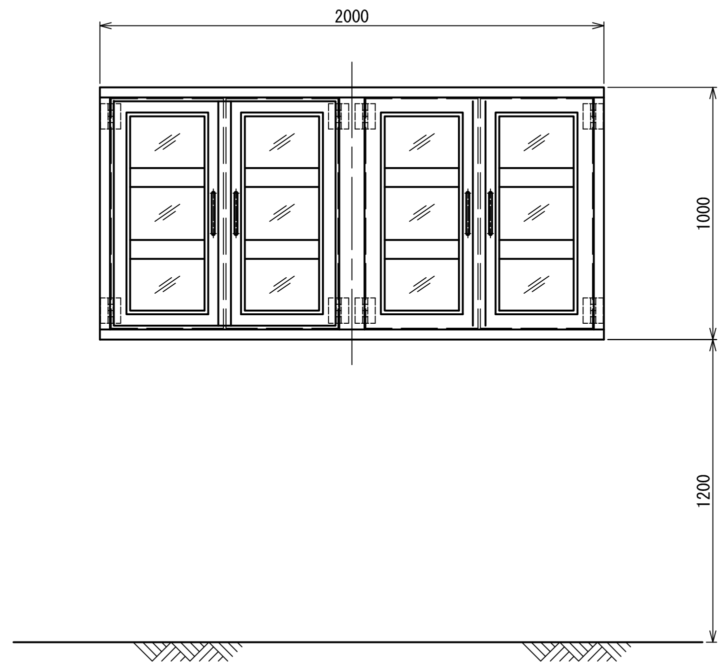

VIEW "A-A"

SCALE A




SECTION "D-D"

SCALE A

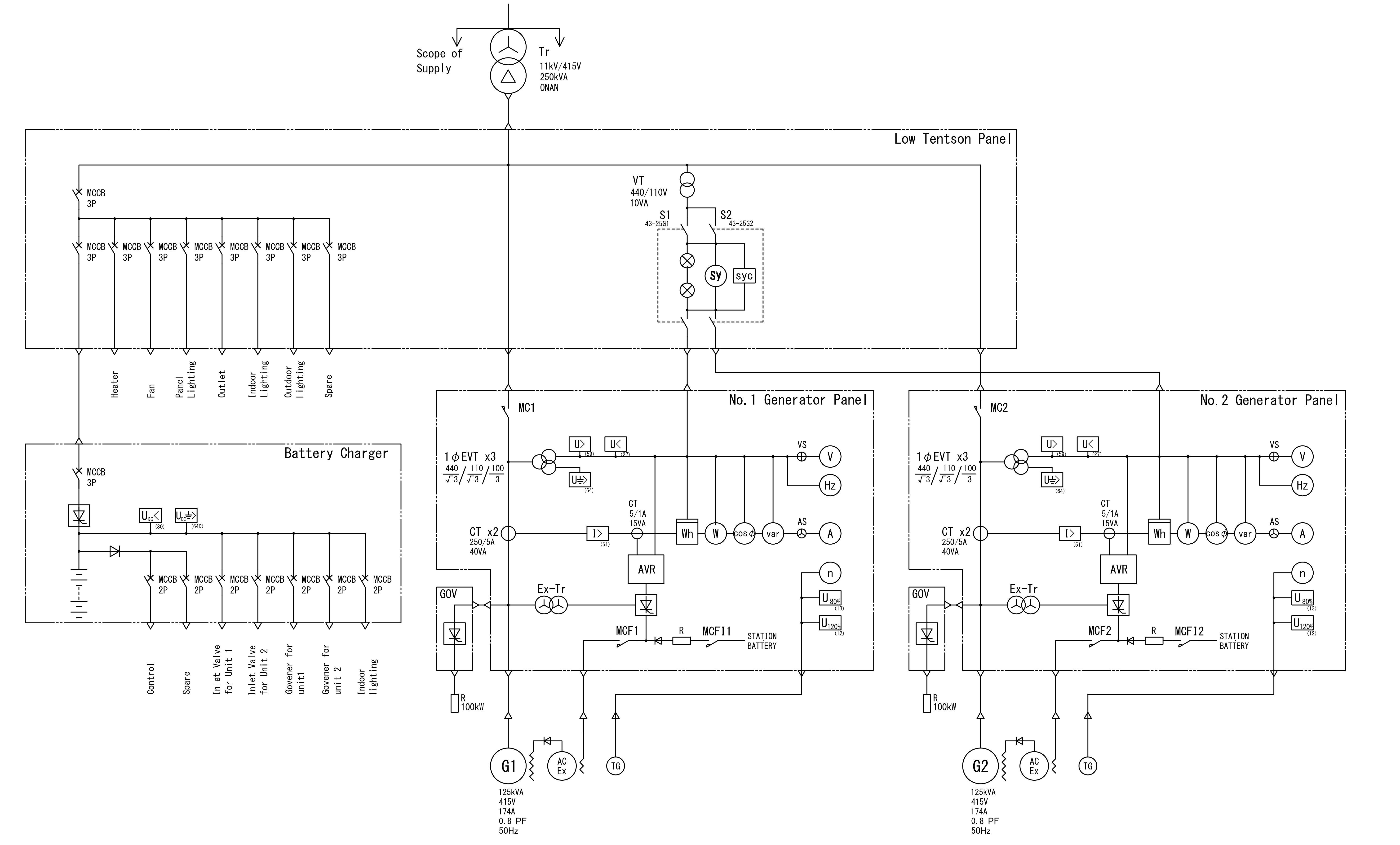



VIEW "C-C"

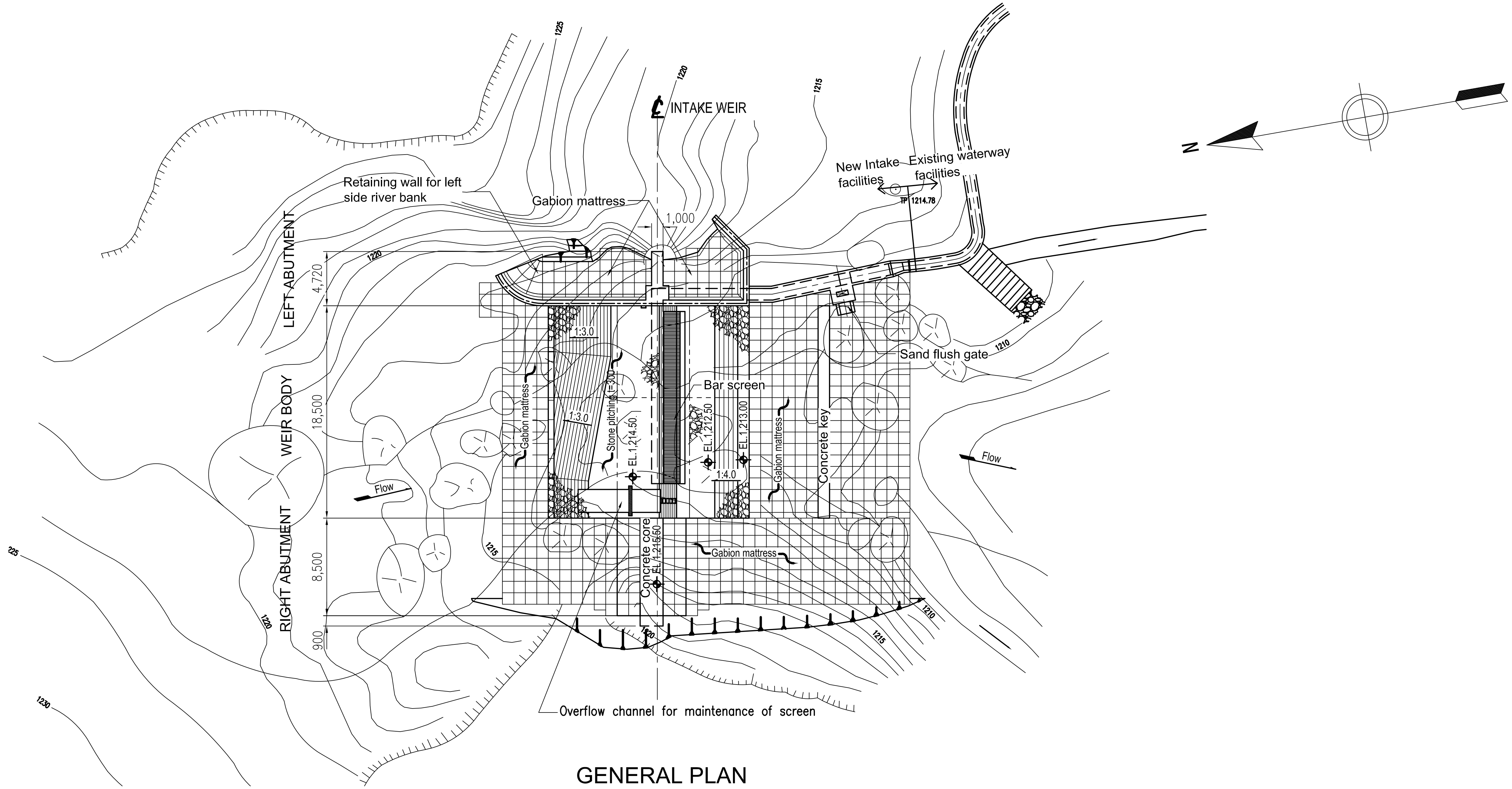
SCALE A

SCALE A 0 0.15 7.5 m

| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO－HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | BAJURA POWER STATION POWER HOUSE(2) | MHI-018 | NIPPON KOEI CO.,LTD. |

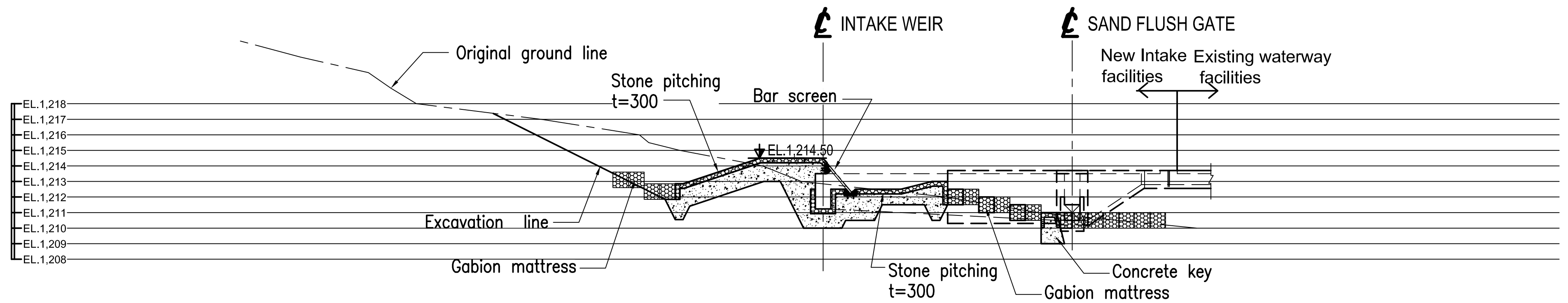



| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO－HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | BAJURA POWER STATION SINGLE LINE DIAGRAM | MHI-019 | NIPPON KOEI CO.,LTD. |




GENERAL PLAN

SCALE A

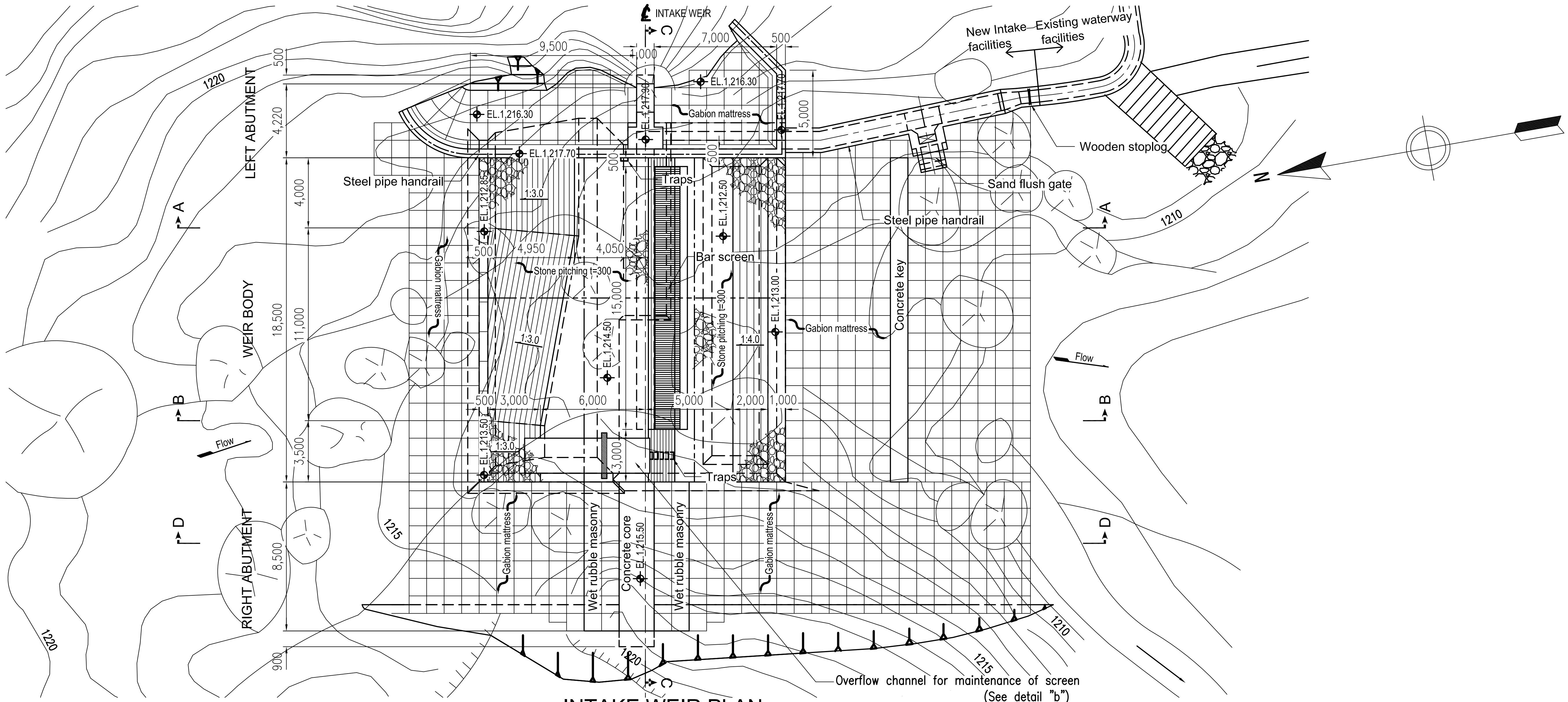



PROFILE

SCALE A

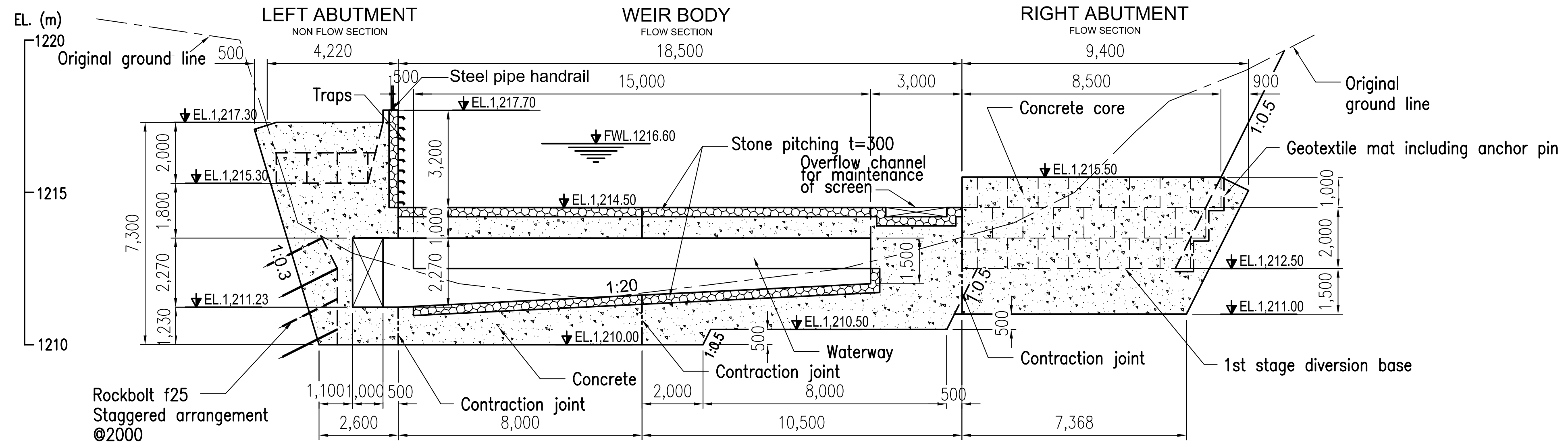
SCALE A 0 2.0 4.0 10.0 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: SYARPUDAHA POWER STATION INTAKE GENERAL PLAN | DRAW. NO.: MHI-020 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|




# INTAKE WEIR PLAN

SCALE A



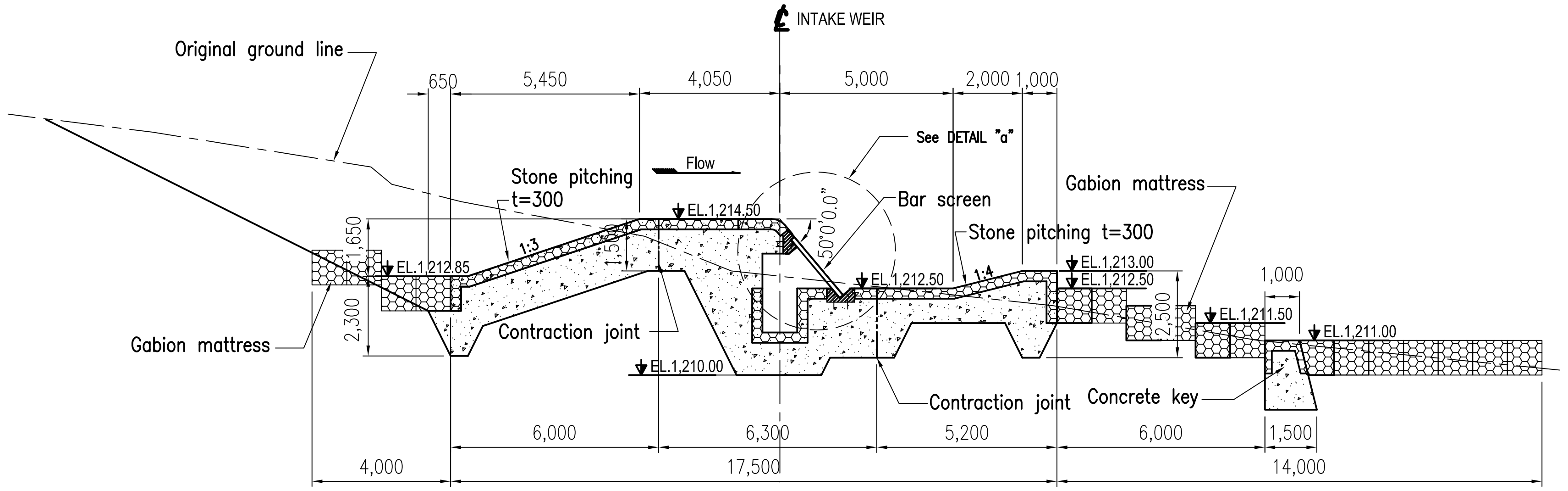

# SECTION C-C

SCALE B

SCALE A 0 1.25 2.5 6.25 m

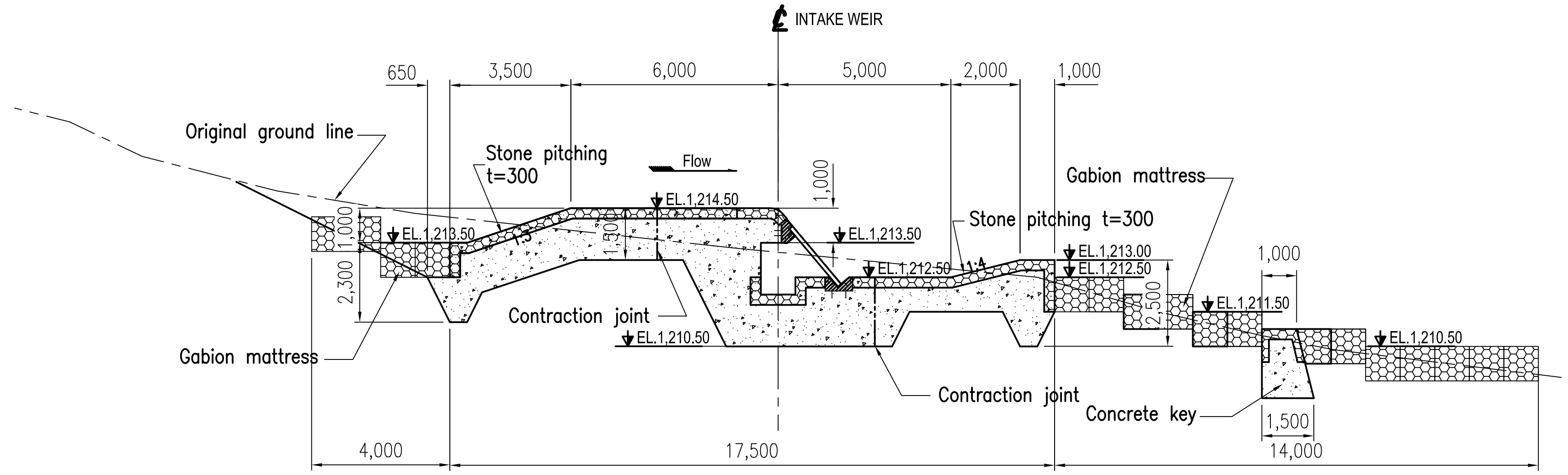
SCALE B 0 1.0 2.0 5.0 m

| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | SYARPUDAHA POWER STATION INTAKE WEIR (1) | MHI-021 | NIPPON KOEI CO.,LTD. |



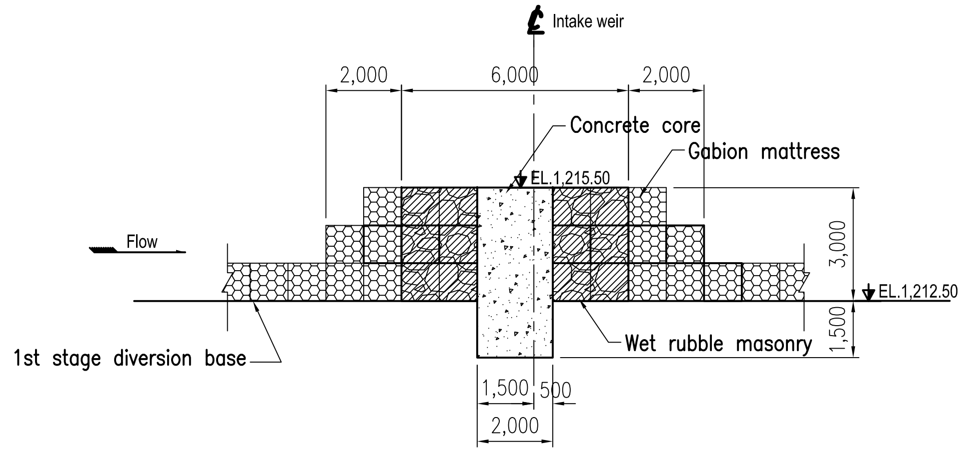

# SECTION A-A

SCALE A



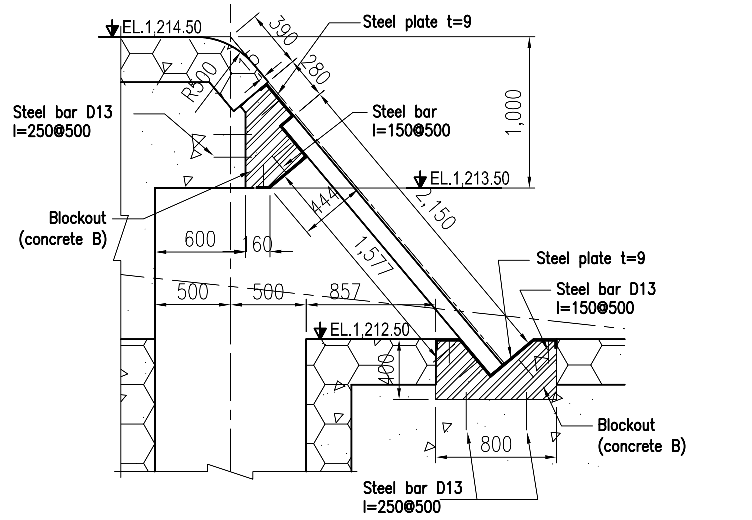

# SECTION B-B

SCALE A



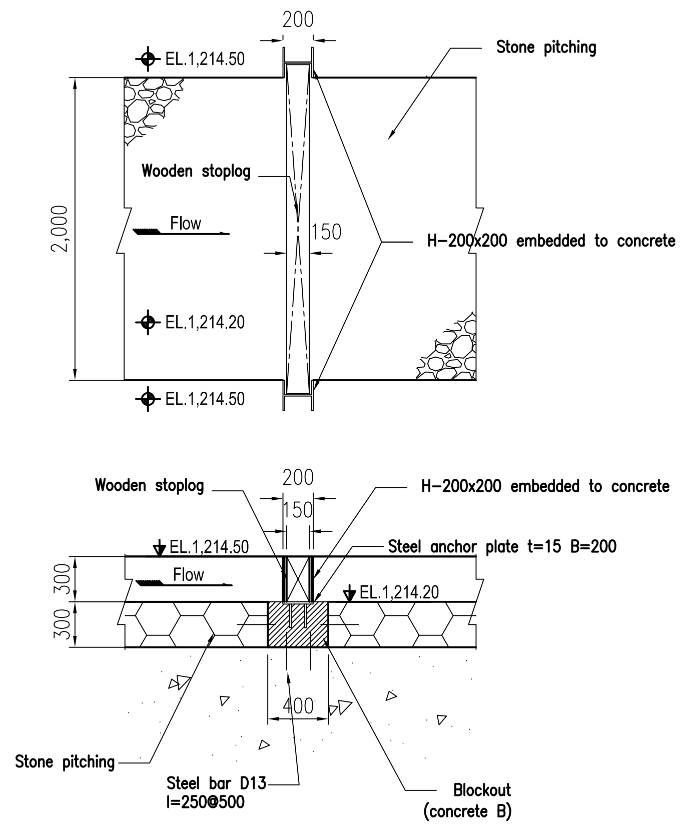

# SECTION D-D

SCALE A




# DETAIL "a"

SCALE B



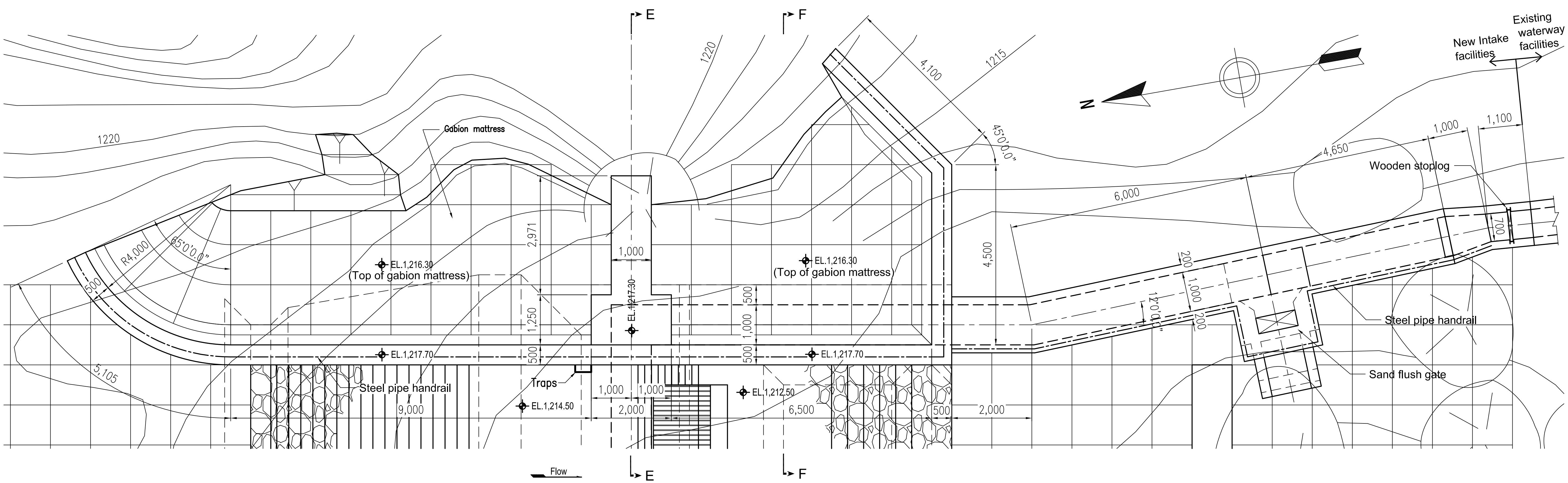

OVERFLOW CHANNEL FOR
MAINTENANCE OF SCREEN

# DETAIL "b"

SCALE B

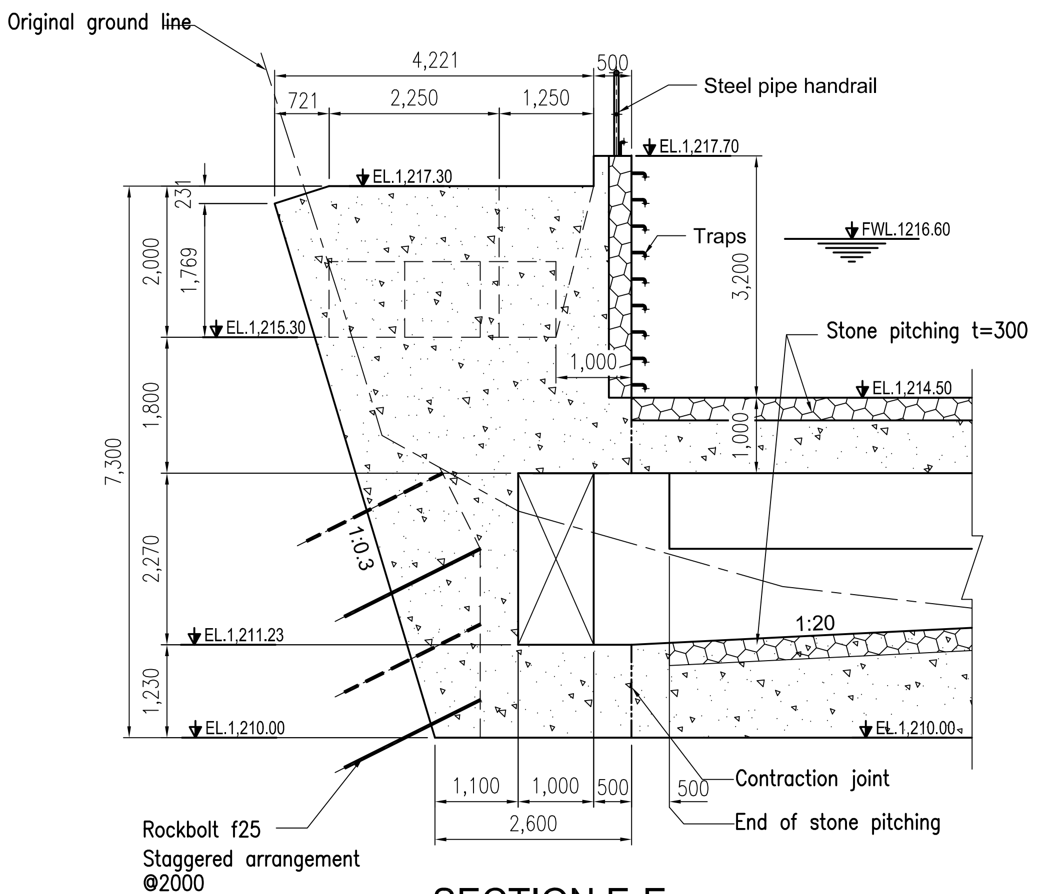
SCALE A 0 1.0 2.0 5.0 m
SCALE B 0 0.25 0.5 1.25 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: SYARPUDAHA POWER STATION INTAKE WEIR (2) | DRAW. NO.: MHI-022 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|



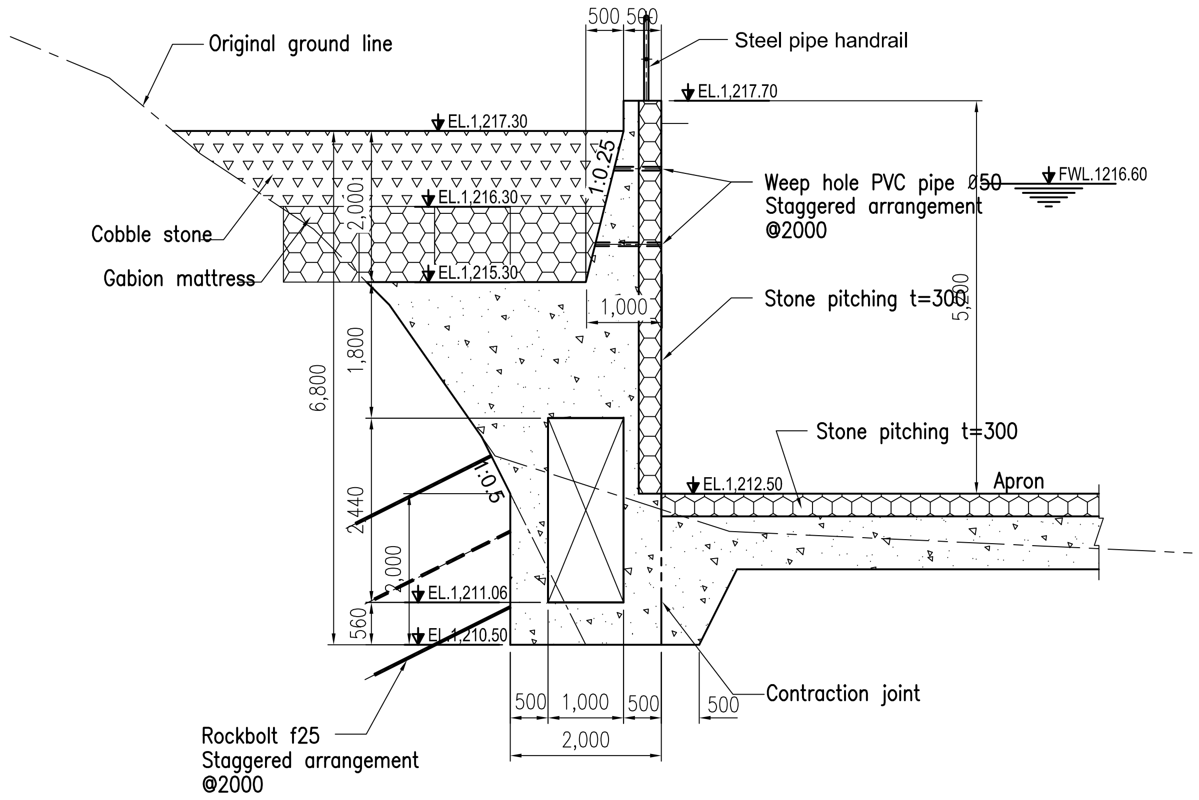

# LEFT ABUTMENT PLAN

SCALE A




## SECTION E-E

SCALE A

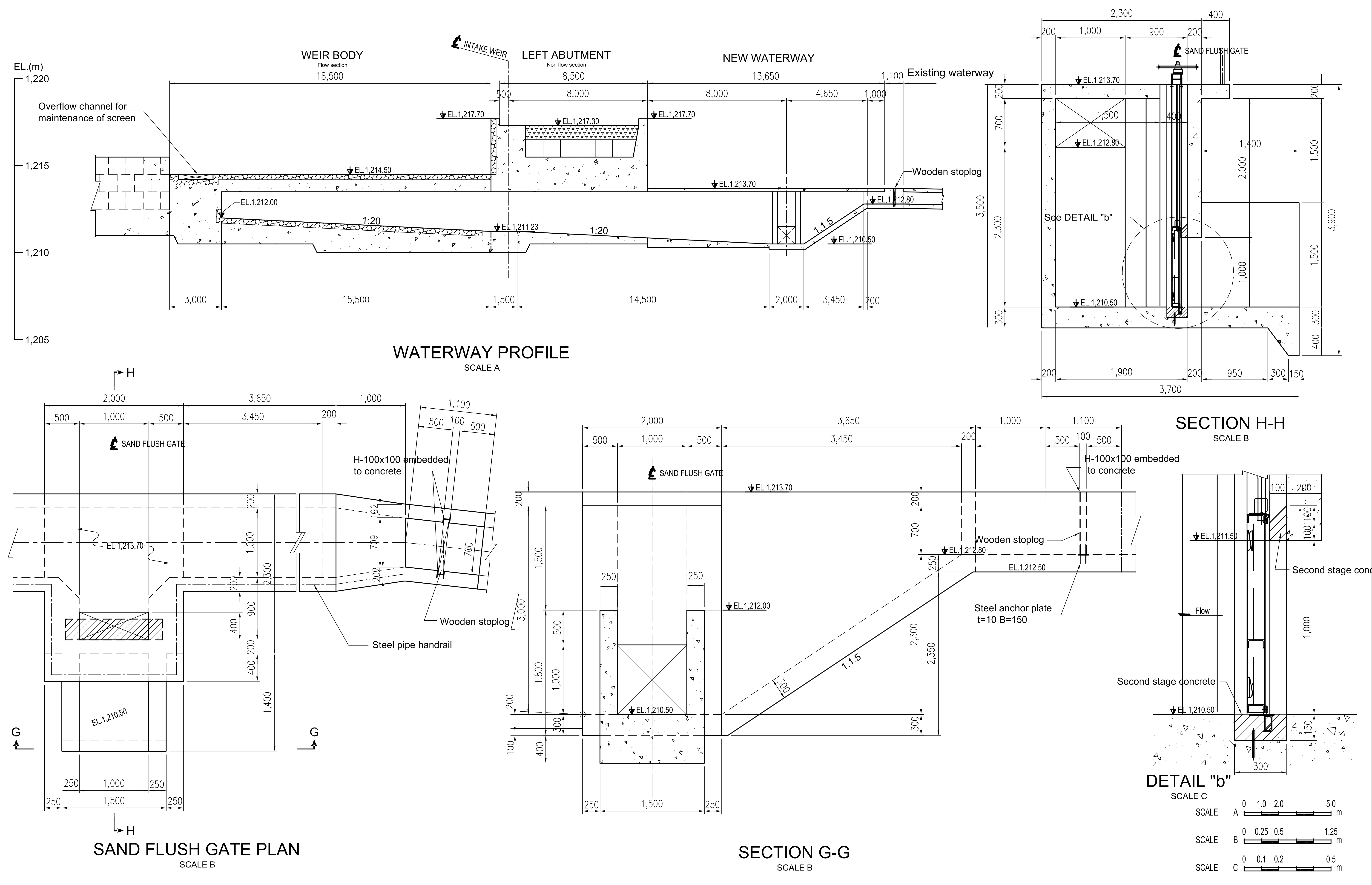



## SECTION F-F

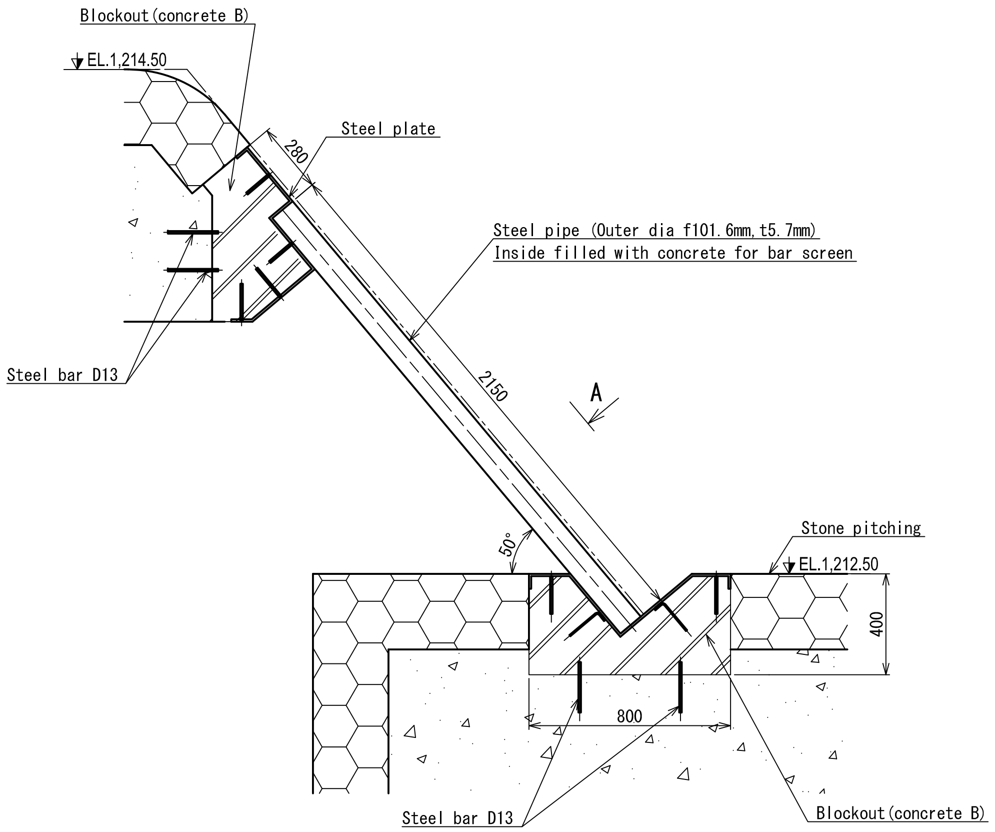
SCALE A

SCALE A 0 0.5 1.0 2.5 m

| | | DRAWING TITLE | DRAW. NO. | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | SYARPUDAHA POWER STATION INTAKE LEFT ABUTMENT | MHI-023 | NIPPON KOEI CO.,LTD. |

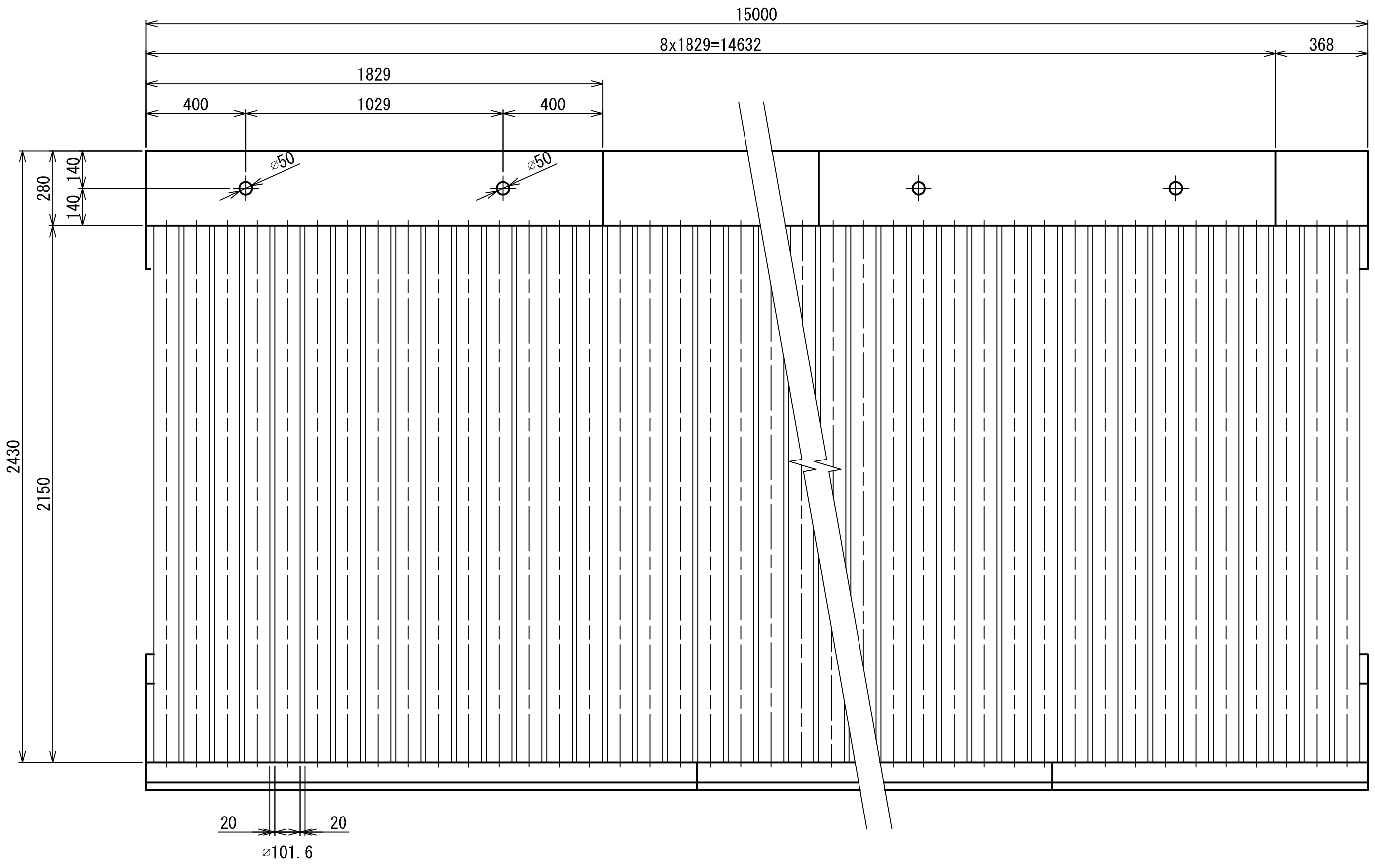



| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: SYARPUDAHA POWER STATION INTAKE SAND FLUSH GATE | DRAW. NO.: MHI-024 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|




FITTING DETAIL PLAN OF BAR SCREEN

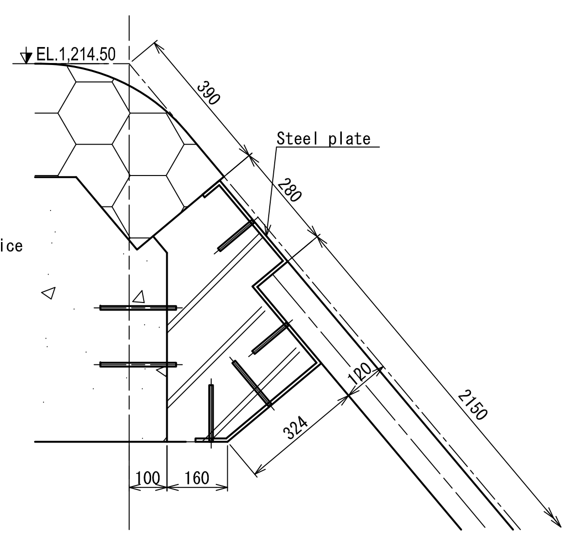
SCALE A




VIEW A

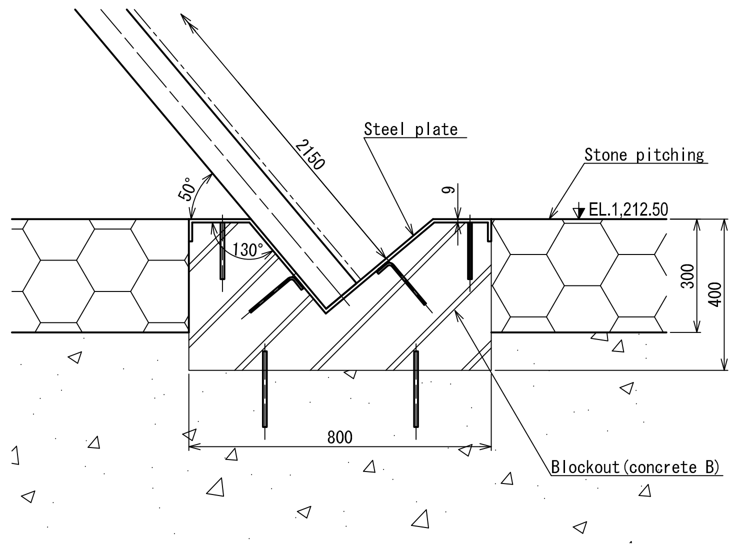
SCALE A

Note:Steel pipe for bar screen
JIS G 3454 Carbon steel pipes for pressure service
STPG410 90A Outer dia 101.6mm, Thickness 5.7mm




DETAIL B

SCALE B



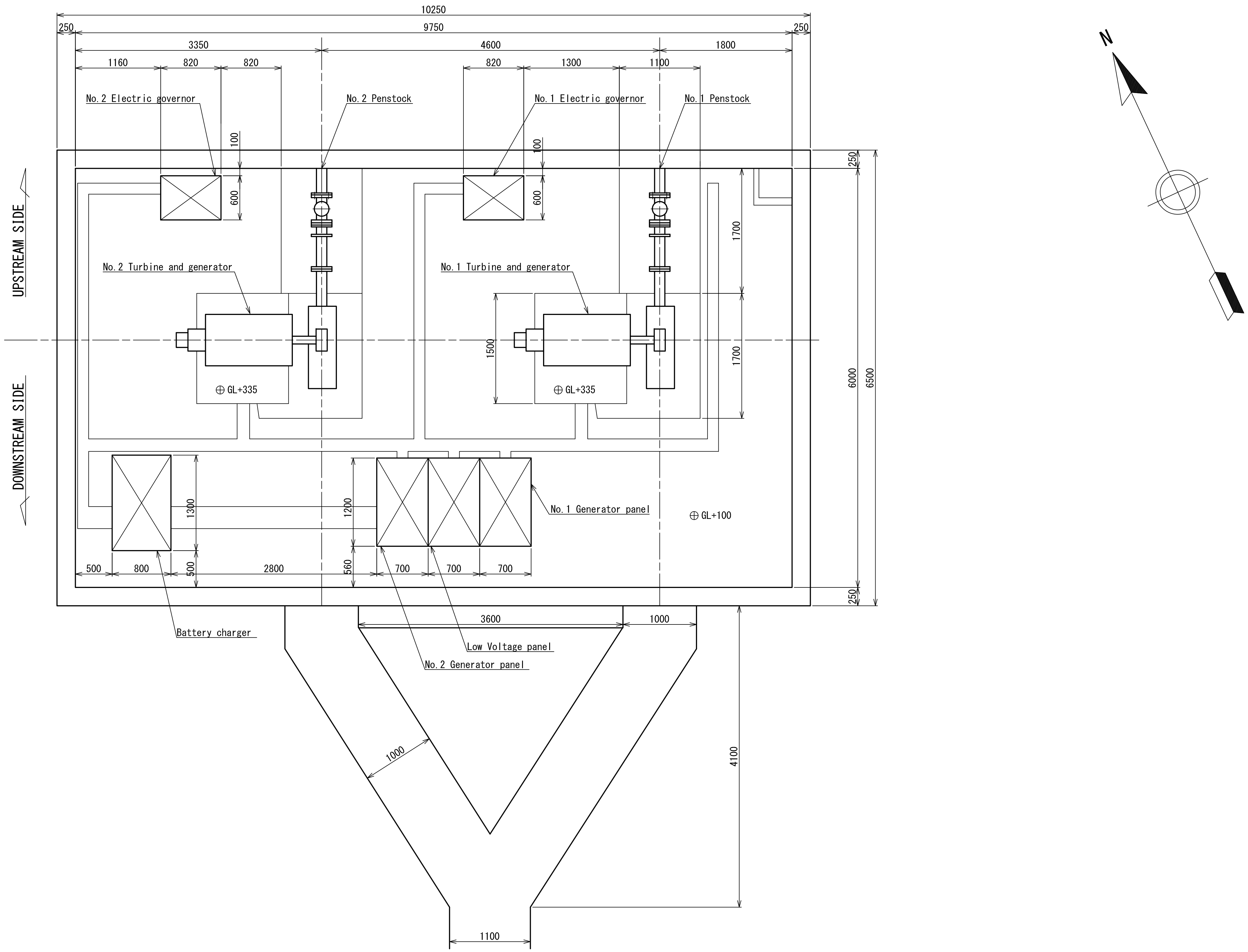

DETAIL C

SCALE B

SCALE A 0 0.15 0.3 0.75 m

SCALE B 0 0.1 0.2 0.5 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: SYARPUDAHA POWER STATION INTAKE BAR SCREEN | DRAW. NO.: MHI-025 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|

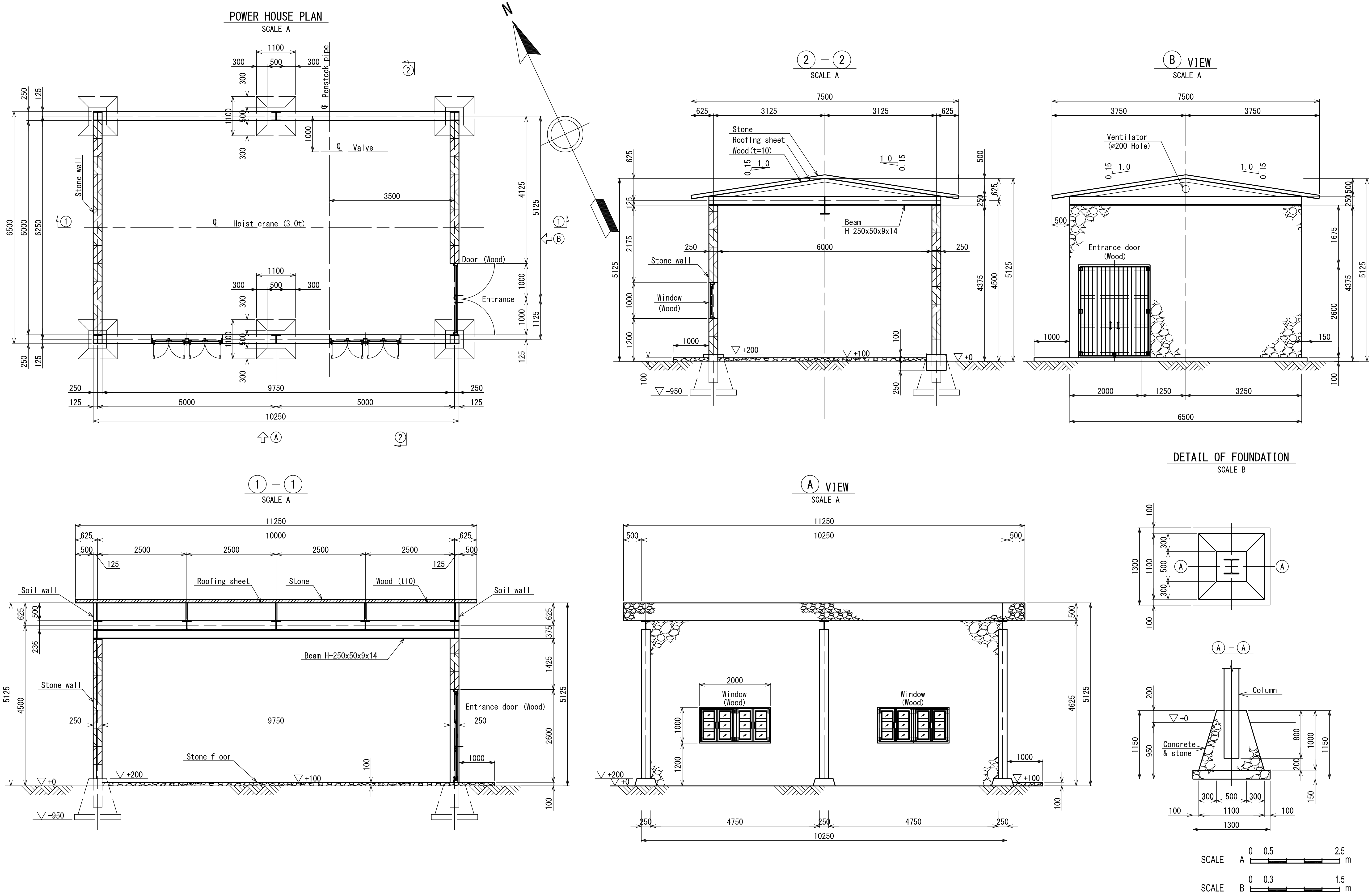



GENERAL LAYOUT OF POWER HOUSE

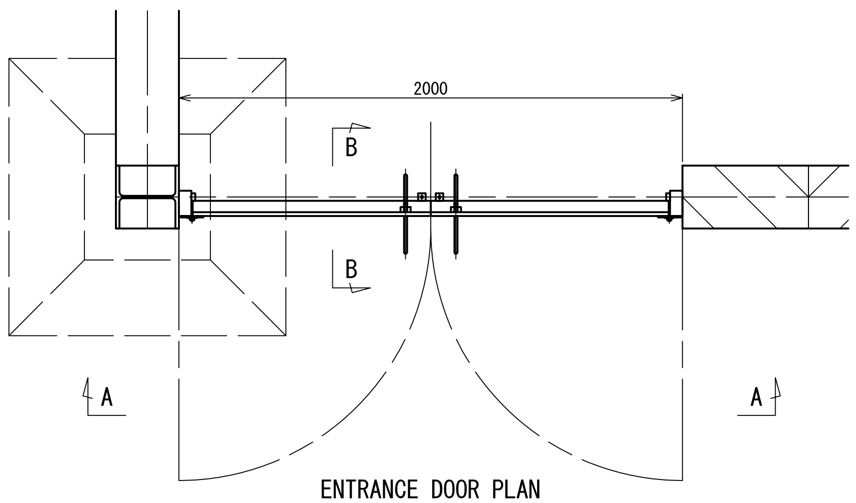
SCALE A

SCALE A 0 0.3 1.5 m

| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO－HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: SYARPUDAHA POWER STATION GENERAL LAYOUT | DRAW. NO.: MHI-026 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|

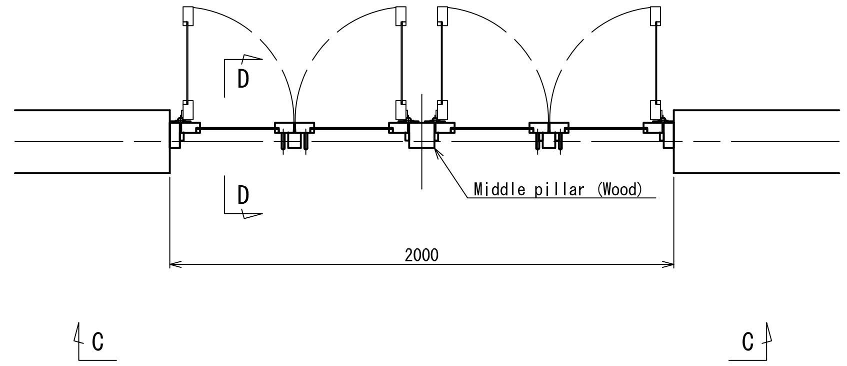



| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO−HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE: SYARPUDAHA POWER STATION POWER HOUSE(1) | DRAW. NO.: MHI-027 | NIPPON KOEI CO.,LTD. |
|---|---|---|---|---|



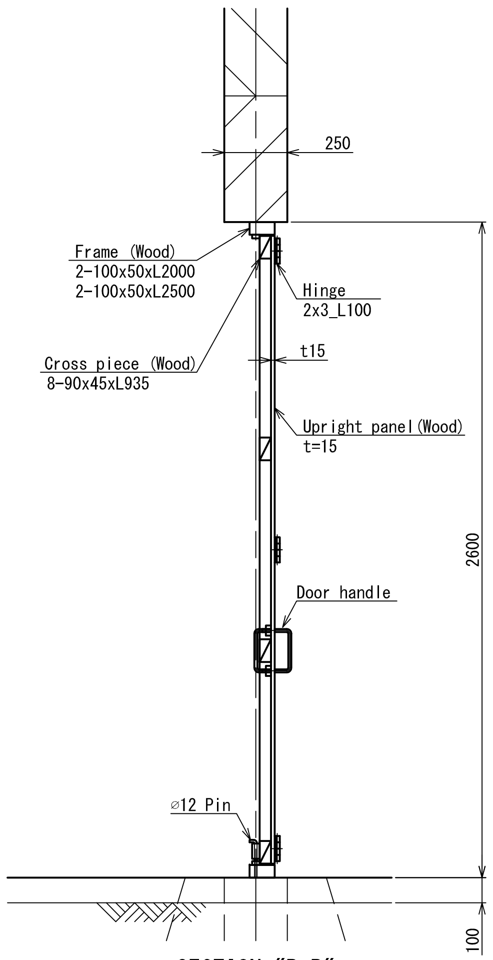

ENTRANCE DOOR PLAN

SCALE A



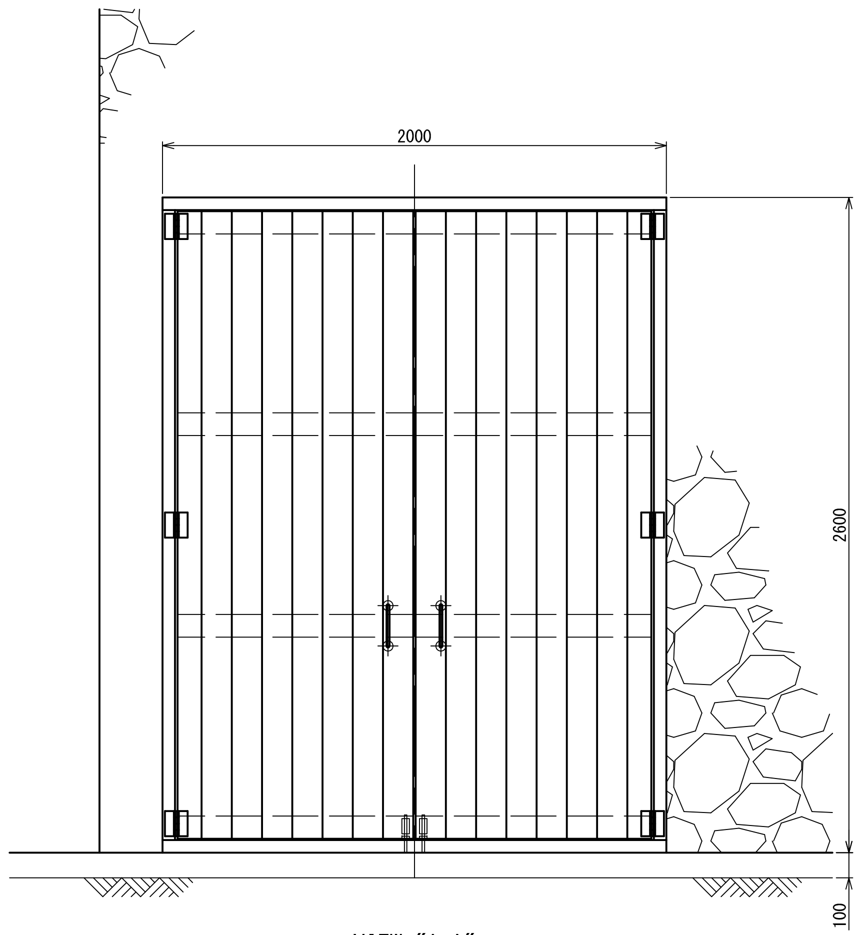

WINDOW PLAN

SCALE A



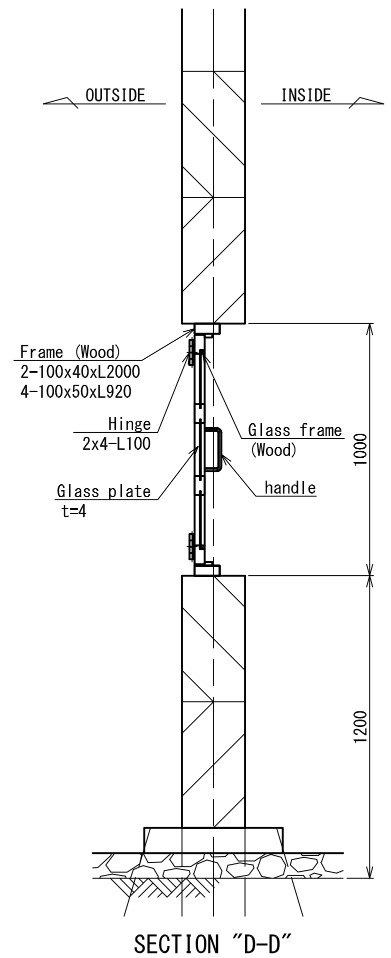

SECTION "B-B"

SCALE A



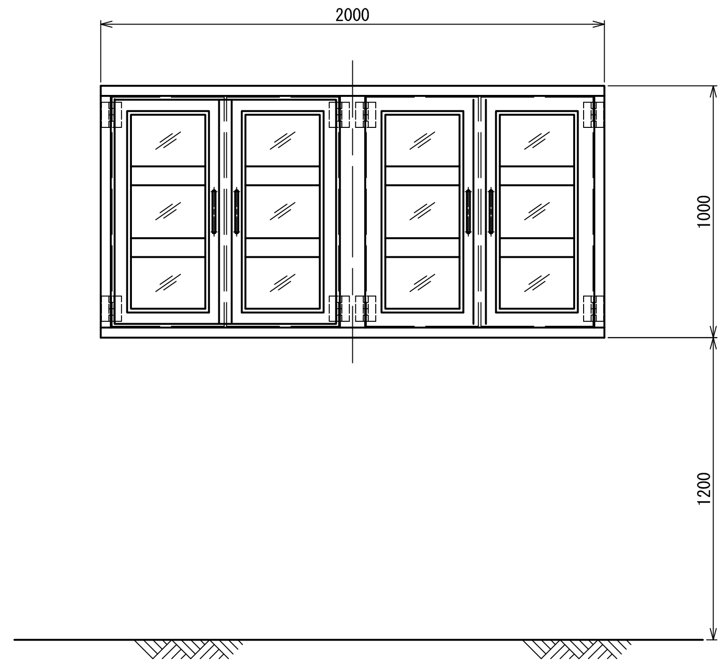

VIEW "A-A"

SCALE A



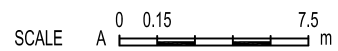

SECTION "D-D"

SCALE A

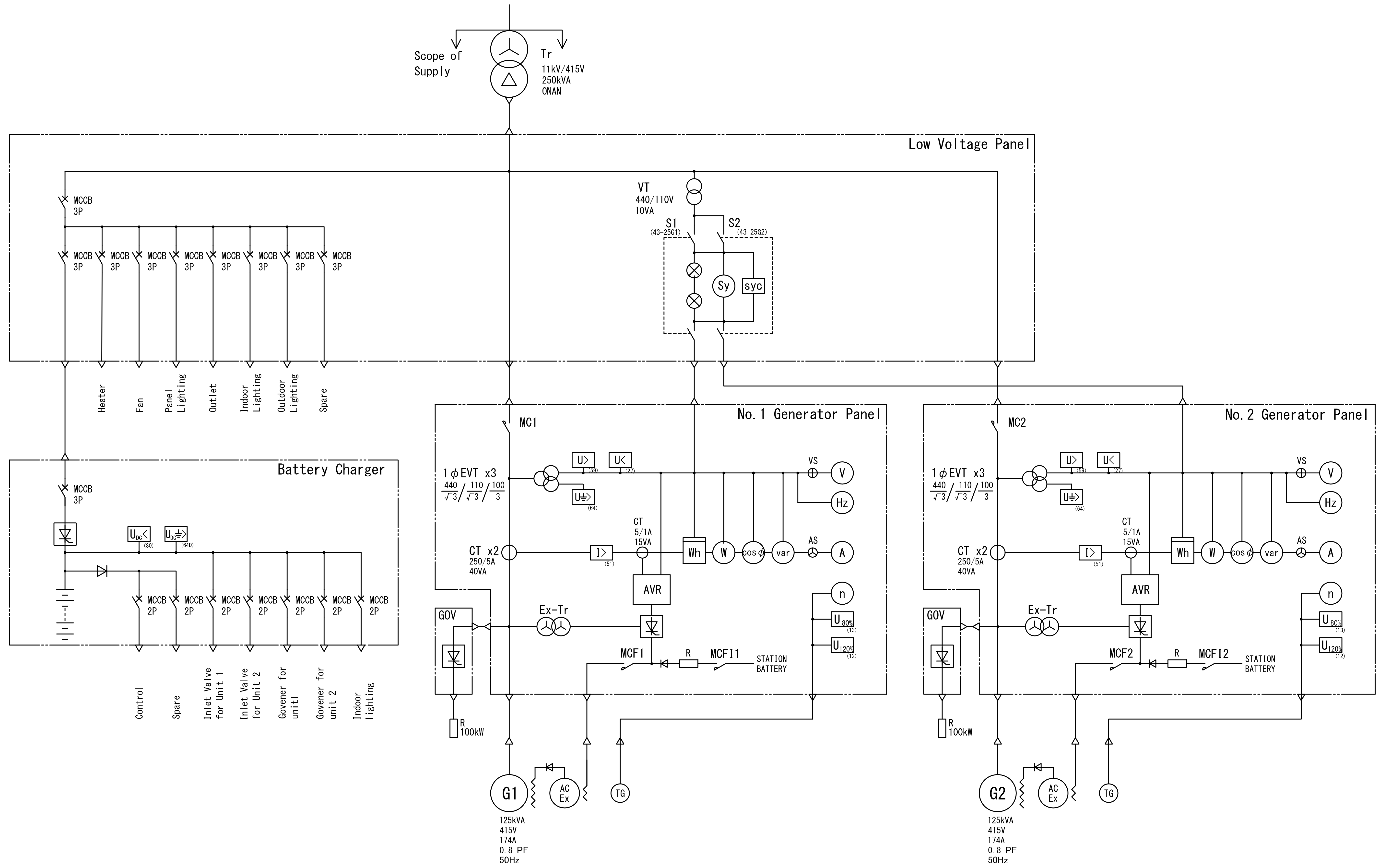



VIEW "C-C"

SCALE A




| | | | | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO−HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE<br>SYARPUDAHA POWER STATION<br>POWER HOUSE(2) | DRAW. NO.<br>MHI-028 | NIPPON KOEI CO.,LTD. |




| | | | | |
|---|---|---|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PREPARATORY SURVEY ON MICRO－HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL | DRAWING TITLE<br>SYARPUDAHA POWER STATION SINGLE LINE DIAGRAM | DRAW. NO.<br>MHI-029 | NIPPON KOEI CO.,LTD. |

# Appendices

# Appendix-1 Member List of the Survey Team

Member List of the Survey Team

First Site Survey

| No. | In Charge | Name | Organization |
|---|---|---|---|
| 1 | Team Leader | Kazunari OSHIMA | Visiting Senior Advisor, JICA |
| 2. | Study Planning | Hidetaka KOSEKI | Energy and Mining Division I, Energy and Mining Group Industrial Development and Public Policy Department, JICA |
| 3. | Chief Consultant | Kenji SETO | Nippon Koei Co., Ltd. |
| 4. | Electrical/Protection & Control | Takamichi HASEGAWA | Nippon Koei Co., Ltd. |
| 5. | Mechanical Equipment Planning | Arata YAMAGUCHI | Nippon Koei Co., Ltd. |
| 6. | Hydrology/Hydrological Observation | Tokuaki KAWAGUCHI | Nippon Koei Co., Ltd. |
| 7. | Civil Design | Toshio KAWAGOE | Nippon Koei Co., Ltd. |
| 8. | Procurement Planning/Cost Estimation | Kazumasa YAZAWA | Nippon Koei Co., Ltd. |
| 9. | Coordination/Cost Estimation | Kazuo SUGANUMA | Nippon Koei Co., Ltd. |

Second Site Survey

| No. | In Charge | Name | Organization |
|---|---|---|---|
| 1. | Chief Consultant | Kenji SETO | Nippon Koei Co., Ltd. |
| 2. | Electrical/Protection & Control | Takamichi HASEGAWA | Nippon Koei Co., Ltd. |
| 3. | Mechanical Equipment Planning | Arata YAMAGUCHI | Nippon Koei Co., Ltd. |
| 4. | Hydrology/Hydrological Observation | Tokuaki KAWAGUCHI | Nippon Koei Co., Ltd. |
| 5. | Civil Design | Toshio KAWAGOE | Nippon Koei Co., Ltd. |
| 6. | Environmental and Social Considerations | Tetsujiro TANAKA | Nippon Koei Co., Ltd. |
| 7. | Economics/Financial Analysis | Mika MATSUMURA | Nippon Koei Co., Ltd. |
| 8. | Construction Planning/Cost Estimation | Katsumi KUROKI | Nippon Koei Co., Ltd. |
| 9. | Coordination/Cost Estimation | Kazuo SUGANUMA | Nippon Koei Co., Ltd. |

Third Site Survey

| No. | In Charge | Name | Organization |
|---|---|---|---|
| 1. | Team Leader | Toru KOBAYAKAWA | Advisor<br>Energy and Mining Division I,<br>Energy and Mining Group<br>Industrial Development and<br>Public Policy Department, JICA |
| 2. | Study Planning | Hidetaka KOSEKI | Energy and Mining Division I,<br>Energy and Mining Group<br>Industrial Development and<br>Public Policy Department, JICA |
| 3. | Chief Consultant | Kenji SETO | Nippon Koei Co., Ltd. |
| 4. | Electrical/Protection & Control | Takamichi HASEGAWA | Nippon Koei Co., Ltd. |
| 5. | Environmental and Social Considerations | Tetsujiro TANAKA | Nippon Koei Co., Ltd. |

Appendix-2 Survey Schedule

Survey Schedule
First Site Survey

| Date | | Schedule | |
|---|---|---|---|
| 28-Jul | Sun | JICA P.M.: Arrival at KTM | |
| 29-Jul | Mon | JICA<br>A.M.: Courtesy call to JICA Nepal Office<br>P.M.: Explanation of the Grant Aid Project and M/D at NEA Office | Consultant<br>P.M.: Arrival at KTM<br><br>P.M.: Explanation of the Grant Aid Project and M/D at NEA Office |
| 30-Jul | Tue | Meeting at JICA Nepal Office<br>Explanation and discussion of Inception Report at NEA Office | |
| 31-Jul | Wed | Preparation of Minutes of Discussion | |
| 1-Aug | Thu | Signing Minutes of Discussion at NEA office, | |
| 2-Aug | Fri | JICA Travel: KTM⇒TYO | Consultant Collection of data |
| 3-Aug | Sat | Arrival at TYO | - ditto - |
| 4-Aug | Sun | Collection of documents and data | |
| 5-Aug | Mon | - ditto - | |
| 6-Aug | Tue | - ditto - | |
| 7-Aug | Wed | - ditto - | |
| 8-Aug | Thu | - ditto - | |
| 9-Aug | Fri | A.M.: Arrival at KTM, P.M.: Courtesy call to JICA Nepal office | |
| 10-Aug | Sat | Preparation of site survey | |
| 11-Aug | Sun | Site survey for Syarpudaha P/S | |
| 12-Aug | Mon | Discontinuance of site survey due to road condition | |
| 13-Aug | Tue | Travel to Nepalgunj, Meeting with person from Bajhang P/S | |
| 14-Aug | Wed | Meeting at NEA Nepalgunj Office | |
| 15-Aug | Thu | Travel to Kathmandu | |
| 16-Aug | Fri | Study about plan of project | |
| 17-Aug | Sat | - ditto - | |
| 18-Aug | Sun | Meeting at JICA KTM Office with person from NEA Attaria Office | |
| 19-Aug | Mon | Discussion survey results at NEA office | |
| 20-Aug | Tue | Study about site survey results | |
| 21-Aug | Wed | Meeting with person from Syarpudaha P/S | |
| 22-Aug | Thu | Site survey for Bajhang P/S | |
| 23-Aug | Fri | - ditto - | |
| 24-Aug | Sat | - ditto - | |
| 25-Aug | Sun | - ditto - | |
| 26-Aug | Mon | - ditto - | |
| 27-Aug | Tue | Meeting with DCS at NEA office, Reporting to JICA Nepal office | |
| 28-Aug | Wed | Travel: KTM⇒TYO | |
| 29-Aug | Thu | Arrival at TYO | |

Second Site Survey

| Date | | Schedule |
|---|---|---|
| 17-Oct | Thu | Travel: TYO → KTM |
| 18-Oct | Fri | P.M.: Arrival at KTM |
| 19-Oct | Sat | Meeting with local consultants |
| 20-Oct | Sun | Collection of data<br>Courtesy call to NEA office |
| 21-Oct | Mon | Collection of data |
| 22-Oct | Tue | Move: Kathmandu → Bajang P/S<br>Site survey |
| 23-Oct | Wed | Move: Chainpur → Dipayal |
| 24-Oct | Thu | Move: Dipayal → Martadi<br>Site survey for Bajura P/S |
| 25-Oct | Fri | Site survey for Bajura P/S<br>Move: Bahura P/S → Dipayal |
| 26-Oct | Sat | Move: Dipayal → Dhangadhi |
| 27-Oct | Sun | Move: Dhangadhi → Tulsipur/Gorahi |
| 28-Oct | Mon | Move: Tulsipur/Gorahi → Jumlikhalanga |
| 29-Oct | Tue | Site survey for Syarpudaha P/S |
| 30-Oct | Wed | Move: Jumlikhalanga → Tulsipur/Gorahi |
| 31-Oct | Thu | Move: Tulsipur/Gorahi → Kathmandu |
| 1-Nov | Fri | Reporting to NEA and JICA office |
| 2-Nov | Sat | Travel: KTM → TYO |
| 3-Nov | Sun | Arrival in TYO |

Third Site Survey

| Date | | Schedule |
|---|---|---|
| 17-Dec | Tue | Travel: TYO → KTM |
| 18-Dec | Wed | P.M.:Arrival at KTM |
| 19-Dec | Thu | (1) Meeting @ JICA Nepal office<br>(2) Meeting with NEA & MoE<br>- Explanation of Draft Final Report(DFR) and Minutes of Discussion (M/D) |
| 20-Dec | Fri | AM:<br>-Preparation of documents including DFR & M/D based on comments from NEA<br>PM:<br>- Sending Revised DFR & M/D |
| 21-Dec | Sat | AM: Signing of M/D w/ NEA & MOE<br>PM: Report to JICA Nepal OfficeMeeting with local consultants |
| 22-Dec | Sun | Travel: KTM → TYO |

# Appendix-3 List of Parties Concerned in the Recipient Country

## List of Parties Concerned in the Recipient Country

1 Ministry of Energy（MoE）
・Gokarna Raj Pantha, Senior Divisional Engineer (Hydropower)

2 NEA Kathmandu
・Mr. Upendra Dev Bhatta, Deputy Managing Director, Distribution and Consumer Services
・Mr. Surya Tamrakar, Deputy Manager
・Mr. Deepak Das Tamrakar, Assistant Manager
・Mr. Deepak Das Tamrakar, Asst. Manager, Civil Engineer
・Mr. Surya Ratna Tamrakar, Manager, Electrical Engineer

3 NEA Nepalgandhi Regional Office
・Mr. Vilayat Hli Shah, Acting Director
・Mr. Tanka Giri, Electrical Engineer

4 NEA Attariya Regional Office
・Mr. Manoj Silwal, Regional Chief

5 Electricity Cooperatives of Bajang
・Mr. Mabraj Jagri, Manager
・Mr. Naba Raj Jagri, Manager
・Mr.Nawaraj Jagri

6 Electricity Cooperatives Bajura Hydropower Plant
・Mr. Daya Ram Pandit, Managing Director
・Mr. Dharma Raj Padhya, Secretary

7 Electricity Cooperatives of Rukum
・Mr. Jokh Bahadur Malla, Chairman of the Commitee
・Mr. Ram Bahadur K.C., Shyarpudaha Hydropower Officer
・Mr. Damodar K.C., Computer
・Mr. Keshab K.C., Accountant
・Mr. Hari Bo K.C., Technical

8 Government of Bajang District
・Mr. Karn Bahadur Khati, Forest Development Office
・Mr. Youa Raj Kattyal, Local Development Officer (LDO)
・Mr. Jagannath Tiwari, Senior Agriculture Development Officer
・Mr. Karn Bahadur, District Forest Office
・Mr. Dhruja Raj Joshi, Chief District Officer (CDO)

9 Government of Bajura District

・Mr. Dhruga Raj Joshi, Chief District Officer (CDO)

・Mr. Daya Ram Pandel, District Forest Officer (DFO)

・Mr. Baj Nalh Mahato, District Agriculture Office

10 Government of Rukum District

・Mr. Bharat Kumar Sharma, Local Development Officer(LDO)

・Mr. Ram Bahadur Shahi, Local Development Office

・Mr. Kul Prasyed Adlikari, Senior Agriculture Development Officer

・Mr. Binod Brasad Kany, Forest Officer

# Appendix - 4 Minutes of Discussions

**Minutes of Discussions**
**on the Preparatory Survey**
**on Micro-Hydropower Improvement Project in Western Area**
**in Federal Democratic Republic of Nepal**

In response to the request from the Government of Federal Democratic Republic of Nepal (hereinafter referred to as "Nepal"), the Japan International Cooperation Agency (hereinafter referred to as "JICA"), in consultation with the Government of Japan, decided to conduct a Preparatory Survey (hereinafter referred to as "the Survey") on Micro-Hydropower Improvement Project in Western Area in Nepal (hereinafter referred to as "the Project").

JICA sent to Nepal the Preparatory Survey Team (hereinafter referred to as "the Team"), headed by Mr. Kazunari Oshima, JICA Visiting Senior Advisor. The Team is scheduled to stay in the country for the first mission from July $29^{th}$ to August $29^{th}$, 2013.

The Team held discussions with the officials of concerned authorities in Nepal (hereinafter referred to as "the Nepalese side"). In the course of discussions, both sides have confirmed the main items described in the sheets attached hereto.

Kathmandu, August 1st, 2013

大嶋一成

Kazunari Oshima
Leader
Preparatory Survey Team
Visiting Senior Advisor
Japan International Cooperation Agency

Upendra Dev Bhatta
Deputy Managing Director
Nepal Electricity Authority

末兼賢太郎

Kentaro SUEKANE
Representative
JICA Nepal Office

Witness:

Raju Maharjan
Senior Divisional Engineer
Ministry of Energy

## ATTACHMENT

### 1. Objective of the Project

The objective of the Project is to repair, maintain and replace hydro-mechanical and electro-mechanical equipment at three micro hydropower stations.

### 2. Locations of Projects

The project sites are located in Bajang District, Bajura District and Rukum District as shown in Annex-1.

### 3. Responsible and Implementing Organizations of the Nepalese side

(1) The responsible organization is Ministry of Energy (MOE)
(2) The implementing organization is Nepal Electricity Authority (NEA).
(3) The implementing organization in the operation and maintenance stage is Electricity Cooperatives (ECs) in the target districts.

The Organization Structures of MOE and NEA are shown in Annex-2 and Annex-3 respectively.

### 4. Components requested by the Nepalese side

The Government of Nepal (hereinafter referred to as "GON") requested repair, maintenance and replacement of electro-mechanical equipment, restoration of civil works and additional new units for micro hydropower stations as shown below:

| Name of power station | Location |
|---|---|
| Bajhang | Bajhang District |
| Bajura | Bajura District |
| Syarpudaha | Rukum District |

The Chaurjhari power station (hereinafter referred to as "P/S") in Rukum District, which was originally included in the request, was excluded from the Survey through discussions between NEA and JICA held during the preliminary survey conducted by JICA in March 2013 considering that the Chaurjhari P/S will be shut down after the national grid reaches the current service area within a few years.

JICA will assess the appropriateness and the priority of the requested components through the Survey from the viewpoint of necessity and relevance as Japan's Grant Aid scheme, and will report the findings to the Government of Japan.

### 5. Japan's Grant Aid Scheme

(1) JICA confirmed that the Nepalese side understood Japan's Grant Aid Scheme explained by the Team as described in Annex-4 and 5.
(2) The Nepalese side will take the necessary measures, as described in Annex-6, for smooth implementation of the Project as the prerequisites for Japan's Grant Aid to be implemented.

### 6. Schedule of the Survey

The Team will continue the first field survey in Nepal until August 29th, 2013. After analysis in Japan, JICA will dispatch a team to Nepal in order to explain and discuss contents of the draft final report of the Survey with the Nepalese side in around December 2013.

### 7. Other Relevant Issues

(1) Status of the Survey
a) The Team explained that the purpose of the Survey is to collect information and data necessary for outline design and cost estimation of the Project components which are

confirmed through the Survey and analysis in Japan.

b) The Nepalese side agreed to share all necessary information and data with the Team.

(2) Environmental and Social Considerations

a) The Team requested the Nepalese side to conduct the required environmental procedures and obtain approval on environmental clearance for implementation of the Project.

b) The Nepalese side agreed to comply with JICA Guidelines for Environmental and Social Considerations (hereinafter referred to as "JICA Guidelines") as well as laws and regulations in Nepal, and was requested to prepare Environmental Checklist and Monitoring Form which are designated by "JICA Guidelines" for an outline design.

c) The Nepalese side agreed to make necessary arrangements with concerned governmental organizations in order to secure funding for and execution of the above environmental matters in a schedule as required for smooth implementation of the Project.

(3) Major Undertakings to be taken by the Nepalese side

a) The Nepalese side agreed to undertake the following particular items out of general undertakings described in Annex-6.

b) The Nepalese side shall secure enough budget and human resources for the following undertakings in accordance with the implementation of the Project,

- Securing access road for transportation of the equipment and materials to the proposed micro hydropower plant.

(4) Coordination among the Nepalese Side

The Team requested the Nepalese side to coordinate among the Nepalese side including MOE, NEA, ECs and other related agencies for the successful implementation of the Project and afterwards.

(5) Customs and tax exemption

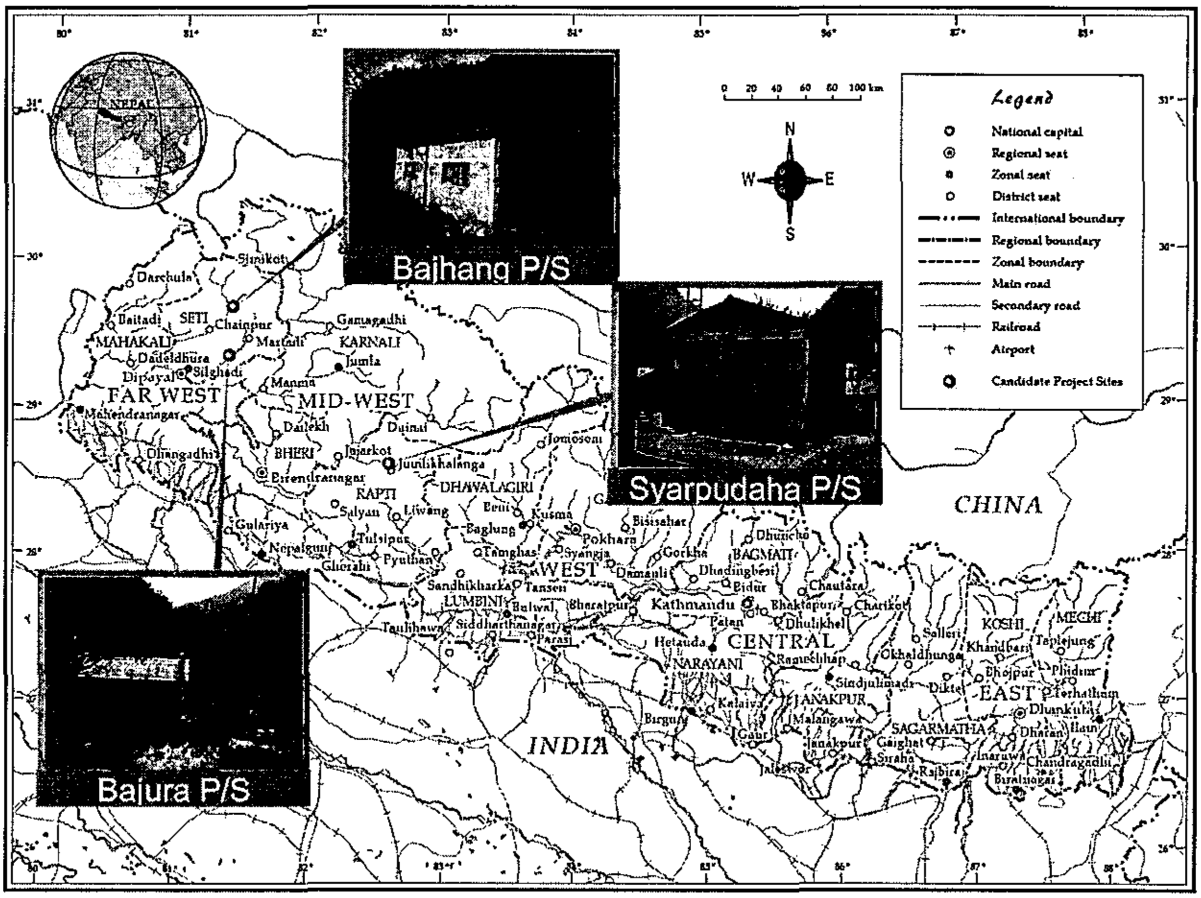
The Nepalese side understood that it shall be fully responsible on exemption of taxes, custom duties and any other levies imposed in Nepal, in case that the Project is implemented.

(End)

Annex-1 Project Sites
Annex-2 Organization Chart of MOE
Annex-3 Organization Chart of NEA
Annex-4 Japan's Grant Aid
Annex-5 Flow Chart of Japan's Grant Aid Procedures
Annex-6 Major Undertakings to be taken by Each Government

**Annex-1**

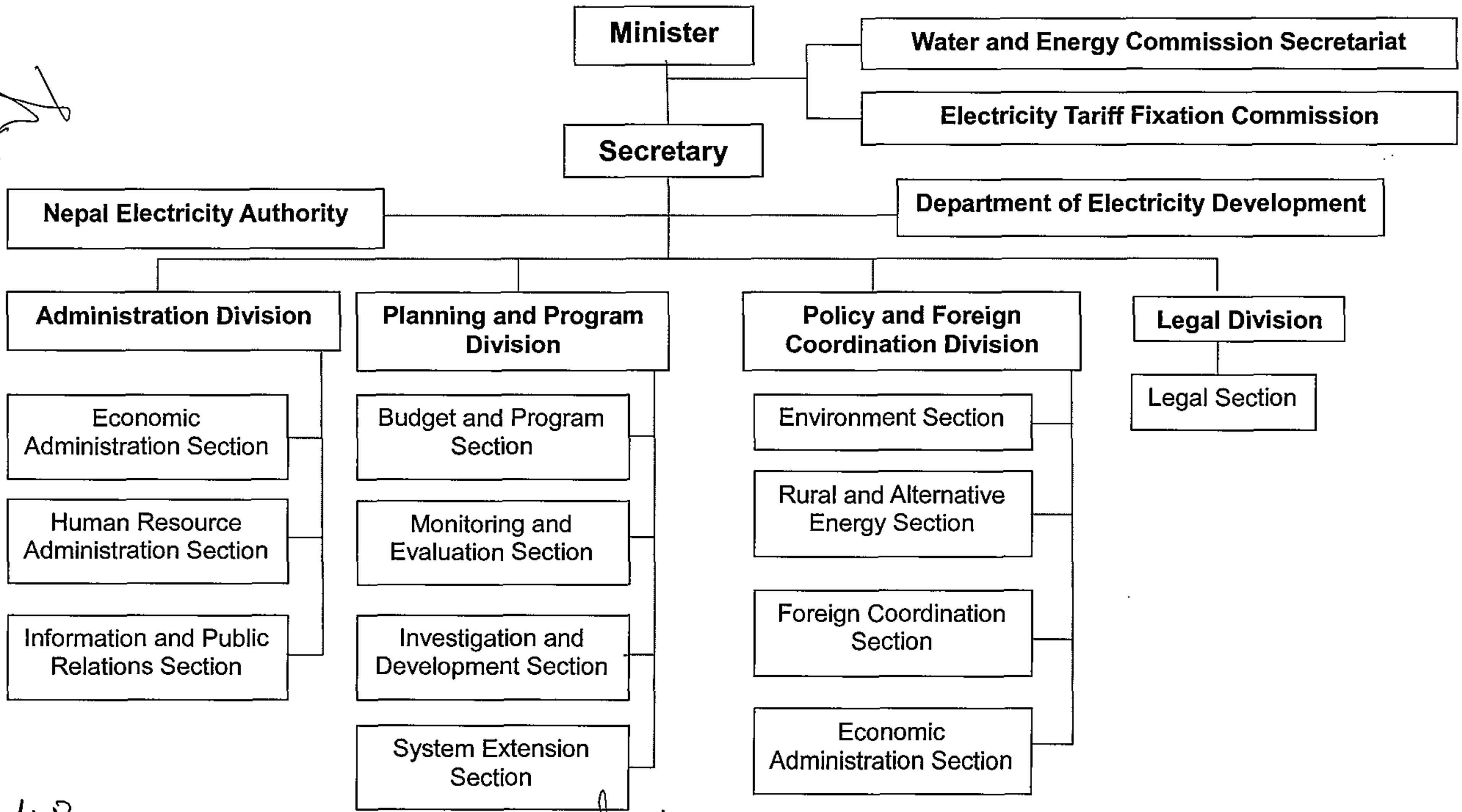
**Project Sites**




(source: United Nations)

Annex-2

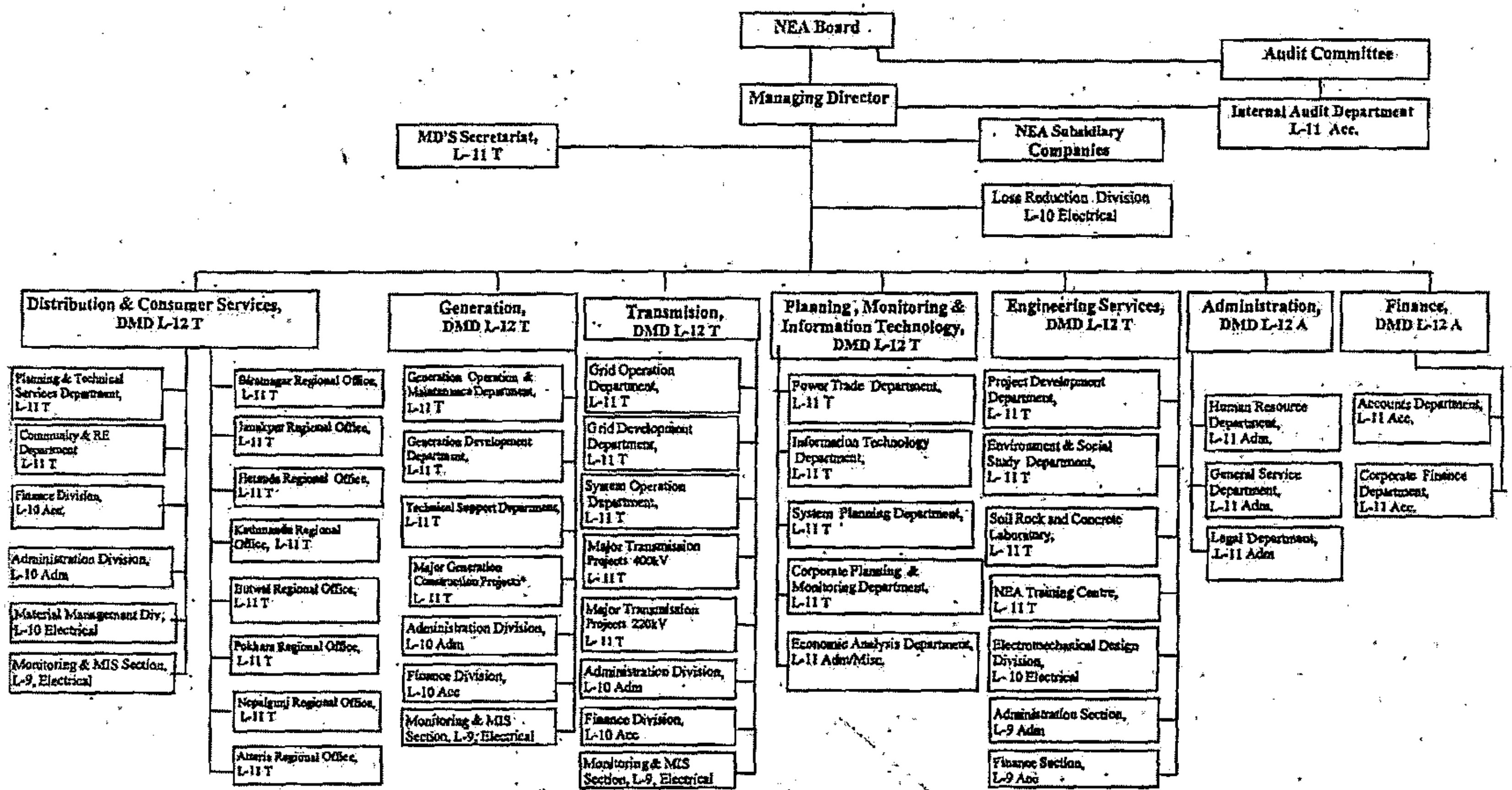
## Organization Chart of Ministry of Energy (MOE)



Annex-3

## Organization Chart of NEA

### Revised Organizational Structure of Nepal Electricity Authority




Note : * Major Generation Construction Projects will be defined by the Board.
T = Technical Services; A = Administration Services: Adm = Administration Group: Acc=Account Group

## Japan's Grant Aid

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as a part of this realignment, a new JICA law was entered into effect on October 1, 2008. Based on this law and the decision of the GOJ, JICA has become the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc.

The Grant Aid is non-reimbursable fund provided to a recipient country to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for its economic and social development in accordance with the relevant laws and regulations of Japan. The Grant Aid is not supplied through the donation of materials as such.

### 1. Grant Aid Procedures

The Japanese Grant Aid is supplied through following procedures :

- Preparatory Survey (hereinafter referred to as "the Survey")
  - The Survey conducted by JICA
- Appraisal &Approval
  - Appraisal by the GOJ and JICA, and Approval by the Japanese Cabinet
- Authority for Determining Implementation
  - The Notes exchanged between the GOJ and the recipient country
- Grant Agreement (hereinafter referred to as "the G/A")
  - Agreement concluded between JICA and a recipient country
- Implementation
  - Implementation of the Project on the basis of the G/A

### 2. Preparatory Survey

(1) Contents of the Survey

The aim of the preparatory Survey is to provide a basic document necessary for the appraisal of the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of relevant agencies of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of a basic design of the Project.

- Estimation of the Project cost.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed based on the guidelines of Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization of the recipient country which actually implements the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA employs (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the Report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the appropriateness of the Project.

**3. Japan's Grant Aid Scheme**

(1) The E/N and the G/A

After the proposed Project is approved by the Cabinet of Japan, the Exchange of Notes(hereinafter referred to as "the E/N") will be singed between the GOJ and the Government of the recipient country to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the recipient country to continue to work on the Project implementation after the E/N and G/A are signed by both sides.

(3) Eligible source country

Under the Japanese Grant Aid, in principle, Japanese products and services including transport of materials or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services from a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals".

(4) Necessity of "Verification"

The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to fulfill accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as shown in Annex-6.

(6) "Proper Use"

The Government of the recipient country is required to maintain and use properly and effectively the facilities constructed and the equipment purchased under the Grant Aid, to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Grant Aid.

(7) "Export and Re-export"

The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account under the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions paid to the Bank.

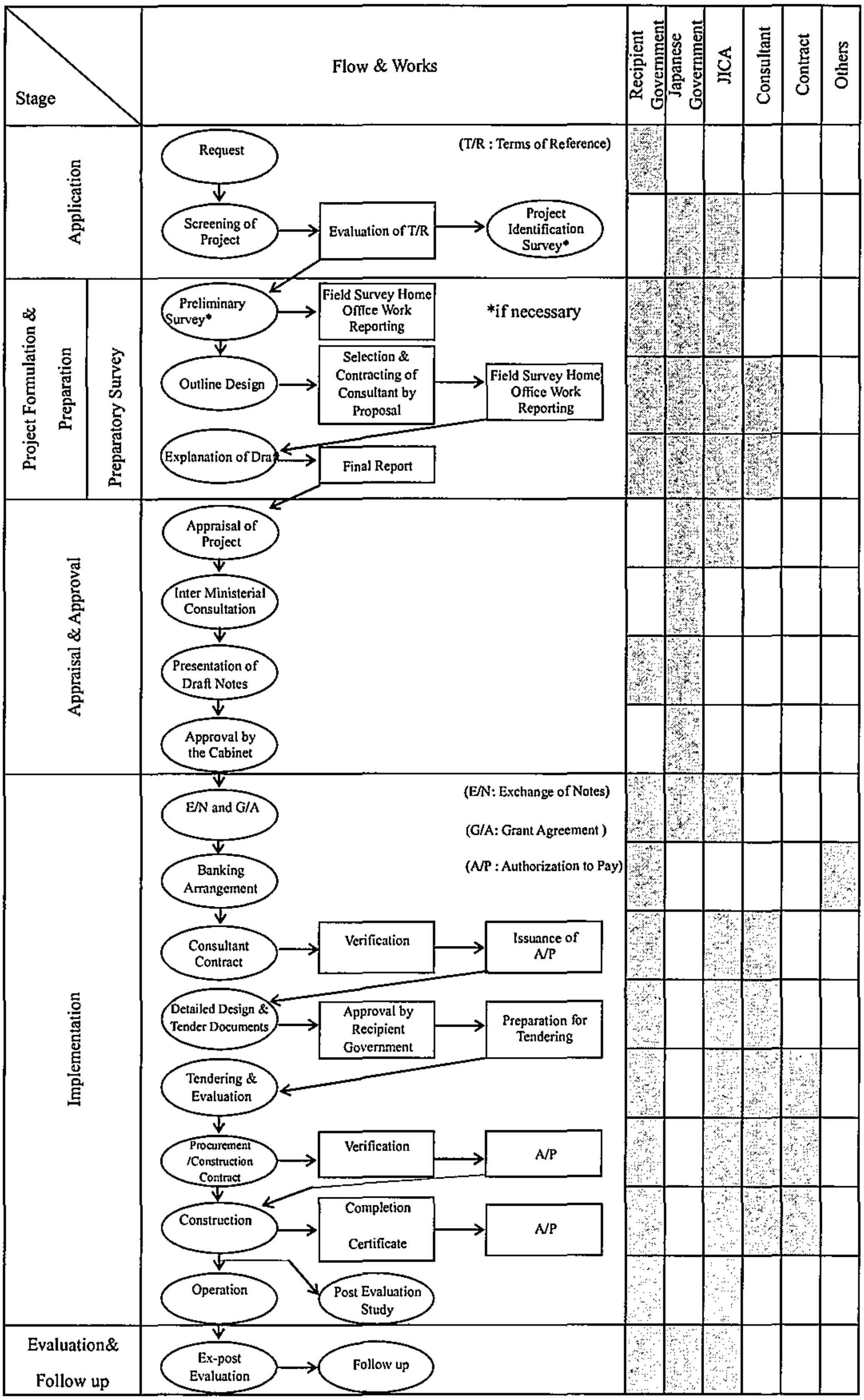
(10) Social and Environmental Considerations

A recipient country must carefully consider social and environmental impacts by the Project and must comply with the environmental regulations of the recipient country and JICA guidelines for Environmental and Social Considerations.

(End)

Annex-5

# Flow Chart of Japan's Grant Aid Procedures



## Major undertakings to be taken by each Government

| No. | Items | To be covered by Grant Aid | To be covered by Recipient Side |
|---|---|---|---|
| 1 | to secure lots of land necessary for the implementation of the Project and to clear the sites; | | ● |
| 2 | To construct the following facilities | | |
| | 1) The building | ● | |
| | 2) The gates and fences in and around the site | | ● |
| | 3) The parking lot | ● | |
| | 4) The road within the site | ● | |
| | 5) The road outside the site | | ● |
| 3 | To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities necessary for the implementation of the Project outside the sites | | |
| | 1)Electricity | | |
| | a. The distributing power line to the site | | ● |
| | b. The drop wiring and internal wiring within the site | ● | |
| | c. The main circuit breaker and transformer | ● | |
| | 2) Water Supply | | |
| | a. The city water distribution main to the site | | ● |
| | b. The supply system within the site (receiving and elevated tanks) | ● | |
| | 3) Drainage | | |
| | a. The city drainage main (for storm sewer and others to the site) | | ● |
| | b. The drainage system (for toilet sewer, common waste, storm drainage and others) within the site | ● | |
| | 4) Gas Supply | | |
| | a. The city gas main to the site | | ● |
| | b. The gas supply system within the site | ● | |
| | 5) Telephone System | | |
| | a. The telephone trunk line to the main distribution frame/panel (MDF) of the building | | ● |
| | b. The MDF and the extension after the frame/panel | ● | |
| | 6) Furniture and Equipment | | |
| | a. General furniture | | ● |
| | b. Project equipment | ● | |
| 4 | To ensure prompt unloading and customs clearance of the products at ports of disembarkation in the recipient country and to assist internal transportation of the products | | |
| | 1) Marine (Air) transportation of the Products from Japan to the recipient country | ● | |
| | 2) Tax exemption and custom clearance of the Products at the port of disembarkation | | ● |
| | 3) Internal transportation from the port of disembarkation to the project site | ● | |
| 5 | To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the products and the services be exempted | | ● |
| 6 | To accord Japanese nationals whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work | | ● |
| 7 | To ensure that the Facilities be maintained and used properly and effectively for the implementation of the Project | | ● |
| 8 | To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project | | ● |
| 9 | To bear the following commissions paid to the Japanese bank for banking services based upon the B/A | | |
| | 1) Advising commission of A/P | | ● |
| | 2) Payment commission | | ● |
| 10 | To give due environmental and social consideration in the implementation of the Project. | | ● |

*1 B/A : Banking Arrangement, A/P : Authorization to pay)

**Minutes of Discussions**
**On the Preparatory Survey**
**on Micro-Hydropower Improvement Project in Western Area**
**in Federal Democratic Republic of Nepal**

In response to the request from the Government of Federal Democratic Republic of Nepal (hereinafter referred to as "Nepal"), the Japan International Cooperation Agency (hereinafter referred to as "JICA"), in consultation with the Government of Japan, decided to conduct a Preparatory Survey (hereinafter referred to as "the Survey") on Micro-Hydropower Improvement Project in Western Area in Nepal (hereinafter referred to as "the Project").

JICA sent to Nepal the Preparatory Survey Team (hereinafter referred to as "the Team"), headed by Mr. Toru Kobayakawa, Advisor, Energy and Mining Division 1, Industrial Development and Public Policy Department, JICA. The Team is scheduled to stay in the country from December 17th to December 21st, 2013.

The Team held discussions with the officials of concerned authorities in Nepal (hereinafter referred to as "the Nepalese side"). In the course of discussions, both sides have confirmed the main items described in the sheets attached hereto.

Kathmandu, 27th January 2014

Tsutomu Shimizu
Chief Representative
Nepal Office
Japan International Cooperation Agency

27.01.2014
Manoj Silwal
Chief
Community And Rural Electrification Department
Nepal Electricity Authority

Witness:

Raju Maharjan
Senior Divisional Engineer
Ministry of Energy

## ATTACHMENT

**1. Contents of the Draft Final Report**

The Nepalese side agreed and accepted in principle the contents of the Draft Final Report explained by the Team.

**2. Objective of the Project**

The objective of the Project is to repair, maintain civil structures, penstock and powerhouse, and replace hydro-mechanical and electro-mechanical equipment at three micro hydropower stations in Western Area of Nepal, thereby contributing to enhancement of the regional economy and public welfare through stabilized power supply.

**3. Locations of Projects**

The project sites are located in Bajang District, Bajura District and Rukum District as shown in Annex-1.

**4. Responsible and Implementing Organizations of the Nepalese side**

(1) The responsible organization is Ministry of Energy (MOE)
(2) The implementing organization is Nepal Electricity Authority (NEA).
(3) The implementing organization in the operation and maintenance stage is Electricity Cooperatives (ECs) in the target districts.

The Organization Structures of MOE and NEA are shown in Annex-2 and Annex-3 respectively.

**5. Components of the Project**

The following table is selected as the Project Components by the Government of Nepal (hereinafter referred to as "GON") and The Team.

| Name of power station | Location | Project Components (in each location) |
|---|---|---|
| Bajhang | Bajhang District | -Replacement of 200kW run-of-river type hydropower plant<br>-Restoration of civil works |
| Bajura | Bajura District | |
| Syarpudaha | Rukum District | |

Initially, GON requested additional units for micro hydropower stations in each location. Nepalese side and Japanese side agreed through discussions between NEA and JICA held during the preliminary survey conducted by JICA in March 2013 that the Project components don't include additional units because of shortage of information especially hydrological data at each of the project sites. The Chaurjhari power station (hereinafter referred to as "P/S") in Rukum District, which was originally included in the request, was also agreed to be excluded from the Survey considering that the Chaurjhari P/S would be shut down after the national grid reaches the current service area within a few years.

**6. Japan's Grant Aid Scheme**

(1) JICA confirmed that the Nepalese side understood Japan's Grant Aid Scheme explained by the Team as described in Annex-4 and 5.
(2) The Nepalese side will take the necessary measures, as described in Annex-6, for smooth implementation of the Project as the prerequisites for Japan's Grant Aid to be implemented.

**7. Environmental and Social Considerations**

(1) JICA Guidelines for Environmental and Social Consideration

The Nepalese side agreed to comply with the JICA Guidelines for Environmental and Social Consideration (April 2010) (hereinafter referred to as "JICA Guidelines") as well as Nepalese laws and regulations.

(2) The Environmental Checklist

NEA and the Team confirmed information on environmental and social considerations including major impacts and relevant mitigation measures which are summarized in the Environmental Checklist attached as Annex-7. NEA confirmed that they would inform JICA of any major changes on the items described in the Checklist which may cause environmentally and socially negative impacts by revising the Checklist in a timely manner.

(3) Land Acquisition and Compensation Plan

Since a piece of land needs to be acquired due to necessary works for Bajhang P/S, NEA and the Team confirmed that internal monitoring to be proposed in the Land Acquisition and Compensation Plan (hereinafter referred to as "LACP") would be conducted by NEA. Then, NEA and the Team confirmed that LACP contents must fulfill JICA Guidelines (e.g., the amount of compensation and monitoring structure) and LACP will be finalized by NEA by the 4th February 2014. NEA agreed that progress of land acquisition and implementation of LACP will be monitored by NEA until land acquisition and compensation activities are complete as described in Annex-8. The Nepalese side also agreed to implement all the necessary activities including compensation and land acquisition based on the LACP before the 16th of May 2014. NEA would report the monitoring results to JICA Nepal Office semiannually by filling the form shown in Annex-9 during the period specified in the Monitoring Plan.

In case there is a remaining issue(s) that needs to be addressed (e.g. insufficient restoration of livelihood of Project Affected Persons (hereinafter referred to as "PAPs")), JICA may request to extend the period of monitoring and reporting until JICA confirms the issue(s) has been properly addressed and solved in accordance with this minutes of discussion between NEA and JICA.

(4) Environmental Monitoring Plan

NEA and the Team confirmed environmental monitoring would be conducted by NEA in accordance with the Environmental Monitoring Form described as Annex-9. NEA agreed to submit the results of monitoring to JICA Nepal Office semiannually by filling the form during the period specified in the Monitoring Plan.

(5) Disclosure

NEA confirmed it would take necessary procedures for information disclosure based on JICA Guidelines. In addition, the Team requested NEA to disclose the monitoring results to local stakeholders, and NEA agreed to disclose monitoring results in their district government offices.

NEA agreed to submit monitoring results to JICA once a half year. NEA also agreed JICA's disclosure of provided monitoring results in the monitoring form attached as Annex-9 on its website.

**8. Project Cost**

The Nepalese side agreed that the cost for the Project should not exceed the amount agreed on Exchange of Notes (E/N). The Nepalese side also agreed that the cost for the Project contains procurement cost of equipment, transportation cost up to the Project site, installation cost, civil works cost and the consultant fees as described in Annex-10.

**9. Confidentiality of the Project**

(1) Detailed specifications of the Facilities and Equipment

Both sides agreed that all the information related to the Project including detailed drawings and specifications of the facilities and equipment and other technical information should not be disclosed to any outside parties (i.e. other than JICA and the Nepalese side) before conclusion(s) of all contract(s) for the Project.

(2) Confidentiality of the Cost Estimation

The Team explained the estimated cost of the Project as described in Annex-10. Both sides agreed that the estimated cost for the Project should never be duplicated or disclosed to any outside parties (i.e. other than JICA and the Nepalese side) before tender(s) for the Project. The Nepalese side understood that the estimated cost for the Project attached as Annex-10 was not the final and to be subject to change.

**10. Possibility of Change in Scope, Schedule and Cost of the Project**

The Team confirmed that the scope, the schedule, and the cost for the Project are tentative and subject to change due to the domestic circumstances in Japan and Nepal. The Nepalese side understood it.

**11. Other Relevant Issues**

(1) Schedule of the Preparatory Survey

JICA will complete the Final Report in accordance with the confirmed items and send it to the Nepalese side by the end of April, 2014.

(2) Counterpart Personnel

The Team requested the Nepalese side that necessary number of counterpart personnel shall be assigned to the Project and necessary arrangements with related organizations shall be made during the implementation stage in Nepal.

(3)Major Undertakings to be taken by the Nepalese side

a) The Nepalese side agreed to undertake the following particular items out of general undertakings described in Annex-6.
   - -Coordination with ECs and consumers in relation to the suspension of power generation during construction period;
   - -Provision or acquisition of land for construction including provision of land for temporary works;
   - -Suspension of operation of each P/S as per the schedule of constructions;
   - -Storage and disposal of removed materials/machineries; and
   - -Monitoring

b) The Nepalese side shall secure enough budget and human in accordance with the implementation of the Project

(4) Coordination among the Nepalese Side

The Team requested the Nepalese side to coordinate among Nepalese side including MOE, NEA, ECs and other related agencies for successful implementation of the Project and afterwards.

(5) Customs and tax exemption

The Nepalese side understood that it shall be fully responsible on tax(es) exemption, custom duties and any other levies imposed in Nepal, in case that the Project is implemented.

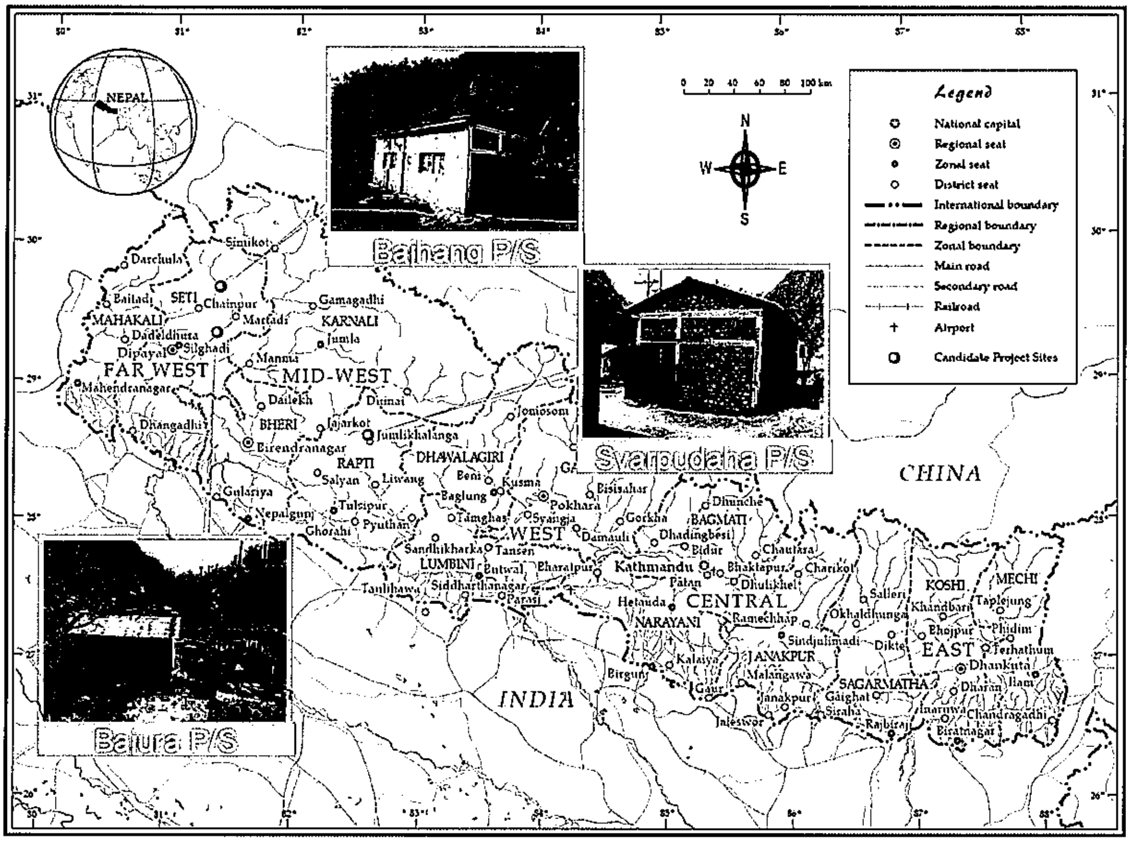
(End)

Annex-1 Project Sites

| | |
|---|---|
| Annex-2 | Organization Chart of MOE |
| Annex-3 | Organization Chart of NEA |
| Annex-4 | Japan's Grant Aid |
| Annex-5 | Flow Chart of Japan's Grant Aid Procedures |
| Annex-6 | Major Undertakings to be taken by Each Government |
| Annex-7 | Monitoring Form |
| Annex-8 | Environmental Checklist |
| Annex-9 | Time Schedule for Socio-Environmental Activities |
| Annex-10 | Estimated Project Cost (Confidential) |

**Annex-1**

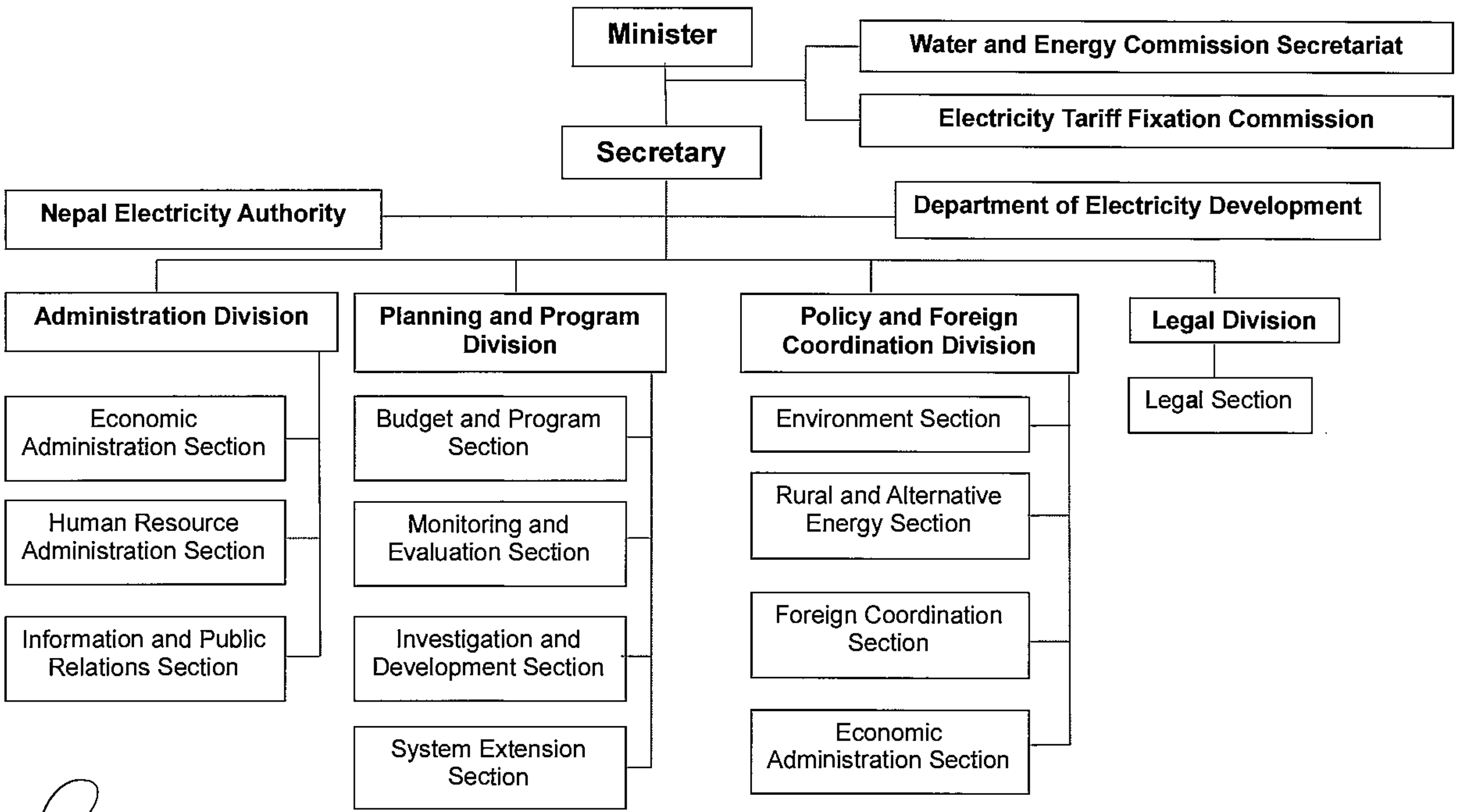
## Project Sites




(source: United Nations)

Annex-2

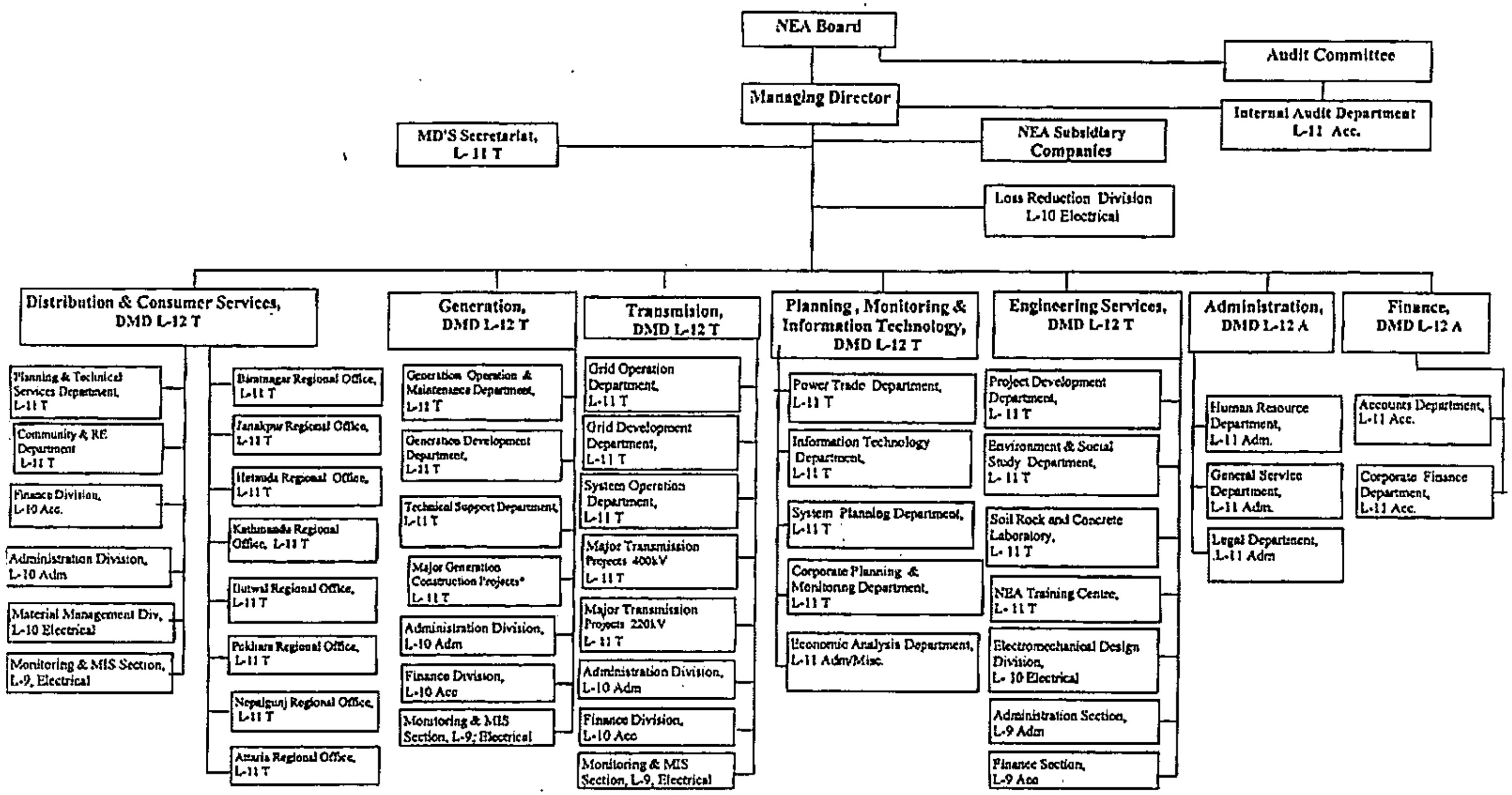
## Organization Chart of Ministry of Energy (MOE)



Annex-3

## Organization Chart of NEA

### Revised Organizational Structure of Nepal Electricity Authority




Note : * Major Generation Construction Projects will be defined by the Board.
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**Annex-4**

## Japan's Grant Aid

The Government of Japan (hereinafter referred to as "the GOJ") is implementing the organizational reforms to improve the quality of ODA operations, and as a part of this realignment, a new JICA law was entered into effect on October 1, 2008. Based on this law and the decision of the GOJ, JICA has become the executing agency of the Grant Aid for General Projects, for Fisheries and for Cultural Cooperation, etc.

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### 1. Grant Aid Procedures

The Japanese Grant Aid is supplied through following procedures :

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- Implementation
  - Implementation of the Project on the basis of the G/A

### 2. Preparatory Survey

(1) Contents of the Survey

The aim of the preparatory Survey is to provide a basic document necessary for the appraisal of the Project made by the GOJ and JICA. The contents of the Survey are as follows:

- Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of relevant agencies of the recipient country necessary for the implementation of the Project.
- Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, financial, social and economic point of view.
- Confirmation of items agreed between both parties concerning the basic concept of the Project.
- Preparation of a basic design of the Project.

- Estimation of the Project cost.

The contents of the original request by the recipient country are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed based on the guidelines of Japan's Grant Aid scheme.

JICA requests the Government of the recipient country to take whatever measures necessary to achieve its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization of the recipient country which actually implements the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country based on the Minutes of Discussions.

(2) Selection of Consultants

For smooth implementation of the Survey, JICA employs (a) registered consulting firm(s). JICA selects (a) firm(s) based on proposals submitted by interested firms.

(3) Result of the Survey

JICA reviews the Report on the results of the Survey and recommends the GOJ to appraise the implementation of the Project after confirming the appropriateness of the Project.

**3. Japan's Grant Aid Scheme**

(1) The E/N and the G/A

After the proposed Project is approved by the Cabinet of Japan, the Exchange of Notes(hereinafter referred to as “the E/N”) will be signed between the GOJ and the Government of the recipient country to make a pledge for assistance, which is followed by the conclusion of the G/A between JICA and the Government of the recipient country to define the necessary articles to implement the Project, such as payment conditions, responsibilities of the Government of the recipient country, and procurement conditions.

(2) Selection of Consultants

In order to maintain technical consistency, the consulting firm(s) which conducted the Survey will be recommended by JICA to the recipient country to continue to work on the Project implementation after the E/N and G/A are signed by both sides.

(3) Eligible source country

Under the Japanese Grant Aid, in principle, Japanese products and services including transport of materials or those of the recipient country are to be purchased. When JICA and the Government of the recipient country or its designated authority deem it necessary, the Grant Aid may be used for the purchase of the products or services from a third country. However, the prime contractors, namely, constructing and procurement firms, and the prime consulting firm are limited to "Japanese nationals".

(4) Necessity of "Verification"

The Government of the recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by JICA. This "Verification" is deemed necessary to fulfill accountability to Japanese taxpayers.

(5) Major undertakings to be taken by the Government of the Recipient Country

In the implementation of the Grant Aid Project, the recipient country is required to undertake such necessary measures as shown in Annex-6.

(6) "Proper Use"

The Government of the recipient country is required to maintain and use properly and effectively the facilities constructed and the equipment purchased under the Grant Aid, to assign staff necessary for this operation and maintenance and to bear all the expenses other than those covered by the Grant Aid.

(7) "Export and Re-export"

The products purchased under the Grant Aid should not be exported or re-exported from the recipient country.

(8) Banking Arrangements (B/A)

a) The Government of the recipient country or its designated authority should open an account under the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). JICA will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to JICA under an Authorization to Pay (A/P) issued by the Government of the recipient country or its designated authority.

(9) Authorization to Pay (A/P)

The Government of the recipient country should bear an advising commission of an Authorization to Pay and payment commissions paid to the Bank.

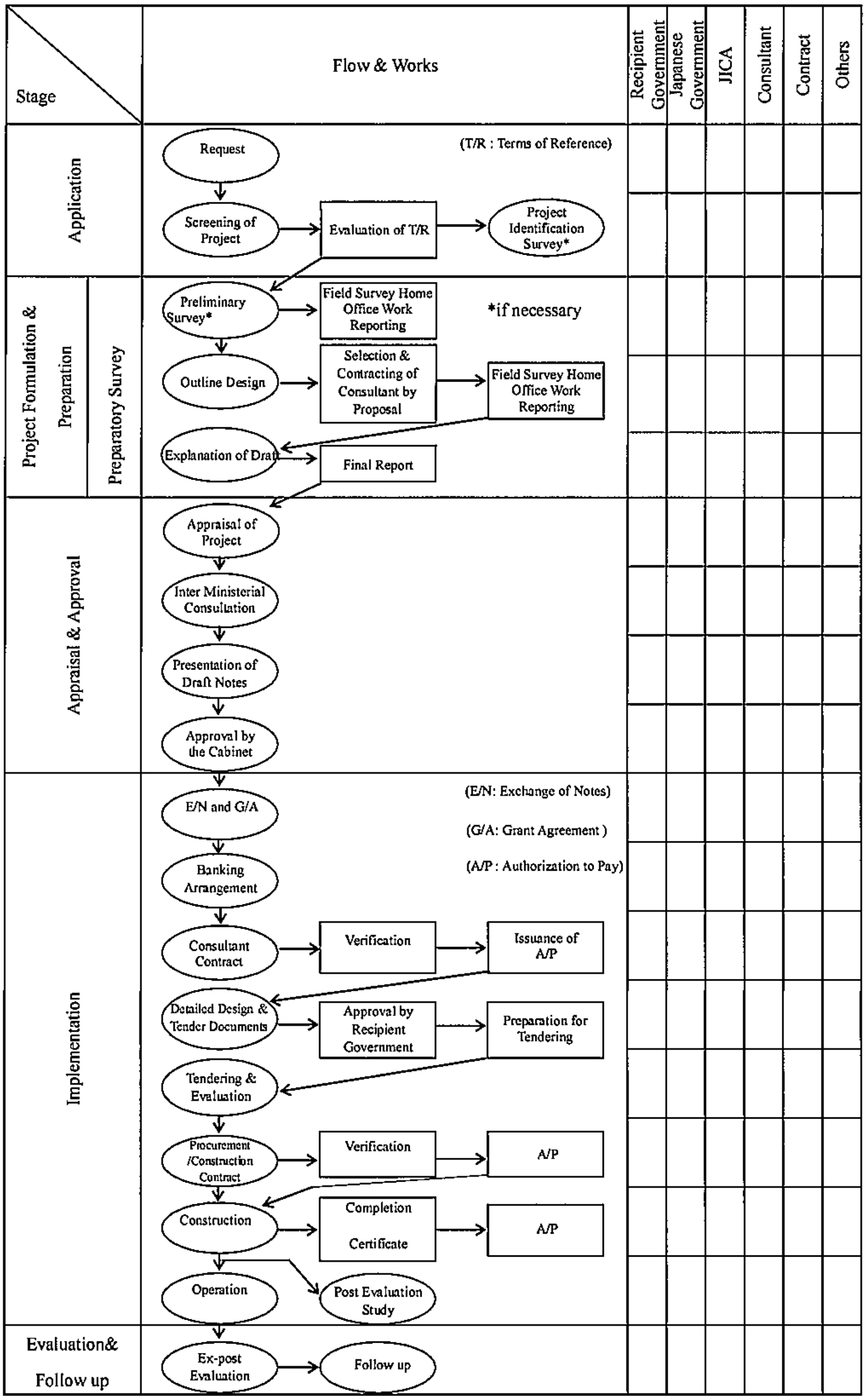
(10) Social and Environmental Considerations

A recipient country must carefully consider social and environmental impacts by the Project and must comply with the environmental regulations of the recipient country and JICA guidelines for Environmental and Social Considerations.

(End)

Annex-5

## Flow Chart of Japan's Grant Aid Procedures



Annex-6

## Major undertakings to be taken by each Government

| No. | Items | To be covered by Grant Aid | To be covered by Recipient Side |
|---|---|---|---|
| 1 | to secure lots of land necessary for the implementation of the Project and to clear the sites; | | ● |
| 2 | To ensure prompt customs clearance of the products and to assist internal transportation of the products in the recipient country | | |
| | 1) Marine (Air) transportation of the Products from Japan to the recipient country | ● | |
| | 2) Internal transportation from the port of disembarkation to the project site | ● | |
| 3 | To ensure that customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the purchase of the products and the services be exempted | | ● |
| 4 | To accord Japanese physical persons and / or physical persons of third countries whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work. | | ● |
| 5 | To ensure that the Facilities be maintained and used properly and effectively for the implementation of the Project | | ● |
| 6 | To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project | | ● |
| 7 | To bear the following commissions paid to the Japanese bank for banking services based upon the B/A | | |
| | 1) Advising commission of A/P | | ● |
| | 2) Payment commission | | ● |
| 8 | To give due environmental and social consideration in the implementation of the Project. | | ● |

( B/A : Banking Arrangement, A/P : Authorization to pay )

## Environmental Checklist

**JICA Environmental Checklist** **MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL**

(for Hydropower Stations, Dams and Reservoirs)

| Category | Environmental Item | Main Check Items | Yes: Y<br>No: N | Confirmation of Environmental Considerations<br>(Reasons, Mitigation Measures) |
|---|---|---|---|---|
| 1 Permits and Explanation | (1) EIA and Environmental Permits | (a) Have EIA reports been already prepared in official process?<br>(b) Have EIA reports been approved by authorities of the host country's government?<br>(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?<br>(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government? | (a) N/A<br>(b) N/A<br>(c) N/A<br>(d) Y | (a) Article 3 of the Electricity Act, 1992 of Nepal states that hydropower project with the power plant capacity up to 1,000 kW does not require any license for survey, construction and operation. Therefore, It does not require any IEE/EIA in association with the application for license.<br>(b) Not applicable<br>(c) Not applicable<br>(d) The project with the installed capacity between 100 and 1,000 kW requires the report on investigations and plans to be submitted to the Department of Electricity Development (DoED). Accordingly, NEA will submit the report (unnecessary with IEE) to DoED for approval. The details and procedures of the report are stated in Article 6 of "Directives on licensing of hydropower projects, 2011". |
| | (2) Explanation to the Local Stakeholders | (a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders?<br>(b) Have the comment from the stakeholders (such as local residents) been reflected to the project design? | (a) Y<br>(b) Y | (a) The stakeholders meeting was conducted on 18th December, 2013. Local stakeholders well understood the project and environmental and social considerations for the project.<br>(b) The comment from the stakeholders has been reflected to the project design such as the construction process. |
| | (3) Examination of Alternatives | (a) Have alternative plans of the project been examined with social and environmental considerations? | (a) Y | (a) Following alternative plans were examined.<br>- The land for stock yard and intake structure with no farmland located far upstream from the intake (Bajhang)<br>This alternative could not be selected since the topographical condition and the accessibility are poorer.<br>- Creation of new access roads (Bajhang, Syarupudaha)<br>This alternative could not be selected by the reason of construction period and environmental impact that the construction of the new road causes. |

| | | | | |
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| 2 Pollution Control | (1) Water Quality | (a) Does the water quality of dam pond/reservoir comply with the country's ambient water quality standards? Is there a possibility that proliferation of phytoplankton and zooplankton will occur?<br>(b) Does the quality of water discharged from the dam pond/reservoir comply with the country's ambient water quality standards?<br>(c) Are adequate measures, such as clearance of woody vegetation from the inundation zone prior to flooding planned to prevent water quality degradation in the dam pond/reservoir?<br>(d) Is there a possibility that reduced the river flow downstream will cause water quality degradation resulting in areas that do not comply with the country's ambient water quality standards?<br>(e) Is the discharge of water from the lower portion of the dam pond/reservoir (the water temperature of the lower portion is generally lower than the water temperature of the upper portion) planned by considering the impacts to downstream areas? | (a) N/A<br>(b) N/A<br>(c) N/A<br>(d) N<br>(e) N/A | (a) Since the scheme of the project is "run of the river generation", it does not include dam or pond/reservoir.<br>(b) Not applicable<br>(c) Not applicable<br>(d) Since the amount of water intake is almost same as that of before the project, the river flow downstream will not be reduced any more. Accordingly, water quality degradation does not occur.<br>(e) Not applicable |
| 2 Pollution Control | (2) Wastes | (a) Are earth and sand generated by excavation properly treated and disposed of in accordance with the country's regulations? | (a) Y | (a) Stones and gravels for the civil work are taken from the river bed, and most aggregates are taken from the existing borrow-pit. Sand to be insufficient is taken from water bed (Bajhang). Residue of sand and gravels should be backfilled in accordance with the District's rule. |
| 3 Natural Environment | (1) Protected Areas | (a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas? | (a) N | (a) There is no protected area in and around the project site. |
| | (2) Ecosystem | (a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?<br>(b) Does the project site encompass the primeval forests, tropical rain forests, ecologically valuable habitats designated by the country's laws or international treaties and conventions?<br>(c) Is there a possibility that the project will adversely affect downstream aquatic organisms, animals, plants, and ecosystems? Are adequate protection measures taken to reduce the impacts on the ecosystem?(d) Is there a possibility that installation of structures, such as dams will block the movement of the migratory fish species (such as salmon, trout and eel those move between rivers and sea for spawning)? Are adequate measures taken to reduce | (a) N<br>(b) N<br>(c) N<br>(d) N | (a) There are no primeval forests, tropical rain forests, ecologically valuable habitats forests that the project site encompasses.<br>(b) There is no valuable habitats and endangered species that the project site encompasses.<br>(c) Since the amount of water intake is almost same as that of before the project, there is no possibility that the project will adversely affect downstream aquatic organisms.<br>(d) There are no migratory fish such as salmon, trout and eel in the river within the project site. |

| | | | | |
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| | | the impacts on these species? | | |
| | (3) Hydrology | (a) Is there a possibility that hydrologic changes due to the installation of structures, such as weirs will adversely affect the surface and groundwater flows (especially in "run of the river generation" projects)? | (a) N | (a) The old intake weirs were washed away by flood. Current temporary weirs are re-constructed by the project. However, since flow rates of downstream from intakes are almost unchanged by the replacement, there will be no change of surface and groundwater flows. |
| | (4) Topography and Geology | (a) Is there a possibility that reductions in sediment loads downstream due to settling of suspended particles in the reservoir will cause impacts, such as scouring of the downstream riverbeds and soil erosion? Is there a possibility that sedimentation of the reservoir will cause loss of the storage capacity, water logging upstream, and formation of sediment deposits at the reservoir entrance? Are the possibilities of the impacts studied, and adequate prevention measures taken?<br>(b) Is there a possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas (especially in run of the river generation projects and geothermal power generation projects)? | (a) N/A<br>(b) N | (a) Not applicable<br>(b) There is no possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas. Though current temporary weirs are replaced by new ones, the scale of the alteration of the river bed is small. |

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| 4 SocialEnvironment | (1) Resettlement | (a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?<br>(b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement?<br>(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?<br>(d) Are the compensations going to be paid prior to the resettlement?<br>(e) Are the compensation policies prepared in document?<br>(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?<br>(g) Are agreements with the affected people obtained prior to resettlement?(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?<br>(i) Are any plans developed to monitor the impacts of resettlement?<br>(j) Is the grievance redress mechanism established? | (a) N<br>(b) Y<br>(c) Y<br>(d) Y<br>(e) Y<br>(f) Y<br>(g) Y<br>(h) Y<br>(i) Y<br>(j) Y | (a) No involuntary resettlement is caused by project implementation. However, land acquisition is necessary (Bajhang). Effort was made to reduce as much as possible the area of land to be acquired.<br>(b) Explanation on land acquisition and compensation was given to landowners on stakeholder meeting and direct communication.<br>(c) NEA shall develop "Land Acquisition and Compensation Plan (LACP)" that includes compensations with full costs based on socioeconomic studies on land acquisition.<br>(d) The compensations shall be paid prior to the land acquisition in cash by NEA.<br>(e) The compensation policies are written on the explanation document of the stakeholder meeting.<br>(f)"Land Acquisition and Compensation Plan (LACP)" will pay particular attention to vulnerable groups or people and indigenous peoples if any.<br>(g) Agreements with the land owners can be obtained prior to land acquisition.<br>(h) NEA will establish the team with necessary capacity and budget secured to implement Land Acquisition and Compensation Plan (LACP).<br>(i) NEA will develop the monitoring plan to monitor the impact of land acquisition.<br>(j) NEA will create the position of the grievance redress and decide the person in charge of the grievance redress (grievance redress officer). |

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| 4 Social Environment | (2) Living and Livelihood | (a) Is there any possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?<br>(b) Is there any possibility that the project causes the change of land uses in the neighboring areas to affect adversely livelihood of local people?<br>(c) Is there any possibility that the project facilities adversely affect the traffic systems?<br>(d) Is there any possibility that diseases, including infectious diseases, such as HIV, will be brought due to the immigration of workers associated with the project? Are adequate considerations given to public health, if necessary?<br>(e) Is the minimum flow required for maintaining downstream water uses secured?<br>(f) Is there any possibility that reductions in water flow downstream or seawater intrusion will have impacts on downstream water and land uses?<br>(g) Is there any possibility that water-borne or water-related diseases (e.g., schistosomiasis, malaria, filariasis) will be introduced?<br>(h) Is there any possibility that fishery rights, water usage rights, and common usage rights, etc. would be restricted? | (a) Y<br>(b) Y<br>(c) N<br>(d) Y<br>(e) Y<br>(f) N<br>(g) N<br>(h) N | (a) There is the possibility that infectious diseases, such as HIV, will be brought due to the immigration of construction workers. Details are shown in "5 Others-(1) Impacts during Construction-(c).<br>(b) There is no impact on land use in the neighboring areas except the agricultural land to be acquired (Bajhang).<br>(c) There is no possibility that the project adversely affects the traffic systems in the region. The project site is located in rural mountainous region area wherein there are only few vehicles passing by on community roads.<br>(d) Details are shown in "5 Others-(1) Impacts during Construction-(c)".<br>(e) Since the amount of water intake is almost same as that of before the project, there is no change in the river maintenance flow.<br>(f) There is no possibility that reductions in water flow downstream or seawater intrusion.<br>(g) There is no possibility that water-borne or water-related diseases will be introduced, since the project does not increase water stagnant zone or spot.<br>(h) Since the amount of water intake is almost same as that of before the project, there is no possibility that water intake by the project is restricted. There is no fishery right in and around the project site. The project does not use the land of "community forest". |
| | (3) Heritage | (a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws? | (a) N | (a) In and around the project site, there is no spot that is significant for local archeological, historical, cultural, and religious heritage. |
| | (4) Landscape | (a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken? | (a) N | (a) There are no activity in the project such as installation of structures or modification of environment that affect the local landscape. |
| | (5) Ethnic Minorities and Indigenous Peoples | (a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?<br>(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources to be respected? | (a) Y<br>(b) Y | (a) There is no activity within the project that particularly affects the culture and lifestyle of ethnic minorities and indigenous peoples. Power supply will be stabilized by the project, which would lead to the improvement of social services in the region. That is a slight but effective benefit for ethnic minorities and indigenous peoples in the region.<br>(b) The project will be executed such that all the rights of ethnic minorities and indigenous peoples in relation to land and resources are to be respected. |

| | | | | |
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| | (6) Working Conditions | (a) Is the project proponent not violating any laws and ordinances<br>associated with the working conditions of the country which the project proponent should observe in the project?<br>(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?<br>(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?<br>(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents? | (a) Y<br>(b) Y<br>(c) Y<br>(d) Y | (a) NEA and the contractor shall be not violating the Labour Act (1992) that covers working conditions, the welfare of workers and safety and health.<br>(b)<br>- Around the charging unit should be set partition with ropes or nets to prevent danger.<br>- Work around high-voltage power line and charging unit and transportation of heavy machines should be done under monitoring by safety management supervisor of the contractor. - In the construction site where heavy machines for construction are operated, intrusiveness except concerned parties should be banned.<br>(c)<br>- The contractor should prepare safety and health management plan, including traffic safety, accident prevention and public sanitation, etc. according to the Labour Act.<br>- The contractor should conduct educational training of safety, health and public sanitation to workers and staffs.<br>- The construction site manager must collect every morning all the workers and staffs and conduct instructions to them on health and safety through control over the construction site.<br>(d) The contractor should implement proper and strict management and education of guards no to infringe safety and security of residents and staffs/ workers. |
| 5 Others | (1) Impacts during Construction | (a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?<br>(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts?<br>(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts? | (a) Y | (a)<br>a1) Noise and vibrations, air pollution<br>Housings are located a substantial distance from the project site, and the construction activities will be temporary on a small scale. Any impact as regards air pollution, noise and vibrations will consequently, be negligible. Additionally, good-quality fuel and oil are used for construction machines and vehicles.<br>a2) Turbid water occurs by transportation and construction activities on the river bed though temporary and quite partly. Therefore, following mitigation measures shall be taken.<br>- The contractor will work to reduce the occurrence of turbid water wherever possible. |

| | | | | |
|---|---|---|---|---|
| | | | (b) N/A<br><br>(c) Y | a3) Wastes<br>- Wastes generated during construction (construction wastes and worker's wastes shall be properly treated and disposed by the contractor in accordance with District's rules.<br>- The contractor shall reduce the quantity of construction waste as much as possible by effective recycling, reuse, etc., and shall provide education and enlightenment for above activities by workers.<br>- By use effectively separation trash bin, proper waste disposal shall be carried out by corresponding to the difference of wastes.<br>- Wastes that cannot be treated and disposed in the district shall be taken away and be treated and disposed according to the rule of the government at the place where the wastes are carried in.<br>(b) Adverse Impacts to the natural environment in land or water areas in construction stage are expected to be negligible.<br>(c) There is the possibility that infectious diseases, such as HIV, will be brought due to the immigration of construction workers. Mitigation measures are as follows.<br>- HIV education for construction workers and residents<br>- Regional workers will be hired preferentially as much as possible. |
| | (2) Accident Prevention Measures | (a) Is a warning system established to alert the inhabitants to water discharge from the dam? | (a) N/A | (a) Not applicable<br>(Accident Prevention Measures in construction works are as follows.)<br>In order to ensure the safety of people in working, acting or moving in and around the project site, The contractor shall prepare following measures.<br>- To inform the construction work plan (description of work, time location) to local residents by posting on village road or public bulletin board<br>- To zone the construction area including stock yard explicitly by rope, fence, or nets, etc.<br>- To set the danger notice of the plate for particularly dangerous construction area |

| | | | | |
|---|---|---|---|---|
| 5 Others | (3) Monitoring | (a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?<br>(b) What are the items, methods and frequencies of the monitoring program?<br>(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?<br>(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities? | (a) Y<br>(b) Y<br>(c) Y<br>(d) Y | (a) NEA developed the monitoring program (draft). NEA will implement the program run from the start of the construction works.Environmental items of monitoring are as follows.<br>- livelihood of land owners after land acquisition (method: hearing from land owners)<br>- noise and vibration (method: hearing from inhabitants)<br>- water turbidity (method: visual monitoring)<br>(b) The monitoring program developed by NEA includes the items, methods and frequencies, etc.<br>(c) NEA is establishing the monitoring framework (team, responsible person, equipment, budget, etc.)<br>(d) According to the Environment Protection Rules (EPR, 1997), for a project that requires IEE/EIA, the proponent should formulate monitoring procedures, including the monitoring agency, time-schedule, monitoring and evaluation indicators, etc. However, for a project that doesn't require IEE/EIA, there is no regulation concerning environmental monitoring. |
| 6 Note | Reference to Checklist of Other Sectors | (a) Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects in the mountains including large areas of deforestation).<br>(b) In the case of dams and reservoirs, such as irrigation, water supply, and industrial water purposes, where necessary, pertinent items described in the Agriculture and Water Supply checklists should also be checked.<br>(c) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities). | (a) N/A<br>(b) N/A<br>(c) N/A | (a) Not applicable<br>(b) Not applicable<br>(c) The scope of the project is the improvement of the existing hydropower system and don't include installation of electric transmission lines and/or electric distribution facilities. |
| | Note on Using Environmental Checklist | (a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming). | (a) N | (a) Since emission of greenhouse gases such as $CO_2$ from transportation vehicles and heavy machines in construction works are quite little and temporary, the impacts to transboundary or global issues are estimated to be negligible. |

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are requested to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

# Annex-8

## Time Schedule for Socio-Environmental Activities

| Activities | Responsible Party | Date | Year 2013 December | Year 2014 January | Februrary | March | April | May |
|---|---|---|---|---|---|---|---|---|
| SHM | NEA | 18 Dec 2013 | △ | | | | | |
| Signing of M/D | NEA/MOE/ JICA | 20 of Dec 2013 | △ | | | | | |
| | | | | | | | | |
| Negotiation with PAPs for compensation plan including compensation policy | NEA | Mid Jan 2014 | | △ | | | | |
| Negotiation & signing of compensation plan by PAPs | NEA | End Jan 2014 | | △ | | | | |
| Finalization of Land Acquisition and Compensation Plan (LACP) | NEA | 3 of Feb 2014 | | | △ | | | |
| Monitoring implementation of LACP | NEA | Feb → Mid May 2014 | | | | | | |
| Completion of Compensation | NEA | Mid May 2014 | | | | | | △ |
| | | | | | | | | |
| Explanation of the Outline Design to the Government of Japan | JICA | 5 Feb 2014 | | | △ | | | |
| Approval by Government of Japan | Government of Japan | Mid Mar 2014 | | | | △ | | |
| E/N and G/A | Governments of Japan and Nepal | Mid Mar 2014 | | | | △ | | |
| | | | | | | | | |
| Contract of consultant | NEA | Mid Apr 2014 | | | | | △ | |
| D/D | JICA | Apr → Jun 2014 | | | | | | |
| | | | | | | | | |

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**Annex-9**

## Environmental Monitoring Form

### 1. Monitoring Plan

| Environmental Item | Item | Measurement Point | Monitoring Method | Frequency (Period) | Implementing Organization | Responsible Organization |
|---|---|---|---|---|---|---|
| Construction Phase | | | | | | |
| Level of livelihood | Livelihood of the PAPs (Project Affected Persons) | Residences of the PAPs | Hearing from the PAPs | twice/year (Jun 2014 – Mar 2016) | Electricity Cooperatives | NEA |
| Noise and Vibration | Noise and Vibration | Near the construction site | Hearing from inhabitants | twice /month (Sep 2014 – Mar 2016) | Electricity Cooperatives | NEA |
| Water quality | Turbidity | a. river near the intake<br>b. canal near the power plant<br>c. river immediately downstream of the power plant | Visual monitoring | twice /month (Sep 2014 – Mar 2016) | Electricity Cooperatives | NEA |

### 2. Responses/Actions to Comments and Guidance from the Government of the District and the Public

| Monitoring Item | | Monitoring Results during Report Period |
|---|---|---|
| Level of Livelihood of PAPs (Construction Phase) | Quantitative and qualitative level of livelihood | Improvement action needs to be taken if living conditions of PAPs get worsened due to the land acquisition.<br>In the above case, frequency, date and results of improvement actions are to be reported. |
| Noise and Vibration (Construction Phase) | Qualitative level of noise and vibration | Improvement action needs to be taken by the proponent when the impact is expected to be considerable ("Level 4: There is impact to the life of inhabitants." in the Table of Turbidity Qualitative Measurement)<br>In the above case, frequency, date and results of improvement actions are to be reported. |
| Turbidity (Construction Phase) | Qualitative level of turbidity | Improvement action needs to be taken by the proponent when the turbidity level is high ("Level 3: There is significant turbidity in the water" in the Table of Turbidity Qualitative Measurement)<br>In the above case, frequency, date and results of improvement actions are to be reported. |

## 3. Method of measurement

**- Level of livelihood of the PAPs**

Measurement Point, Frequency, Method, etc. are shown in 1. Monitoring Plan

**- Noise / Vibration Qualitative Measurement**

| Item | Method of rating for level of noise and vibration in the monitoring (by comments from inhabitants) | Remarks (Measurement Point, Frequency, Method, etc.) |
|---|---|---|
| Noise and Vibration | Level 4: There is impact to the life of inhabitants.<br>Level 3: There is tolerable temporary impact.<br>Level 2: There is tolerable slight impact.<br>Level 1: There is no impact, or there is negligible impact. | Measurement Point, Frequency, etc. are shown in 1. Monitoring Plan |

**- Water Quality**
**Turbidity Qualitative Measurement**

| Item | Method of rating for level of turbidity measured by visual monitoring | Remarks (Measurement Point, Frequency, Method, etc.) |
|---|---|---|
| Turbidity | Level 3: There is significant turbidity in the water<br>Level 2: There is turbidity to some extent in the water<br>Level 1: Water is clear and includes no turbidity | Measurement Point, Frequency, etc. are shown in 1. Monitoring Plan |

## 4. Monitoring Form

| **Environmental Item** | **Measurement Point** | **Period**<br><br>**(from dd/mm/yyyy to dd/mm/yyyy)** | **Frequency** | **Results**<br><br>**Qualitative Data** | **Results Comments**<br><br>**Responses/Actions to Comments and Guidance from the Public (with date)** |
|---|---|---|---|---|---|
| **Construction Phase** | | | | | |
| Level of Livelihood of land owners | | | | | |
| Noise and Vibration | | | | | |
| Water Quality<br><br>-Turbidity | | | | | |

This page is closed due to the confidenciality.

# Appendix - 5 Soft Component Plan

Appendix-5　Soft Component Plan

# PREPARATORY SURVEY
# ON
# MICRO-HYDROPOWER IMPROVEMENT PROJECT
# IN WESTERN AREA
# IN
# FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

# SOFT COMPONENT PLAN

NIPPON KOEI CO., LTD.

**PREPARATORY SURVEY**

**ON**

**MICRO-HYDROPOWER IMPROVEMENT PROJECT**

**IN WESTERN AREA**

**IN**

**FEDERAL DEMOCRATIC REPUBLIC OF NEPAL Soft Component Plan**

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## 1. Background of Soft Component Plan

The aim of the Project is to respond to increasing demand for electricity in village areas by repairing micro-hydropower plants in areas that are not connected to the main electricity network, and thus contribute to development of regional economies and improvement of the people's livelihood. The target sites are the Bajhang Micro-hydropower Plant (200kW), Bajura Micro-hydropower Plant (200kW) and Syarpudaha Micro-hydropower Plant (200kW). The Nepal Electricity Authority (hereafter called NEA) of the Attaria Regional Office has jurisdiction over Bajhang and Bajura Micro-hydropower Plants, and the Nepalgunj Regional Office has jurisdiction over Syarpudaha Micro-hydropower Plant.

The concerned micro-hydropower plants are each operated by an independent electricity company or cooperative (hereafter called Ec) that leases the power plant including generating equipment/facilities and power distribution lines from the respective NEA Regional Offices. The respective Ecs have kept operation logs on operating hours, non-operating hours, power supply generated, and the like, but they have not kept logs on maintenance such as inspections, failures and repairs. In addition, there are no established instructions such as manuals and drawings concerning operation and maintenance. The storage conditions of spare parts and repair tools are also unknown. The current maintenance system is not necessarily satisfactory. Each Ec prepares and submits financial statements including a profit and loss statement and a balance sheet to the NEA, but they are not always prepared appropriately in accordance with rules, with expense items varying on an annual basis, for example. As a result, assistance with the soft component to improve operation and maintenance and management capability is required.

## 2. Target of Soft Component Plan

In order for the project to be effective, it is necessary to acquire correct knowledge about machinery, materials and installations, and about civil engineering facilities, and to implement maintenance according to drawings, instruction manuals, and operation and maintenance manuals. Adding to above, stably profitable operations are required to enable the formation of a budget for necessary administrative and maintenance expenses.

This soft component is provided to continuously maintain the effect of this repair and stabilize the power supply from the power plants for the long term by improving the operation, administration and maintenance capabilities of the staff of NEA Regional Offices, which have jurisdiction over the micro-hydropower plants of the concerned sites, and the staff of the Ecs, which operate the power generation facilities. The goal is that the above staff acquires techniques for operation, maintenance, administration and preparation of financial statements.

## 3. Output of Soft Component Plan

The results to be achieved when implementation of the soft component is completed are as below.

(1) Acquisition of operation and maintenance skills

- The operating method and the maintenance and inspection methods of the generator sets are understood and can be implemented.

(2) Acquisition of administrative and maintenance skills

- Operation logs, accident and failure logs and inspection logs are kept and stored appropriately.

- Design drawings, instruction manuals, etc. are organized and stored, and the storage condition of spare parts and tools is understood.

(3) Acquisition of financial statement preparation skills

- Profit and loss statements and balance sheets are prepared and stored appropriately.
- Financial analysis is possible with the prepared financial statements, and more appropriate budgeting of administrative and maintenance expenses is performed, including the cost of purchasing spare parts, consumables, and repairs.

4. Confirmation Method for Achievement

The results of the soft component are verified as below.

(1) Acquisition of operation and maintenance skills

- Operation manuals, maintenance and inspection manuals are prepared, lectures about the operation, maintenance and inspection procedures are performed, and the knowledge is tested by a comprehension test.

(2) Acquisition of the administrative and maintenance skills

- It is verified that methods are decided for keeping logs of operation, accidents and failures and for the storage of logs, and that the logs are reliably kept.
- It is verified that stored manuals such as design drawings, instruction manuals and log books of spare parts and repair tools are created, and maintenance and storage of said parts and tools are conducted according to the manuals and the log books.

(3) Acquisition of financial statement preparation skills

- It is verified that profit and loss statements and balance sheets are appropriately created in the standard formats.
- It is verified that appropriate budgeting of administrative and maintenance expenses and implementation of operations based on financial analysis are conducted.

5. Activities of Soft Component

(1) Details of activities

There are technical departments composed of electrical and civil engineers in both the NEA Attaria Regional Office and Nepalgunj Regional Office, which have jurisdiction over the three sites, and they are currently providing technical support for the micro-hydropower plants in the jurisdiction. The operation of the power plants is conducted by the Ecs staff. In order to acquire operation, maintenance and administration skills, it is effective to tailor the soft component to the actual facilities. Therefore, instructions are given for each site.

The NEA and Ecs staff below will receive the training of the soft component, and the activities below will be implemented at each power plant.

| | | |
|---|---|---|
| NEA Attaria Regional Office | : | Civil engineers and electrical engineers (2 persons each) |
| Bajhang Ec | : | 6 operators and 1 staff member in charge of finance. 7 persons in total |
| Bajura Ec | : | 4 operators and 1 staff member in charge of finance. 5 persons in total |
| NEA Nepalgunj Regional Office | : | Civil engineers and electrical engineers (2 persons each) |
| Syarpudaha Ec | : | 7 operators and 1 staff member in charge of finance. 8 persons in total |

1) Acquisition of operation and maintenance skills

The following technology transfer activities will be conducted with a focus on on-the-job training in operation and maintenance.

-Operation procedures for starting and stopping and the items to be confirmed

-Actions to take in case of an accident and procedures for recovery

2) Acquisition of administrative and maintenance skills

The following technology transfer activities will be conducted with a focus on on-the-job training in maintenance and administration.

-Inspections (regular inspections and detailed inspections), inspection items, and inspection schedules

-The storage method for operation and accident log sheets

-The storage method for spare parts log books

-The storage method for drawings and instruction manuals

3) Acquisition of financial statement preparation skills

Appropriate techniques for preparing financial statements will be transferred.

Concerning the operation and inspection method of each machine and material delivered during the Project, the suppliers of the machines and the materials will instruct the Ec staff on how to handle the renewed machines and materials. Meanwhile, in this soft component, not only the Ec staff but also the NEA staff who manage the Ecs will receive instructions from the viewpoint that function as a whole power plant should be maintained. 1) The details of instructions, acquisition of basic knowledge required for operation of a power plant and 2) acquisition of the maintenance techniques for the equipment and devices of the power plant will be taken into consideration. Therefore, instructions will be provided in line with instructions on each machine and material by the suppliers of the machines and materials, after having adequately understood the details of said instructions. In addition, an operation, maintenance and administration manual which comprehensively summarizes the facilities of the whole power plant will be created.

(2) Input plan

One Japanese electrical engineer, one locally employed electrical engineer, one locally employed civil engineer and one locally employed person in charge of finance for four persons in total, will be assigned as the soft component staff to implement the soft component.

The detailed activities of the soft component of the Project conducted in Japan and on site are listed in Table 1 and Table 2, respectively.

Table-1 Detailed plan of the soft component activities (in Japan)

| Category | Activity details | Implementation period |
|---|---|---|
| Instructions for operation and maintenance | (1) Preparation of manuals concerning operation of the power plant<br>-Start/stop procedures<br>・Actions to take in case of an accident/procedures for recovery<br>(2) Preparation of manuals concerning maintenance and inspection implementation methods<br>-Types and purposes of inspection<br>(Regular inspection and detailed inspection)<br>-Inspection items/ inspection period | 1 month × 1 person |
| Instructions for maintenance and administration | (1) Preparation of log books concerning operation and maintenance<br>・Operation log<br>・Inspection log<br>・Accident/failure log<br>・Maintenance log (repair and replacement log) history table<br>(2) Creation of a draft of the book storage manual<br>(3) Creation of a draft of the spare parts and repair tools management log book | |
| **Total** | | **1.0 man-month** |

Table-2 Detailed plan of the soft component activities (on-site activities)

| Category | Activity details | Implementation period |
|---|---|---|
| Instructions for operation and maintenance | (1) Instructions concerning operation of the power plant<br>-Training using the operation manual<br>(2) Instructions concerning the implementation method and timing of maintenance and inspection<br>-Training using the maintenance and inspection manual<br>-On-the-job training for repair construction work | Japanese<br>1.5 months × 1 person<br><br>Person employed on site<br>1.4 months × 2 person |
| Instructions for maintenance and administration | (1) Establishment of a method to keep operation logs, accident/failure logs and maintenance logs<br>-Method of managing operation log books<br>-Method of managing inspection log books<br>-Method of managing accident log books<br>-Method of managing maintenance log books<br>(2) Instructions for storage of instruction manuals, machines, materials and civil engineering drawings<br>(3) Instructions for management of the spare part/repair tool log book | |
| Instructions on how to prepare the financial statements | (1) Instructions on how to prepare financial statements<br>-How to prepare profit and loss statements<br>-How to prepare balance sheets<br>(2) Instructions on how to conduct financial analysis<br>(3) Instructions concerning the plan for procurement of spare parts/ consumables | Person employed on site<br>0.53 months × 1 person |
| **Total** | | **4.83 man-months** |

## 6. Procurement of Implementation Resource for Soft Component

It is assumed that an electrical engineer will join as the Japanese soft component member, and will provide instructions about the generator sets. During this soft component, the engineer will also provide instructions about maintenance of civil engineering facilities and preparation of financial statements. It is assumed that an electrical engineer employed on site, a civil engineer and a finance specialist will be assigned for the reasons below.

(1) It is possible to instruct in English for the NEA staff, but the instructions should be preferably made in Nepali for the NEA and Ecs staffs to achieve complete communication in their mother tongue.

(2) Because of reason (1), preparation of manuals and instructions in Nepali is necessary.

Therefore, in this soft component, an electrical engineer and a civil engineer who have technical knowledge about hydraulic power generation will be assigned as assistants to a Japanese staff, and will help prepare manuals and instructions in the local language. In addition, a local finance specialist will be assigned.

## 7. Implementation Schedule of Soft Component

This construction work is assumed to be conducted for 18 months from October 2014 to March 2016 except the period from June to September, which is the rainy season. Removal of existing equipment and installation of new equipment are planned from November 2015 to February 2016. Originally, it is desirable that the soft component be implemented using the newly introduced equipment. However, in the Project, removal/installation work for the Bajura Micro-hydropower Plant among the 3 sites will be completed just before the start of the construction period from February 2016. There is no time interval for implementing the soft component after introduction of the equipment. Therefore, the soft component will be implemented before completion of removal/installation of the equipment in Bajura. The soft component concerning the whole power generation facilities other than the equipment will be implemented at the actual facilities in Bajura, and instructions about the equipment will be provided by on-site instruction at Bajhang Micro-hydropower Plant after completion of installation work in addition to the instructions provided in the classroom in order to provide the necessary supplementary instructions.

It is necessary to prepare the operation, maintenance and inspection manuals used in the soft component based on the supplier's instruction manuals and equipment maintenance manuals. Normally, the manufacturer of a machine prepares and submits the maintenance manual when it has almost finished manufacturing the machine. The period the equipment manufacturer submits the maintenance manual is assumed to be 10 months to 1 year after concluding the contract. Therefore, the on-site works of the soft component will be implemented in October 2015 or later.

The implementation processes of the soft component are listed in Table-3.

Table-3 Implementation processes of the soft component

| Year | 2015 | | | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|
| Month | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| Repair work processes | | | | | | | | |
| Operation and maintenance staff member (Japanese) | | | | | | | | |
| -Domestic work | | | | | 30 days | | | |
| -Transfer (Japan → Katmandu) | | | | | 1 day | | | |
| -On-site work (Bajura)*1 | | | | | | 16 days | | |
| -On-site work (Bajhang)*2 | | | | | | 13 days | | |
| -On-site work (Syarpudaha)*3 | | | | | | | 16 days | |
| -Transfer (Katmandu → Japan) | | | | | | | 2 days | |
| Electrical engineer assistant (employed on site) | | | | | | | | |
| -On-site work (Bajura)*1 | | | | | | 16 days | | |
| -On-site work (Bajhang)*2 | | | | | | 13 days | | |
| -On-site work (Syarpudaha)*3 | | | | | | | 16 days | |
| Civil engineer assistant (employed on site) | | | | | | | | |
| -On-site work (Bajura)*1 | | | | | | 16 days | | |
| -On-site work (Bajhang)*2 | | | | | | 13 days | | |
| -On-site work (Syarpudaha)*3 | | | | | | | 16 days | |
| Financial statement preparation method instructor (employed on site) | | | | | | | | |
| -On-site work (Bajura)*4 | | | | | 5 days | | | |
| -On-site work (Bajhang)*5 | | | | | 4 days | | | |
| -On-site work (Syarpudaha)*6 | | | | | | 7 days | | |

Legends: Work in Japan On-site work

Instructions for operation, maintenance and administration

*1 On-site work (Bajura):

| | |
|---|---|
| Preparation for the soft component work | 2 days |
| Transfer (Katmandu → Bajura Micro-hydropower Plant) | 3 days |
| Instructions on operation and maintenance (classroom instruction) | 6 days |
| Instructions on maintenance and administration (classroom instructions) | 5 days |
| | 16 days in total |

*2 On-site work (Bajhang):

Transfer (Bajura Micro-hydropower Plant → Bajhang Micro-hydropower Plant)
2 days

Instruction on operation and maintenance (including the Bajura staff)
6 days

Instruction on maintenance and administration (including the Bajura staff)
5 days

13 days in total

*3 On-site work (Syarpudaha):

Transfer (Bajhang Micro-hydropower Plant → Syarpudaha Micro-hydropower Plant)
3 days

Instructions on operation and maintenance 6 days

Instructions on maintenance and administration 5 days

Transfer (Syarpudaha Micro-hydropower Plant → Katmandu)
2 days

16 days in total

<u>Instructions on how to prepare financial statements</u>

*4 On-site work (Bajura):

Transfer (Katmandu → Bajura Micro-hydropower Plant) 3 days

Instructions on how to prepare financial statements 2 days

5 days in total

*5 On-site work (Bajhang):

Transfer (Bajura Micro-hydropower Plant → Bajhang Micro-hydropower Plant)
2 days

Instructions on how to prepare financial statements 2 days

4 days in total

*6 On-site work (Syarpudaha):

Transfer (Bajhang Micro-hydropower Plant → Syarpudaha Micro-hydropower Plant)
3 days

Instructions on how to prepare financial statements 2 days

Transfer (Syarpudaha Micro-hydropower Plant → Katmandu)
2 days

7 days in total

8. Items as Part of Output of Soft Component

Output acquired by implementation of the soft component of the Project and the period of submission are as below.

| Output | Period of submission |
|---|---|
| (1) Soft component completion report (Japanese/ English): | February 2016 |
| (2) Operation and maintenance manual (English): | February 2016 |
| (3) Log books (English): | February 2016 |

9. Responsibilities of NEA and Electricity Company/Cooperatives

In order to continue smooth operation and the effect of implementation, it is important that the NEA, the implementing organization, instructs the Ecs of Bajhang District (Bajhang Micro-hydropower Plant), Bajura District (Bajura Micro-hydropower Plant) and Rukum District (Syarpudaha Micro-hydropower Plant) to improve their maintenance abilities. Based on above, the NEA and the Ecs of the concerned districts shall bear the following responsibilities for implementation of the soft component.

Responsibilities for smooth implementation of the soft component

(1) Select the person in charge and the participants from the NEA
(2) Select the person in charge of power generating equipment operation and the person in charge of finance from the Ec of each district
(3) Provide the venue for the lectures
(4) Stop operation of the equipment for implementation

Responsibilities to continue the effects of implementation
(1) Implement regular inspections (daily, monthly and yearly)
(2) Implement maintenance of the facilities accompanying suspension of their operation and implement inspections of power generating equipment
(3) Budget for purchasing spare parts, repair tools, etc.
(4) Implement educational training for the staff members who are concerned with operation and maintenance

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# Appendix - 6 Reference Data

- Land Acquisition and Compensation Plan
- Outline Design Report
- Reference Data of Hydrology Analysis
- Reference Data for Expansion Possibility of Installed Capacity in the Existing Plant

# LAND ACQUISITION AND COMPENSATION PLAN （LACP） FOR MICRO-HYDROPOWER IMPROVEMENT PROJECT IN WESTERN AREA IN NEPAL

4th February, 2014

Nepal Electricity Authority

# LAND ACQUISITION AND CONPENSATION PLAN (LACP)
# FOR
# MICRO-HYDROPOWER IMPROVEMENT
# PROJECT IN WESTERN AREA IN NEPAL

## CONTENTS

# 1. Necessity of land acquisition

## 1-1 Project Outline

The three target power plants belong to the Nepal Electricity Authority (NEA) Distribution and Consumer Services, and are controlled by the following NEA regional offices:

| | | |
|---|---|---|
| 1. | Bajhang Hydroelectric Power Plant: | Attaria Regional Office |
| 2. | Bajura Hydroelectric Power Plant: | Attaria Regional Office |
| 3. | Syarpudaha Hydroelectric Power Plant: | Nepalgunj Regional Office |

These sites are not connected to the main transmission system but are supplied with electric power using the independent distribution network of each power plant as the only power source. In the three target sites, the respective electricity operators run power supply using the power generation and distribution equipment leased from NEA.

The lease agreement between NEA and each electricity operator stipulates that the electricity operator is responsible for running and maintaining the electric power equipment, minor repair of the equipment is covered by the budget of the electricity operator, and major repair, if necessary, may be covered by the saved budget of NEA and electricity operator. However, due to the lack of any large-scale upgrading program for the equipment or fund accumulation for the program, partial repairs of the devices were repeated to the extent covered by the organizations' operating costs. After around 25 years from the start of operations, the equipment has significantly degraded and the operating power generation machines left broken. Thus, the village areas lose electricity, and it is only a matter of time before the equipment becomes fully broken down.

This project intends to repair the degraded or damaged existing equipments, restore the reliability of power generation functions and power supply, and extend the life of the equipments for the purpose of maintaining electric power development through micro-hydropower generation and sustaining power supply in the village areas of the three target sites. The stable and sustained power supply is expected to contribute significantly to a better and improved life that the areas have desired.

This cooperative project of the three sites includes civil engineering works and machine procurement to reconstruct intake works, repair the existing headraces, and replace the power generation equipment.

## 1-2 Project affected area

Although the Project does not involve involuntary resettlement, part of the land in Bajhang site must be acquired for intake structures, construction materials stock yard and construction work space.

The Project site is located in a narrow valley with little flatland, which is hardly secured for construction, except for the land owned by NEA and Electricity Cooperatives.

## 1-3 Initial alternatives that were considered to avoid or minimize land acquisition

Alternative 1

Other land having no farmland, located far upstream from the selected site

However, the alternative could not be selected due to poorer conditions than the selected area.

- Impossible to take land size required.
- Accessibility is very poor and cost for transportation becomes higher.
- There are many Landslide-prone areas.

(a) Alternative 2

Other land having no farmland, located far downstream from the selected site

However, the alternative could not be selected due to the reason below.

- Drop of water and water flow rate required cannot be secured.
- Civil engineering costs become to double.

(b) Effort to reduce the necessary area

Necessary land was designed to minimize and to design as a continuous integrated land with the land for construction materials stock yard, intake structures and construction work space.

In addition, construction materials storage stock yard and construction work space were designed to minimize as much as possible within a tolerance of topographical conditions.

The measures described above, the entire required area were reduced than originally expected.

## 2. Legal and policy framework

### 2-1 Laws of Nepal related to land acquisition

The core law concerning the acquisition of land/assets and resettlement activities in Nepal is the Land Acquisition Act (1977). The framework of this act is used for land acquisition and compensation for public purpose.

Besides, any institutions seeking land acquisition may also request Government of Nepal (GON) to acquire the land under the regularity provisions subject to be compensated by such institution’s resources.

As per the prevailing government rules, the compensation to be provided for land acquisition should generally be in cash as per current market value.

As per the regulatory provision, while acquiring land, GON forms a Compensation Fixation Committee (CFC) under a central role of Chief District Officer (CDO) of the district.

CFC is formed for actual verification of land to be acquired, reviewing and fixing compensation rate, identification of proper owners, distribution of compensation, providing necessary administrative support addressing associated issues. Formally the implementation process of CFC begins by formal approval of GON for the land acquisition. After the approval, CFC shall issue a “Notification of land acquisition”. The notification contains particulars in respect to the land.

The main members to be included in the Committee are as follows (Clause 13).

- Land Administrator or Chief of the Land Revenue Office
- An Officer assigned by CDO
- Representative from District Development Committee (DDC)
- Concerned Project Officer.

In determining the compensation, the committee must consider the loss incurred by persons due to acquisition of land, shifting of residence or place of business to another place.

If the land has to be acquired for institutions fully owned by the government, the Committee has to consider the following while fixing the compensation amount.

- Price of land prevailing at the time of the notification of land acquisition;
- Price of standing crops and structures, and damage incurred by being compelled to shift the PAPs ( Project Affected Persons) residence or place of business in consequence of the acquisition of land.

The Land Acquisition Act stipulates a series of procedures for the acquisition of and compensation as follows.

> Preliminary action relating to acquire land >>Report to be submitted in respect to findings of preliminary action >>Notification of land acquisition >>Particulars to be given relating to land acquisition >>Right of landowner to file complain >>Form of CFC >>Criteria to be considered while determining compensation >>Notice to be given after fixation of compensation >>Devolution of ownership ( >> procedure for lawsuit.)

## 2-2 JICA’s Policy

The key principle of JICA’s policy on land acquisition is summarized below.

Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

I. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.
II. Compensation must be based on the full replacement cost*as much as possible.
III. Compensation and other kinds of assistance must be provided prior to displacement.
IV. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.
V. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring
VI. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that “JICA confirms that projects do not deviate significantly from the World Bank’s Safeguard Policies”.

Additional key principle based on World Bank OP 4.12 is as follows. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the Project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

VII. Provide support for the transition period (between displacement and livelihood restoration).

VIII. Particular attention must be paid to the needs of the vulnerable groups among those displaced,
especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

In addition to the above core principles on the JICA policy, it also laid emphasis on a detailed land acquisition policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and detailed financial plan etc.

Note *: Description of “replacement cost for Agricultural Land” is as follows.

| | |
|---|---|
| Agricultural Land | The pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes. |

## 2-3 Comparison with JICA Guideline and Nepal Legislation

Table 1 Comparison with JICA Guideline and Nepal Legislation

| No. | JICA Guidelines/World Bank | Laws of Nepal | Gaps between JICA Guideline /World Bank and Laws of Nepal | Resolution Measures of Gaps |
|---|---|---|---|---|
| 1 | Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives (JICA GL) | None | No law was identified | There is no law of Nepal, including the provisions corresponding.<br><br>In land acquisition policy of the project (the Project Policy), it is described that "land acquisition is to be avoided when feasible by exploring all vaiable alternatives." |
| 2 | People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income | Land Acquisition Act (1977) (Clause 16) | Clause 16;<br>While determining the amount of compensation for land to be acquired, the CFC shall take the following criteria into consideration:<br>(a) The price of the land at the time of the publication of “Notification of Land Acquisition”. | Because there is little difference, "policy on improvement or at least restoration of means of livelihood of PAPs " is described in the Project Policy according to JICA policy. |

| No. | JICA Guidelines/World Bank | Laws of Nepal | Gaps between JICA Guideline /World Bank and Laws of Nepal | Resolution Measures of Gaps |
|---|---|---|---|---|
| | opportunities and production levels to pre-project levels. (JICA GL)<br><br>Compensation must be based on the full replacement cost as much as possible. (JICA GL) | | (b) The value of the crops, houses, walls, sheds etc, if any, acquired along with the land.<br>(c) Losses which the concerned person will suffer as a result of shifting his/her residence or the place of his/her business, by reason of the acquisition of his/her land. | |
| 3 | Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL) | Land Acquisition Act (Clause 19) | Clause 19;<br>After the CFC has determined the amount of compensation, the CDO shall notify GON accordingly. | Since the result of determination of compensation is notified to GON before the payment of compensation and transfer of land ownership, there is no difference. |
| 4 | In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.<br>(JICA GL) | None | No law specifically mentions the requirement of resettlement action plans for involuntary resettlement. | It is described in the Project Policy that "making land acquisition and compensation plan is to be requested." |
| 5 | Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.<br>(JICA GL) | None | Same as above | It is described in the Project Policy that "PAPs are to be participated in the process of land acquisition and compensation." |
| 6 | Appropriate and accessible grievance mechanism must be established for the affected people and their communities. (JICA GL) | Land Acquisition Act (Clause 10, 11) | Clause 10;<br>After the “Notification of Land Acquisition”, the concerned person can submit an application claiming compensation within a minimum time-limit of fifteen days, along with documentary evidence of his/her title to the land.<br>Clause 11;<br>Within a time-limit of seven days from the date of the publication the “Notification of Land Acquisition”, plus the time required for the journey involved, the concerned landowner may file a complaint with the Ministry of Home Affairs, GON | There is no fundamental difference. |

| No. | JICA Guidelines/World Bank | Laws of Nepal | Gaps between JICA Guideline /World Bank and Laws of Nepal | Resolution Measures of Gaps |
|---|---|---|---|---|
| | | | through the local officer, explaining the reasons, if any, why his/her land should not be acquired. | |
| 7 | Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits (WBOP4.12 Para.6) | Land Acquisition Act (Clause 8) | Clause 8:<br>The officer (of the proponent) responsible for Preliminary Action shall complete such Action within fifteen days from the starting of it, determinate whether the land is suitable for acquisition, and then submit a report containing necessary information in respect to such Action to the local office as early as possible. | There is no fundamental difference. |
| 8 | Eligibility of benefits includes the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal right to the land they are occupying. (WB OP4.12 Para.15) | Land Acquisition Act (Clause 2) | The Act stipulates that "Concerned person" means the person who is entitled to the compensation payable for lands acquired under this Act. However, the eligibility for the PAPs other than described above is not clearly prescribed in the Act. | It is not clearly prescribed that eligibility of benefits includes the PAPs who do not have formal legal rights to land.<br>In the Project Policy it is described that "those who do not have a legal right are also included in the PAPs." |
| 9 | Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4.12 Para.6) | None | No law was identified on the provision of support for the transition period. | In the Project Policy it is described that "support to PAPs for the transition period is to be provided." |
| 10 | Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc. (WB OP4.12 Para.8) | None | No law was identified on particular attention to vulnerable groups. | In the Project Policy it is described that "Particular attention must be paid to the needs of the vulnerable groups among PAPs." |

Source: Land related laws of Nepal, JICA Guidelines and World Bank OP 4.12.

## 2-4 Policy setting for the Project

NEA will use this Land Acquisition Policy (the Project Policy) for the Project.

The Project Policy is basically due Legal and policy framework of Nepal.

Existing laws and regulations of Nepal have been designed to basically address according to international practice including JICA's policy, some gaps exist between them. Accordingly, the Project Policy is supplemented by JICA's policy.

(1) Land acquisition will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the Project area.

(2) Where land acquisition is unavoidable, all PAPs losing land will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions

(3) Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which on account of project implementation would have his, her or their;

- Standard of living adversely affected;
- Right, title or interest in any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently.
- Income earning opportunities, work adversely affected temporarily or permanently.

(4) All PAPs residing, working, doing business and/or cultivating land within the Project impacted areas as of the date of the latest census and inventory of lost assets, are entitled to compensation for their lost assets (land and/or non-land assets), at replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.

(5) PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the land acquisition process.

(6) After receiving the detailed preliminary report relating land to be acquired and the landowners, CDO shall issue the "Notification of land acquisition" with particulars in respect to the land. The Notification shall be affixed at concerned offices and public places.

(7) The LACP will be disclosed for the reference of PAPs as well as other interested groups.

(8) Payment for land will be based on the principle of replacement cost.

(9) Land acquisition assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs.

(10) The LACP must consider the needs of those most vulnerable to the adverse impacts of land acquisition (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled). Assistance should be provided to help them improve their socio-economic status.

(11) PAPs and their communities will be consulted about the Project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the decisions that are made concerning their loss of land.

(12) Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition within the agreed implementation period. The funds for all replacement activities will come from NEA.

(13) Acquisition of land, payment of compensation will be completed prior to any construction activities, except when a court of law orders so in expropriation cases.

(14) Organization and administrative arrangements for the effective preparation and implementation of the LACP will be identified and in place prior to the commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities.

(15) Appropriate reporting (including redress functions and monitoring) will be identified and set in place as part of the LACP system.

## 3. Scope of land acquisition

### 3-1 Occupancy of land the Project will require

Table 2 Occupancy of land the Project will require

| Site | Location | Area | Purpose of land use for the Project | Owner or jurisdiction |
|---|---|---|---|---|
| Bajhang | Left bank paddy field at intake weir | 1,394 $m^2$ | Construction for intake weir | Left bank paddy field owned by two different individuals |
| | River bed and river terrace at intake weir | 6,517 $m^2$ | Construction for intake weir | Almost land is owned by NEA, the remaining land owned by government) |
| Bajura | River bed at intake weir | 2,153 $m^2$ | Construction for intake weir | The land is owned by NEA. |
| | Left bank area just downstream of intake weir | 390 $m^2$ | Temporary stock yard for construction of intake weir | The land is owned by the local government. |
| Syarpudaha | River bed at intake weir | 5,117 $m^2$ | Construction for intake weir and temporary stock yard | The land for intake is owned by NEA. Land for temporary stockyard is owned by government. |
| | Land purchased by Electricity Cooperatives for the power station | 3,000 $m^2$ | Temporary office for contractor during the construction | The land is owned by the lease holding company. |

## 3-2 Scope of Land Acquisition

Table 3 Scope of Land Acquisition

| Site | Usage in the Project | Necessary Area | Land owner | Current use | Policy for compensation |
|---|---|---|---|---|---|
| Bajhang | stock yard | 230 $m^2$ * | Two owners<br>A : 975 $m^2$<br>B : 145 $m^2$ | A: paddy field<br>B: farm land currently not cultivated | As written in 6. Specific procedures of the Project for land acquisition and compensation |
| | work space | 487 $m^2$ * | | | |
| | intake structure | 677 $m^2$ * | | | |
| | Total | 1,394 $m^2$ | 1,120 $m^2$ | | |
| Bajura | unnecessary | | | | |
| Syarpudaha | unnecessary | | | | |

Note *: The area above is the area of the required land. The actual acquired area may change in the process of land acquisition.

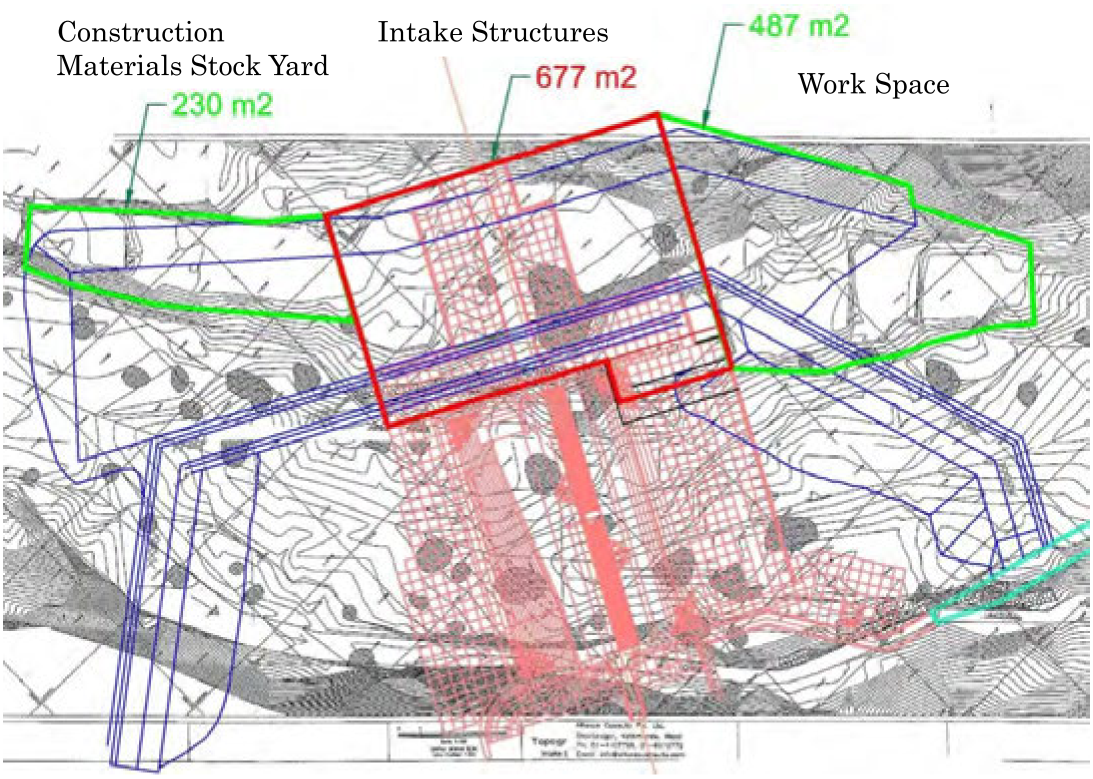


Figure 1 Design of necessary Land for the Project (Bajhang)

# 4. Population Census

## 4-1 Survey of occupants in the land to be acquired (Bajhang site)

Table 4 Occupants in the land to be acquired (Bajhang)

| Item | | Land owner (A) | Land owner (B) |
|---|---|---|---|
| Status of the land to be acquired | Area required for the acquisition | 975 $m^2$ | 145 $m^2$ |
| Current usage | Farm land | Cultivating<br>Rice, Wheat | Not cultivating |
| Trees, Structures, etc. | | none | none |

## 4-2 Survey of land owners (household, family, income etc.)

Table 5 Land owners (household, family, income etc.)

| Item | | Land owner (A) | Land owner (B) |
|---|---|---|---|
| Land Owner | | Mr.A<br>Name and Age are hidden (personal information) | Mr.B<br>Name and Age are hidden (personal information) |
| Address | | Dhaulichaur VDC, Bajhang | Dhaulichaur VDC, Bajhang |
| Houshold/Family | Living together | Hidden (personal information) | Hidden (personal information) |
| | Non-living together | Hidden (personal information) | Hidden (personal information) |
| Ethnic | | Chetri | Chetri |
| Religion | | Hinduism | Hinduism |
| Household Income (Except for different Household) | Working away from home | (5,6 month/year)<br>Income is hidden (personal information | |
| | Farming | Self-consumption | Self-consumption |

## 5. Requirement for compensation entitlements for land loss

A copy of Legal certificates (land registration document) of each land owner and be verified for land ownership.

The letters from two land owners addressed to the NEA have been already received. On the letters it is written that they agree to comply with the procedures of land acquisition.

## 6. Specific procedures of the Project for land acquisition and compensation

The Project specifies the following procedure for land acquisition based on the Land Acquisition Act (1977), including the provision for the Compensation Fixation Committees (CFC).

Table 6 Procedures of the Project for land acquisition and compensation

| | Steps in the process for land acquisition | Status |
|---|---|---|
| 1 | NEA has finalized the plan of the Project. | NEA based on feasibility studies has finalized the designs, including the layout for the Project |
| 2 | NEA requests MOE (Ministry of Energy) to acquire land specifying objectives and committing payments of compensation and other expenses. | NEA will submit the request to MOE seeking approval for acquiring land.<br>Provision for land acquisition and compensation made within NEA budget. |
| 3 | MOE approves and orders the initiation process to Bajhang District Government | To be approved once the commitment for funding for the Project is obtained. |
| 4 | Chief District Officer (CDO) of Bajhang District forms Compensation Fixation Committee(CFC). (usually within 7 days) | |
| 5 | Land revenue officer confirms on the area and location of land to be acquired including likely compensation and amount of loss. | To be carried out once the approval from the MOE to initiate the process of land acquisition is obtained. |
| 6 | CDO issues “Notification of land acquisition” including purpose of acquisition and detail of land to be acquired.<br>Land transactions are banned within the notified area. | |
| 7 | Owner can file complaints within 7 days through the CDO.<br>Resolution of grievance within 15 days of complaint. | |
| 8 | CFC determines the amount of compensation. | |
| 9 | Compensation Payment/Disbursement | NEA will disburse the compensation amount to the district administration office (DAO).<br>The money will be deposited in DAO account.<br>The PAPs can receive money immediately.<br>The PAPs can claim their compensation with legal entitle documents any time. |
| 10 | Devolution of ownership | After the payment, land ownership devolves to NEA. |

Members of the Compensation Fixation Committee compensation committee will be as follows.

- Chief District Officer : CDO
- Local Development Officer : LDO
- Member of Village Development Committee (VDC)
- Representative of District Survey Office
- Representative of District Account and Audit Office
- Representative of District Land Administration Office
- Land owners
- An Officer of the proponent

For the Project, details of land to be acquired only two land owners are only clearly identified. Accordingly, the procedure of land acquisition is possible to initiate the procedure from the stage of forming the CFC (Compensation Fixation Committee), and is possible to skip the previous stage.

The committee members include all officers being related to the practice of land acquisition and familiar with that.

As described above, it is possible that the procedure is processed smoothly and the procedure of land acquisition can be completed in a short period of time.

The committee decides the amount of compensation where the land owner and NEA are attending. So, the committee also has some aspects of a place of negotiation.

The committee figures out the amount of compensation basing on the concept of replacement cost with reference to the market price and the transaction price in the region where the Project site is located.

As described above, there is no particular difference between this process to determine the compensation and the policy in the JICA guideline.

## 7. Measures of rehabilitation for entitlements

In addition to the compensation for land itself, in the case that the land owner cultivates on the land, for supporting livelihood of the owner, NEA shall compensates the amount equivalent of market price for annual production of the crops. One of the two land owners currently cultivates and products are all self-consumption.

## 8. Grievance Redress Mechanism

(1) Constitutional grievance redress mechanism

The constitutional basis of activities relating grievances is Land Acquisition Act (1977). The Act stipulates CDO as the central responsible person to manage land acquisition activities and to address the grievances related to the land acquisition activities. In keeping with the legal provision mentioned in the Act, the basic process of grievances redress to be undertaken will be as follows.

- The various queries, complaints and problems that are likely to be generated among the PAPs shall be resolved in constitutional mechanism.
- Decisions should be given within fifteen days after receiving the complaints.
- Processing of the complaints or any decision should be taken only after consultation with the CDO and also the NEA officer, if deemed necessary.
- Ministry of Home Affairs can exercise legal authority as of District Court and consults CDO and NEA on complaints by PAPs occurred in the process of land acquisition.
- Decision on complaints (including final decision of the court) shall be made within prescribed days.

(2) NEA side grievance redress mechanism

In addition to the constitutional mechanism, NEA will maintain an ongoing interaction with PAPs to identify problems and undertake appropriate remedial measures. For this aim, NEA will put the person in charge of grievance redress (Grievance redress officer).

Grievance redress mechanism shall be easily accessible for PAPs, and oral or verbal grievance can be applied.

It is important that the grievance redress officer always presents in the NEA office during the process of land acquisition with land owners, and addresses any queries, disputes and complains that may arise.

- Determination in correspondence should be given as soon as possible when after receiving any grievances.
- For issues that cannot be corresponding the grievance redress officer, the officer requests the correspondence and the resolution to CDO in CFC, in accordance with the Land Acquisition Act.
- The officer must records all complains and respective actions and report to CDO in CFC.
- The expenses relating to grievance redress activities above burden on NEA.

## 9. LACP implementation management system in NEA

For LACP implementation management, NEA will build up the LACP management team and assigns following officers.

(a) LACP supervising manager

The officer will supervise all over the implementation process of LACP.

(b) LACP task management officer

The role of the officer is to ensure the smooth and timely implementation of LACP.

The officer will manage and support the tasks in NEA relating to LACP

(c) Grievance redress officer

The key objective of this officer is to ensure good relations with both the PAPs and CDO for adequate response to grievance from PAPs..

(d) Accounting officer

The officer manages compensation payment process and manages the expense in LACP implementation.

## 10. Organizations with responsibility and duty for land acquisition

### 10-1 Organizations with responsibility and duty for land acquisition

Organizations with responsibility and duty for land acquisition in the Project are shown in Table 7.

Table 7 Organizations with responsibility and duty for land acquisition

| Organization | Role | Description of responsibility and duty |
|---|---|---|
| MOE<br>(Ministry of Energy) | Jurisdiction over the land acquisition in the Energy Sector<br>The line Ministry of NEA | - Approval of the application of land acquisition<br>-Order of the initiation process to Bajhang district government |
| NEA<br>(Nepal Electricity Authority) | Role as the proponent | -Submission of identified data of land to be acquired and land owners<br>-Close communication with landowners, CDO, MOE and MOHA<br>-Adequate Response for grievance from PAPs with ongoing interaction<br>-Payment of compensation<br>-Support of livelihood of PAPs after the completion of the process in CFC |
| The government of the Bajhang District | Jurisdiction over the land acquisition in the district. | -Forming CFC（Compensation Fixation Committee) |
| CFC | Handling the procedure and all issues related to land acquisition and compensation | -Confirmation identified data of land and land owners affected by the Project.<br>-Decision of compensation amounts<br>-Grievance redress<br>-Support for district administrative practical work of the payment of compensation and devolution of ownership |
| Ministry of Home Affairs (MOHA) | Legal authority as of District Court | -For complaint filed by landowners MOHA shall consults CDO and NEA<br>-Decision on complaints (including final decision on the court) shall be made within prescribed days. |
| Consultants | Support and consultation for NEA | -Preliminary survey of land to be acquired and preliminary survey of PAPs<br>-Preliminary survey of replacement cost of land to be acquired<br>-Preliminary survey of the amount equivalent of market price for annual production of the crops |
| NGOs, Mass media | Appropriate activities are expected in line with purpose of their activities. | |

## 10-2 Entitle Matrix for land acquisition

Table 8 Entitle Matrix

| Type of loss | Entitled Persons (Beneficiaries | Entitlement (Compensation Package) | Implementation issues | Responsible Organization |
|---|---|---|---|---|
| Loss of agricultural land | Legal owners of land | Replacement value of land (Cash Compensation under Law and additional grant to cover the market value of land as at market price to be determined. | a. Assessment of quantity and quality of land<br>b. Assessment of Cash Compensation under Law<br>c. Assessment of Market Value by land market information<br>d. Updating of title of the affected persons<br>e. Payment of Cash Compensation under Law<br>f. PAPs will be fully informed of the entitlements and procedures regarding payments | a. NEA/CFC<br>b. CFC<br>c. CFC<br>d. CFC/NEA<br>e. NEA<br>f. NEA/CFC |

## 11. Compensation cost estimates and source of funds and LACP Implementation budget

Table 9 Estimated cost of Compensation, source of funds and LACP Implementation budget

| No. | Description | Unit | Quantity | Rate (NRs /Unit) | Amount (NRs) |
|---|---|---|---|---|---|
| 1. | Land acquisition | $m^2$ | 1,300 (necessary area 1,120 $m^2$ +allowance) | 80 | 104,000 |
| 2 | Support for Livelihood | Area : $m^2$<br>Land Productivity : kg/ $m^2$/year<br>Crops Price: NRs/ kg | 975 $m^2$ | Rice: 0.29 kg/$m^2$/year*<br>Wheat: 0.17 kg/$m^2$/year*<br>Rice : 63 NRs/ kg**<br>Wheat : 50 NRs/ kg** | 26,100<br>Rice: 17,800<br>Wheat: 8,300 |
| 3. | Cost relating CFC<br>Burden of operating costs of CFC,<br>Various commission fee,<br>Transportation, and others | Lump sum | | | 100,000 |
| 4. | Office supplies etc. | Lump sum | | | 20,000 |
| | Subtotal Total (A) | | | | 250,100 |
| 5 | General and administrative cost & Contingency (B)<br>20% of (A) | | | | 50,020 |
| | Total | | | | 300,120 |

Note *: Setting as 1.25 times of statistics values in Bajhang district. The reason of using 1.25 times is considering the fluctuations in productivity.

**: The higher of values obtained by hearing in the Bajhang area

Compensation amounts in the table above are estimated values, because actual amounts will be determined by CFC

The total cost required for acquiring the land of private land owners in Bajhang project site will be estimated to 300,000 NRs.

## 12. Monitoring plan and monitoring form

1. Monitoring Plan

| Environmental Item | Item | Measurement Point | Monitoring Method | Frequency (Period) | Implementing Organization | Responsible Organization |
|---|---|---|---|---|---|---|
| Construction Phase | | | | | | |
| Level of livelihood | Livelihood of the PAPs | Residences of the PAPs | Hearing from the PAPs | twice/year (Jun 2014- Mar 2016) | Electricity Cooperatives | NEA |

2. Responses/Actions to Comments and Guidance from the Government of the District and the Public

| Monitoring Item | | Monitoring Results during Report Period |
|---|---|---|
| Level of Livelihood of PAPs (Construction Phase) | Quantitative and qualitative level of livelihood | Improvement action needs to be taken if PAPs' living conditions get worsened due to the land acquisition and other project activities. |

3. Monitoring Form

| Environmental Item | Measurement Point | Period (from dd/mm/yyyy to dd/mm/yyyy) | Frequency | Results -Qualitative Data | Results -Comments -Responses/Actions to Comments and Guidance from the Public (with date) |
|---|---|---|---|---|---|
| Construction Phase | | | | | |
| Level of Livelihood of PAPs | | | | | |

## 13. Result of the stakeholders meeting

Date: 18th December, 2013 Wednesday

Venue: MD's Meeting Room, Nepal Electricity Authority, Kathmandu

The consultant of JICA study team who is in charge of environmental and Social Consideration explained regarding land acquisition and compensation of the Project.

He mentioned that NEA shall settle the compensation by paying in cash immediately after completion of fixation of compensation based on the replacement cost. He also informed that the compensation shall also include annual value of crops equivalent to market value. As per supporting for land owner's livelihood after the acquisition shall be monitored for at least one and half year after compensation. He also informed the meeting that NEA shall support his livelihood in case the landowner's standard of living goes down.

Then, an officer of NEA explained the land acquisition procedure in Nepal to be adopted for the Project.

NEA is a government entity so it has to follow the Land Acquisition Act and to inform the line ministry i.e. MOE about the requirement. Then the process is initiated and CFC is formed. Land owners participate CFC. In accordance with the necessary procedures, CFC will examine and discuss the land acquisition and compensation. Actually, negotiating with land owners is included in the process. Finally compensation will be fixed. After the compensation will be paid the ownership will be transferred to NEA.

The committee will decide the rate of the land in presence of the land owner and the basis of rate would be the market price of land and the transaction price in the area. NEA will also try to provide fair compensation to the land owner as per their expectation.

One of the two land owners attended the meeting. He said he understood the policy of land acquisition and compensation of the Project and thought there is no any particular problem or question for the explanation.

## 14. LACP implementation schedule

| Item | January, 2014 | February | March | April | May | June |
|---|---|---|---|---|---|---|
| Building up LACP Implementation System, Initiation of Action | | △ | | | | |
| Date of Grant Aid Agreement* | | | △ | | | |
| Appointment of acquisition officer | | | | | | |
| Finalization of process, compensation amount | | | | | | |
| Compensation, ownership transfer, and land demarcation | | | | | | |
| Grievances address | | | | | | |
| Completion of Procedure for Land Acquisition | | | | | | △ |
| Compensation Payment Devolution of ownership | | | | | | △ |
| Completion of Preparation of LACP by NEA | | △ | | | | |
| Monitoring of Livelihood of PAPs | | | | | | |

>> to March, 2016

* The procedure for land acquisition will be started upon the date of Grant Aid Agreement

Appendix-6 Reference Data

# PREPARATORY SURVEY
# ON
# MICRO-HYDROPOWER IMPROVEMENT PROJECT
# IN WESTERN AREA
# IN
# FEDERAL DEMOCRATIC REPUBLIC OF NEPAL

# OUTLINE DESIGN REPORT

NIPPON KOEI CO., LTD.

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# 1. Design of Torrent Intake

## 1-1 Torrent Intake Type

### (1) Required Condition of Torrent Intake Type

According to the information from NEA regional office, the intakes constructed in all three torrent areas were of the bar screen bottom intake type (Tyrolean type). These intakes have all been washed away due to flooding over the years.

All of these torrents have a steep gradient, a sharp discharge hydrograph regardless of their catchment area, a high velocity in the river containing large volumes of sand and cobblestones, and frequent bed change. In these conditions, intake facilities need to fulfill the following requirements:

- Able to withdraw sufficient amount of water in the circumstance of sudden change of river discharge
- Have a stable water intake despite the flow containing a high amount of sand, gravel and floating trash
- Be strong enough to withstand pressure due to wood, sand and gravel and allow their safe passage
- Have a simple structure of a reasonable construction cost amenable to easy maintenance
- Be in harmony with surrounding scenery and environment

Although it is difficult to design a structure that satisfies all the above requirements, more so in steep rivers like the ones in the target areas, having a strong structure able to withstand the impact of sand and gravel is most important.

### (2) Selection of Torrent Intake Type

Two types of torrent intakes were selected out of the several types available, namely, bar screen bottom intake type (Tyrolean type) and bar screen back stream intake type. Both types are often applied at sites in steep rivers containing sand and gravel. Table 1-1 shows comparison of these two types.

Table 1-1 Selection of torrent intake type

| | Bar screen bottom intake type (Tyrolean type) | Bar screen back stream intake type |
|---|---|---|
| Description | A bar screen with appropriate angle, length and interval is placed on crest of an intake weir (ground sill). Water enters spaces between bars but prevents entry of gravel and trash. | A bar screen with appropriate angle, length and interval is positioned on downstream slope of an intake weir (ground sill), and water cushion is provided downstream of the weir. The water on the weir slope as well as back water from the water cushion enters through the spaces between the bars. |
| River condition | This type of intake can be constructed in rivers where:<br>● Sabo dams (check dams) are installed upstream, and/or there is less gravel in the runoff.<br>● Water route is stable. | This type of intake can be constructed in rivers where:<br>● No Sabo dams (check dams) are installed upstream, and/or is more gravel in the runoff.<br>● Water route is unstable. |
| Applicability at target sites | Not applicable | **Applicable** |

| | Bar screen bottom intake type (Tyrolean type) | Bar screen back stream intake type |
|---|---|---|
| Maintenance | • A bar screen is easily clogged with gravels and floating trash due to mild angle of bar screen.<br>• A bar screen is easily damaged by gravels if long bars are applied.<br><br>**Maintenance difficult** | • Due to steep angle of bar screen, it is not easily clogged with gravels and floating trash<br>• A bar screen is not easily damaged by gravels due to steep angle of bar screen.<br>• It needs a water cushion as a sedimentation countermeasure.<br><br>**Maintenance easy (However, countermeasure against sedimentation is needed.)** |
| Conclusion | From the study, a bar screen back stream intake type is recommended in target sites due to better applicability and easier maintenance than a bar screen bottom intake type (Tyrolean type). | |

**$\theta$ :Less than 30°**

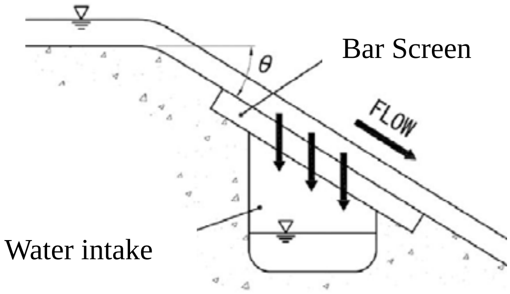



Figure 1-1 Bar screen bottom intake type (Tyrolean type)

**$\theta$ :between 50° and 60°**

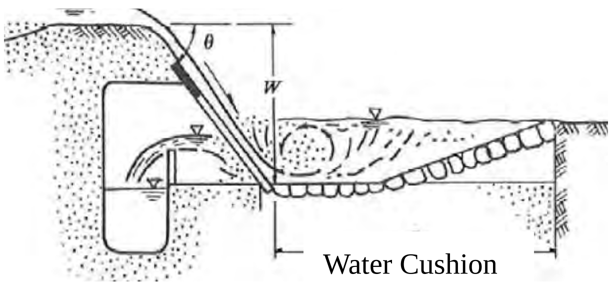



Figure 1-2 Bar screen back stream intake type

## 1-2 Hydraulic Dimensions of Bar Screen Back Stream Intake Type

The hydraulic dimensions of a bar screen back stream intake type are determined as follows[1].

$$L_0 = \frac{Q_0}{\mu\varphi B\sqrt{2gE_0}} \qquad \text{(Eq.1-1)}$$

$L_o$ ; Intake width (parallel with barscreen)
$Q_o$ ; Intake discharge
$B$ ; Intake length (perpendicular to barscreen)
$a$ ; Opening of barscreen
$\mu$ ; Coefficient of Inflow
$\varphi$ ; Opening rate of barscreen ($\sum a/B$)
$\varphi BL_0$ ; Area of space between barscreen
$\sqrt{2gE_0}$; Flow velocity in upstream of barscreen
$E_0$ ; Energy head

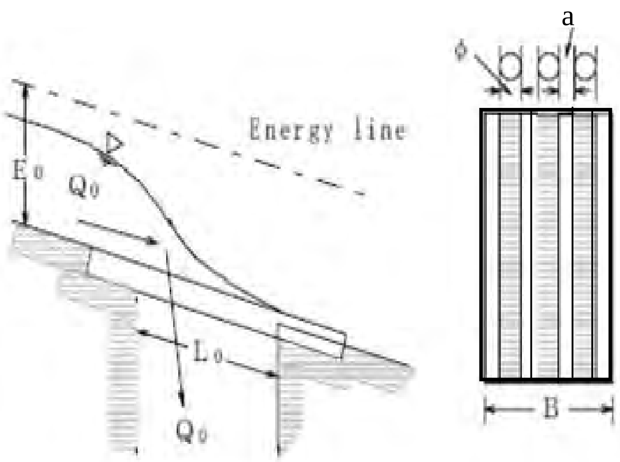



Figure 1-3 Dimensions of bar screen back stream intake type

[1] Design of Torrent Intake, Land improvement Project Technical Standard "Head Works"

Referring application examples, we adopted that spacing between the bar screens, a=20mm and φ=101.6mm(STPG t=5.7mm) considering friction against impact by gravels and water adhesion to bars. Hence, the numbers of bars are as follows:

20m / (0.1016+0.02) =164 nos., $\phi$ / a=101.6 / 20=5.08,

Opening between bar screens is:

$\varphi = \sum a / B = 163 * 0.02/20.0 = 0.163$

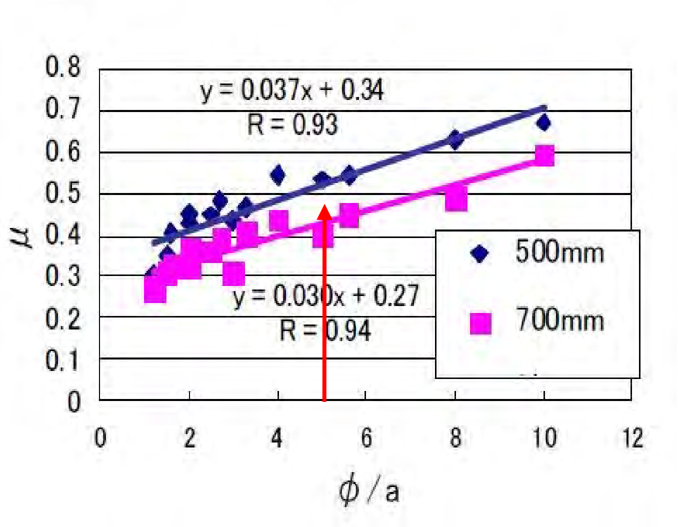
Coefficient of inflow $\mu$ is 0.4~0.5, which is determined from Figure 1-4.

Eo(energy head), hc(critical depth), Vc(critical velocity) and Lo(bar screen length) in Eq.1-1 is calculated as shown in Figure 1-4, assuming Critical flow is at the crest of intake weir.

$$E_0 = h_c + \frac{V_c^{\ 2}}{2g} \qquad \text{(Eq.1-2)}$$

$$h_c = \sqrt[3]{\frac{\alpha Q_0^{\ 2}}{gB^{\ 2}}} \qquad \text{(Eq.1-3)}$$

$$V_c = \sqrt{gh_c} \qquad \text{(Eq.1-4)}$$




$\mu$ ; Coefficient of Inflow, $\phi$ ; Bar Width, a; Bar Interval

Figure 1-4 Coefficient of inflow for bar screen back stream intake type (Meiji University)

Table 1-2 shows the relationship between intake discharge $Q_o$ and bar screen length $L_o$ in Bajhang. The result indicates that screen of $L_o$=0.6 m is required for intake discharge of 1.0 $m^3$/s. However to ensure sufficient withdrawal for continuous power generation, reduction of intake capacity caused by partial clogging of the screen due to gravel and trash must be prevented. Therefore, bar screen is designed to withdraw a greater amount of water through the intake by providing a large area of screen that can divert enough water for power generation even in the circumstance of partial clogging of screen.

Table 1-3 and 1-4 shows the relationship between intake discharge $Q_o$ and bar screen length $L_o$ in Bajura and Syarpudaha, respectively. Table 1-5 shows the hydraulic dimensions of the bar screen back stream intake type for the three sites. Maximum capacity of intake discharge at Bajhang, Bajura and Syarpudaha is about 4.5 $m^3$/s, 1.8 $m^3$/s and 3.3 $m^3$/s, respectively, in the circumstance of normal water flow and with no clogging in the screen.

Table 1-2 Relation between intake discharge $Q_o$ and bar screen length $L_o$ (Bajhang)

| Coefficient of inflow | Opening | Overflow width | Intake width | Overflow discharge | Intake discharge | Critical depth | Critical velocity | Energy head | Bar screen length |
|---|---|---|---|---|---|---|---|---|---|
| μ | φ | B(m) | Bo(m) | Q(m3/s) | Qo(m3/s) | hc(m) | Vc(m/s) | Eo(m) | Lo(m) |
| 0.4 | 0.163 | 24.5 | 20.0 | 0.50 | 0.41 | 0.036 | 0.594 | 0.054 | 0.304 |
| 0.4 | 0.163 | 24.5 | 20.0 | 1.00 | 0.82 | 0.057 | 0.749 | 0.086 | 0.483 |
| 0.4 | 0.163 | 24.5 | 20.0 | 1.50 | 1.22 | 0.075 | 0.857 | 0.112 | 0.633 |
| 0.4 | 0.163 | 24.5 | 20.0 | 2.00 | 1.63 | 0.091 | 0.943 | 0.136 | 0.766 |
| 0.4 | 0.163 | 24.5 | 20.0 | 2.50 | 2.04 | 0.105 | 1.016 | 0.158 | 0.889 |
| 0.4 | 0.163 | 24.5 | 20.0 | 3.00 | 2.45 | 0.119 | 1.080 | 0.178 | 1.004 |
| 0.4 | 0.163 | 24.5 | 20.0 | 3.50 | 2.86 | 0.132 | 1.137 | 0.198 | 1.113 |
| 0.4 | 0.163 | 24.5 | 20.0 | 4.00 | 3.27 | 0.144 | 1.188 | 0.216 | 1.216 |
| 0.4 | 0.163 | 24.5 | 20.0 | 4.50 | 3.67 | 0.156 | 1.236 | 0.234 | 1.316 |
| 0.4 | 0.163 | 24.5 | 20.0 | 5.00 | 4.08 | 0.167 | 1.280 | 0.251 | 1.412 |
| 0.4 | 0.163 | 24.5 | 20.0 | 5.50 | 4.49 | 0.178 | 1.322 | 0.267 | 1.504 |
| 0.4 | 0.163 | 24.5 | 20.0 | 6.00 | 4.90 | 0.189 | 1.360 | 0.283 | 1.594 |

Table 1-3 Relation between intake discharge $Q_o$ and bar screen length $L_o$ (Bajura)

| Coefficient of inflow | Opening | Overflow width | Intake width | Overflow discharge | Intake discharge | Critical depth | Critical velocity | Energy head | Bar screen length |
|---|---|---|---|---|---|---|---|---|---|
| μ | φ | B(m) | Bo(m) | Q(m3/s) | Qo(m3/s) | hc(m) | Vc(m/s) | Eo(m) | Lo(m) |
| 0.4 | 0.164 | 11.5 | 8.0 | 0.50 | 0.35 | 0.060 | 0.765 | 0.089 | 0.500 |
| 0.4 | 0.164 | 11.5 | 8.0 | 1.00 | 0.70 | 0.095 | 0.963 | 0.142 | 0.794 |
| 0.4 | 0.164 | 11.5 | 8.0 | 1.50 | 1.04 | 0.124 | 1.103 | 0.186 | 1.041 |
| 0.4 | 0.164 | 11.5 | 8.0 | 2.00 | 1.39 | 0.150 | 1.214 | 0.225 | 1.261 |
| 0.4 | 0.164 | 11.5 | 8.0 | 2.50 | 1.74 | 0.174 | 1.307 | 0.262 | 1.463 |
| 0.4 | 0.164 | 11.5 | 8.0 | 3.00 | 2.09 | 0.197 | 1.389 | 0.295 | 1.653 |

Table 1-4 Relation between intake discharge $Q_o$ and bar screen length $L_o$ (Syarpudaha)

| Coefficient of inflow | Opening | Overflow width | Intake width | Overflow discharge | Intake discharge | Critical depth | Critical velocity | Energy head | Bar screen length |
|---|---|---|---|---|---|---|---|---|---|
| μ | φ | B(m) | Bo(m) | Q(m3/s) | Qo(m3/s) | hc(m) | Vc(m/s) | Eo(m) | Lo(m) |
| 0.4 | 0.164 | 18.0 | 15.0 | 0.50 | 0.42 | 0.044 | 0.659 | 0.066 | 0.371 |
| 0.4 | 0.164 | 18.0 | 15.0 | 1.00 | 0.83 | 0.070 | 0.830 | 0.105 | 0.589 |
| 0.4 | 0.164 | 18.0 | 15.0 | 1.50 | 1.25 | 0.092 | 0.950 | 0.138 | 0.772 |
| 0.4 | 0.164 | 18.0 | 15.0 | 2.00 | 1.67 | 0.112 | 1.045 | 0.167 | 0.935 |
| 0.4 | 0.164 | 18.0 | 15.0 | 2.50 | 2.08 | 0.129 | 1.126 | 0.194 | 1.085 |
| 0.4 | 0.164 | 18.0 | 15.0 | 3.00 | 2.50 | 0.146 | 1.197 | 0.219 | 1.226 |
| 0.4 | 0.164 | 18.0 | 15.0 | 3.50 | 2.92 | 0.162 | 1.260 | 0.243 | 1.358 |
| 0.4 | 0.164 | 18.0 | 15.0 | 4.00 | 3.33 | 0.177 | 1.317 | 0.266 | 1.485 |
| 0.4 | 0.164 | 18.0 | 15.0 | 4.50 | 3.75 | 0.191 | 1.370 | 0.287 | 1.606 |

Table 1-5 Dimensions of the bar screen back stream intake type
for the three sites

| Site | Intake width | Bar screen length | Number of bars | Maximum capacity of intake discharge |
|---|---|---|---|---|
| Bajhang | 20 m | 1.5 m | 164 | 4.5 $m^3/s$ |
| Bajura | 8 m | 1.5m | 66 | 1.8 $m^3/s$ |
| Syarpudaha | 15 m | 1.5 m | 124 | 3.3 $m^3/s$ |

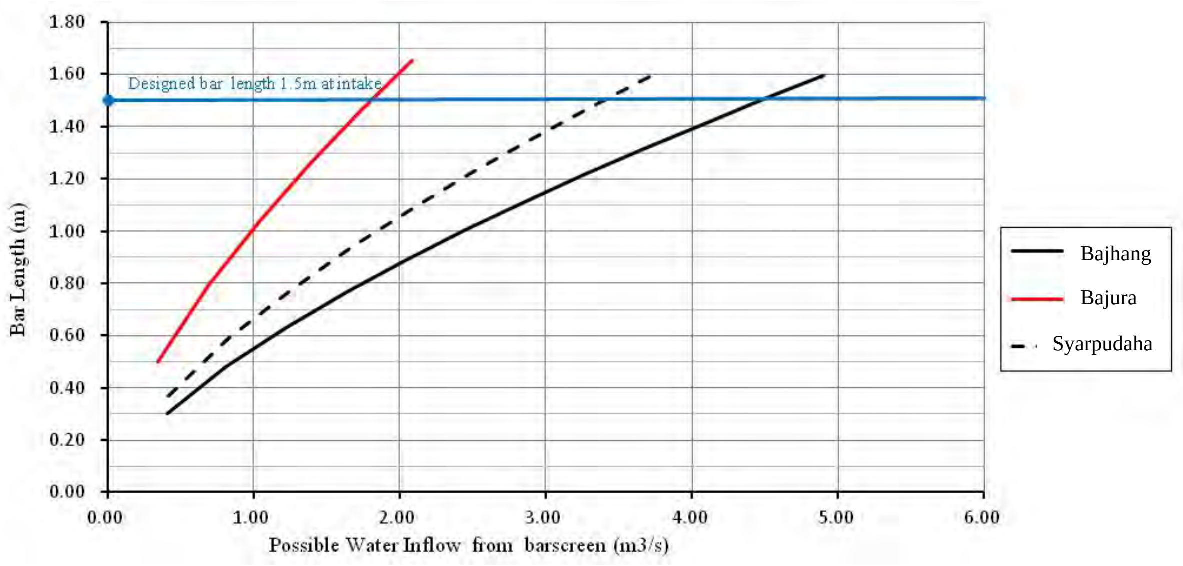



Figure 1-5 Maximum capacity of intake discharge and bar screen length for the three sites

## 1-3 Sand Flush

A sand flushing gate is installed in order to remove large sized sediments that are not trapped by a screen. This gate will also be helpful to dewater headrace channel. In this section, we validated appropriateness of sand flushing design by calculating tractive force of sediment in the headrace channel.

### (1) Process of Sand Flushing

Sand flushing in the headrace channel is done by diverting sufficient water through the inlet. The flowing water creates a tractive force which helps to remove sand grains through the outlet. Sand flushing is done by carrying out the following steps: 1) Sand flushing gate is opened, 2) Water flows in the headrace channel, and 3) Sediment is flushed out to river from sand flushing gate.

### (2) Discharge from Sand Flushing Gate[2]

Outflow, Q, from the flushing gate is calculated by the following equation:

[2] Collection of Hydraulic Formulae, Japan Society of Civil Engineers,1999, p.254

Q=C x a x B x (2gH)$^{0.5}$

Where;

Q: Outflow (m$^3$/s)

C: Coefficient（from Figure (b)）

a: Maximum opening height, 1.0 (m)

B: Gate width 1.0(m)

H: Water depth at upstream (m)

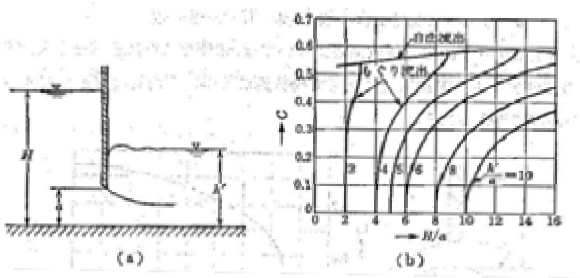



Table 1-6 Outflow from Sand Flush Gate

| H(m) | a(m) | H/a | h'(m) | h'/a | Flow condition | C | Q (m$^3$/s) |
|---|---|---|---|---|---|---|---|
| 2.5 | 1.0 | 2.5 | 0.5 | 0.5 | Free flow | 0.54 | 3.78 |
| 2.0 | 1.0 | 2.0 | 0.5 | 0.5 | | 0.53 | 3.32 |
| 1.5 | 1.0 | 1.5 | 0.5 | 0.5 | | 0.52 | 2.82 |
| 1.0 | 1.0 | 1.0 | 0.5 | 0.5 | | 0.51 | 2.26 |

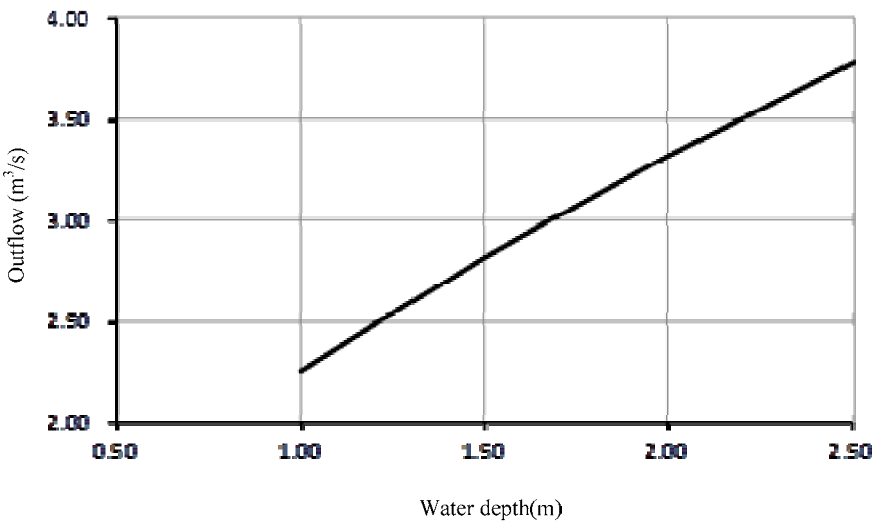



Figure 1-6 Relationship between Outflow from Sand Flushing Gate (m$^3$/s) and Water Depth (m) in headrace channel

### (3) Tractive Force in Headrace Channel[3]

Tractive force of sediment, $\tau$ , is calculated by following equation:

$\tau = \rho \times g \times R \times I_e$ Eq.1.5

where

$\tau$: Tractive force of sediment (gr/cm$^2$)

$\rho$: gravity of water body (gr)

g: 9.8 m/s$^2$

R: hydraulic radius (cm)

$I_e$: Energy slope

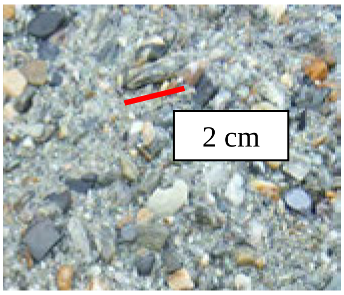



Figure 1-7 Sand deposited in the existing headrace channel (near intake)

Relations between tractive force, square of shear velocity and grain size of critical tractive force are as follows:

Square of shear velocity;

$$U_*^2 = \tau / \rho = g \times R \times I_e (cm^2 / s^2) \qquad \text{Eq.1.6}$$

Grain size of critical tractive force dc is from Iwagaki's formulae for critical tractive force;

$$u_{*c}^2 = 80.9 \times d_c \qquad d_c \geq 0.303 cm \qquad \text{Eq.1.7}$$

Tractive force at Bajhang was studied since the force is the smallest among the three sites due to gentle slope and greater distance of channel to sand flushing gate compared to others . Table 1-7 shows tractive force calculated with Eq.1.6. According to the results, flushing of sediment with a grain size of 1.5 cm can be done even with a small tractive force immediately after opening a sand flush gate. After complete opening, flow velocity increases with decreasing water depth in the channel, and sand with grain sizes of about 7-8 cm can be flushed. This indicates that the sand grains deposited between the intake and the sand trap as shown in Figure 1-7 can be flushed by the designed flushing gates.

Table 1-7 Grain Size of Sediment Flushed out from Sand Flushing Gate

| Discharge Q (m$^3$/s) | Mean velocity V (m/s) | Mean depth H (m) | Energy slope $I_e$ | Mean hydraulic radius R(m) | Square of shear velocity $U_*^2$=9.8*R*$I_e$ (m$^2$/s$^2$) | Grain size of critical tractive force $d_c=U_*^2/80.9$ (cm) |
|---|---|---|---|---|---|---|
| 3.78[4] | 1.608 | 2.135 | 0.003 | 0.403 | 0.012 | 1.46 |
| 3.32 | 2.132 | 1.638 | 0.004 | 0.380 | 0.015 | 1.84 |
| 2.82 | 2.452 | 1.216 | 0.011 | 0.350 | 0.038 | 4.66 |
| 2.26 | 2.534 | 0.902 | 0.018 | 0.321 | 0.062 | 7.63 |

[3] Collection of Hydraulic Formulae, Japan Society of Civil Engineers,1999, p.156-158

[4] Discharge immediately after opening the sand flushing gate . The table shows that the tractive force is increasing with decreasing water depth in channel with lapse of time.

# 2. Crest Elevation of Retaining Wall

## 2-1 Free Board[5]

Retaining wall crest elevation was determined based on Technical Standard for Designing Sabo Facilities against Debris Flow and Driftwood. Flood water level was estimated under the condition of uniform flow. Table 2-1 and 2-2 show free board required at various design discharges.

Table 2-1 Required free board

| Design discharge* | Free board | Site applied |
|---|---|---|
| Less than 200 $m^3/s$ | 0.6m | |
| 200 - 500 $m^3/s$ | 0.8m | |
| More than 500 $m^3/s$ | 1.0m | Bajhang, Bajura,Syarpudaha |

Qmax; Bajhang = 1,520$m^3/s$, Bajura = 560 $m^3/s$, Syarpudaha = 830 $m^3/s$

Table 2-2 Minimum Ratio between free board and design discharge depending upon river bed slope

| River bed slope* | Free board / Design discharge | Site applied |
|---|---|---|
| 1/10 | 0.5 | Syarpudaha |
| 1/10-1/30 | 0.4 | Bajura |
| 1/30-1/50 | 0.3 | Bajhang |
| 1/50-1/70 | 0.25 | |
| *This is the slope after sediment deposition. Here, we assume half of the existing river bed slopes at the three sites. | | |

## 2-2 Hydraulic Characteristics at Torrent Intake

Table 2-4, 2-5 and 2-6 shows design discharge and velocity at the three sites, calculated by the Manning's formula using river cross section data at intakes.

Manning's formula:

$$V = \frac{1}{n} R^{2/3} I^{1/2}, \quad Q = AV, \quad R = A/S$$

Where:

V: Average velocity (m/s), R; Hydraulic radius (m), I; River slope,

A: Area ($m^2$), n; Roughness coefficient as shown in Table-2.3, applied for 0.042.

S: Wetted perimeter (m), Q: Discharge ($m^3/s$)

[5] Technical Standard for Designing Sabo Facilities against Debris Flow and Driftwood.

Table-2.3 Relationship between representative grain-diameter on the river bed and roughness coefficient

| dR: Representative grain-diameter | n : Roughness coefficient A | n : Roughness coefficient B | Classification method A and B |
|---|---|---|---|
| Rock bed | 0.035～0.050 | | A: Flat river bed, Non-descript sandbar and non-descript stick out big rock on the river bed. B: High relief river bed and stick out big rock on the river bed |
| Boulder(40cm～60cm) | 0.037 | 0.042 | |
| Boulder (20cm～40cm) | 0.034 | | |
| Boulder (10cm～20cm) | 0.030 | | |
| Coarse gravel [Big] (5cm～10cm) | 0.035 | | |
| Coarse gravel [Small] (2cm～ 5cm) | 0.029 | 0.034 | |

Source: Basic Policy for Disaster Rehabilitation to Protect Beautiful Mountains and Rivers in Japan

Table-2.4 Bajhang I=1/21

| Water level (EL.m) | Width (m) | Wetted perimeter (m) | Area (m2) | Hydraulic radius (m) | Velocity (m/s) | Discharge (m3/s) |
|---|---|---|---|---|---|---|
| 98.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 |
| 98.61 | 13.95 | 14.15 | 4.28 | 0.30 | 2.34 | 10 |
| 99.10 | 23.05 | 23.43 | 13.74 | 0.59 | 3.64 | 50 |
| 99.42 | 23.92 | 24.51 | 21.20 | 0.87 | 4.72 | 100 |
| 99.90 | 25.22 | 26.13 | 32.97 | 1.26 | 6.07 | 200 |
| 100.28 | 26.27 | 27.44 | 42.88 | 1.56 | 7.00 | 300 |
| 100.62 | 27.17 | 28.56 | 51.78 | 1.81 | 7.72 | 400 |
| 100.92 | 27.99 | 29.58 | 60.03 | 2.03 | 8.33 | 500 |
| 101.23 | 30.07 | 31.80 | 68.94 | 2.17 | 8.70 | 600 |
| 101.51 | 32.42 | 34.26 | 77.91 | 2.27 | 8.98 | 700 |
| 101.77 | 34.24 | 36.25 | 86.34 | 2.38 | 9.27 | 800 |
| 102.00 | 35.92 | 38.08 | 94.50 | 2.48 | 9.52 | 900 |
| 102.21 | 37.48 | 39.79 | 102.45 | 2.57 | 9.76 | 1,000 |
| 102.42 | 38.94 | 41.38 | 110.20 | 2.66 | 9.98 | 1,100 |
| 102.61 | 40.31 | 42.89 | 117.78 | 2.75 | 10.19 | 1,200 |
| 102.79 | 41.62 | 44.32 | 125.20 | 2.83 | 10.38 | 1,300 |
| 102.96 | 42.86 | 45.67 | 132.48 | 2.90 | 10.57 | 1,400 |
| 103.13 | 44.04 | 46.97 | 139.64 | 2.97 | 10.74 | 1,500 |
| 103.16 | 44.27 | 47.22 | 141.06 | 2.99 | 10.78 | 1,520 |
| 103.28 | 45.18 | 48.21 | 146.67 | 3.04 | 10.91 | 1,600 |

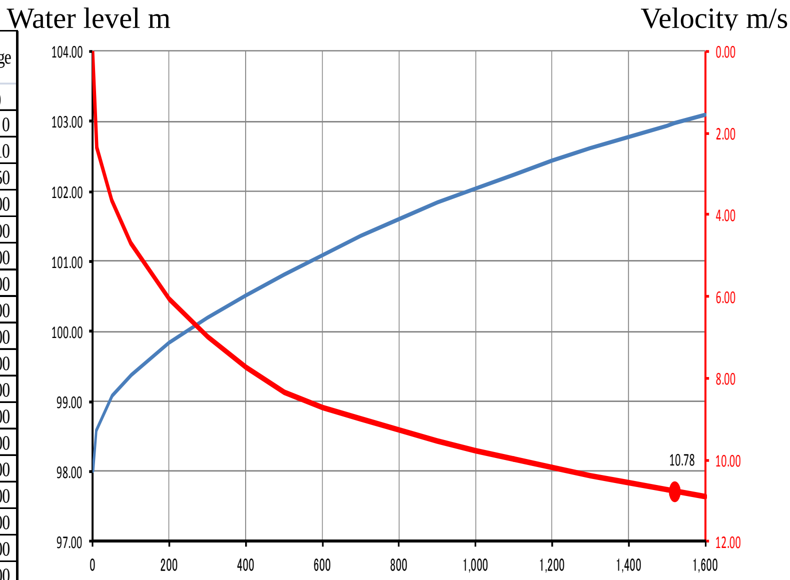



Figure-2.1 Bajhang Discharge～Waterlevel, Velocity

Table-2.5 Bajura I=1/12

| Water level (EL.m) | Width (m) | Wetted perimeter (m) | Area (m2) | Hydraulic radius (m) | Velocity (m/s) | Discharge (m3/s) |
|---|---|---|---|---|---|---|
| 1,579.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 |
| 1,579.53 | 13.69 | 14.11 | 3.61 | 0.26 | 2.77 | 10 |
| 1,579.95 | 20.83 | 21.66 | 11.26 | 0.52 | 4.44 | 50 |
| 1,580.23 | 21.05 | 22.28 | 17.25 | 0.77 | 5.80 | 100 |
| 1,580.67 | 21.38 | 23.22 | 26.59 | 1.15 | 7.52 | 200 |
| 1,581.03 | 21.66 | 24.00 | 34.36 | 1.43 | 8.73 | 300 |
| 1,581.35 | 21.90 | 24.68 | 41.30 | 1.67 | 9.69 | 400 |
| 1,581.64 | 22.12 | 25.31 | 47.69 | 1.88 | 10.49 | 500 |
| 1,581.81 | 22.25 | 25.66 | 51.33 | 2.00 | 10.91 | 560 |
| 1,581.91 | 22.33 | 25.89 | 53.68 | 2.07 | 11.18 | 600 |

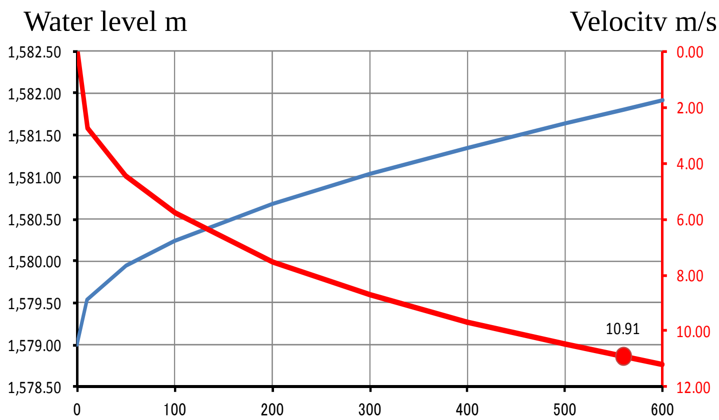



Figure-2.2 Bajura Discharge～Waterlevel, Velocity

Table-2.6 Syarpudaha I=1/4.5

| Water level (EL.m) | Width (m) | Wetted perimeter (m) | Area (m2) | Hydraulic radius (m) | Velocity (m/s) | Discharge (m3/s) |
|---|---|---|---|---|---|---|
| 1,212.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 |
| 1,212.24 | 11.15 | 11.22 | 2.46 | 0.22 | 4.08 | 10 |
| 1,212.61 | 14.40 | 14.57 | 7.16 | 0.49 | 6.99 | 50 |
| 1,212.89 | 16.90 | 17.14 | 11.57 | 0.68 | 8.64 | 100 |
| 1,213.29 | 20.38 | 20.73 | 18.93 | 0.91 | 10.56 | 200 |
| 1,213.58 | 22.53 | 22.98 | 25.16 | 1.10 | 11.92 | 300 |
| 1,213.81 | 23.35 | 23.93 | 30.39 | 1.27 | 13.16 | 400 |
| 1,214.01 | 24.07 | 24.77 | 35.23 | 1.42 | 14.19 | 500 |
| 1,214.19 | 24.33 | 25.23 | 39.59 | 1.57 | 15.16 | 600 |
| 1,214.36 | 24.57 | 25.66 | 43.72 | 1.70 | 16.01 | 700 |
| 1,214.52 | 24.80 | 26.07 | 47.67 | 1.83 | 16.78 | 800 |
| 1,214.56 | 24.87 | 26.19 | 48.82 | 1.86 | 17.00 | 830 |
| 1,214.67 | 25.02 | 26.46 | 51.46 | 1.95 | 17.49 | 900 |

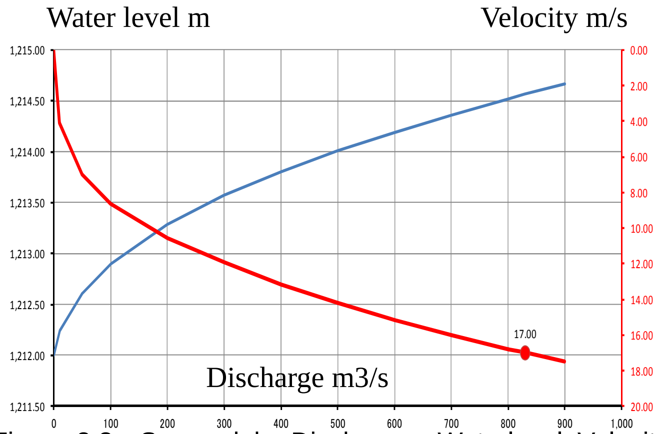



Figure-2.3 Syarpudaha Discharge～Waterlevel, Velocity

## 2-3 Result of Study on Flood Water Level, Overflow Depth, Free Board and Retaining Wall Crest Elevation

For the design of retaining wall crest elevation, required free board and flood water level estimated in the previous section were used. Table 2-7 shows results of retaining wall crest elevation.

Table 2-7 Results of retaining wall crest elevation

| Site | Flood discharge Q (m3/s) | River bed slope | Velocity V (m/s) | Overflow width B (m) | Overflow depth H (m) | Overflow crest elevation E.L (m) | Flood water level F.W.L (m) | Required free board (m) *1 | | | Free board selected (m) | Retraining wall crest elevation E.L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Slope*2 | Ratio against design water depth | | | |
| Bajhang | 1,520 | 1/21 | 10.8 | 44.5 | 3.6 | 101.5 | 105.1 | 1/42 | 30 % | 1.08 | 1.08 | 106.2 |
| Bajura | 560 | 1/12 | 10.9 | 19.0 | 3.1 | 1,582.0 | 1,585.1 | 1/24 | 40 % | 1.24 | 1.24 | 1,586.3 |
| Syarpudaha | 830 | 1/4.5 | 17.0 | 27.0 | 2.1 | 1,214.5 | 1,216.6 | 1/9 | 50 % | 1.06 | 1.06 | 1,217.7 |

*1 Based on Technical Standard for Designing Sabo Facilities against Debris Flow and Driftwood

*2 Slope after sediment deposition, which is assumed as half of existing river bed slope

# 3. Design of Weir

Torrent intake weirs in this study aim to divert river water for hydropower generation, and do not have a function for Sabo countermeasure as Sabo dams. The intake weirs are ground sills that are constructed on the foundation of cobble stone with gravel. Therefore, we applied design criteria as outlined in Manual of Design for Ground Sill[6] and confirmed the following design items of intake weir:

- Design of downstream apron which connect to main body of ground sill (called 'weir') and design of downstream river-bed protection
- Design of downstream apron length that prevent seepage failure
- Stability analysis of weir

## 3-1 Design Water Level

Back water effect of weir in the case of flood might be small since the design height of weir crest from existing riverbed is less than 2m and the river bed slope is steep, 1/21-1/4.5. Flow over the intake weir during flood is assumed to be supercritical, and supercritical flow is expected over the crest. Based on these hydraulic conditions, design water level was calculated by considering uniform flow speed applying river cross section of intake weir axis point, and results are shown in Table 3-1. Flow conditions at three sites are super critical as indicated by Froude number exceeding 1.0.

As a reference, critical flow depth calculated with Eq.3.1 is also shown in Table 3-1. All critical flow depth exceeds uniform flow depth in super critical flow condition.

$$h_c = \sqrt[3]{\frac{Q^2}{gB^2}} \qquad \text{Eq.3.1} \qquad F_r = \frac{V}{\sqrt{gh}} \qquad \text{Eq.3.1'}$$

Where;

$h_c$: Critical flow depth (m), Q: Discharge ($m^3/s$), g: Gravitational acceleration,

B: Overflow width (m), $F_r$: Froude number, V: Velocity(m/s), h: Overflow depth (m)

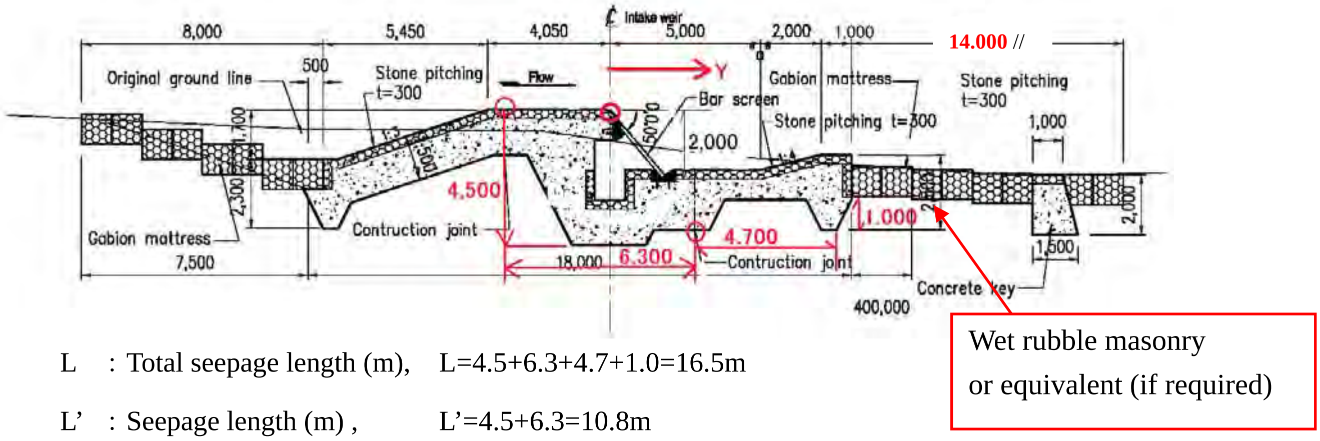
Table 3-1 Calculation Results of Uniform Flow

| | Bajhang | Bajura | Syarpudaha |
|---|---|---|---|
| River bed slope | 1/21 | 1/12 | 1/4.5 |
| Roughness coefficient | 0.042 | | |
| Overflow width B(m) | 44.5 | 19.0 | 27.0 |
| Design discharge Q (cms) | 1,520 | 560 | 830 |
| Design overflow depth (m) | 3.6 | 3.1 | 2.1 |
| Design overflow velocity (m/s) | 10.8 | 10.9 | 17.0 |
| Froude number in the case of flood | 1.8 | 2.0 | 3.7 |
| Reference ; Critical depth $h_c$ (m) | 4.9 | 4.5 | 4.6 |

6 Manual of Design Ground Sill (Japan Institute of Country-technology and Engineering (JICE)

## 3-2 Design of Downstream Apron

Generally, length of downstream apron is determined to prevent seepage failure based on the location of water drop estimated by Rand's equation which assumes complete overflow condition with critical depth at the top of weir. However, the Rand's equation is not applicable for supercritical flow. Since, the flow over the crest is supercritical in all the projects under study, Ski jump equation is used to calculate the location of water drop, and design the length and thickness of downstream apron to prevent scouring at the dropping point.




L : Total seepage length (m), L=4.5+6.3+4.7+1.0=16.5m

L' : Seepage length (m) , L'=4.5+6.3=10.8m

Figure 3-1 Longitudinal section of weir

### (1) Apron Length

Table 3-2 shows length of downstream apron considering the location of water drop by Ski jump formula[7]:

$$\left.\begin{aligned} x &= v_0\sqrt{\frac{2y}{g}} \\ y &= \tan\theta\cdot x - \frac{gx^2}{2v_0^2\cos^2\theta}(\theta=0) \end{aligned}\right\} \quad \text{Eq. 3.2}$$

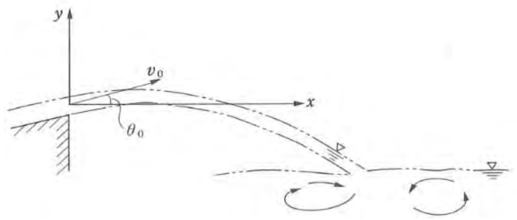



Figure 3-2 Water drop profile of overflow

where;

x : Distance from weir crest to water drop point (m)

y : Drop height between weir crest and downstream apron (m)

$\theta$ : Angle of overflow（degree）

g : acceleration due to gravity, 9.8 m/s$^2$

[7] Collection of Hydraulic Formulae, Japan Society of Civil Engineers,1999, p.274

From Table 3-2, distances from weir crest to water drop point at the two sites are in the range of 6.9 to 7.0 m. Length of downstream apron of 8.0 m was adopted at Bajhang and Bajura, considering margin of safety for scouring due to the impact of falling water. The apron, 8.0m length from weir axis, has enough length for preventing piping failure at three sites. Therefore the same length of 8m was adopted at Syarpudaha. However the falling water may impact gabion mattress at Syarpudaha. It was recommended that the surface of downstream gabion mattress shall protect with wet rubble masonry or equivalent against surface scouring.

Furthermore, flowing water doesn't completely lose energy after dropping and causes scouring in the areas downstream of the apron. Thus, gabion mattress is provided to prevent scouring in these areas.

Table 3-2 Water drop point

| | Bajhang | Bajura | Syarpudaha |
|---|---|---|---|
| Overflow velocity of flood $V_o$ (m/s) | 10.8 | 10.9 | 17.0 |
| Drop height y (m) | 2.0 | 2.0 | 2.0 |
| Distance from weir crest to water drop point x (m) | 6.9 | 7.0 | 10.9 |

(2) Apron Thickness

Apron thickness was estimated by the following formula considering uplift pressure.

$$t \geq \frac{4}{3} \times \frac{\Delta h - \Delta u}{W_c - 1.0} = \frac{4}{3} \times \frac{2.0 - 1.309}{2.4 - 1.0} = 0.658m \qquad \text{Eq. 3.3}$$

where;

$W_c$ : Unit weight of concrete of downstream apron 2.4 x $10^3$kgf/cm$^2$

$\Delta h$ : Upstream and downstream water level difference 2.0m (equals to height difference between weir crest and apron)

$\Delta u$ : Loss of uplift pressure at the starting point of apron (m) =(L' / L)x $\Delta$h=(10.8/16.5) x 2.0=1.309m

L : Total seepage length (m), L' : Seepage length (m) (Ref. Figure3-1)

L=4.5+6.3+4.7+1.0=16.5m L'=4.5+6.3=10.8m

Apron thickness of 1.0m is determined considering the calculated results by Equation③ and design margin of safety on standard thickness of apron as shown in Table 3-3.

Table 3-3 Standard thickness of apron [8]

| Drop height | Sand and gravel foundation | Minimum thickness of soft rock I, II (m) | | Minimum thickness of medium soft rock (m) | |
|---|---|---|---|---|---|
| Less than 5m | | More than 70% of sand and gravel foundation | More than 0.5m | More than 40% of sand and gravel foundation | More than 0.3m |
| 5m~10m | 0.7~3.0m | | More than 0.7m | | More than 0.5m |
| More than 15m | | | More than 1.0m | | More than 0.6m |

[8] Manual of Design for Ground Sill (Japan Institute of Country-technology and Engineering(JICE)

## 3-3 Design of Bed Protection at Downstream

The length of downstream bed protection is calculated with Bligh's creep theory. This equation is used to estimate the total length of the downstream protection works including both apron and bed protection. This length of protection should be provided to prevent foundation erosion . The equation is shown below:

$$L=0.67 \times Co \times (D \times q)^{0.5} \qquad \text{Eq.3.4}$$

Where;

L:Total length of downstream protection including apron and bed protection (m)
Co: Seepage (refer to Table 3-4)
D: Head between the crest elevation of apron and the crest of weir.
q: Unit discharge ($m^3/s/m$)

Table 3-4 Coefficient of Seepage

| Type of bed material | $C_o$ |
|---|---|
| Fine sand or Silt | 18 |
| Fine sand | 15 |
| Medium sand | 12 |
| Coarse sand | 9 |
| Coarse sand and gravel with cobblestone | 4 - 6 |

Table 3-5 Length of Apron and Bed protection by Bligh's Equation

| | Bajhang | Bajura | Syarpudaha |
|---|---|---|---|
| D (m) | 2.0 | 2.0 | 2.0 |
| Co | 4 | 4 | 4 |
| L (m) | 22.2 | 20.6 | 21.0 |
| Design Discharge ($m^3/s$) | 1,520 | 560 | 830 |
| Width of Overflow Weir (m) | 44.5 | 19.0 | 27.0 |
| Unit discharge ($m^3/s/m$) | 34.2 | 29.5 | 30.7 |

As shown in the table 3-5, the total length of apron and bed protection required to prevent foundation scour is calculated as 20 – 22 m. The calculated length at all site seem to be similar. Considering uncertainty of local scouring, the bed protection shall be constructed for as great a length as possible. Therefore the length of 22 m computed for Bajhang, consisting of apron (8.0 m) and bed protection **(**14.0m), is adopted for Bajura and Syarpudaha. The bed protection is done by constructing a gabion mattress. The mattresses are flexible and attain the bed shape if the bed profile changes. In addition, the gabion mattresses can be easily constructed at site. A concrete cut off is designed at the downstream end of bed protection in order to prevent the movement of gabion caused by erosion. Likewise, the cutoff will also protect the foundation of the gabion mattress from being washed away by water.

Each gabion mattress is required to be structurally strong so it should be covered and tied with strong steel wire. The materials inside the gabion mattress should not be subject to wash-out even without covering lid. It is recommended that rock materials in gabion shall be mutually bonded by mortal similar wet masonry structure.

## 3-4 Design of Apron at Upstream

The apron is designed with the downward slope (1:3.0)[9] at the beginning of the upstream apron in

9 In the case of a flat apron, local scouring can be caused intermittently by the strong tractive force.
The downward sloping apron will not be scoured by the tractive force since the sandbank on the apron slope makes the river bed smooth. (Source; Design of Torrent Intake, Land improvement Project Technical Standard "Head Works")

order to reduce local scouring. This also protects the retaining wall foundation from scouring. Furthermore, this apron makes the seepage path longer and saves the weir body against seepage failure. The exposed area upstream of the apron is designed to be covered with gabion mattress to prevent bed scouring.

## 3-5 Seepage Analyses

The three intake sites have a foundation of Cobble stone with Gravel ~ Rocks with Cobblestone and Gravel. To prevent the piping, a safe creep length must be provided below the foundation of weir and apron. The creep length must be larger than the values calculated by following Lane's weighted creep theory.

$$C_L \leq \frac{\frac{L}{3}+\sum l}{\Delta h} \qquad \text{Eq.3.5}$$ [10]

Where;

$C_L$ : Coefficient which varies with type of ground (Table3-6)

L : Creep length in horizontal direction

$\sum l$ : Creep length in vertical direction

$\Delta h$ : Maximum difference of water heads (m)

Table 3-6 Coefficient ( Lane's method)

| Foundation | $C_L$ |
|---|---|
| Silty sand | 8.5 |
| Fine sand | 7.0 |
| Medium sand | 6.0 |
| Coarse sand | 5.0 |
| Gravel | 4.0 |
| Coarse Gravel | 3.5 |
| Cobble stone with Gravel | 3.0 |
| Rocks with Cobblestone and Gravel | 2.5 |

The coefficients, calculated using the above relations are summarized in the following table.

Table 3-7 Calculation result of coefficient (Lane's method)

| Item | | Unit | Bajhang | Bajura | Syarpudaha |
|---|---|---|---|---|---|
| Maximum water heads difference | Δh | m | 2.0 | 2.0 | 2.0 |
| Creep length in horizontal direction (Length of weir, apron) | L | m | 12.3 | 12.0 | 12.0 |
| Creep length in vertical direction | Σl | m | 7.0 | 7.0 | 7.0 |
| Calculated Coefficient | $\frac{\frac{L}{3}+\sum l}{\Delta h}$ | - | 5.6 | 5.5 | 5.5 |
| Required Coefficient (Lane's method) | $C_L$ | - | 2.5 – 3.0 | 2.5 – 3.0 | 2.5 – 3.0 |
| Assessment | The calculated coefficients, necessary to prevent the damage of foundation by piping, are larger than the coefficient computed by Lane's method. Therefore all the proposed weirs are safe from damage to the foundation by piping. | | | | |

Generally, a bed protection foundation composed of sand or silt, can be scoured by piping action. To prevent piping, a suction prevention sheet is provided in the foundation. However a suction prevention sheet is not required for the three sites under study, since the foundation is composed of Cobble stone with Gravel.

[10] Manual of Design Ground Sill (Japan Institute of Country-technology and Engineering (JICE)

## 3-6 Structural Calculation of Weir

The proposed weir is constructed over cobblestone and gravel. The maximum height from the foundation to the weir crest is 4.5m. The weir body is structurally separated with upstream and downstream aprons. The design was based on the calculation method outlined in “Design of ground sill works” (prepared by Japan Institution Country-technology and Engineering). The result of the weir stability analysis is summarized in Table 3-11, 3-12, and 3-13. In all the loading conditions, the proposed design is found to be stable.

### (1) Design Condition

1) Design Load

a. Dead Load

Concrete without reinforcement; 2.4 t/m$^3$ (2,400 kgf/m$^3$)

Water ($W_o$); 1.0 t/m$^3$ (1,000 kgf/m$^3$)

Gravel (wet); 2.2 t/m$^3$ (2,200 kgf/m$^3$)

Gravel (water); 0.9 t/m$^3$ ( 900 kgf/m$^3$)

b. Water Condition

Table 3-8 Analysis Cases and Water Condition (Bajhang)

| | Upstream Water Level (Water Height from the crest of Weir (m)) | Downstream Water Level (Water Height from the top of Apron (m)) |
|---|---|---|
| 1. Normal: Normal water * | 0.2[11] | 0.7 |
| 2. Normal: Flood | 3.6 | 4.1 |
| 3. Seismic: Normal Water +$K_h$ =0.20* | 0.2 | 0.7 |

* Water level of condition -1 and that of -3 in Table 3-8 is same as in Table 3-9 Bajura and Table 3-10 Syarpudaha

Table 3-9 Analysis Cases and Water Condition (Bajura)

| | Water Height form the crest of Weir (m) | Water Height from the crest of Apron (m) |
|---|---|---|
| 1 . Normal: Normal water | 0.2 | 0.7 |
| 2 . Normal: Flood | 3.1 | 3.6 |
| 3 . Seismic: Normal Water +Kh =0.20 | 0.2 | 0.7 |

Table 3-10 Analysis Cases and Water Condition (Syarpudaha)

| | Water Height form the crest of Weir (m) | Water Height from the crest of Apron (m) |
|---|---|---|
| 1 . Normal: Normal water | 0.2 | 0.7 |
| 2 . Normal: Flood | 2.1 | 2.6 |
| 3 . Seismic: Normal Water +Kh =0.20 | 0.2 | 0.7 |

[11] Water depth, during annual mean discharge 1.0 m$^3$/s, on a weir crest is 0.1~0.15 m. Thus “0.2m” is used.

d. Uplift

The effective uplift of intake weir is shown in the load figure.

e. Seismic Inertia Force

The seismic inertia force is calculated by multiplying the dead load by the horizontal seismic coefficient.

Horizontal Seismic Coefficient ($K_h$); 0.20

f. Seismic Water Pressure

Calculation water pressure is applied by the Westergaard formula.

$$P_{dw} = \frac{7}{12} \times W_o \times K_h \times (h \times y^3)^{0.5}, \; y = \frac{2}{5} h$$

y; a point of load, h; water depth (m), $W_{o;}$ unit weight of water 1.0tf (1,000kgf/m3)

### (2) Condition to satisfy the safety on stability

a. Normal

( no seismic condition and flood condition )

- Reaction: horizontal section is all compressive stress and allowable bearing capacity $\sigma_t \leq 30$(tf/m$^2$)
- Safety factor against overturning: $|e| \leq B/3$, e: eccentricity of resultant load(m), B: base width (m)
- Safety factor against sliding: more than 1.5

b. Seismic ( during Normal water level condition)

- Reaction: horizontal section is more than 75% compressive stress and allowable bearing capacity $\sigma_t \leq 45$(tf/m$^2$)
- Safety factor against overturning: $|e| \leq B/6$, e: eccentricity of resultant load(m), B: base width (m)
- Safety factor against sliding: more than 1.2

### (3) Result of Stability Analyses

The result is summarized as Table 3-11, 3-12 and 3-13. As shown in the result, the structure is safe against bearing capacity, tension failure, and sliding.

Table 3-11 Result of stability Analysis (Bajhang)

| | 1. Normal (Normal Water) | 2. Normal (Flood) | 3. Seismic (Normal Water) |
|---|---|---|---|
| Bearing Capacity (tf/m$^2$) | 4.0 – 5.3 < 30<br>OK | 0.3 -10.2 < 30<br>OK | 2.1 - 7.2 < 45<br>OK |
| Eccentricity of resultant load (m) | 0.15 < B/6 = 1.10<br>OK | 1.03 < B/6 = 1.10<br>OK | 0.61 < B/3 = 2.20<br>OK |
| Safety factor against sliding | 1.5 < 3.41<br>OK | 1.5 < 2.80<br>OK | 1.2 < 1.43<br>OK |
| Assessment | The stability factor is satisfied in all conditions. | | |

Table 3-12 Result of stability Analysis (Bajura)

| | 1. Normal (Normal Water) | 2. Normal (Flood) | 3. Seismic (Normal Water) |
|---|---|---|---|
| Bearing Capacity ($tf/m^2$) | 3.7 - 5.5 < 30<br>OK | 0.3 – 9.8 < 30<br>OK | 1.7 - 7. 5 < 45<br>OK |
| Eccentricity of resultant load (m) | 0.21 < B/6 = 1.05<br>OK | 0.98 < B/6 = 1.05<br>OK | 0.67 < B/3 = 2.10<br>OK |
| Safety factor against sliding | 1.5 < 3.22<br>OK | 1.5 < 2.81<br>OK | 1.2 < 1.40<br>OK |
| Assessment | The stability factor is satisfied in all conditions. | | |

Table 3-13 Result of stability Analysis (Syarpudaha)

| | 1. Normal (Normal Water) | 2. Normal (Flood) | 3. Seismic (Normal Water) |
|---|---|---|---|
| Bearing Capacity ($tf/m^2$) | 3.7 - 5.5 < 30<br>OK | 1.8 – 8.1 < 30<br>OK | 1.7 - 7.5 < 45<br>OK |
| Eccentricity of resultant load (m) | 0.21 < B/6 = 1.05<br>OK | 0.68 < B/6 = 1.05<br>OK | 0.67 < B/3 = 2.10<br>OK |
| Safety factor against sliding | 1.5 < 3.22<br>OK | 1.5 < 3.38<br>OK | 1.2 < 1.40<br>OK |
| Assessment | The stability factor is satisfied in all conditions. | | |

## Table 3-14 Result of stability Analysis (Bajhang, Normal Water, Normal)

| | Load | Calculation | | | Unit | Vertical (ton) | Arm x(m) | Resist M (t·m) | Horizontal (ton) | Arm y(m) | Rotation M (t·m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water weight | | | | | | | | | | |
| Ww 1 | Upstream | 3.8*0.2 | | | | 0.76 | 4.55 | 3.46 | | | |
| Ww 2 | Downstream | 0.7*2.8 | | | | 1.96 | 1.40 | 2.74 | | | |
| Ww 3 | Waterway | 1.0*2.2 | | | | 2.2 | 2.80 | 6.16 | | | |
| | Earth pressure | | | | | | | | | | |
| Ps 1 | Horizontal earth pressure | KA=0.5 | H=3.0m | γs=0.9tm3 | ton f | | | | 2.03 | 0.40 | 0.81 |
| | Upstream water level +0.2, Downstream water level +0.7 | | | | | | | | | | |
| Pw 1-1 | H=1.7m | 0.5*1.7^2 | | | ton f | | | | 1.45 | 3.07 | 4.43 |
| Pw 1-2 | H=3.0m | 0.5*(1.7+1.7)*3.0 | | | ton f | | | | 5.10 | 1.50 | 7.65 |
| Pw 2-1 | H=2.7m (Resist force) | 0.5*2.7^2 | | | ton f | | | | -3.65 | 0.90 | -3.28 |
| Pw 2-2 | H=0.5m | 0.5*(2.7+2.7)*0.5 | | | ton f | | | | 1.35 | 0.25 | 0.34 |
| | Uplift | | | | | | | | | | |
| U 1 | | 0.5*(1.7+2.7)*6.6 | | | ton f | -14.52 | 3.05 | -44.29 | | | |
| | Weir body | | | | | | | | | | |
| Wc 1 | | 1.5*3.8*2.4 | | | ton f | 13.68 | 4.70 | 64.30 | | | |
| Wc 2-1 | | 0.5*1.55*2.5*2.4 | | | ton f | 4.65 | 4.82 | 22.40 | | | |
| Wc 2-2 | | 2.5*1.0*2.4 | | | ton f | 6 | 4.10 | 24.60 | | | |
| Wc 3-1 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 4.43 | 0.67 | | | |
| Wc 3-2 | | 0.5*2.75*2.4 | | | ton f | 3.3 | 2.98 | 9.82 | | | |
| Wc 3-3 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 1.52 | 0.23 | | | |
| Wc 4 | | 1.0*0.5*2.4 | | | ton f | 1.2 | 2.80 | 3.36 | | | |
| Wc 5 | | 2.3*2*2.4 | | | ton f | 11.04 | 1.15 | 12.70 | | | |
| | Total | | | | | 30.57 | | 106.14 | 6.28 | | 9.95 |
| | | | | | | V | | MV | H | | MH |
| | Results of Analysis | | | | | | | | | | |
| | Base width | B | | | m | 6.60 | | | | | |
| | Eccentricity of resultant load | e=B/2-(MV-MH)/V | | | m | 0.15 | < | 1.10 | B/6 | OK | |
| | Overturning | S.F=MV/MH | | | s.f | 10.67 | > | 1.50 | | OK | |
| | Bearing capacity | q 1=V/B x (1+6e/B) | | | tf/m2 | 5.28 | < | 30.00 | | OK | |
| | | q 2=V/B x (1-6e/B) | | | tf/m2 | 3.99 | < | 30.00 | | OK | |
| | Sliding | S.F=f x V / H | | f=tan 35 = 0.7 | | s.f | 3.41 | > | 1.50 | | OK |

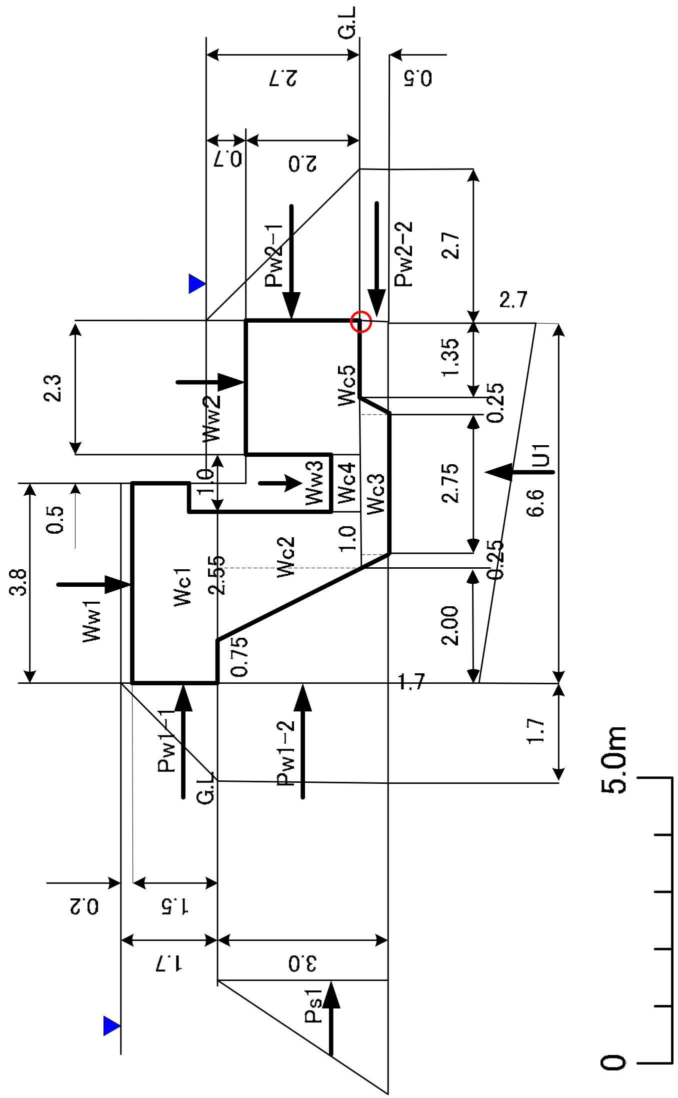


Table 3-15 Result of stability Analysis (Bajura、Syarpudaha, Normal Water, Normal)

| | Load | Calculation | | | Unit | Vertical (ton) | Arm x(m) | Resist M (t·m) | Horizontal (ton) | Arm y(m) | Rotation M (t·m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water weight | | | | | | | | | | |
| Ww 1 | Upstream | 3.5*0.2 | | | | 0.7 | 4.55 | 3.19 | | | |
| Ww 2 | Downstream | 0.7*2.8 | | | | 1.96 | 1.40 | 2.74 | | | |
| Ww 3 | Waterway | 1.0*2.2 | | | | 2.2 | 2.80 | 6.16 | | | |
| | Earth pressure | | | | | | | | | | |
| Ps 1 | Horizontal earth pressure | KA=0.5 | H=3.0m | γs=0.9tm3 | ton f | | | | 2.03 | 0.40 | 0.81 |
| | Upstream water level +0.2, Downstream water level +0.7 | | | | | | | | | | |
| Pw 1-1 | H=1.7m | 0.5*1.7^2 | | | ton f | | | | 1.45 | 3.07 | 4.43 |
| Pw 1-2 | H=3.0m | 0.5*(1.7+1.7)*3.0 | | | ton f | | | | 5.10 | 1.50 | 7.65 |
| Pw 2-1 | H=2.7m (Resist force) | 0.5*2.7^2 | | | ton f | | | | -3.65 | 0.90 | -3.28 |
| Pw 2-2 | H=0.5m | 0.5*(2.7+2.7)*0.5 | | | ton f | | | | 1.35 | 0.25 | 0.34 |
| | Uplift | | | | | | | | | | |
| U 1 | | 0.5*(1.7+2.7)*6.3 | | | ton f | -13.86 | 2.91 | -40.35 | | | |
| | Weir body | | | | | | | | | | |
| Wc 1 | | 1.5*3.5*2.4 | | | ton f | 12.6 | 4.55 | 57.33 | | | |
| Wc 2-1 | | 0.5*1.25*2.5*2.4 | | | ton f | 3.75 | 4.72 | 17.69 | | | |
| Wc 2-2 | | 2.5*1.0*2.4 | | | ton f | 6 | 3.80 | 22.80 | | | |
| Wc 3-1 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 4.13 | 0.62 | | | |
| Wc 3-2 | | 0.5*2.45*2.4 | | | ton f | 2.94 | 2.83 | 8.31 | | | |
| Wc 3-3 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 1.52 | 0.23 | | | |
| Wc 4 | | 1.0*0.5*2.4 | | | ton f | 1.2 | 2.80 | 3.36 | | | |
| Wc 5 | | 2.3*2*2.4 | | | ton f | 11.04 | 1.15 | 12.70 | | | |
| | Total | | | | | 28.83 | | 94.76 | 6.28 | | 9.95 |
| | | | | | | V | | MV | H | | MH |
| | Results of Analysis | | | | | | | | | | |
| | Base width | B | | | m | 6.30 | | | | | |
| | Eccentricity of resultant load | e=B/2-(MV-MH)/V | | | m | 0.21 | < | 1.05 | B/6 | OK | |
| | Overturning | S.F=MV/MH | | | s.f | 9.53 | > | 1.50 | | OK | |
| | Bearing capacity | q 1=V/B x (1+6e/B) | | | tf/m2 | 5.48 | < | 30.00 | | OK | |
| | | q 2=V/B x (1-6e/B) | | | tf/m2 | 3.67 | < | 30.00 | | OK | |
| | Sliding | S.F=f x V / H | | f=tan 35 = 0.7 | s.f | 3.22 | > | 1.50 | | OK | |

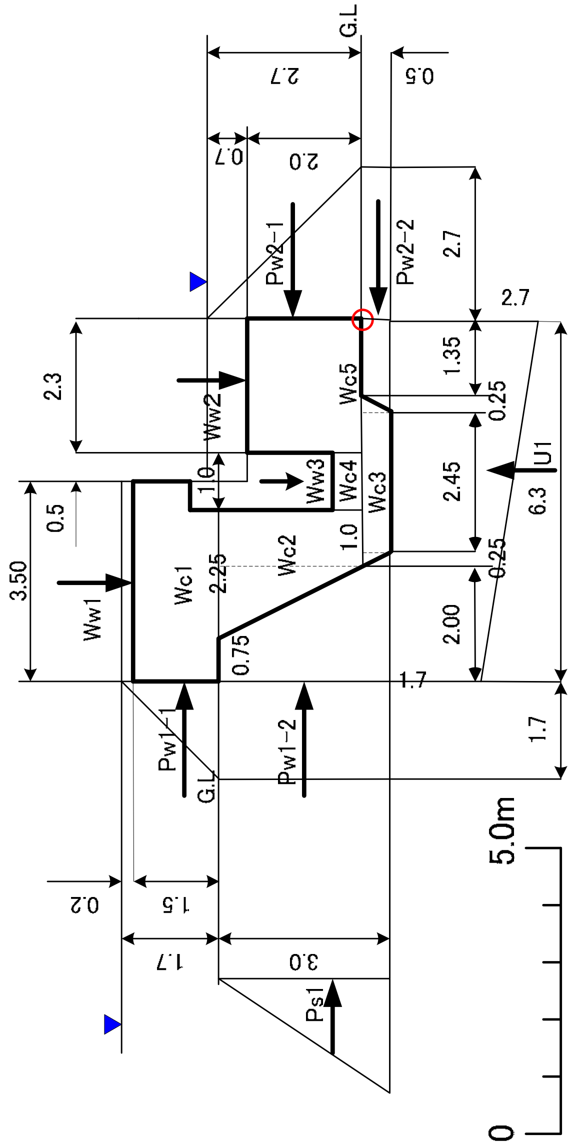


Table 3-16 Result of stability Analysis (Bajhang, Flood,Normal)

| | Load | Calculation | | | Unit | Vertical (ton) | Arm x(m) | Resist M (t·m) | Horizontal (ton) | Arm y(m) | Rotation M (t·m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Water weight** | | | | | | | | | | |
| Ww 1 | Upstream | 3.8*3.6 | | | | 13.68 | 4.70 | 64.30 | | | |
| Ww 2 | Downstream | 2.8*4.1 | | | | 11.48 | 1.40 | 16.07 | | | |
| Ww 3 | Waterway | 1.0*5.4 | | | | 5.4 | 2.80 | 15.12 | | | |
| | **Earth pressure** | | | | | | | | | | |
| Ps 1 | Horizontal earth pressure | KA=0.5 | H=3.0m | γs=0.9tm3 | ton f | | | | 2.03 | 0.40 | 0.81 |
| | **Upstream flood water level +3.6, Downstream flood water level +4.1** | | | | | | | | | | |
| Pw 1-1 | H=5.1m | 0.5*5.1^2 | | | ton f | | | | 13.01 | 4.20 | 54.62 |
| Pw 1-2 | H=3.0m | 0.5*(5.1+5.1)*3.0 | | | ton f | | | | 15.30 | 1.50 | 22.95 |
| Pw 2-1 | H=6.1m (Resist force) | 0.5*6.1^2 | | | ton f | | | | -18.61 | 2.03 | -37.83 |
| Pw 2-2 | H=0.5m | 0.5*(6.1+6.1)*0.5 | | | ton f | | | | -3.05 | 0.25 | -0.76 |
| | **Uplift** | | | | | | | | | | |
| U 1 | | 0.5*(5.1+6.1)*6.6 | | | ton f | -36.96 | 3.20 | -118.34 | | | |
| | **Weir body** | | | | | | | | | | |
| Wc 1 | | 1.5*3.8*2.4 | | | ton f | 13.68 | 4.70 | 64.30 | | | |
| Wc 2-1 | | 0.5*1.25*2.5*2.4 | | | ton f | 3.75 | 5.02 | 18.81 | | | |
| Wc 2-2 | | 2.5*1.3*2.4 | | | ton f | 7.8 | 3.95 | 30.81 | | | |
| Wc 3-1 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 4.43 | 0.67 | | | |
| Wc 3-2 | | 0.5*2.75*2.4 | | | ton f | 3.3 | 3.13 | 10.31 | | | |
| Wc 3-3 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 1.52 | 0.23 | | | |
| Wc 4 | | 1.0*0.5*2.4 | | | ton f | 1.2 | 2.80 | 3.36 | | | |
| Wc 5 | | 2.3*2*2.4 | | | ton f | 11.04 | 1.15 | 12.70 | | | |
| | Total | | | | | 34.67 | | 118.33 | 8.68 | | 39.79 |
| | | | | | | V | | MV | H | | MH |
| | **Results of Analysis** | | | | | | | | | | |
| | Base width | B | | | m | 6.60 | | | | | |
| | Eccentricity of resultant load | e=B/2-(MV-MH)/V | | | m | 1.03 | < | 1.10 | B/6 | OK | |
| | Overturning | S.F=MV/MH | | | s.f | 2.97 | > | 1.50 | | OK | |
| | Bearing capacity | q 1=V/B x (1+6e/B) | | | tf/m2 | 10.19 | < | 30.00 | | OK | |
| | | q 2=V/B x (1-6e/B) | | | tf/m2 | 0.31 | < | 30.00 | | OK | |
| | Sliding | S.F=f x V / H | | f=tan 35 = 0.7 | s.f | 2.80 | > | 1.50 | | OK | |

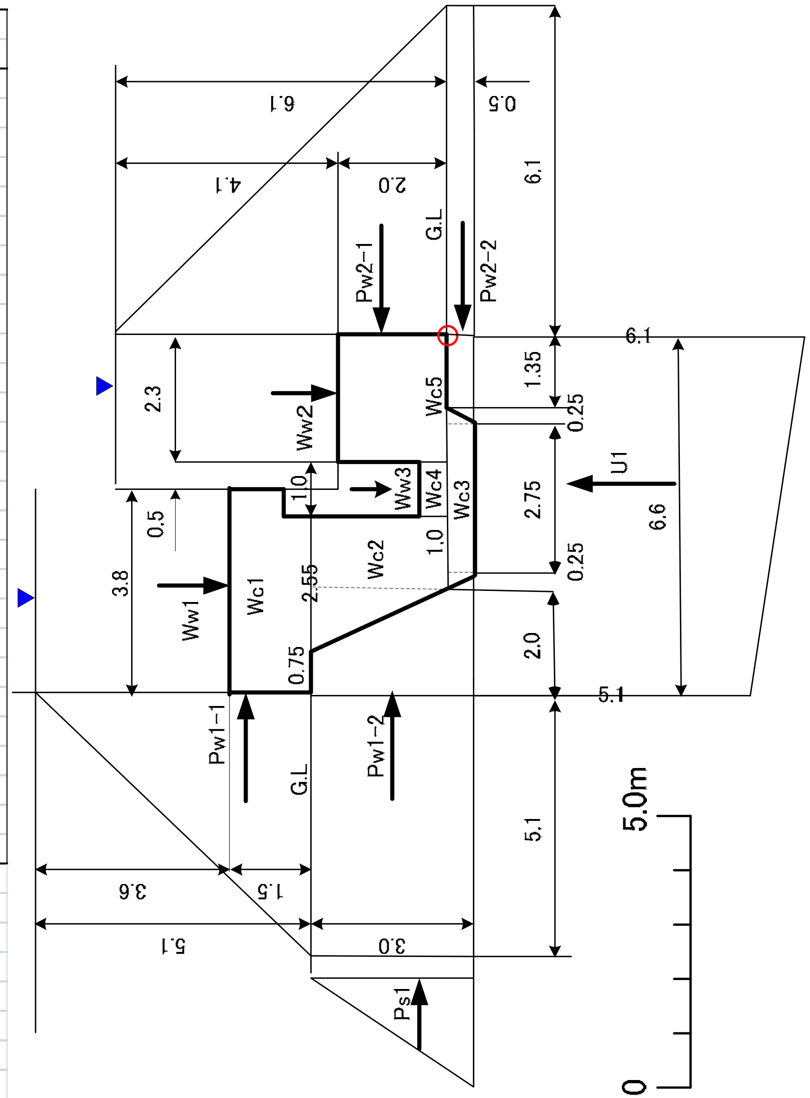
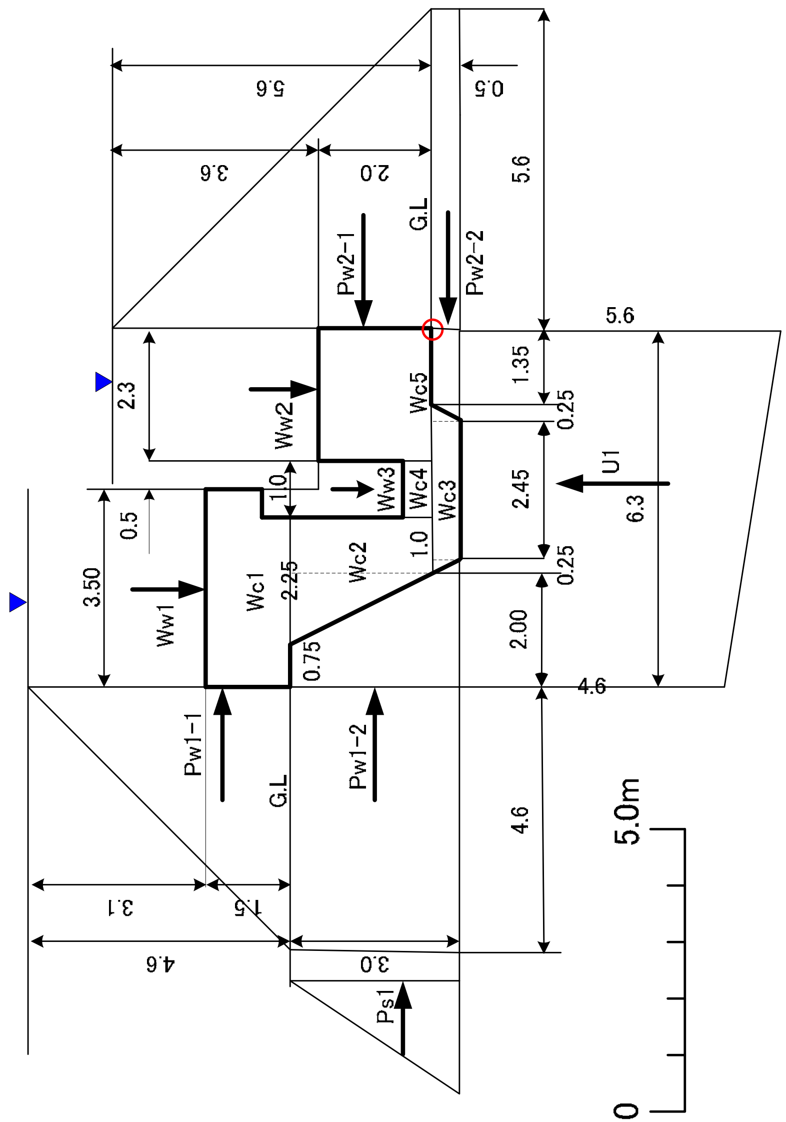


Table 3-17 Result of stability Analysis (Bajura, Flood, Normal)

| | Load | Calculation | | | Unit | Vertical (ton) | Arm x(m) | Resist M (t·m) | Horizontal (ton) | Arm y(m) | Rotation M (t·m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water weight | | | | | | | | | | |
| Ww 1 | Upstream | 3.5*3.1 | | | | 10.85 | 4.55 | 49.37 | | | |
| Ww 2 | Downstream | 2.8*3.6 | | | | 10.08 | 1.40 | 14.11 | | | |
| Ww 3 | Waterway | 1.0*5.2 | | | | 5.2 | 2.80 | 14.56 | | | |
| | Earth pressure | | | | | | | | | | |
| Ps 1 | Horizontal earth pressure | KA=0.5 | H=3.0m | γs=0.9tm3 | ton f | | | | 2.03 | 0.40 | 0.81 |
| | Upstream flood water level +3.1, Downstream flood water level +3.6 | | | | | | | | | | |
| Pw 1-1 | H=4.6m | 0.5*4.6^2 | | | ton f | | | | 10.58 | 4.03 | 42.67 |
| Pw 1-2 | H=3.0m | 0.5*(4.6+4.6)*3.0 | | | ton f | | | | 13.80 | 1.50 | 20.70 |
| Pw 2-1 | H=5.6m (Resist force) | 0.5*5.6^2 | | | ton f | | | | -15.68 | 1.87 | -29.27 |
| Pw 2-2 | H=0.5m | 0.5*(5.6+5.6)*0.5 | | | ton f | | | | -2.8 | 0.25 | -0.70 |
| | Uplift | | | | | | | | | | |
| U 1 | | 0.5*(4.6+5.6)*6.3 | | | ton f | -32.13 | 3.05 | -97.90 | | | |
| | Weir body | | | | | | | | | | |
| Wc 1 | | 1.5*3.5*2.4 | | | ton f | 12.6 | 4.55 | 57.33 | | | |
| Wc 2-1 | | 0.5*1.25*2.5*2.4 | | | ton f | 3.75 | 4.72 | 17.69 | | | |
| Wc 2-2 | | 2.5*1.0*2.4 | | | ton f | 6 | 3.80 | 22.80 | | | |
| Wc 3-1 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 4.13 | 0.62 | | | |
| Wc 3-2 | | 0.5*2.45*2.4 | | | ton f | 2.94 | 2.83 | 8.31 | | | |
| Wc 3-3 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 1.52 | 0.23 | | | |
| Wc 4 | | 1.0*0.5*2.4 | | | ton f | 1.2 | 2.80 | 3.36 | | | |
| Wc 5 | | 2.3*2*2.4 | | | ton f | 11.04 | 1.15 | 12.70 | | | |
| | Total | | | | | 31.83 | | 103.16 | 7.93 | | 34.21 |
| | | | | | | V | | MV | H | | MH |
| | Results of Analysis | | | | | | | | | | |
| | Base width | B | | | m | 6.30 | | | | | |
| | Eccentricity of resultant load | e=B/2-(MV-MH)/V | | | m | 0.98 | ＜ | 1.05 | B/6 | OK | |
| | Overturning | S.F=MV/MH | | | s.f | 3.02 | ＞ | 1.50 | | OK | |
| | Bearing capacity | q 1=V/B x (1+6e/B) | | | tf/m2 | 9.79 | ＜ | 30.00 | | OK | |
| | | q 2=V/B x (1-6e/B) | | | tf/m2 | 0.32 | ＜ | 30.00 | | OK | |
| | Sliding | S.F=f x V / H | | f=tan 35 = 0.7 | s.f | 2.81 | ＞ | 1.50 | | OK | |



## Table 3-18 Result of stability Analysis (Syarpudaha, Flood, Normal)

| | Load | Calculation | | | Unit | Vertical | Arm | Resist M | Horizontal | Arm | Rotation M |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (ton) | x(m) | (t·m) | (ton) | y(m) | (t·m) |
| | Water weight | | | | | | | | | | |
| Ww 1 | Upstream | 3.5*2.1 | | | | 7.35 | 4.55 | 33.44 | | | |
| Ww 2 | Downstream | 2.8*2.6 | | | | 7.28 | 1.40 | 10.19 | | | |
| Ww 3 | Waterway | 1.0*4.4 | | | | 4.4 | 2.80 | 12.32 | | | |
| | Earth pressure | | | | | | | | | | |
| Ps 1 | Horizontal earth pressure | KA=0.5 | H=3.0m | γs=0.9tm3 | ton f | | | | 2.03 | 0.40 | 0.81 |
| | Upstream flood water level +2.1, Downstream flood water level +2.6 | | | | | | | | | | |
| Pw 1-1 | H=3.6m | 0.5*3.6^2 | | | ton f | | | | 6.48 | 3.70 | 23.98 |
| Pw 1-2 | H=3.0m | 0.5*(3.6+3.6)*3.0 | | | ton f | | | | 10.8 | 1.50 | 16.20 |
| Pw 2-1 | H=4.6m (Resist force) | 0.5*4.6^2 | | | ton f | | | | -10.58 | 1.53 | -16.22 |
| Pw 2-2 | H=0.5m | 0.5*(4.6+4.6)*0.5 | | | ton f | | | | -2.3 | 0.25 | -0.58 |
| | Uplift | | | | | | | | | | |
| U 1 | | 0.5*(3.6+4.6)*6.3 | | | ton f | -25.83 | 3.02 | -78.06 | | | |
| | Weir body | | | | | | | | | | |
| Wc 1 | | 1.5*3.5*2.4 | | | ton f | 12.6 | 4.55 | 57.33 | | | |
| Wc 2-1 | | 0.5*1.25*2.5*2.4 | | | ton f | 3.75 | 4.72 | 17.69 | | | |
| Wc 2-2 | | 2.5*1.0*2.4 | | | ton f | 6 | 3.80 | 22.80 | | | |
| Wc 3-1 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 4.13 | 0.62 | | | |
| Wc 3-2 | | 0.5*2.45*2.4 | | | ton f | 2.94 | 2.83 | 8.31 | | | |
| Wc 3-3 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 1.52 | 0.23 | | | |
| Wc 4 | | 1.0*0.5*2.4 | | | ton f | 1.2 | 2.80 | 3.36 | | | |
| Wc 5 | | 2.3*2*2.4 | | | ton f | 11.04 | 1.15 | 12.70 | | | |
| | Total | | | | | 31.03 | | 100.92 | 6.43 | | 24.19 |
| | | | | | | V | | MV | H | | MH |
| | Results of Analysis | | | | | | | | | | |
| | Base width | B | | | m | 6.30 | | | | | |
| | Eccentricity of resultant load | e=B/2-(MV-MH)/V | | | m | 0.68 | < | 1.05 | B/6 | OK | |
| | Overturning | S.F=MV/MH | | | s.f | 4.17 | > | 1.50 | | OK | |
| | Bearing capacity | q 1=V/B x (1+6e/B) | | | tf/m2 | 8.10 | < | 30.00 | | OK | |
| | | q 2=V/B x (1-6e/B) | | | tf/m2 | 1.75 | < | 30.00 | | OK | |
| | Sliding | S.F=f x V / H | | f=tan 35 = 0.7 | s.f | 3.38 | > | 1.50 | | OK | |

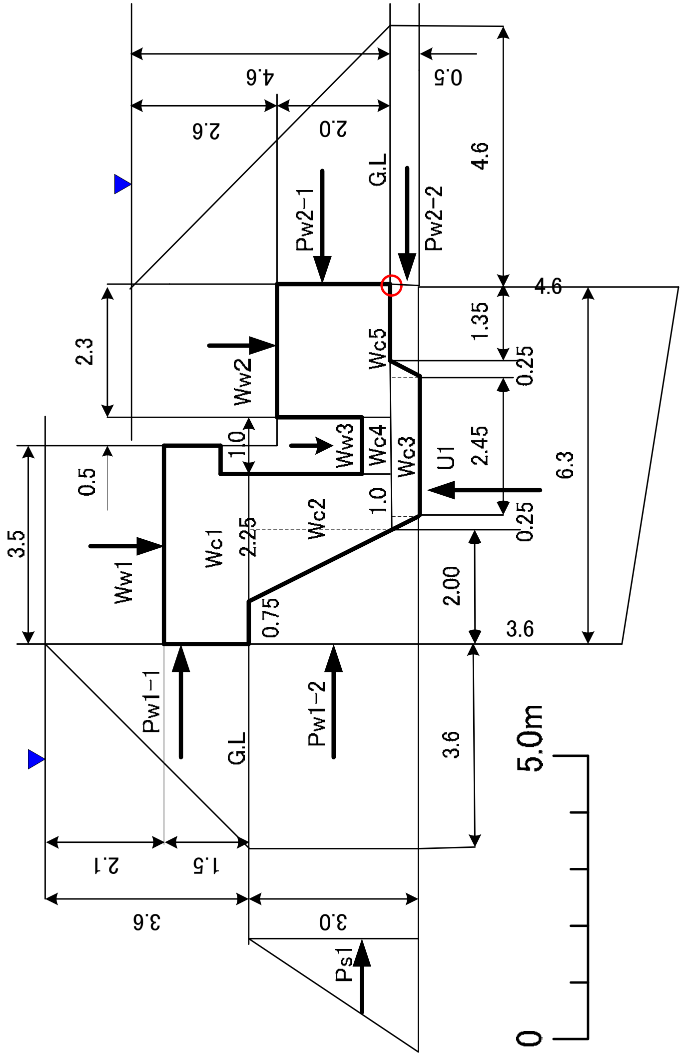
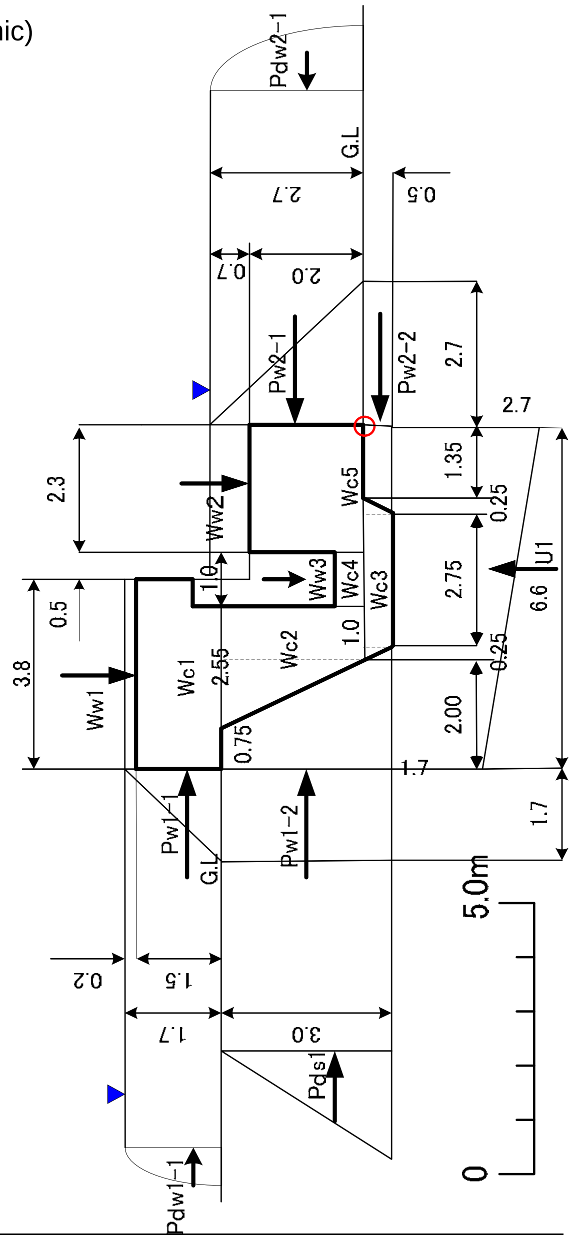


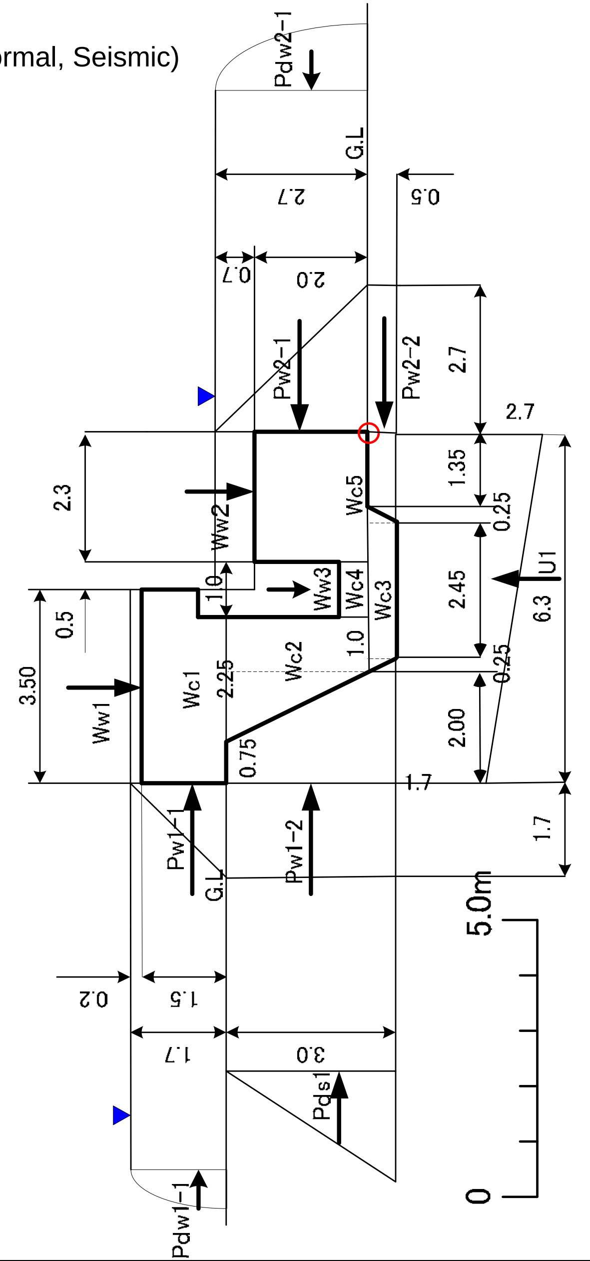
Table 3-19 Result of stability Analysis (Bajhang, Normal, Seismic)

| | Load | Calculation | | | Unit | Vertical (ton) | Arm x(m) | Resist M (t·m) | Horizontal (ton) | Arm y(m) | Rotation M (t·m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Water weight** | | | | | | | | | | |
| Ww 1 | Upstream | 3.8*0.2 | | | | 0.76 | 4.70 | 3.57 | | | |
| Ww 2 | Downstream | 0.7*2.8 | | | | 1.96 | 1.40 | 2.74 | | | |
| Ww 3 | Waterway | 1.0*2.2 | | | | 2.2 | 2.80 | 6.16 | | | |
| | **Dynamic Earth pressure** | | | | | | | | | | |
| Ps 1 | Horizontal earth pressure | KA=0.5 | H=3.0m | γs=0.9tm3 | ton f | | | | 2.77 | 0.40 | 1.11 |
| | | Kh'=γd/(γd −1)*Kh=(2.2/2.2−1)*0.2=0.37 | | | | | | | | | |
| | **Upstream water level +0.2, Downstream water level +0.7** | | | | | | | | | | |
| Pw 1-1 | H=1.7m | 0.5*1.7^2 | | | ton f | | | | 1.45 | 3.07 | 4.43 |
| Pw 1-2 | H=3.0m | 0.5*(1.7+1.7)*3.0 | | | ton f | | | | 5.10 | 1.50 | 7.65 |
| Pw 2-1 | H=2.7m (Resist force) | 0.5*2.7^2 | | | ton f | | | | −3.65 | 0.90 | −3.28 |
| Pw 2-2 | H=0.5m | 0.5*(2.7+2.7)*0.5 | | | ton f | | | | 1.35 | 0.25 | 0.34 |
| Pdw1-1 | Dynamic H=1.7m, y=2/5*1.7=0.68m | 7/12*1.0*0.2*(((2*1.7/5)^3)*1.7)^0.5 | | | ton f | | | | 0.09 | 0.68 | 0.06 |
| Pdw2-1 | Dynamic H=2.7m, y=2/5*2.7=1.08m | 7/12*1.0*0.2*(((2*2.7/5)^3)*2.7)^0.5 | | | ton f | | | | −0.22 | 1.08 | −0.23 |
| | **Uplift** | | | | | | | | | | |
| U 1 | | 0.5*(1.7+2.7)*6.6 | | | ton f | −14.52 | 3.05 | −44.29 | | | |
| | **Weir body ( including seismic loard )** | | | | | | | | | | |
| Wc 1 | | 1.5*3.8*2.4 | | | ton f | 13.68 | 4.70 | 64.30 | 2.74 | 3.25 | 8.89 |
| Wc 2-1 | | 0.5*1.55*2.5*2.4 | | | ton f | 4.65 | 4.82 | 22.40 | 0.93 | 1.67 | 1.55 |
| Wc 2-2 | | 2.5*1.0*2.4 | | | ton f | 6 | 4.10 | 24.60 | 1.20 | 1.25 | 1.50 |
| Wc 3-1 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 4.43 | 0.67 | 0.03 | −0.17 | −0.01 |
| Wc 3-2 | | 0.5*2.75*2.4 | | | ton f | 3.3 | 2.98 | 9.82 | 0.66 | −0.25 | −0.17 |
| Wc 3-3 | | 0.5*0.25*0.5*2.4 | | | ton f | 0.15 | 1.52 | 0.23 | 0.03 | −0.17 | −0.01 |
| Wc 4 | | 1.0*0.5*2.4 | | | ton f | 1.2 | 2.80 | 3.36 | 0.24 | 0.25 | 0.06 |
| Wc 5 | | 2.3*2*2.4 | | | ton f | 11.04 | 1.15 | 12.70 | 2.21 | 1.00 | 2.21 |
| | **Total** | | | | | **30.57** | | **106.25** | **14.93** | | **24.11** |
| | | | | | | **V** | | **MV** | **H** | | **MH** |
| | **Results of Analysis** | | | | | | | | | | |
| | Base width | B | | | m | 6.60 | | | | | |
| | Eccentricity of resultant load | e=B/2−(MV−MH)/V | | | m | 0.61 | < | 2.20 | B/3 | OK | |
| | Overturning | S.F=MV/MH | | | s.f | 4.41 | > | 1.20 | | OK | |
| | Bearing capacity | q 1=V/B x (1+6e/B) | | | tf/m2 | 7.21 | < | 45.00 | | OK | |
| | | q 2=V/B x (1−6e/B) | | | tf/m2 | 2.05 | < | 45.00 | | OK | |
| | Sliding | S.F=f x V / H | | f=tan 35 = 0.7 | s.f | 1.43 | > | 1.20 | | OK | |



# Table 3-20 Result of stability Analysis (Bajura, Syarpudaha, Normal, Seismic)

| | Load | Calculation | Unit | Vertical (ton) | Arm x(m) | Resist M (t·m) | Horizontal (ton) | Arm y(m) | Rotation M (t·m) |
|---|---|---|---|---|---|---|---|---|---|
| | **Water weight** | | | | | | | | |
| Ww 1 | Upstream | 3.5*0.2 | | 0.7 | 4.55 | 3.19 | | | |
| Ww 2 | Downstream | 0.7*2.8 | | 1.96 | 1.40 | 2.74 | | | |
| Ww 3 | Waterway | 1.0*2.2 | | 2.2 | 2.80 | 6.16 | | | |
| | **Dynamic Earth pressure** | | | | | | | | |
| Ps 1 | Horizontal earth pressure | KA=0.5 H=3.0m γs=0.9tm3 | ton f | | | | 2.77 | 0.40 | 1.11 |
| | | Kh'=γd/(γd −1)*Kh=(2.2/2.2−1)*0.2=0.37 | | | | | | | |
| | **Upstream water level +0.2, Downstream water level +0.7** | | | | | | | | |
| Pw 1−1 | H=1.7m | 0.5*1.7^2 | ton f | | | | 1.45 | 3.07 | 4.43 |
| Pw 1−2 | H=3.0m | 0.5*(1.7+1.7)*3.0 | ton f | | | | 5.10 | 1.50 | 7.65 |
| Pw 2−1 | H=2.7m (Resist force) | 0.5*2.7^2 | ton f | | | | −3.65 | 0.90 | −3.28 |
| Pw 2−2 | H=0.5m | 0.5*(2.7+2.7)*0.5 | ton f | | | | 1.35 | 0.25 | 0.34 |
| Pdw1−1 | Dynamic H=1.7m, y=2/5*1.7=0.68m | 7/12*1.0*0.2*(((2*1.7/5)^3)*1.7)^0.5 | ton f | | | | 0.09 | 0.68 | 0.06 |
| Pdw2−1 | Dynamic H=2.7m, y=2/5*2.7=1.08m | 7/12*1.0*0.2*(((2*2.7/5)^3)*2.7)^0.5 | ton f | | | | −0.22 | 1.08 | −0.23 |
| | **Uplift** | | | | | | | | |
| U 1 | | 0.5*(1.7+2.7)*6.3 | ton f | −13.86 | 2.91 | −40.35 | | | |
| | **Weir body ( including seismic loard )** | | | | | | | | |
| Wc 1 | | 1.5*3.5*2.4 | ton f | 12.6 | 4.55 | 57.33 | 2.52 | 3.25 | 8.19 |
| Wc 2−1 | | 0.5*1.25*2.5*2.4 | ton f | 3.75 | 4.72 | 17.69 | 0.75 | 1.67 | 1.25 |
| Wc 2−2 | | 2.5*1.0*2.4 | ton f | 6 | 3.80 | 22.80 | 1.20 | 1.25 | 1.50 |
| Wc 3−1 | | 0.5*0.25*0.5*2.4 | ton f | 0.15 | 4.13 | 0.62 | 0.03 | −0.17 | −0.01 |
| Wc 3−2 | | 0.5*2.45*2.4 | ton f | 2.94 | 2.83 | 8.31 | 0.59 | −0.25 | −0.15 |
| Wc 3−3 | | 0.5*0.25*0.5*2.4 | ton f | 0.15 | 1.52 | 0.23 | 0.03 | −0.17 | −0.01 |
| Wc 4 | | 1.0*0.5*2.4 | ton f | 1.2 | 2.80 | 3.36 | 0.24 | 0.25 | 0.06 |
| Wc 5 | | 2.3*2*2.4 | ton f | 11.04 | 1.15 | 12.70 | 2.21 | 1.00 | 2.21 |
| | **Total** | | | **28.83** | | **94.76** | **14.46** | | **23.12** |
| | | | | **V** | | **MV** | **H** | | **MH** |
| | **Results of Analysis** | | | | | | | | |
| | Base width | B | m | 6.30 | | | | | |
| | Eccentricity of resultant load | e=B/2−(MV−MH)/V | m | 0.67 | 〈 | 2.10 | B/3 | OK | |
| | Overturning | S.F=MV/MH | s.f | 4.10 | 〉 | 1.20 | | OK | |
| | Bearing capacity | q 1=V/B x (1+6e/B) | tf/m2 | 7.47 | 〈 | 45.00 | | OK | |
| | | q 2=V/B x (1−6e/B) | tf/m2 | 1.68 | 〈 | 45.00 | | OK | |
| | Sliding | S.F=f x V / H   f=tan 35 = 0.7 | s.f | 1.40 | 〉 | 1.20 | | OK | |



# 4. River Diversion Works

## 4-1 Scale of River Diversion Works

Design of River diversion works, including the selection of diversion flood, is the responsibility of the contractor. The river diversion work is also-called “Optional Temporary Works”

This chapter studies the river diversion channel by providing cofferdam.

The flood to be considered in the diversion designs, in general, is selected considering construction period, damage cost if it is flooded, safety of workmen and downstream inhabitants in case the failure of diversion works results in unnatural flooding.

Based on the hydrometeorology study, the design flood during construction, dimensions of diversion channel is shown in the Table below.

Table 4-1 Diversion Flood and Channel (During Construction)

| Design flood for Diversion works | | | Temporary Diversion Channel | | | |
|---|---|---|---|---|---|---|
| Site | Catchment Area ($km^2$) | Design flood during construction ($m^3/s$) | Slope | Base Width (m) | Water Depth (m) | Bank Protection |
| Bajhang | 104 | 390 | 1/21 | 11.0 | 2.5～3.5 | Stream Side: Covering gabion, placing sandbag against seepage Back Side: Sandbag and embankment |
| Bajura | 27 | 150 | 1/12 | 4.0 | 2.0～2.5 | |
| Syarupudaha | 41 | 220 | 1/4.5 | 4.0 | 2.0～2.5 | |

## 4-2 Coffer Dam

The intakes of the three projects are on steep valley where the flow velocity is high especially during flood . The cofferdam should be safe from such flood during construction. For instance, in the Bajhang diversion channel, the tractive force has sufficient energy to flush out a boulder with diameter around 2m. Thus, the diversion channel and cofferdam is designed to be protected towards the flow side with gabion and sandbag being placed behind the gabion to reduce seepage. Likewise, backside embanks with soil for counterweight.

Tractive Force for Bajhang diversion

$\tau = \rho \times g \times h \times I$

| | | |
|---|---|---|
| $\tau$: | Tractive Force (gr/cm$^2$) | |
| $\rho$: | Mass of Water (gr) | 1.2 |
| g: | Gravity (=9.8 m/s$^2$) | |
| h: | Water Depth (cm) | 332 |
| I: | Slop | 1/21 |

$\tau =$ 18.971 gr/cm$^2$

Friction Velocity: $U_*^2$

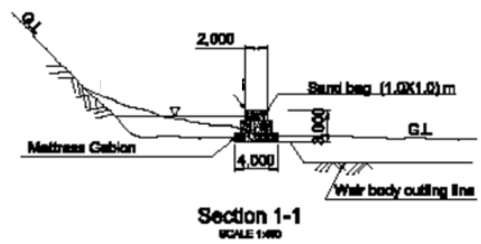
$U_*^2 = \tau / \rho$ (cm$^2$/s)

$U_*^2 =$ 15,493 (cm$^2$/s)

Critical Grain Size for tractivation, based on Iwagaki-Formula

$U_*^2 = 80.9 \times \mathrm{d_c}$ $\quad \mathrm{d_c} \geq 0.303$ cm

$\mathrm{d_c} = 192$ cm



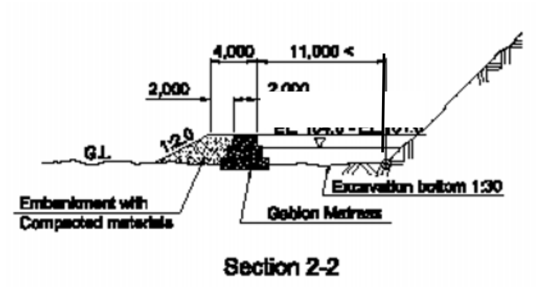




Figure 4-1 Typical Type of Temporary Dimension Channel

The flow capacity of Bajhang, Bajura, and Syarpudaha Diversion is estimated by Manning-Formula and result shown below.

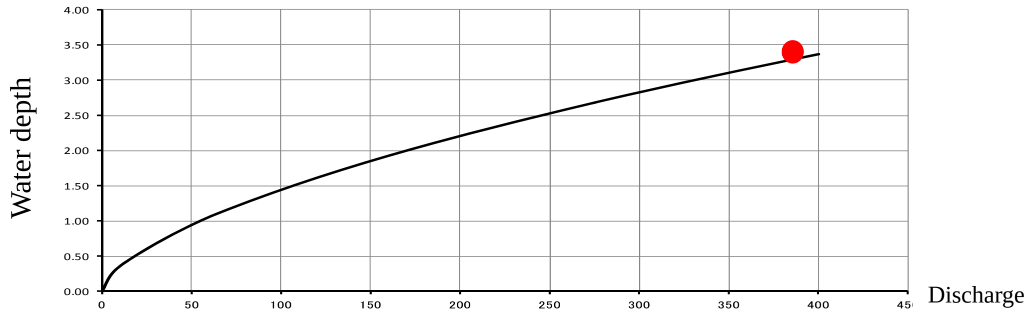



Figure 4-2 Capacity Flow of Temporary Diversion Channel at Bajhang

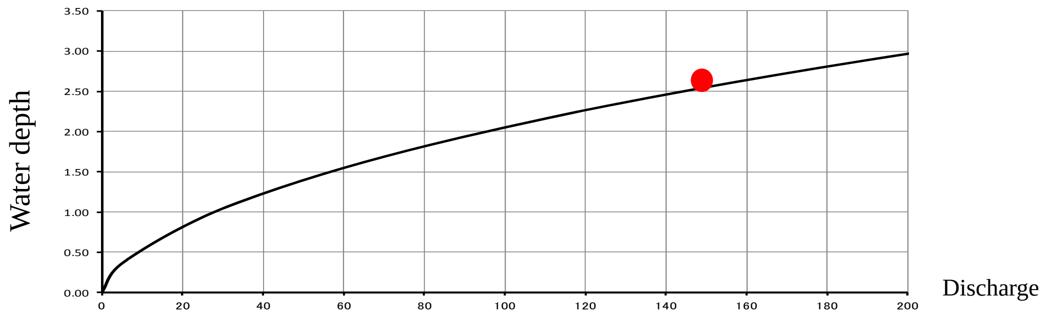



Figure 4-3 Capacity Flow of Temporary Diversion Channel at Bajura

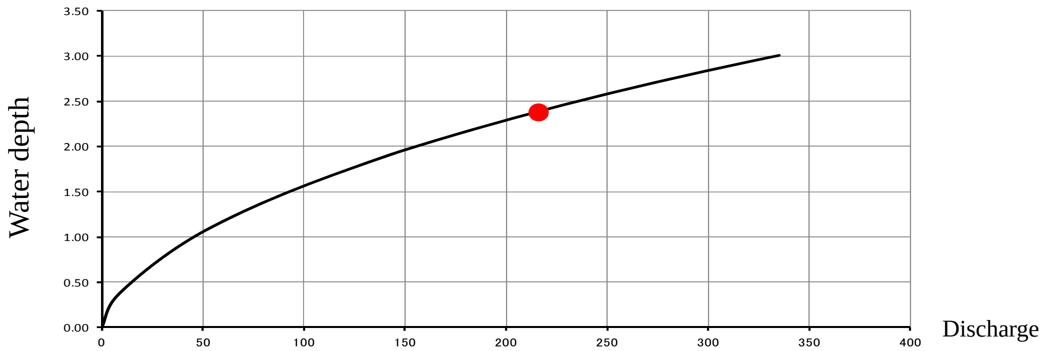



Figure 4-4 Capacity Flow of Temporary Diversion Channel at Syapudaha

## 4-3 Sequence for Construction of Intake

In order to construct the intake across a river, the temporary diversion channel is required. The diversion will keep the river bed isolated from water and thus keep the working area dry. Hence the construction work of intake will be done during the dry season when the river discharge is low. The basic sequence of diversion works for construction of Bajhang intake is shown below. Same sequence will be followed in Bajura and Syarpudha.

<table>
<tr>
<td>
(1) 1st stage of Construction<br>
Firstly, temporary diversion channel is constructed on the left side. Then the river is diverted towards the left side. Construction of intake on the right side and connection of the headrace canal<br>
1) 1st Stage (1)<br>
・ Excavation for diversion channel towards the left side<br>
・ Strengthening cofferdam with Sandbag and gabion<br>
・ Extension of the cofferdam upstream in order to operate the powerplant during construction.
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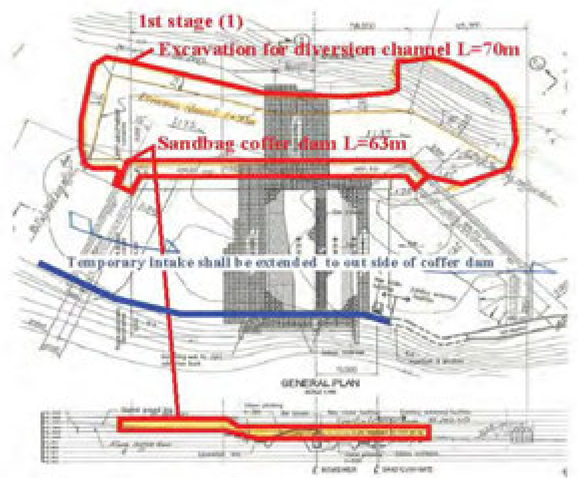

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<tr>
<td>
2) 1st Stage (2)<br>
・ Construction of cofferdam with sandbag and gabion on the right side.<br>
・ On the back side of the cofferdam, counterweight embankment and sand bag is placed until there is no disturbance during the construction of weir.<br>
・ The power plant can be operated until the river flow is diverted towards the left side.
</td>
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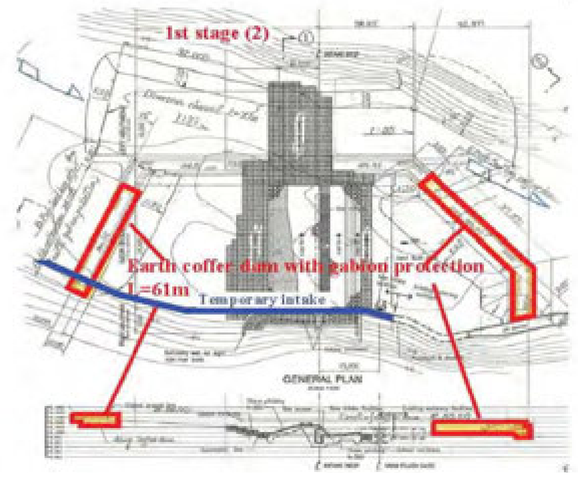

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</tr>
<tr>
<td>
3) 1st Stage (3)<br>
・ After constructing the temporary cofferdam, excavate left side of the river for diversion channel. Thereafter, divert the river towards the temporary diversion channel on the left side.<br>
・ Prevent water leakage through the cofferdam by placing sandbag and gabion. In addition, install drainage pumps to pump out water and maintain the working area in a dry condition.
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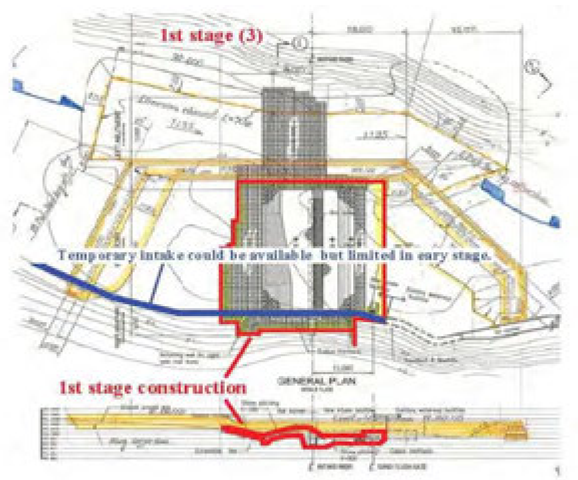


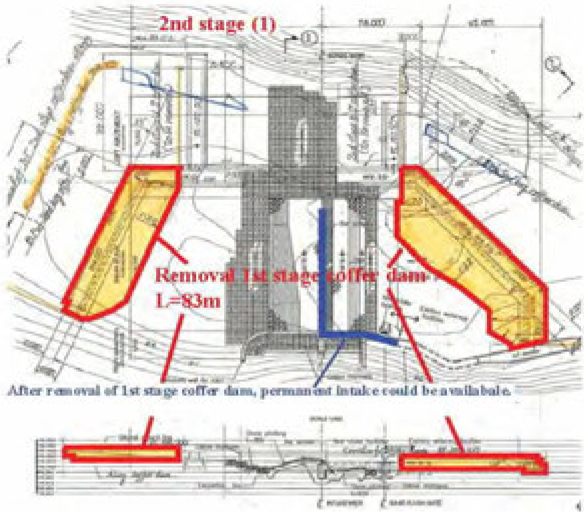
</td>
</tr>
</table>

(2) 2nd stage of Construction

After finishing the construction of the right side of intake and connecting the diversion channel to existing channel, 2nd stage construction commences. The construction at this stage is to ensure seepage control and construction of bank protection and bed protection by placing the gabion.

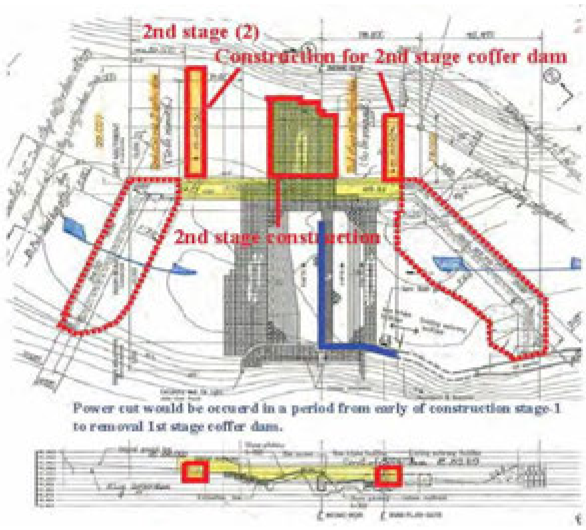
1) 2nd Stage (1)

- Remove the primary temporary drainage channel
- The river flows along the primary transfer water channel. If necessary, in order to remove the temporary retaining wall, excavate the river bed.(Rerouting)



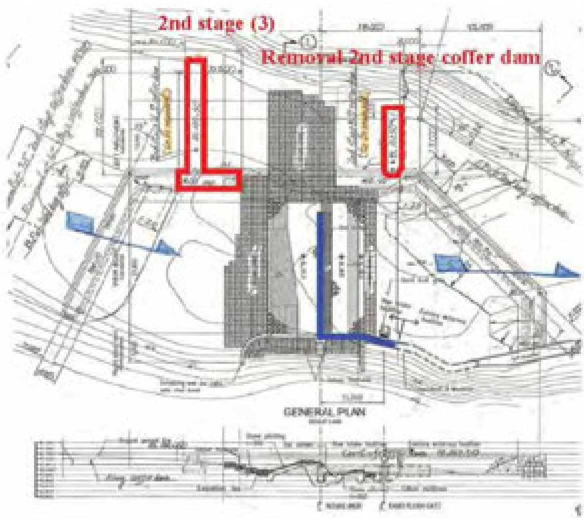

2) 2nd Stage (2)

- By removal the primary temporary closure wall, the river water flows from the right side of the river.
- The river water will now flow over the completed part of the right intake. Some part of water goes into the headrace canal for power generation and excess water flows downstream.
- After rerouting the flow, construction of the second temporary closure wall as shown in right figure.




3) 2nd Stage (3)

- After placing the concrete closure wall on the left side, place the gabion for bank and bed protection.
- Prevent the water leakage through the cofferdam by placing sandbag and gabion
- Install the drainage pump at proper site as long as possible to pump out water and maintain construction site in dry condition.
- Remove the secondary temporary cofferdam after constructing on left side.



# 5. Rehabilitation of Existing Structures

## 5-1 Condition of Existing Civil Structures

To obtain relevant information on the existing conditions for existing civil structures, the inspection of following items was carried out at intake, waterway, penstock line, power house and tailrace at Bajhang, Bajura, and Syarpudaha power stations.

1) Inspection of existing civil structures for obtaining information on existing conditions.
2) Identification of items for repair and rehabilitation based on the above result.
3) Calculation of quantity of repair and rehabilitation works for project cost estimation.

The repairing and rehabilitation works were extracted based on the inspection results by using Table 5-1, Judgment and Measures.

The summary of quantity for repair and rehabilitation works of three power stations is presented at the end of this chapter. These results are expected to be useful for O/M of power stations in the future.

Table 5-1 Judgment and Measures

| Category | Judgment | Measures |
|---|---|---|
| A | The damage and the deformation are serious.<br>The following problems may occur if no measures are taken:<br>▪ Power supply may become difficult then power failure will occur.<br>-or-<br>▪ The third party (villagers, road and cultivated fields) may become unsafe. | ▪ Emergency measures shall be executed.<br>▪ Then permanent measures shall be carried out. |
| B | The damage and deformation exists. The problem is not serious now, but the problems of category A may occur in case the current damage and deformation is left unattended and worsens.<br>-or-<br>The facility is disfigured much by current damage. | ▪ Emergency measures are not required.<br>▪ The following measures shall be executed taking account of damage conditions.<br>✓ Repair<br>✓ Strengthening<br>✓ Continuous monitoring<br>✓ Further inspection (in case of the causeless damages) |
| S | The damage and deformation does not exist or is limited to minimal degree. Following problems will not occur even if no measures are taken;<br>▪ Power supply may become difficult then power failure will occur.<br>-or-<br>▪ Third party (villagers, road, and cultivated field) may become unsafe. | ▪ Periodic monitoring |

## 5-2 Rehabilitation Works for Existing Civil Structures

The repairing and rehabilitation works required in power stations are shown in subsequent pages in Table 5-2 ~5-6 for Bajhang, Table 5-7~5-12 for Bajura, and Table 5-13~5-17 for Syarpudaha power station. The measures are indicated with ● symbol.

Table 5-2 Repairing, Rehabilitation Items for Bajhang power station (1)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 1 | ✓ Intake weir does not exist at site.<br>● Construction of new intake facilities which could improve the following damages of 2,3, is proposed. | **A** |  |
| 2 | ✓ The temporary intake facility made from river bed materials has been provided along the river.<br>✓ The temporary intake is flushed out in every flood, and needs to repair during dry season.<br>✓ Temporary intake have following problems:<br>• Intake discharge from river is not stable due to change of river course.<br>• Difficulty in diverting sufficient amount of water for power generation<br>• The water contains more sand.<br>● The temporary intake facility should be replaced by a permanent intake to divert sufficient discharge for power generation. | **A** |  |
| 3 | ✓ Foundation of headrace is scoured.<br>✓ At present, stability of headrace is low during events like earthquake and additional scouring by flood<br>● This damage should be improved by construction of new intake facility | **A** |  |
| 4 / 5 / 6 | ✓ Sand flushing gate is leaking.<br>✓ Hoisting equipment is broken.<br>✓ Operation of sand flushing gate is required for maintenance of headrace.<br>● Therefore replacement of the gate facility is required.<br>● The stoplog arrangement is needed for maintenance of headrace. | **B** |   |

Table 5-3 Repairing, Rehabilitation Items for Bajhang power station (2)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 7 | ✓ The sediment deposition in settling basin was observed.<br>✓ The sand flushing gate is not functioning.<br>✓ The sediment may cause scouring of headrace, reduction of cross section and hence flow.<br>● The sediment should be removed. | B |  |
| 8 | ✓ The sand flushing gate is plugged with concrete to prevent leakage.<br>● The replacement of gate is proposed for improvement of sediment handling. | B |  |
| 9 | ✓ The bank protection is scoured.<br>✓ The bank protection will become unstable in case of additional scouring by flood.<br>✓ The similar damage was observed near outlet of bank protection.<br>● The repairing works for bank protection is proposed. | B |  |
| 10 | ✓ The walls are broken at least at six places to spill or withdraw water for irrigating field.<br>● Stealing water from headrace should be prohibited and the wall should be repaired or replaced. | B |  |
| 11 | ✓ The concrete cover slab is provided in landslide area and is in good condition during normal conveyance condition. In some areas, especially at the start of the landslide, the cover slab is missing or displaced<br>✓ The collapsed sediment from slope may plug the headrace.<br>● The slab on top should be provided to prevent sediment entering into the waterway.<br>● Continuous monitoring of the slope is required. | B | Collapsed slope; 250m width, 100m height<br> |

Table 5-4 Repairing, Rehabilitation Items for Bajhang power station (3)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 12 / 13 | ✓ The crest of masonry wall is damaged, the water is spilling.<br>● Repairing works at crest is proposed. | **B** |  |
| 14 | ✓ Sediment is deposited in the head pond.<br>● The removal of sediment is proposed for the following points of view;<br>• to prevent deterioration of mechanical equipments by reducing suspended sand.<br>• to maintain maximum storage capacity in head pond for power generation. | **B** |  |
| 15 | ✓ Harmful cracks around 90m length in total area was observed on invert and wall in the head pond.<br>● Repair of invert and wall is proposed. | **B** |  |
| 16 | ✓ Sand flushing gate at the head pond is leaking.<br>✓ Gate equipment is deteriorating.<br>✓ Hoisting operation is difficult to operate.<br>● Replacement of gate is proposed. | **B** |  |

Table 5-5 Repairing, Rehabilitation Items for Bajhang power station (4)

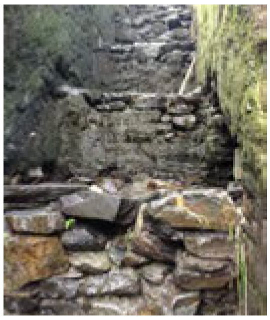
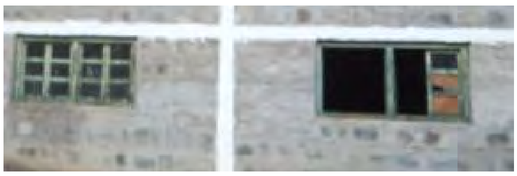
| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 17 | ✓ Lots of debris is accumulated on trash rack.<br>✓ Significant water level difference before and after trash rack incurs energy loss.<br>● Debris should be removed daily.<br>● Providing portable rake is proposed for trash rack cleaning work. | **S** |  |
| 18 | ✓ Same damages and measures as item 17. | **S** |  |
| 19 / 20 | ✓ Deterioration due to aging is observed on spillway.<br>✓ However, current spillway functioning properly.<br>✓ It is reported that water from spillway does not cause damages to the third parties.<br>✓ Therefore the deterioration is not a serious problem.<br>● Continuous monitoring of spillway condition is required. | **B** |   |
| 21 / 21-1 | ✓ The tubercles, paintings have been removed from the surface of penstock pipe.<br>✓ Bifurcation pipe is buried without sufficient coating against corrosion.<br>● Deterioration control in steel pipes is needed. Surface preparation and painting is required.<br>● Capping with concrete at exposed section of the bifurcation and further downstream is proposed. | **B** |   |
| 22 | Architecture<br>✓ Deteriorations of window frame is observed.<br>● Replacement of frame is proposed. | **B** |  |

Table 5-6 Repairing, Rehabilitation Items for Bajhang power station (5)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 23<br>24 | Architecture<br>✓ The roof has been repaired several times to prevent leakages caused by aging.<br>● Repairing the roof is proposed to safeguard the electrical equipments inside the powerhouse. | **A** |  |
| 25<br>/<br>26<br>/<br>27 | Architecture<br>✓ The walls have deteriorated due to aging.<br>✓ The entrance is too small, the lighting equipments are not sufficient for O/M.<br>● Replacing building walls and providing adequate lighting for O/M is proposed.<br>● The improvement of the building should be combined with floor rehabilitation during replacement of mechanical and electrical equipments. | **B** |  |
| 28<br>/<br>29 | ✓ The invert of tailrace channel is scored.<br>● Replacement of invert is proposed. | **B** |  |
| 30 | ✓ The bank protection in tailrace outlet is damaged by river bed scouring.<br>✓ Without any measures, the damage may worsen and the outlet may become unsafe.<br>● Replacement of bank protection is required. | **A~B** |  |
| Other<br>31 | ✓ The lack of proper administration office, rest house, and warehouse for daily O/M works reduces working efficiency.<br>● The facilities are required on site for efficient execution of daily O/M works. | **(A)** | |

Table 5-7 Repairing, Rehabilitation Items for Bajura power station (1)

| **Nos.** | **Damages, Deformations, Judgment, and Measures** | **Category** | **Photos** |
|---|---|---|---|
| 1 | ✓ Intake weir does not exist at site.<br>● Construction of new intake facilities which could improve the following damages of 2, 3 is proposed. | **A** |  |
| 2 | ✓ The temporary intake facility made from river bed materials has been provided along the river.<br>✓ The temporary intake is flushed out during flood, and needs to be repaired during dry season.<br>✓ Temporary intake has following problems:<br>• Intake discharge from river is not stable due to change of river course by flood.<br>• Difficulty in diverting sufficient amount of water for power generation<br>• The water contains more sand.<br>● The temporary intake facility should be replaced by a permanent intake to divert sufficient discharge for power generation. | **A** |  |
| 3 | ✓ The sand flushing operation is not possible since the gate is completely buried in debris.<br>● It is proposed to install the sand flushing gate at an appropriate location. | **A～B** |  |
| 4 | ● The stoplog arrangement will be helpful during maintenance of headrace. The water after installing the stoplogs will be discharged through the sand flushing gate. | **B** | |
| 5 | ✓ About 15m long headrace canal upstream of the settling basin is leaking due to deterioration of concrete by ageing.<br>● Rehabilitation for headrace channel by reinforced concrete is proposed. | **B** |  |

Table 5-8 Repairing, Rehabilitation Items for Bajura power station (2)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 6 | ✓ The settling basin is leaking. Deterioration due to aging is observed.<br>✓ The capacity of settling basin is sufficient for hydraulic function.<br>● Construction of a new settling basin, with reinforced concrete, having same dimension as the existing one is proposed. | **B** |  |
| 7 | ✓ The sand flushing gate is leaking. Concrete and the steel structures had deteriorated due to aging Operation of sand flushing gate is needed for maintenance of headrace canal.<br>● Replacement of the gate facility is required. | **B** |  |
| 8 | ✓ The collapsed slope mark is observed downstream of the basin. However the slope is stable.<br>● Continuous monitoring on the collapsed slope is required. | **S** |  |
| 9 / 10 | ✓ Deterioration of headrace canal due to aging is observed at invert, wall for a length of 150m, downstream of settling basin.<br>✓ Sediment from collapsed slope is observed.<br>● Replacement of headrace channel by new structure with cover slab is proposed. | **A～B** |  |

Table 5-9 Repairing, Rehabilitation Items for Bajura power station (3)

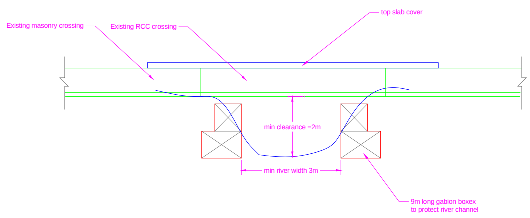
| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| **11** | ✓ Headrace canal is leaking. Deterioration of headrace due to aging is observed at walls over a total length of 200m.<br>● Waterproof repairing from inside of the channel is proposed. | **B** |  |
| **12** | ✓ The crest of masonry wall is damaged over a total length of 340m.<br>✓ Spilling water from crest of wall is observed.<br>● The repairing of wall is proposed. | **B** |  |
| **13** | ✓ Flood mark is observed on headrace channel.<br>✓ Flood water from the mountain stream sometimes overflow into headrace channel.<br>✓ Without measures, headrace channel may be washed away.<br>● Widening of mountain stream bed is required to avoid flood impact to headrace.(See the figure on the right)<br>● Headrace canal should be covered with slab to avoid flood deposit. | **A** |  |
| **14** | ✓ Small collapse of slope is observed along headrace channel at six places.<br>✓ Headrace canal can be plugged with deposit or can be damaged in case of severe collapse.<br>● Slope protection is proposed. | **B** |  |

Table 5-10 Repairing, Rehabilitation Items for Bajura power station (4)

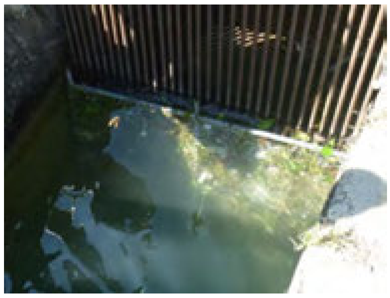
| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| **15** | ✓ Stone masonry at head pond is leaking.<br>✓ The capacity of head pond is enough for hydraulic function.<br>● Repairing of masonry and joint mortar is required. | **B** |  |
| **16 / 17** | ✓ Lots of debris is accumulated on trash rack.<br>✓ Significant water level difference before and after trash rack incurs energy loss.<br>● Debris should be removed daily.<br>● Providing portable rake is proposed for efficient trash rack cleaning. | **S** |  |
| **18** | ✓ Sand flushing gate at the headpond is leaking.<br>✓ Deterioration of gate equipment are observed.<br>✓ Hoisting mechanism is difficult to operate.<br>● Replacement of gate is proposed. | **B** |  |
| **19** | ✓ Erosion by water spilled from the head pond was observed. However it has not caused trouble to the villagers at the moment.<br>● Continuous monitoring of the spillway channel is required. | **B～S** |  |
| **20** | ✓ The tubercles, paintings have been removed from the penstock pipe surface.<br>✓ Harmful cracks were observed in a total of 20 saddles.<br>✓ Scouring of some of the saddle foundations was observed.<br>● Deterioration control on steel pipe is needed.<br>● Surface preparation and painting is required.<br>● Replacement of 20 damaged saddles is required | **A** |  |

Table 5-11 Repairing, Rehabilitation Items for Bajura power station (5)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 21 | ✓ Harmful cracks were observed on saddle concrete.<br>● The cracks are caused by expansion joint resting on saddle.<br>Therefore location of new saddle should avoid the joint above. | A |  |
| 22 | ✓ The steel pipe is buried in deposit.<br>✓ The tubercles and paintings have been removed from the surface of the penstock.<br>✓ Without measures, the stability of penstock pipe may not exist in case of additional force to the pipe.<br>● Removal of deposit from pipe and protection of excavated slope is required.<br>● Deterioration control in steel pipe is needed. The surface preparation and painting is required. | A～B |  |
| 23 | ✓ The steel pipe is buried at a shallow depth under the village road.<br>✓ Without measures, the penstock pipe may collapse when heavy vehicle moves on the road.<br>● Removal of backfilling material over the pipe and protection of side slope is required.<br>● Further deterioration of steel pipes should be prevented. Surface preparation and painting is required.<br>● The village road over the penstock pipe should be separated from penstock by providing a bridge crossing. | A～B |  |
| 24 | ✓ The tubercles and paintings have been removed.<br>● Further deterioration of steel pipe should be prevented. Surface preparation and painting is required. | B |  |

Table 5-12 Repairing, Rehabilitation Items for Bajura power station (6)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 25 / 28 | Architecture<br>✓ Deterioration of window frame was observed.<br>● Replacement of frame is proposed.<br>✓ The roof has been repaired several times to prevent leakage caused by deterioration due to aging.<br>✓ The leakages have to be prevented by repairing the roof, mainly to protect the electrical equipments inside the power plant.<br>Deterioration due to aging is observed on the building wall.<br>✓ The entrance is too small, and the lighting equipments are not adequate for O/M.<br>● Replacing the building wall and providing sufficient lighting for O/M is proposed.<br>● The improvement of the building should be combined with floor rehabilitation during replacement of mechanical and electrical equipments. | B | <br> |
| 32 | ✓ The deterioration due to aging is observed at tail race channel.<br>✓ The invert and wall are scoured and washed away.<br>● Complete replacement of tailrace is proposed. | A |  |
| 33 | ✓ The bank protection at tailrace outlet is damaged by foundation scouring.<br>✓ Without any rehabilitation measures, the damage may increase and the outlet may become unsafe.<br>● Replacement of bank protection is required. | A~B |  |
| Others | ✓ The lack of proper administration office, rest house, and warehouse for daily O/M works reduces working efficiency.<br>● The facilities are required on-site for efficient execution of daily O/M works. | (A) | |

Table 5-13 Repairing, Rehabilitation Items for Syarpudaha power station (1)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 1 | ✓ Intake weir does not exist at site.<br>✓ Some surface flow and flow underneath the boulders were observed.<br>● Construction of new intake facility which could improve the damages discussed in 2, 3 is proposed. | A |  |
| 2 | ✓ The temporary intake is constructed by locally available riverbed material along the river.<br>✓ The temporary intake is flushed out during flood, and needs to be repaired during dry season.<br>✓ Temporary intake have following problems:<br>• Intake discharge from river is not stable due to change of river course by flood.<br>• Difficulty in diverting sufficient amount of water for power generation<br>• The water contains more sand.<br>● The temporary intake facility should be replaced by a permanent facility to divert sufficient discharge for power generation. | A |  |
| 3 / 4 / 6 | ✓ The sand flushing gate is leaking. Deterioration due to aging was observed.<br>✓ Operation of sand flushing gate and the stop log arrangement is needed for maintenance of headrace canal.<br>● Replacement of the gate facility including installation of stop log is required. | B |  |
| 5 | ✓ Headrace is leaking. Deterioration due to aging is observed along a 7m length of headrace channel.<br>● Replacement headrace channel is required. | A |  |
| 7 | ✓ The collapse of slope has occurred leading to realignment of the headrace channel.<br>✓ The channel is buried under the debris of the collapsing slope.<br>✓ Without slope protection, the channel may be damaged by further collapsing.<br>● Protection of slope against erosion by rain is proposed. | A |  |

Table 5-14 Repairing, Rehabilitation Items for Syarpudaha power station (2)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 8 | ✓ The headrace channel crest has no free board during normal power operation.<br>✓ This is due to the restriction of flow at the realigned section of the channel. The bottleneck is created at the landslide which increases the water level upstream.<br>● Spilling will be prevented by increasing the crest height. | **B** |  |
| 9 | ✓ Headrace channel is leaking. Deterioration due to aging was observed.<br>● Repairing or Replacement of channel for a total length of 65m is required. | **B** |  |
| 10<br>/<br>11 | ✓ The crest of masonry is damaged for a total length of 65m.<br>✓ Moss on the inside of channel was observed along headrace channel.<br>● The repairing of crest or replacement of wall is proposed.<br>● Removal of moss and cleaning the channel is proposed. | **B** |  |
| 12 | ✓ Sand flushing gate at head pond is leaking.<br>✓ Deteriorations of gate equipment were observed.<br>✓ Operation of the gate is difficult due to problem in hoisting mechanism.<br>● Replacement of gate is proposed. | **B** |  |
| 13<br>/<br>14 | ✓ Lots of debris is accumulated on trash rack.<br>✓ The significant water level difference before and after trash rack incurs energy loss.<br>● Debris should be removed daily.<br>● Providing portable rake is proposed for efficient trash rack cleaning. | **S** |  |

Table 5-15 Repairing, Rehabilitation Items for Syarpudaha power station (3)

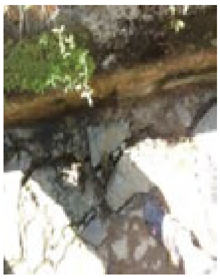
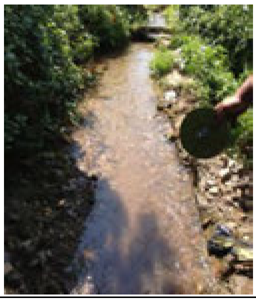
| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 15 | ✓ Stone masonry head pond is leaking.<br>✓ The capacity of head pond is enough for hydraulic function.<br>● Repairing of masonry and joint mortar is required. | **B** |  |
| 16 | ✓ Spillway channel wall is cracked and joint mortar is damaged.<br>✓ The spillway is leaking.<br>● Repairing of masonry and joint mortar is required.<br>● Continuous monitoring of the spillway is proposed. | **B** |  |
| 17 / 18 / 19 | ✓ Spillway invert is damaged and leakages were observed.<br>✓ Spilling water has been used for irrigation purpose.<br>● Replacement of invert is proposed.<br>● Continuous monitoring for slope stability along spillway is required for the safety of villagers. | **B** |   |
| 20 | ✓ Harmful cracks along joint mortar were observed on 4 of the saddle blocks.<br>✓ The opening of the crack is in the range of 10~1cm.<br>✓ The crack is caused by expansion joint on saddle<br>✓ Without rehabilitation measures, the penstock pipe will not be safe and can collapse after some years.<br>● Therefore 4of the saddle blocks should be replaced.<br>● The location of new saddle should avoid the joint. | **A** |  |

Table 5-16 Repairing, Rehabilitation Items for Syarpudaha power station (4)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 21 / 22 | ✓ Expansion joint is leaking.<br>✓ The tubercles, painting have been removed from the penstock pipe surface.<br>● Further deterioration of steel pipe should be prevented. The surface preparation and painting is required. | **B** | <br> |
| 23 | ✓ The tubercles, paintings are removed from the penstock pipe surface.<br>✓ Bifurcation pipe is buried without adequate coating against corrosion.<br>● Further deterioration of the steel pipe should be controlled. The surface preparation and painting over the surface is required.<br>● Concrete encasing of the exposed bifurcation pipe is proposed. | **B** | <br> |

Table 5-17 Repairing, Rehabilitation Items for Syarpudaha power station (5)

| Nos. | Damages, Deformations, Judgment, and Measures | Category | Photos |
|---|---|---|---|
| 24 / 25 | ✓ Tailrace invert and wall is damaged.<br>● Repair of invert and wall is required. | **B** |  |
| 26 | ✓ The bank protection in tailrace outlet is damaged by scouring.<br>✓ Without preventive measures, the damage may develop which will make the outlet unsafe.<br>✓ Replacement of bank protection is required. | **A~B** |  |
| 27 / 28 / 29 | Architecture<br>**Maintenance of power house has been conducted. However deteriorations due to aging were observed, therefore following measures are proposed.**<br>✓ Deterioration of window frame was observed.<br>● Replacement of frame is proposed.<br>✓ The roof has been repaired several times<br>● Repairing of roof is proposed to protect electrical equipment from damage due to leakage of water by repairing the roof.<br>✓ The deterioration of building walls due to aging was observed.<br>✓ The entrance is too small, and the lighting equipments are not sufficient for O/M.<br>● Replacement of building wall is proposed. Likewise, adequate lighting for O/M is proposed.<br>● The improvement of the building should be combined with floor rehabilitation during replacement of mechanical and electrical equipments. | **B** | <br> |
| Others | ✓ The lack of proper administration office, rest house, and warehouse for daily O/M works reduces working efficiency.<br>● The facilities are required on-site for efficient execution of daily O/M works. | (**A**) | |

## 5-3 Summary of Quantities for Repairing and Rehabilitation Works

The summary of quantities for repair and rehabilitation work in Micro-Hydropower Improvement Project in Bajhang, Bajura, and Syarpudaha are shown in Table 5-18.

Table 5-18 Repairing and Rehabilitation work

| Working Items | Unit | Bajhang | Bajura | Syarpu daha | Total |
|---|---|---|---|---|---|
| Removal of headrace concrete | $m^3$ | 12 | 0 | 16 | 29 |
| Removal of masonry wall | $m^3$ | 63 | 155 | 94 | 313 |
| Removal of sediment | $m^3$ | 380 | 0 | 0 | 380 |
| Dismantling of existing sand flush gate | Ls | 1 | 2 | 0 | 3 |
| Replacement of sand flush gates | Ls | 2 | 2 | 1 | 5 |
| Wooden stop log | unit | 1 | 1 | 1 | 3 |
| Stop log guide metal | Kg | 34 | 41 | 30 | 105 |
| Gabion mattress (protection of waterway, slope) | $m^3$ | 229 | 578 | 710 | 1,517 |
| Tipping 5cm on existing structure | $m^2$ | 118 | 298 | 109 | 525 |
| Formwork (F2) | $m^2$ | 93 | 144 | 15 | 252 |
| Concrete(E) | $m^3$ | 23 | 65 | 9 | 97 |
| Reinforcing bar (30kg/m3) | Kg | 690 | 1,923 | 270 | 2,883 |
| Wet rubble masonry | $m^3$ | 63 | 140 | 94 | 296 |
| Crack repairing work | M | 90 | 20 | 20 | 130 |
| Portable hand rake | Ls | 1 | 1 | 1 | 3 |
| Painting on Penstock pipe | | See Metal works | | | |
| Replacement of saddle plate | Kg | 0 | 592 | 118 | 710 |
| Excavation (common) | $m^3$ | 9 | 668 | 588 | 1,266 |
| Embankment with compacted backfill | $m^3$ | 0 | 41 | 198 | 239 |
| Geotextile mat ( including anchor pin) | $m^2$ | 12 | 130 | 1,495 | 1,637 |
| Sod facing | $m^2$ | 0 | 0 | 1,320 | 1,320 |
| Plaster mortal with chicken mesh | $m^3$ | 5 | 7 | 4 | 16 |
| Stone pitching | $m^3$ | 0 | 56 | 1 | 57 |
| Removal moss from waterway | $m^2$ | 0 | 1,540 | 840 | 2,380 |

# 6. Survey Works

## 6-1 Objective and Scope of Work

Topographic Survey was conducted for three micro hydropower projects in Western Nepal as part of "Preparatory Survey on Micro-Hydropower Improvement Project is Western Nepal". The projects are located in Martadi of Bajhang district, Chainpur of Bajura district and Syarpudaha of Rukum district.

The main objective of the assignment is to conduct detailed topographic survey of the project components starting from intake weir, settling basin, headrace channel, head pond, penstock alignment, and power house to tail race. The survey was conducted individually for three hydropower projects: Bajhang, Bajura and Syarpudaha. The main activities done during the assignment were:

- Installation of control points surrounding site (5 points per site) and checking of existing control points
- Preparation of bench marks at each intake weir site and power house site by leveling survey (elevation of bench mark and adjustment of elevation by available geoid model)
- Preparation of topographic maps for intake, head pond, power house and tailrace
- Preparation of profile for headrace, penstock, spillway and tailrace
- Preparation of cross sections for intake, headrace and penstock alignment
- Preparation of general structure drawings by measurement of shapes and dimension of structures

Table 6-1 Survey Quantities

| | Item | | Description |
|---|---|---|---|
| 1 | Name of Project | : | Preparatory Survey on Micro-Hydropower Improvement Project in Western Area in Nepal |
| 2 | Location of Projects | : | Bajhang, Bajura and Syarpudaha |
| 3 | Terrain | : | Mid Hill |
| 4 | Climate | : | Warm and Moderate (Sub-tropical) |
| 5 | Hydrology | : | Precipitation controlled by monsoon |
| 6 | Topographic Survey | | |
| | Bajhang | : | 2.396 ha |
| | Bajura | : | 1.049 ha |
| | Syarpudaha | : | 2.086 ha |
| 7 | Centre Line Survey | | |
| | Bajhang | : | 1,100 m |
| | Bajura | : | 2,523 m |
| | Syarpudaha | : | 1,850 m |
| 8 | Cross Section Survey | | |
| | Bajhang | : | 1,500 m |
| | Bajura | : | 1,500 m |
| | Syarpudaha | : | 1,500 m |
| 9 | Summary of Bajhang Survey | | |
| | RL of Intake Weir | : | 142.77 |
| | RL of Head pond | : | 139.25 |
| | RL of Powerhouse | : | 100.35 |
| | Length of Headrace | : | 950 m |

| Item | | | Description |
|---|---|---|---|
| | Length of Penstock | : | 100 m |
| | Length of Tailrace | : | 50 m |
| 10 | Summary of Bajura Survey | | |
| | RL of Intake Weir | : | 1577.63 |
| | RL of Head pond | : | 1569.04 |
| | RL of Powerhouse | : | 1,318.38 |
| | Length of Headrace | | 1813 m |
| | Length of Penstock | | 690 m |
| | Length of Tailrace | : | 20 m |
| 11 | Summary of Syarpudaha Survey | | |
| | RL of Intake Weir | : | 1,211.31 |
| | RL of Head pond | : | 1,205.77 |
| | RL of Powerhouse | : | 932.83 |
| | Length of Headrace | : | 1,270 m |
| | Length of Penstock | : | 450 m |
| | Length of Tailrace | : | 80 m |

## 6-2 Accessibility

The project districts are in a mountainous region with limited accessibility. Though the aerial distance is less, owing to difficult terrain and mountainous road, a travel time of at least 2 days is required to reach the project site from Kathmandu. The routes followed to reach the project sites are tabulated below.

Table 6-2 Bajhang

| S.N. | From | To | Means | Description Route |
|---|---|---|---|---|
| 1 | Kathmandu | Dhangadi | Air / 4-wheeler | Blacktopped Road, Highway |
| 2 | Dhangadi | Dadeldhura | 4-wheeler | Blacktopped Road |
| 3 | Dadeldhura | Khodpe | 4-wheeler | Blacktopped Road |
| 4 | Khodpe | Baghthala | 4-wheeler | Blacktopped Road |
| 5 | Bagthala | Chainpur | 4-wheeler | Blacktopped Road |
| 6 | Chainpur | Project Site | 3 hours trek | Trek Road |

Table 6-3 Bajura

| S.N. | From | To | Means | Description Route |
|---|---|---|---|---|
| 1 | Kathmandu | Dhangadi | Air / 4-wheeler | Blacktopped Road, Highway |
| 2 | Dhangadi | Dadeldhura | 4-wheeler | Blacktopped Road |
| 3 | Dadeldhura | Sanfebagar | 4-wheeler | Blacktopped Road |
| 4 | Sanfebagar | Barjughat | 4-wheeler | Graveled Road |
| 5 | Barjughat | Project Site | 4-wheeler | Earthen road (Seasonal) |

Table 6-4 Syarpudaha, Rukum

| S.N. | From | To | Means | Description Route |
|---|---|---|---|---|
| 1 | Kathmandu | Bhairahawa | Air / 4-wheeler | Blacktopped Road, Highway |
| 2 | Bhairahawa | Tulsipur (Dang) | 4-wheeler | Blacktopped Road |
| 3 | Tulsipur | Sitalpati /Salyan | 4-wheeler | Graveled Road (under upgrading) |
| 4 | Sitalpati | Musikt /Rukum | 4-wheeler | Graveled Road (under upgrading) |
| 5 | Musikot | Sani Bheri | 4-wheeler | Earthen Road |
| 6 | Sani Bheri | Syarpudaha Powerplant | 4-wheeler | Earthen Road |
| 7 | Powerplant | Intake Site | 4-wheeler | Earthen Road |


Figure 6-1 General Map of Nepal

## 6-3 Preparatory for Survey

### (1) Survey Procedure

The fieldwork consisted of detailed engineering survey of the project. The linear traverse method was adopted for the survey. All reading was taken using TOTAL STATION and leveling instrument and data were recorded. Contours were generated from the field recorded topographical data.

The Reduced Level (RL) of center point of the cross section were measured using TOTAL STATION. The observation of horizontal angles at each right and mean of two was done with both left and right faces and mean of two was used for calculation to eliminate errors due to eccentricity and centering. The TOTAL STATION instrument carried out profile leveling at required interval and wherever sudden change of topography was observed. During the field works, all the data needed were recorded and registered. Bench Marks (BM) were established where deemed necessary, details of which have been presented in the description card.

### (2) Instrument Station

Instrument is placed on the site from where forward and backward view is clearly seen for taking maximum detailed point for detailing.

### (3) Site Mobilization

The Study team members organized a meeting with the client before departure to the field survey. Topographic survey maps of the sites were obtained from the client. The literature review was briefly conducted and necessary information about the sites was gathered.

Before the commencement of the detailed survey works, a core team comprising of team leader and other team members visited the site to assess the site conditions and necessary procedure to be adopted for timely completion of the assignment. The survey team consisted of senior surveyor, assistant surveyors, field management staff and other technical assistants.

### (4) Group Involved for Survey Work

As the project was to be completed at the earliest possible time, two different groups were involved in the survey works. One of the groups was assigned the task of topographic survey of the project at Syarpudaha while the other group surveyed the Bajhang and Bajura sites.

Each group involved for the survey work consisted of two teams. The two teams were assigned the following tasks:

- TP fixing and baseline survey - 1st team
- Detailing (center line, cross section & others) - 2nd team

### (5) Equipments Used for Surveying

Following equipments were used in addition to other accessories for surveying.

- Total Station

Engineering survey works consisted of the following:

- Establishment of Bench Marks and Control Points
- Bench Mark Survey
- Traverse Survey
- Topographical Survey of road in 25 m wide strip meters (12.5 m on either side of centre line of road)

## 6-4 Establishment of Bench Marks and Control Points

Permanent BM were established along the alignment at about 0.5 km interval at secured and easily visible area. Concrete blocks of 15 cm X 15 cm X 60 cm (LxBxH) with nails flushed at top surface were fixed on the ground. The upper surface of the monument was placed at least 5 cm above the natural ground surface.

Apart from this, supplementary control points were established at intermediate visible locations. Additional offset survey point was established as required to get the detailed topographic features of the proposed area. Reference points for numbers of BM were located.

The numbers of BM were provided for vertical control points for the survey and also serve as baseline stations and traverse points for horizontal ground control. The position of each BM was marked by three permanent reference points. Moreover, auxiliary points were provided between these monuments, as required.

Description cards (D-Cards) have been prepared. The D-Cards shall be helpful for all permanent monuments for easy retrieval during construction. All permanent benchmarks and survey control points were surveyed.

Benchmark survey was carried out by running a double run second order split-level circuits. All closing errors were kept within the acceptable limits of second order accuracy. Benchmark at the powerhouse has been considered as the base point for local benching system.

Altogether 13 benchmarks have been established in the three sites. The numbers of Permanent Benchmarks established were:

| | | |
|---|---|---|
| Bajhang | : | 4 |
| Bajura | : | 6 |
| Syarpudaha | : | 3 |

Benchmarks in Bajhang (N, E, local elevation)

BM 1 : 3275230.048, 514319.020, 146.26

BM 2 : 3275186.959, 514382.624, 146.24

BM 3 : 3274613.890, 515102.940, 127.24

BM 4 : 3274660.150, 515139.250, 100.58

Benchmarks in Bajura (N, E, local elevation)

BM 1 : 3274888.46, 514772.10, 142.06

BM 2 : 3274792.51, 514842.54, 139.96

BM 3 : 3274697.66, 514896.88, 140.70

BM 4 : 3274619.70, 514961.35, 140.24

IP 1 : 3275059.140, 514456.836, 142.41

IP 2 : 3274937.709, 514590.237, 143.68

Benchmarks in Syarpudaha (N, E, local elevation)

BM 1 : 3172150.737, 351154.805, 932.00

BM 2 : 3172489.372, 351392.668, 1209.931

BM 3 : 3173432.396, 351801.359, 1212.781

A closed traverse survey of baseline stations and traverse points was carried out starting from accepted primary control points using TOTAL STATION. Reciprocal linear measurements and two sets of angular measurements were taken between two consecutive baseline stations/traverse points. The traverse survey provided horizontal control for surveys.

## 6-5 Topographical Survey

Topographical survey was carried out along Intake weir, Head pond, Powerhouse / Tailrace to show necessary details for design and to prepare plans. In general, the survey covered 50 m width or more. The density of survey points were at least 1 point per 2 square meters.

The topographic survey was carried out by tachometric method. It provided topographic details as well as reduced levels. It produced the data for preparing topographic map with plans, detailed spot levels, settlements with starting and end points, landslide/slope instabilities, natural stream, structures and contours of the survey area to the required scale.

Table 6-5 Topographic Survey

| S.N | Site / Details | Area as per TOR | Actual Area Surveyed | Scale |
|---|---|---|---|---|
| 1. | Bajhang | | | 1:100 |
| i. | Intake weir | 0.1 ha | 0.967 ha | |
| ii. | Head pond | 0.1 ha | 0.836 ha | |
| iii. | Power house / Tailrace | 0.2 ha | 0.593 ha | |
| 2. | Bajura | | | |
| i. | Intake weir | 0.1 ha | 0.455 ha | |
| ii. | Head pond | 0.1 ha | 0.247 ha | |
| iii. | Power house / Tailrace | 0.2 ha | 0.347 ha | |
| 3. | Syarpudaha | | | |
| i. | Intake weir | 0.5 ha | 1.276 ha | |
| ii. | Head pond | 0.1 ha | 0.294 ha | |
| iii. | Power house / Tailrace | 0.2 ha | 0.515 ha | |

## 6-6 Centerline Survey

The centerline survey consisted of fixing of IPs (Intersection Points) in the field along the headrace canal, penstock alignment, spillway and tailrace and measurement of included angles and distances to the preceding and succeeding IPs. The total quantity of centerline survey for each site is as listed below.

Table 6-6 Centerline Survey (Profile)

| S.N | Site / Details | Area as per TOR | Actual Area Surveyed | Scale |
|---|---|---|---|---|
| 1. | Bajhang | | | |
| i. | Head pond | 1,100 m | 950 | H 1:2,000, V 1:100 |
| ii. | Penstock | 120 m | 100 | |
| iii. | Spillway | 40 m | | |
| iv | Tailrace | 40 m | 50 | |
| 2. | Bajura | | | |
| i. | Head pond | 2050 m | 1813 | H 1:4,000, V 1:500 |
| ii. | Penstock | 650 m | 450 | |
| iii. | Spillway | 80 m | | |
| iv | Tailrace | 25 m | 80 | |
| 3. | Syarpudaha | | | |
| i. | Head pond | 1,400 m | 1270 | H 1:4,000, V 1:500 |
| ii. | Penstock | 550 m | 450 | |
| iii. | Spillway | 50 m | | |
| iv | Tailrace | 50 m | 80 | |

## 6-7 Cross Section Survey

Cross sections were taken at appropriate interval of 20m or less depending upon the terrain conditions. Cross section was taken with the level and covered a width of 20m or more, in general. All the features lying on the cross sections were noted. The total quantity of cross section survey for each site is as listed below.

Table 6-7 Cross Section Survey

| S.N | Site / Details | Length as per TOR | Actual length Surveyed | Scale |
|---|---|---|---|---|
| 1. | Bajhang | | | |
| i. | River | 1250 m | 880 m | 1:200 |
| ii. | Headrace | 500 m | 350 m | 1:100 |
| iii. | Penstock | 300 m | 270 m | 1:100 |
| 2. | Bajura | | | |
| i. | River | 1250 m | 500 m | 1:200 |
| ii. | Headrace | 1400 m | 560 m | 1:100 |
| iii. | Penstock | 800 m | 440 m | 1:100 |
| 3. | Syarpudaha | | | |
| i. | River | 1250 m | 750 m | 1:200 |
| ii. | Headrace | 650 m | 390 m | 1:100 |
| iii. | Penstock | 700 m | 360 m | 1:100 |

## 6-8 Mapping

The processing of field data using suitable software so as to obtain the topographic map of the terrain is known as Mapping. “Auto CAD Land Development” program was used for the purpose of mapping..

Finally, a Digital Terrain Model (DTM) was created. Hence, a topographical map of the project area is obtained. The topographic map of the required project area shall be prepared in the scale of 1:1000.

## 6-9 Photographs

The photographs at Bajhang are shown in Figure 6-2, Figure 6-3.

Intake

Survey group start to work

Bench Mark at Intake


Setting up Bench Mark

Figure 6-2 Bajhang (1)

Survey along the Canal Alignment

Survey along the Head pond

Survey along the Head pond

Survey along the Head pond

Penstock Alignment, Spillway,
Power House & Tailrace

Tailrace

Figure 6-3 Bajhang (2)

# 7. Geological Reconnaissance

Geological reconnaissance was carried out to reveal general geological conditions in the three project sites of Bajhang, Bajura and Syarpudaha. Test pits were installed to sound riverbed layer for intake foundation design. Grain size analyses were executed for permeability design of weir. This chapter shows the result of the field reconnaissance.

## 7-1 Regional Geology of Nepal Himalaya

The 800 km long Nepal Himalaya is situated in the central part of the Himalayan Arc, located between the Kumaon Himalaya in the west and the Sikkim-Bhutan Himalaya in the east. The Nepal Himalaya is divided into the Indo-Gangetic Plain, Sub-Himalaya (Siwalik Group), Lesser Himalaya, Higher Himalaya, and Tibetan-Tethys Himalaya from south to north, separated by almost east-west running regional thrust systems that pass through the entire Himalayan region. The General subdivision of the Himalaya is as follows:

**TIBETAN TETHYS**
(Fossiliferous sedimentary rocks such as Shaleandstone And Limestone)
--------------------- *South Tibetan Detachment System (STDS)* ---------------------
**HIGHER HIMALAYA**
(Kyanite- to Sillimanite-grade Gneisses)
--------------------- *Main Central Thrust (MCT)* ---------------------
**LESSER HIMALAYA**
(Meta-sedimentary rocks like Shaleandstone, Conglomerate, Slate, Phyllite, Schist, Quartzite, Limestone, Dolomite)
--------------------- *Main Boundary Thrust (MBT)* ---------------------
**SUB HIMALAYA (SIWALIK)**
(Conglomerates, Sandstones and Mudstones)
--------------------- *Main Frontal Thrust (MFT)* ---------------------
**INDO-GANGETIC PLAIN (TERAI)**
(Fluvial deposits)

### (a) Indo-Gangetic Plain or Terai Plain

The Indo-Gangetic Plain or Terai forms the southernmost tectonic unit of the Nepal Himalaya, having elevation from 100 to 200 m from mean sea level and covering alluvial deposits of Pleistocene to recent in age. The average thickness of the deposits is about 1,500 m.

### (b) Sub-Himalaya (Siwalik Group)

The Siwalik Group is delimited by the Main Boundary Thrust (MBT) to the north and the Main Frontal Thrust (MFT) to the south, and lying between the Lesser Himalaya and Indo-Gangetic Plain. About 6,000 m thick Neogene molasses type sediments were accumulated into the foreland basin during middle Miocene to lower Pleistocene in age. The sediment comprises mudstone, sandstone and conglomerate.

(c) Lesser Himalaya

The Lesser Himalaya lies between the Siwalik Group to the south and the Higher Himalaya to the north. Both the southern and the northern limits of the Lesser Himalaya is represented by the thrust fault; the Main Boundary Thrust (MBT) and the Main Central Thrust (MCT), to the south and north, respectively. It is represented by thick piles of the sedimentary rocks and low-grade metamorphic rocks, ranging from the Pre-Cambrian to Tertiary in age. Total thickness of the Lesser Himalayan rocks are exposed more than 14 km. Nappe, Klippe and Schuppen like tectonic structures have made the Lesser Himalayan geology complex.

(d) Higher Himalaya

The Higher Himalaya is occupied by the high mountains, and lies between the Lesser Himalaya to south and the Tibetan-Tethys Himalaya to the north, which is separated by the Main Central Thrust (MCT) in the south and north by the South Tibetan Detachment System (STDS). The Higher Himalaya is comprised of high-grade metamorphic rocks of schist with granite bodies, pelitic gneisses and migmatites, and attains 6 to 12 km in thickness.

(e) Tibetan-Tethys Himalaya

The Tibetan-Tethys Himalaya is distributed in the northern part of the territory. The northern border of the Tethys Himalaya is represented by a fault called as the South Tibetan Detachment System (STDS). About 10 km thick shallow marine sedimentary rocks were deposited from Cambrian to Cretaceous in age.

Geologically, all the three projects lie on the lesser Himalaya consisting of low grade metamorphic rock. The location of projects is shown in Figure 7-1.

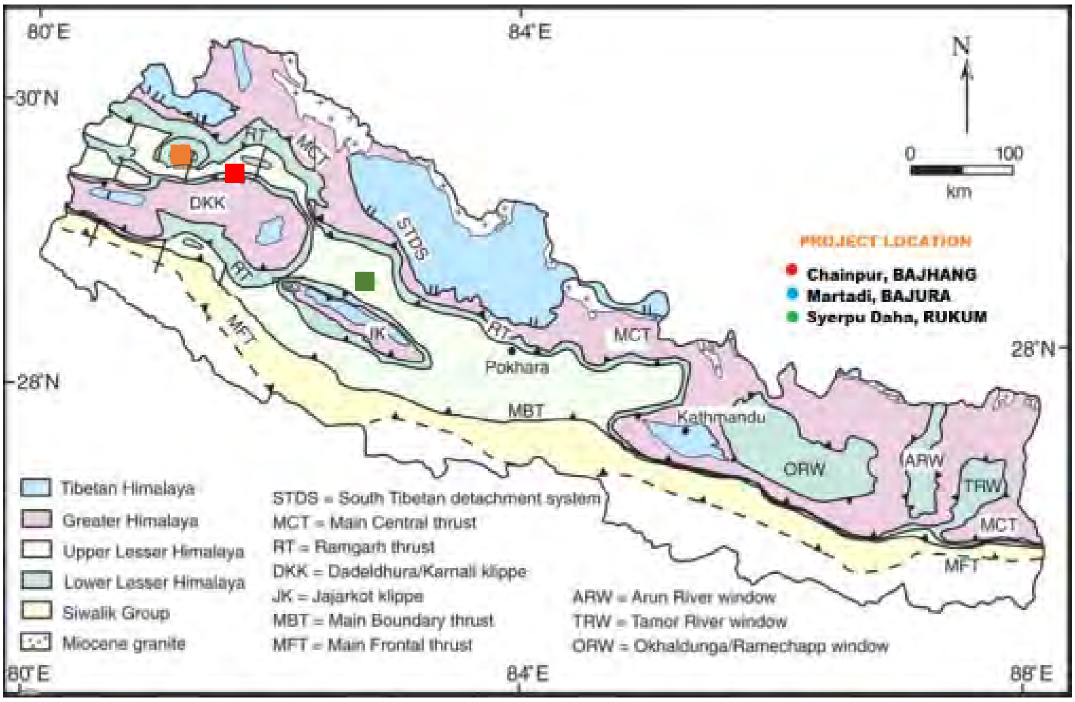



Figure 7-1 Geological Map of Nepal Himalaya

## 7-2 Bajhang,Chainpur

### (1) Project Description

The project area composes of headworks, currently washed away by flood, about 950m long canal alignment and powerhouse along with transmission line. All the project components are built on the right bank of the Jeuli Gad. The entire project location lies within Dogadi village. The main objective of the project is to supply electricity to Chainpur, district headquarter of Bajhang. The project location is presented in following Figure 7-2.

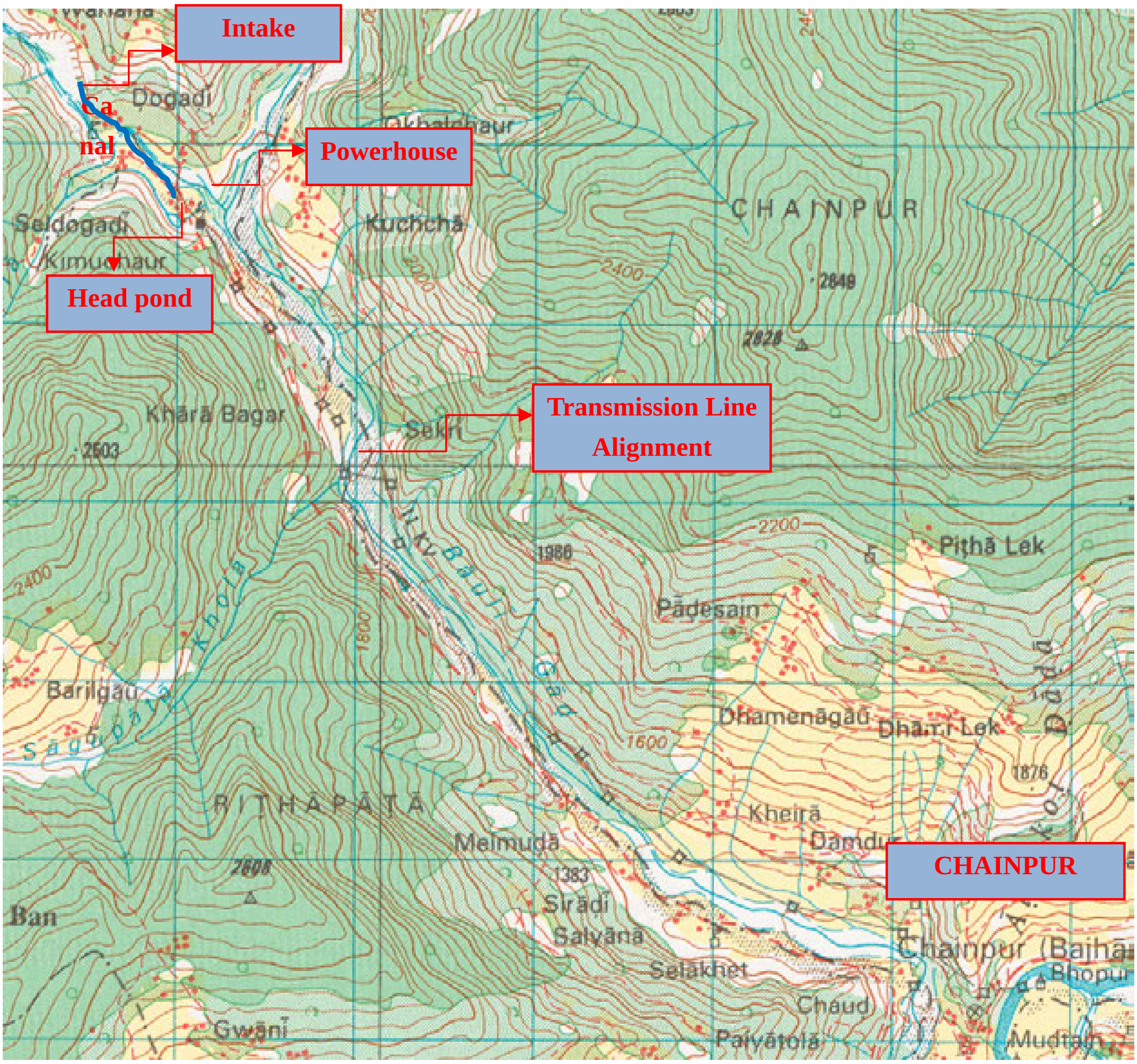



Figure 7-2 Project Location

## (2) Geology of the Project Area

Geologically, the project area lies on the far-western Nepal lesser Himalaya. The geological map near the project area is shown on Figure 7-4. The rocks near the project area can be grouped under following formations.

(a) **Kusma Formation (Ks)**: White to grey fine to medium grained, massive at places ripple marked quartzite intercalated with green chioritic phyllite.

(b) **Ulleri Formation (Ul)**: Augen gneisses and feldspathic schist

(c) **Lakharpata Formation (Lk)**: Fine grained, grey limestone and dolomitic limestone with thin intercalations of black to grey shale. White dolomitic limestone purple and green shale at the top. Algal structures and stromatolites are observed.

(d) **Galyang Formation (Gl)**: Dark grey slates finely intercalated with grey calcareous slates and sandstones giving brown yellow and grey laminations oblique joint planes on weathering. Frequently dark grey to bluish grey fine grained limestone and dolomitic limestone of various sizes within the slate

(e) **Baitadi Carbonates (Ba)**: Grey siliceous dolomite

(f) **Suntar Formation (Sn)**: Fine to medium grained, greenish grey sandstone and purple shale with intercalations of green splintery shale

(g) **Ranimata Formation (Rm)**: Grey, greenish grey, gritty chioritic phyllie and phyllitic quartzite metasandstone and conglomerate beds with white massive quartzite in the upper and lower parts. Basic intrusions are frequent.

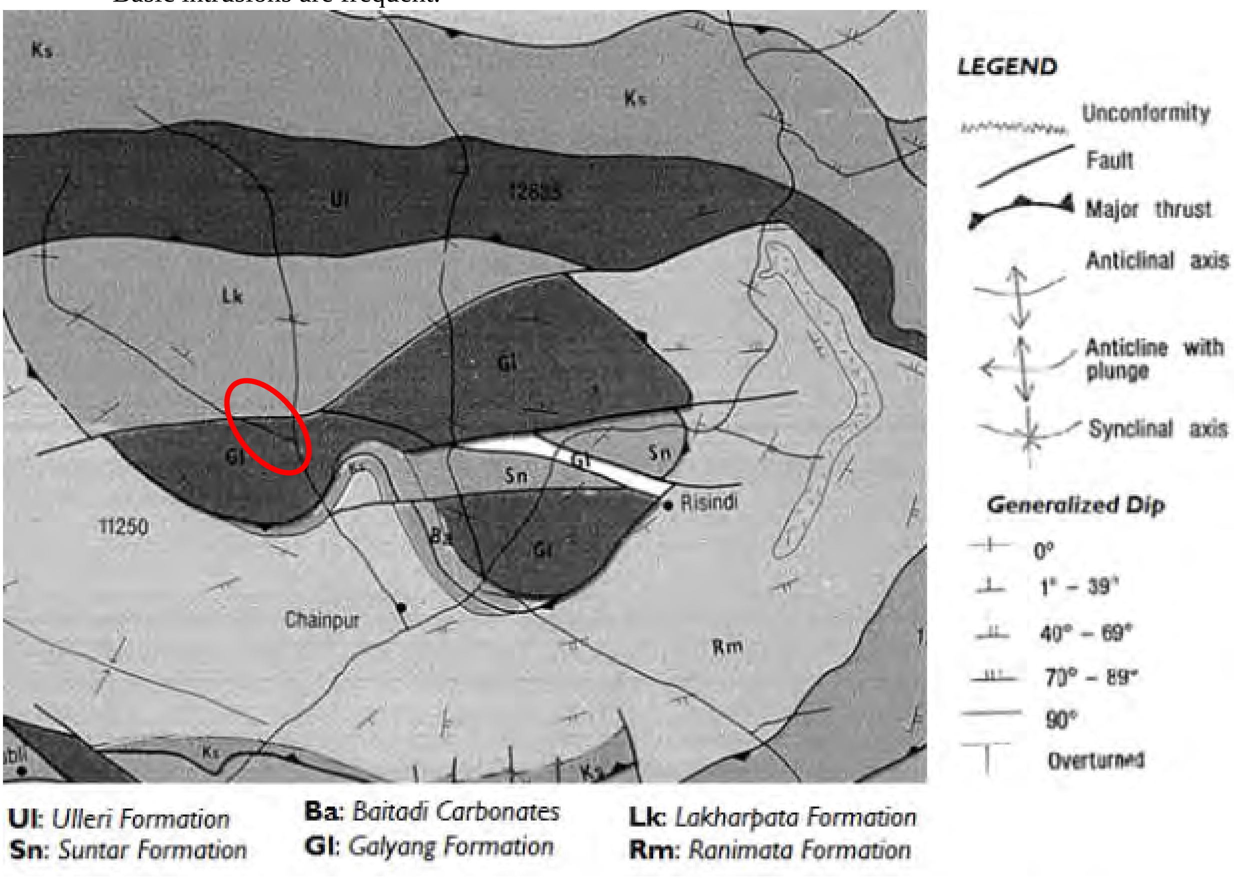



Figure 7-3 Geological Map of Chainpur Area

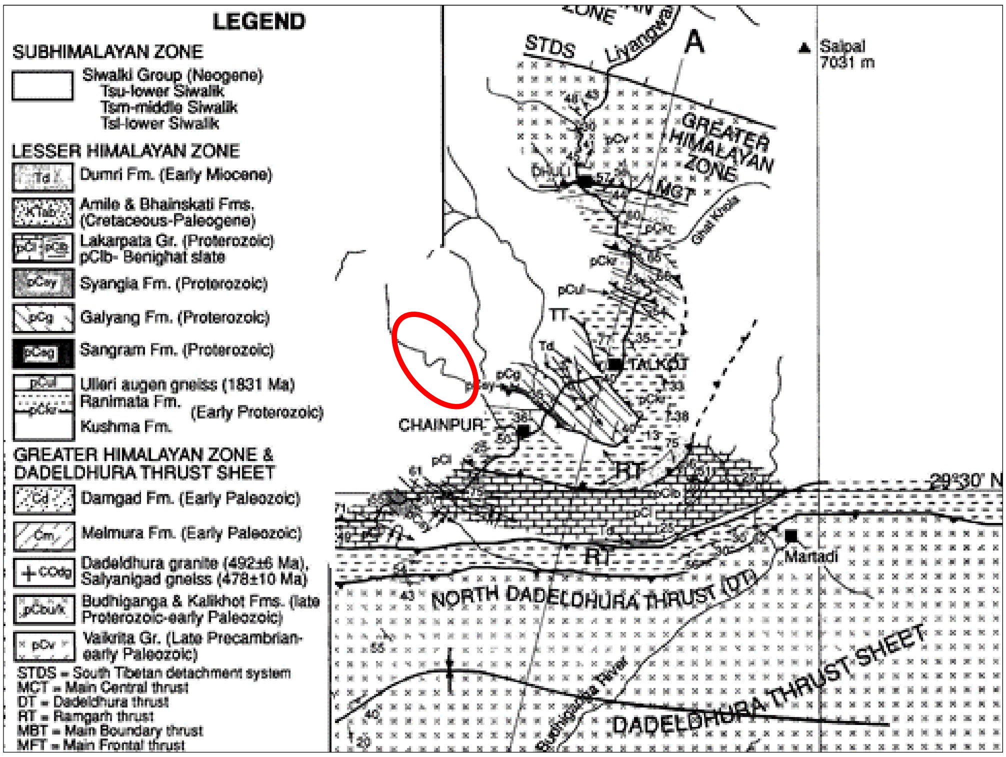



Figure 7-4 Geological Map near the Project Area (Shrestha et al, 1987; Fuchs, 1977)

1) **Bed Rocks**

Main rock type within the project area is composed of limestone, dolomitic limestone, slate and quartzite. The limestone is fine grained, grey in color, thinly to thickly foliated, slightly to moderately weathered. Slates are dark grey in color, thinly foliated, intercalated quartzite and sandstones.

2) **Sacrificial Deposits**

The main surface deposits within the project area are alluvial soil, colluvium soil and residual soil. Residual soil is the main soil type in the project area. Majority of the canal alignment passes within the residual soil. Within the project area, alluvial soil is confined near the river banks and in river terrace deposits. Alluvial Deposits are seen in the low lands of the project area and mainly seen in Power House area and extensively along the Bauli Gad. Residual Soil are present in the canal alignment and penstock alignment.

The alluvial terrace in the powerhouse area is made up of thick gravel deposit. Residual soil is found in the later part of the canal alignment and in the head pond area. These residual soils are frequently used for settlement and agriculture fertile land. A huge landslide is present from Chainage 0+185 to 0+420. Colluvium deposits are found on the left bank of the river in the headworks area as well.

## (3) Engineering Geology

### 1) **Headworks and Intake Area**

The channel width at the headworks area is about 25 m. Although the gradient of the river is mild at the headworks, the gradient of river is high in the near vicinity of headworks area. Large boulders are accumulated in the river channel. Bed rock is present in the right bank of the river. The bedrock is composed of smoky grey to dirty white, fine grained, hard, slightly weathered massively foliated quartzite. Intake is also built in the right bank of river.

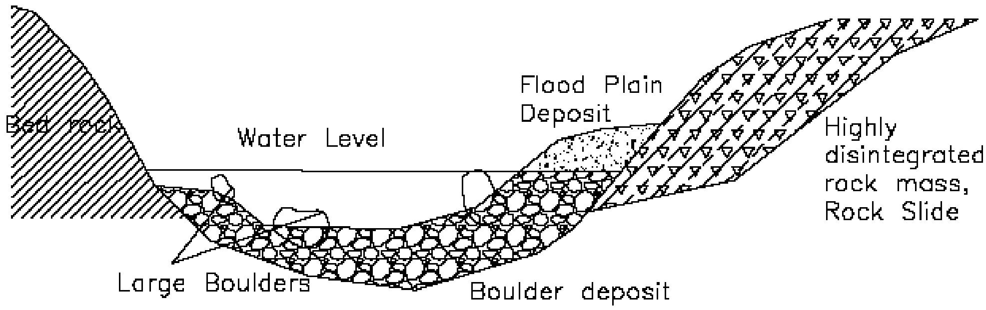



Figure 7-5 Generalized Cross Section near Weir Area (not to scale)

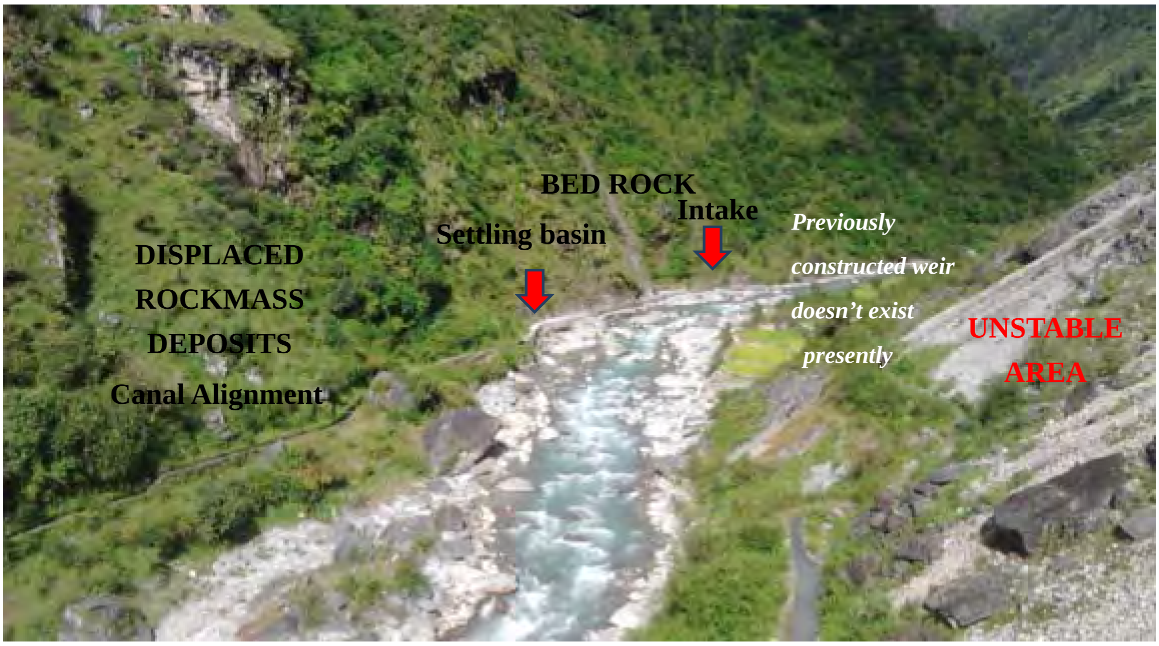



Figure 7-6 General Arrangement in Headworks Area

The left bank slope is composed of unstable area. Large rocks slides were observed in the left bank of the river and colluvial deposit is the major constituent of the left bank. Few larger diameter boulders (Ø>5m) are also seen near the intake area. Flat river terrace deposit is also present in the left bank. Geologically, the right bank slope is stable and the left bank area is unstable.

Due to the higher gradient of river in the previous weir area and somewhat mild gradient upstream, if the new weir is to be constructed, it is recommended to construct the weir at some distance upstream of the previously constructed weir area.

(a) Test Pit Analysis at the Headworks Site

Three test pits were dug at and near weir area. The test pits logs are presented on Figure 7-8. Sediment log deposit shows that the soil is dominated by coarse grained soil. Clayey soil is only found in the flood plain. Cobble and boulders are found after 0.5 meters depth.

| Test pit | Latitude, Longitude | Ground Elevation | Remarks |
|---|---|---|---|
| 1 | 0514357, 3275256 | 1628 m | Left bank of the weir area |
| 2 | 0514313, 3275367 | 1630 m | Right bank of the weir area |
| 3 | 0514309, 3275305 | 1639 m | Flood plain are, left bank 71m u/s of Intake |

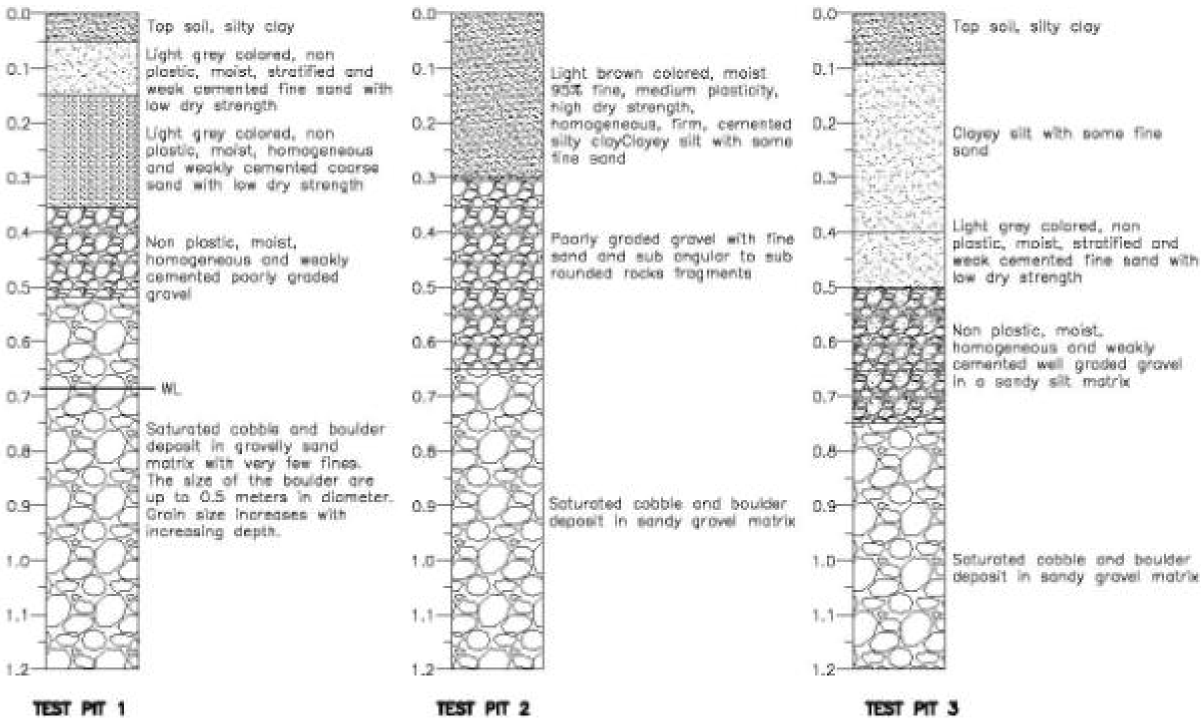



Figure 7-7 Test Pit Log near Weir Area


Figure 7-8 Bed Rock Exposed Near the Intake Area

2) **Canal Alignment**

The first half portion of the canal alignment almost passes parallel to the river whereas the later half passes through the residual soil, presently used for settlement and cultivation. Bed rocks are observed in the right bank slope. The whole canal alignment can be divided into three parts viz. bed rock, landslide deposit and residual soil.

Chainage 0+000 to 0+150: In this section canal alignment passes through the rock deposit. The bedrock is composed of smoky grey to dirty white, fine grained, hard, slightly weathered massively foliated limestone. The section 0+015 to 0+150 m is composed of displaced rock material. Small streams are also present in the area. These deposits are not expected to pose serious problem, some stabilization methods can be applied.

Chainage 0+185 to 0+420: Geologically, Canal alignment between Chainage 0+185 to 0+315 lies on the unstable region. A slide of dimension about 100m height by 250m length is present in the area. The slide material is composed of black colored crushed slate deposit. Hill slope of the area ranges between 25 to 30 degrees (Figure 7-10). Canal alignment between Chainage 0+315 to 0+390 is composed of stable rock mass with crushed slate in between. After Chainage 0+390 to 0+420 is also composed of black colored crushed slate deposit.

Geologically, this portion of the canal alignment is the most critical part of the project. Although majority of the canal in this section is covered, some portion was still found uncovered. Covering of canal is strongly recommended in the area. Also, detailed engineering geological/ geotechnical investigation of the landslide is also recommended. Since, there is no alternative route to divert the canal, stabilization of the slope is the major concern for the project area.

Chainage 0+420 to 0+460: This section is composed of off-white colored, coarse grained, medium strong, moderately weathered bedrock of meta-sandstone. The slope is stable.


Figure 7-9 Highly Disintegrated Rock between Chainage 0+185 and 0+420

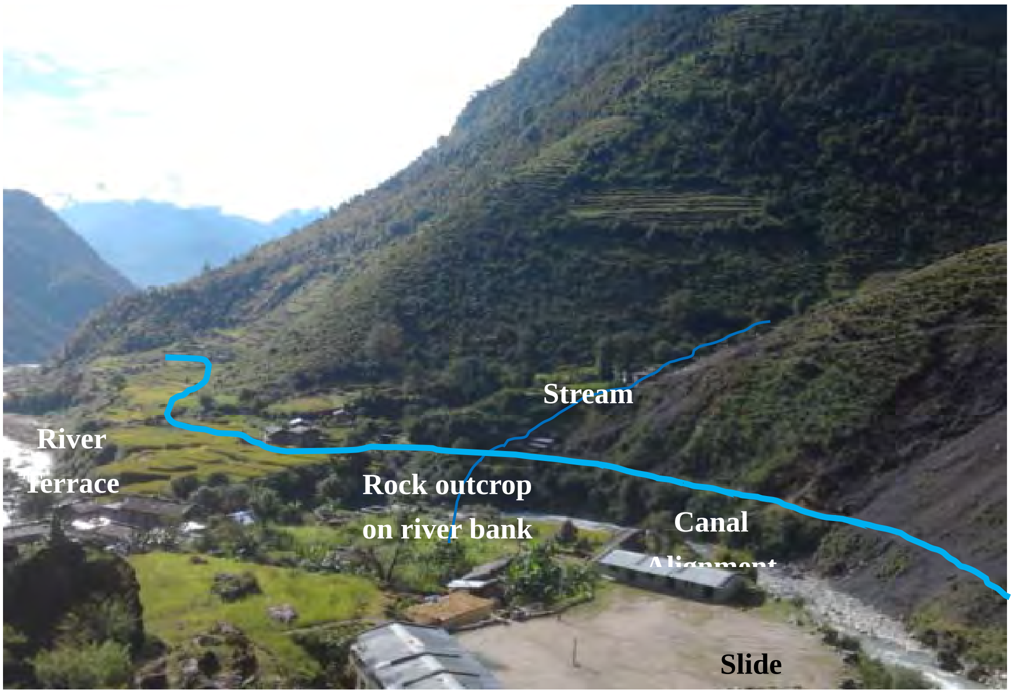



Figure 7-10 Middle Part of the Canal Alignment
(Photograph taken from the Opposite Bank)

Chainage 0+460 to 0+490: Canal at this section crosses a high gradient stream. Bed rocks along colluvium deposit is the major constituent of the section. No instability problem is expected.

Chainage 0+490 to 0+940: On this stretch, the canal passes through a gently sloped river terrace deposit currently used for cultivation purpose. The soil depth in the region is greater than 20 m. The soil is composed of brownish grey to dark grey soil with low plasticity, low to medium dry strength, moist, homogeneous, firm and gritty clayey silt with few angular rock fragments. Up to Chainage 0+650, the canal passes through the middle on the flat alluvial terrace. However on the later portion, from Chainage 0+ 650, the canal fallows the base of the hill. Hill slope in the area is about 30 to 35 degree. The slope is composed of colluvial deposit consisting of boulder sized angular fragments of rocks in a sandy silt matrix.

Figure 7-11 Latter part of the Canal alignment

### 3) Head pond

The head pond area is composed of slightly sloping landmass consisting of residual soil. The soil is composed of dark grey colored soil with low plasticity, low to medium dry strength, moist, firm silty clay with few angular rock fragments of slate.

The uphill slope of the head pond is currently used for cultivation for a terrace. These terrace forms a natural benching for slope instability. Also, the general hill slope is about 25 degree. So, the possibility of landslide is minimal.

Figure 7-12 Head pond Area

#### 4) Penstock Alignment and Spill Way Alignment

The penstock and spillway alignment almost runs parallel to each other. Entire penstock alignment as well as spillway alignment lies within residual soil deposit and river terrace. A trench was excavated in the upper part for the penstock pipe which is still left with pipe uncovered. It is recommended to cover the penstock pipe. Parallel aligned spillway canal is built above the similar deposit, however the spillway is steeper than the penstock pipe. The degradation of walls and steps makes seepage in the alignment.

#### 5) Powerhouse and Tailrace

Powerhouse is located on a relatively flat alluvial terrace deposit formed by Bauli Gad. These deposits are comprises of sub-rounded to well-rounded boulders (<1 m dia.), cobbles, pebbles and gravels in sandy clayey silt matrix. The deposit contains 30-40% fine materials and 60-70% coarse materials. Permeability of such soil is expected to be high. The thickness of this deposit is greater than 5 meters. No rock outcrops are observed in the powerhouse area.


Figure 7-13 Powerhouse and Spillway Alignment

### (4) Instability in the Project Area

Geological map of the area shows a fold and two thrusts i.e. Ramgarh thrust and Telkot Thrust passing within the project area. Lesser Himalayan rocks in western Nepal consist of steeply southward asymmetric to overturned folds and imbricate panels of lower and upper Nawakot units overlain by Gondwanan and Tertiary units. These imbricate thrust sheets generally dip 400-55 degrees NNE. Between the villages of Talkot and Chainpur a complex, southeast plunging antiform is cored by Lakarpata Group, Amile Formation, and Dumri Formation. The Dumri is overlain by an enveloping, antiformal thrust sheet of the Galyang and Syangia Formations. This sheet is in turn overlain structurally on both sides of the antiform by the Kushma-Ranimata succession. The southern belt of Kushma- Ranimata (which surrounds Chainpur) is folded into a broad east-west trending syncline.

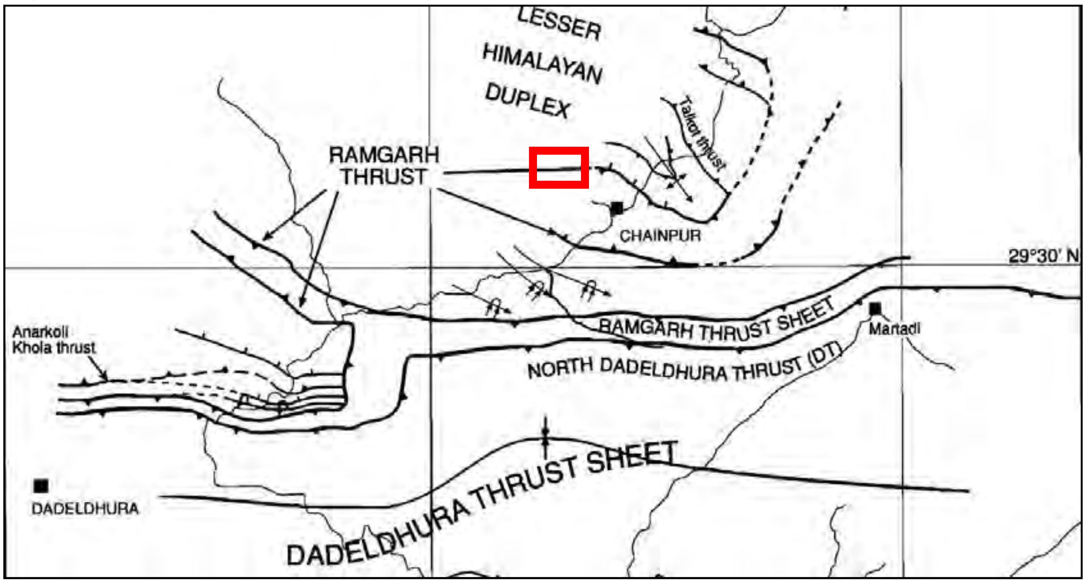



Figure 7-14 Regional Structural Map near the Project area

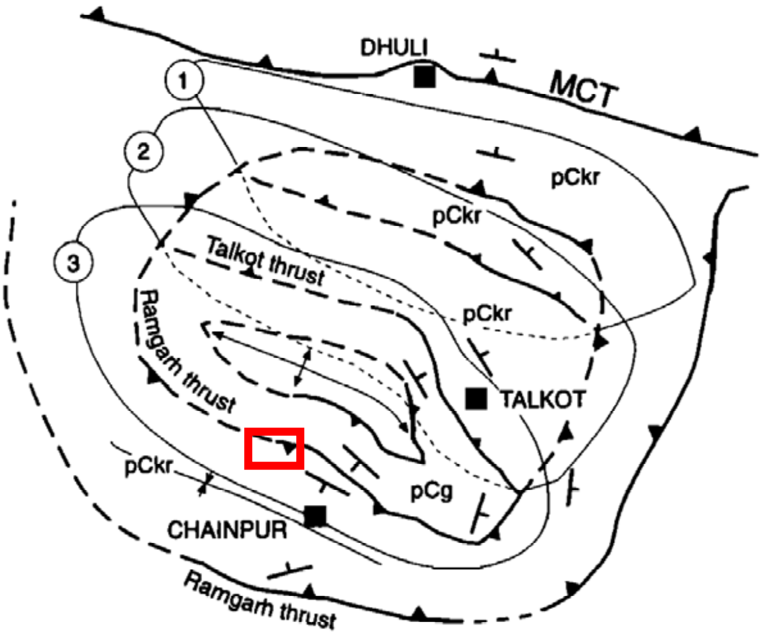



Figure 7-15 Simplified branch line map of the Lesser Himalayan duplex in the Talkot and Chainpur areas showing buried branch lines (solid lines) and eroded branch lines (dashed lines)[12].

/[12] DeCelles P. G. at al, 2001, Stratigraphy, structure, and tectonic evolution of the Himalayan fold-thrust belt in western Nepal, TECTONICS, VOL. 20, NO. 4PAGES 487-509

### (5) Recommendation and Conclusion

- Sediment log analysis suggests that the soil near the headworks area is composed of very coarse grained soil, predominantly of cobbles and boulders on sandy gravel matrix. Also, permeability between these deposits will be a major concern during the construction of weir. As the gradient of river in the previous weir area is higher than that in the upstream area, it is recommended to construct the weir at some distance upstream of the previously constructed weir area.
- Although the instability of the area is structurally controlled, action for stabilization of the slope is recommended in the landslide area (Chainage 0+185 to 0+420). A few parts of the canal in the area is uncovered and covering of canal in the slide slope is recommended.
- Timely removal of soil deposited on the canal and the head pond is also recommended.
- The trench dug during the placement of penstock pipe is still left uncovered. Also, Spillway canal is steep and was found to be degraded, and the problem of seepage was found at places.

## 7-3 Bajura, Martadi

### (1) Project Description

The project area comprises of headworks, currently washed away by flood, about 1800m long canal alignment and powerhouse along with transmission line. All the project components are built on the left bank of the Bauli Gad. The entire project location lies within Gadkhet and Martadi area. The main objective of the project is to supply electricity to Martadi, district headquarter of Bajura. The project location is presented in Figure 7-16.


Figure 7-16 Project Location

### (2) Geology of the Project Area

The main rock types present within the project area is composed of chioritic phyllite and quartzite. Geologically, the bedrock near the project area falls under following rock formation (Figure 7-18).

(a) Ranimata Formation: Grey, greenish grey, gritty chioritic phyllie and phyllitic quartzite metasandstone and conglomerate beds with white massive quartzite in the upper and lower parts. Basic intrusions are frequent

(b) Kalikot formation: Garnetiferous biotite schist and micaceous quartzite with gneisses

(c) Ghatte Gad Carbonates: Bluish Crystalline Limestone calcareous schist and quartz biotite schist

(d) Budhi Ganga Gneiss: Augen Gneisses granitic gneiss and feldspathic schist

1) Bed Rocks

Bed rocks are present on the both banks of the headworks area. The rocks present at the headworks area is composed of dark green colored, slightly weathered, massively foliated, strong, gritty chioritic phyllite with quartz veins. Intercalation of bluish grey colored quartzite with gneiss beds are also exposed on the canal alignment as well.

2) Surface Deposits

The main surface deposits within the project area are alluvial soil, colluvial soil and residual soil. Colluvial deposit and residual soil are the main soil types in the project area. Majority of the canal alignment passes along the colluvium deposit and residual soil. In the project area, alluvial soil are confined near the river banks and in river terrace deposits. Alluvial deposits are seen in the low lands of the project area and mainly seen at headworks and powerhouse area and extensively along the Bauli Gad. The alluvial terrace in the powerhouse area is made up of thick gravel deposit. Residual Soil are present in the latter half of the canal alignment and penstock alignment. These residual soils are frequently used for settlement and agriculture fertile land. The colluvial deposits are found on first half of the canal alignment.

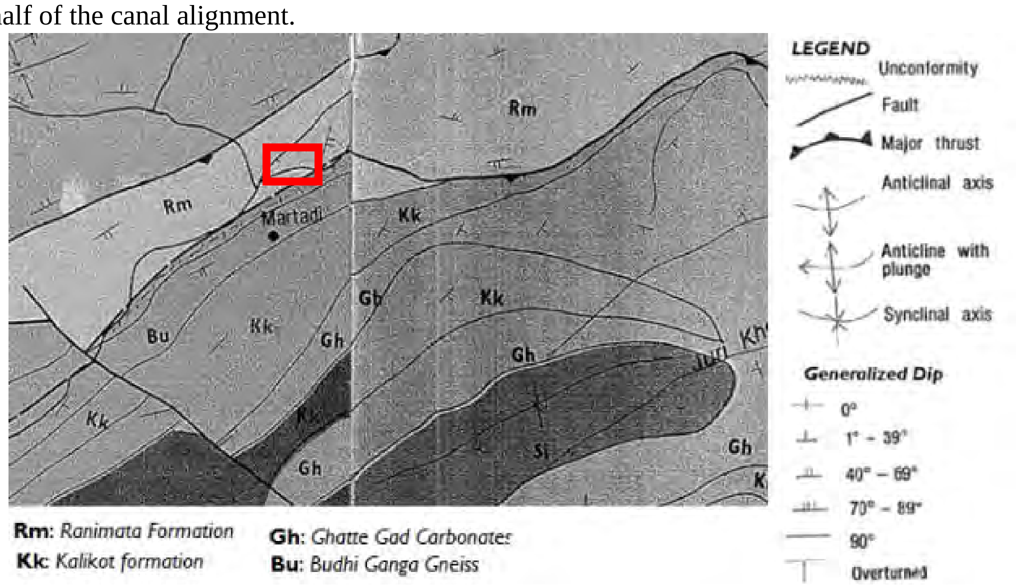



Figure 7-17 Geological Map of Martadi Area

## (3) Engineering Geology of the Project Area

### 1) Headworks Area

The headworks area is located about 5 m upstream of the suspension bridge crossing Bauli Gad. Both banks of the intake area are composed of steep cliff. Width of the river at headworks area is about 25 m. The intake is located on the left bank of the river, just below the suspension bridge. In the near vicinity of the intake, river gradient is moderate. Large boulders are present in the right bank of the river forming point bar and hence majority of the flow is accumulated towards the left bank of the river. These boulders are semi-rounded to rounded and are made of phyllite, schist and quartzite. Due to the gradient of river, fines are washed away from the channel and are found on the point bar and flood plains area only. Due to the presence of stiff cliffs on the both banks of river, problem of slope failure is not expected in the area. The bed rocks is composed of dark green colored, slightly weathered, massively foliated, strong, gritty chioritic phyllite with quartz veins. The weir is recommended to be built few meters upstream of the suspension bridge. The attitude of foliation ranges between S30 to 35°/E20 to 25°.

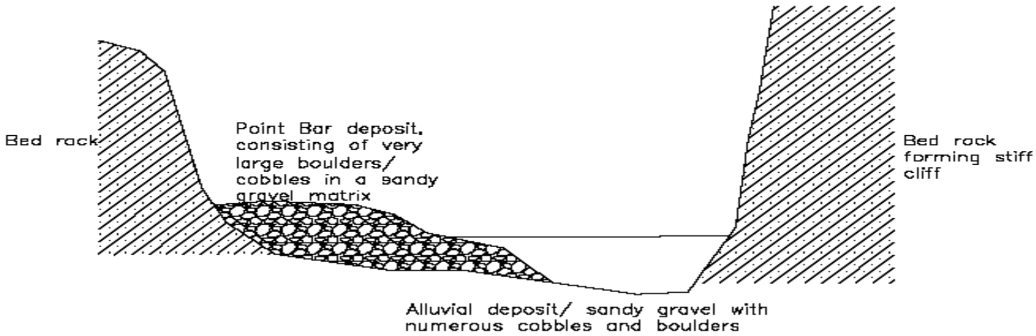



Figure 7-18 Generalized Cross Section near Weir Area (not to scale)


Figure 7-19 Intake photo (View from bridge)

(a) Test Pit Analysis at the Headworks Site

Three test pits were dug at and near weir area. Due to the presence of very large boulders, the first test pit was stopped at depth of 30 cm. Sediment log deposit shows that the soil are dominated by coarse grained soil. Clayey soils are only found in the flood plain. Cobble and boulders are found after 0.2 to 0.4 meters depth. The sediment log is also clearly visible on the banks of the river.

| Test pit | Latitude, Longitude | Ground Elevation | Remarks |
|---|---|---|---|
| 1 | | | Right bank of the weir area, 50 m d/s of weir |
| 2 | 29°27.177’,<br>81°29.306’ | 1628 | Flood plain area, 50m d/s of weir area |
| 3 | 0547549, 3258975 | 1635 | Left bank of the weir area |

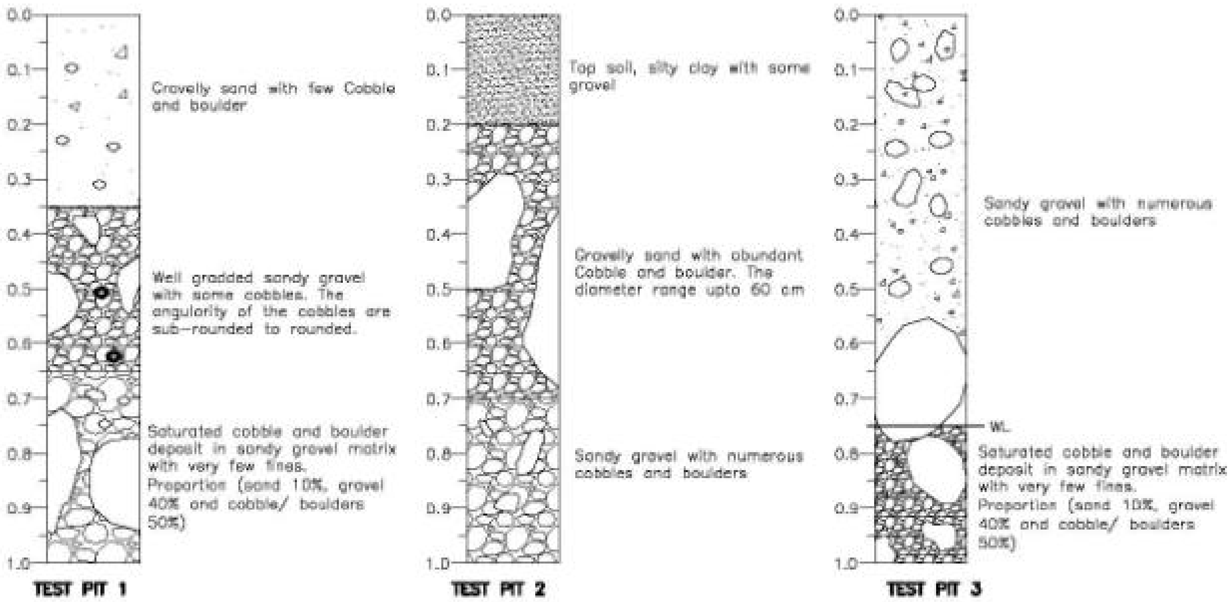



Figure 7-20 Test pit Log

2) Canal Alignment

The canal alignment passes through the bedrock, side area and the residual soil and residential area.

The canal starts with the stable bed rock deposit for the 10 meters. After that, rocks are numerously jointed and there is a change of topple failure and wedge failure. The foundation of the slab is on the alluvial deposit. Seepage from the canal was observed. A kholsa is flowing between Chainage 0+040 and 0+060. Slide materials are found scattered in the alignment. Block falls from the uphill slope were observed up to 0+180. Gabion wall was observed for the stabilization of the slope. Hill slope of the area is about 35 to 40 degrees in the area. The slope downstream of the canal is gently sloped alluvial deposit and is stable. Since the rock blocks are interlocked within sand-silt matrix, the slope can be stabilized by up-grading/ constructing the gabion wall present. The slope between Chainage 0+180 to 0+260 is composed of a talus deposit. The slope is stable if the observed seepage is controlled.

Between Chainage 0+260 and Chainage 0+270, the formation consists of intercalation of bluish grey colored quartzite with gneiss beds. Between Chainage 0+270 and Chainage 0+300, a Khosli flows where big boulders are observed falling downstream. Few check dams can be constructed to trap the sediment and the boulders falling downstream.

Rocks are exposed on the uphill part between Chainage 0+300 and 0+410. The steep slope downstream of the canal is composed of talus, residual soil and is stabilized by deep rooted grass. However, a slide and slide scars is present in the downhill slope between Chainage 0+410 and 0+470. Seepage from the canal was also observed. So, the area should be stabilized. Then, the canal for the 270 meter passes across flat residual soil deposit with some highly weathered soils in between, currently used for cultivation.

The most critical portion of the canal alignment lies between Chainage 0+740 and 0+755, where a high gradient river crosses the canal and there is the possibility of carrying of large boulders downstream. Lateral falling of the banks of the stream was also observed. It is highly recommended to provide easy and clear passage for the water and the sediments carried downstream. Stabilization works are also required up to Chainage 0+800.

Afterward, till Chainage 1+260, the canal passes through talus deposit turned residual soil and highly weathered silvery colored schist bed rock. A slide of 15m width lies between Chainage 1+080 and 1+095. The stone masonry wall at the end of the stretch is falling and its maintenance is recommended.

From Chainage 1+260, the canal passes between the residential areas. The area is composed of residual soil. The gradient of hill slope is gentle (about 10 to 20 degrees) and hence is stable. Seepage is the main concern in the stretch.

Figure 7-21 Headrace Channel slope

3) Head pond Area

The head pond area is located on gently sloping residual soil deposit. The uphill slope of the area is about 30 degrees whereas the downhill slope is about 25 degrees. The soil depth in the region is greater than 20 m. The soil is composed of brownish grey to dark grey soil with low plasticity, low to medium dry strength, moist, homogeneous, firm and gritty clayey silt with few angular rock fragments. No rock exposure were observed in the near vicinity. All the slopes surrounding the head ponds are cultivated. No problem of instability is observed in the area.

Figure 7-22 Head pond slope

4) Penstock Alignment

The first 240 m of the penstock alignment follows gradient of the hill slope. The slope is presently cultivated. Geologically, slope is composed of residual soil. The soil depth is greater than 10 meters. The soil is composed of brownish grey to dark grey soil with low plasticity, low to medium dry strength, moist, homogeneous, firm and gritty clayey silt with few angular rock fragments. No rock exposure were observed in the stretch. No slope instability problem is expected in the area.

The penstock pipe is observed at the road, which crossed the penstock pipe at Chainage 0+250. It is strongly recommended to bury the pipe so that the impact of the vehicle transport to the pipe be nullified. After Chainage 0+250 up to 0+360, the slope is composed of boulder mixed soil. Afterwards, the pipe follows left bank of a stream. Lateral failing of the stream banks were also observed. As the spilled water from the headpond is channelized, the stream banks should be stabilized.

After Chainage 0+410 to Chainage 0+510, the pipe follows the steep slope composing of sub angular to rounded blocks in a sandy silt matrix. The proportion of fines are higher, but the rock fragments are abundant. In this stretch, the penstock passes along the ridge between two slopes. 15 to 20 meters apart, small streams are found on the both sides of the pipe. Rock outcrop was observed along those streams, suggesting the rock between these stretches at shallow depth. Slight dislodgement and cracks at support piers were also observed. Jointed rock mass were observed between Chainage 0+515 and 0+530.

The penstock pipe after Chainage 0+545 rests over angular boulder deposits. The amount of angular blocks increases as we descend towards the Powerhouse.

5) Powerhouse and Tailrace

The powerhouse is located on relatively flat flood plain deposit formed by the Bauli Gad. The depth of the terrace above the river is about 5-7m. The alluvial terrace deposit comprises of sub-rounded to well-rounded boulders (<1 m dia.), cobbles, pebbles and gravels in sandy clayey silt matrix. The deposit contains 25-35% fine materials and 65-75% coarse materials.

Permeability of such soil is expected to be high. The thickness of this deposit is several meters. No rock outcrops were observed in the direct vicinity.

Lateral falling of the left bank of the river just upstream of the powerhouse was observed. This may affect the stability of the powerhouse. Although gabion wall is present at the powerhouse area, the support is not sufficient and it is recommended to protect the river bank further upstream near the powerhouse area.

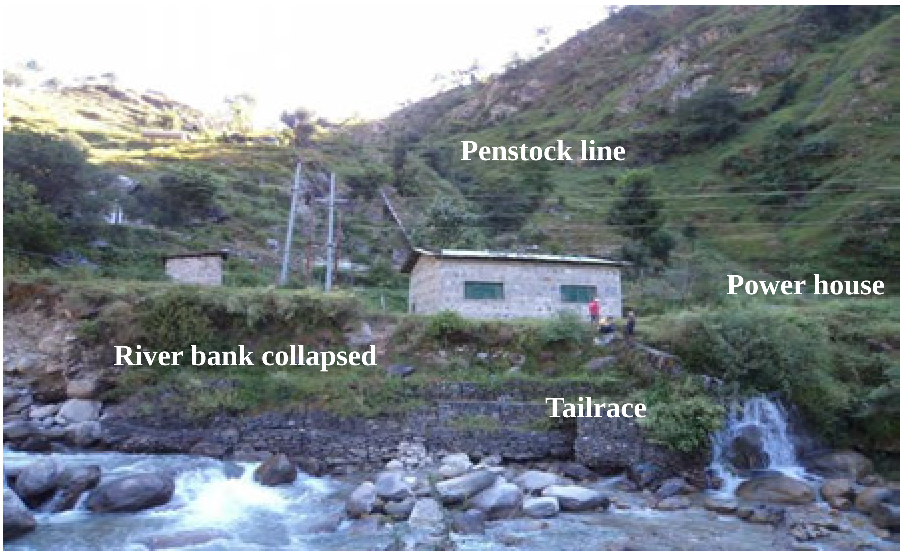



Figure 7-23 Penstock line, Power house, and tailrace

## (4) Recommendation and Conclusion

- Although few minor instability problems were observed within the project area, there is no major instability problem.
- Majority of the downhill slope for the first half of the canal alignment is steep and the deep rooted grass acts as a stabilization agent. However, seepage from almost of the entire canal was observed. Continuous seepage may increase the pore pressure down the slope and instability of the slope may occur. Control of seepage is required.
- Clearing of the passage for the high gradient stream between Chainage 0+740 to Chainage 0+755 is recommended. Furthermore, stabilization of the upstream slope is also required.
- Just above the road, the support piers were found to be degraded, it is recommended to upgrade the support piers. At a few places, the lateral fallings of the banks of the spill way canal was observed, it is also recommended to protect the banks at such places.

- It is recommended to cover the penstock pipe exposed on the road to reduce the impact of transportation over it.
- Further river training works are recommended near the powerhouse area as well.

## 7-4 Syarpudaha, Rukum

### (1) Project Description

The headworks of the project area lies on the Sanidaha area whereas the powerhouse is located at Bhagle area. All the project components are present on the Left bank of the Darne Khola. Syarpudaha (Syarpu Lake) is the major source of water for the project.

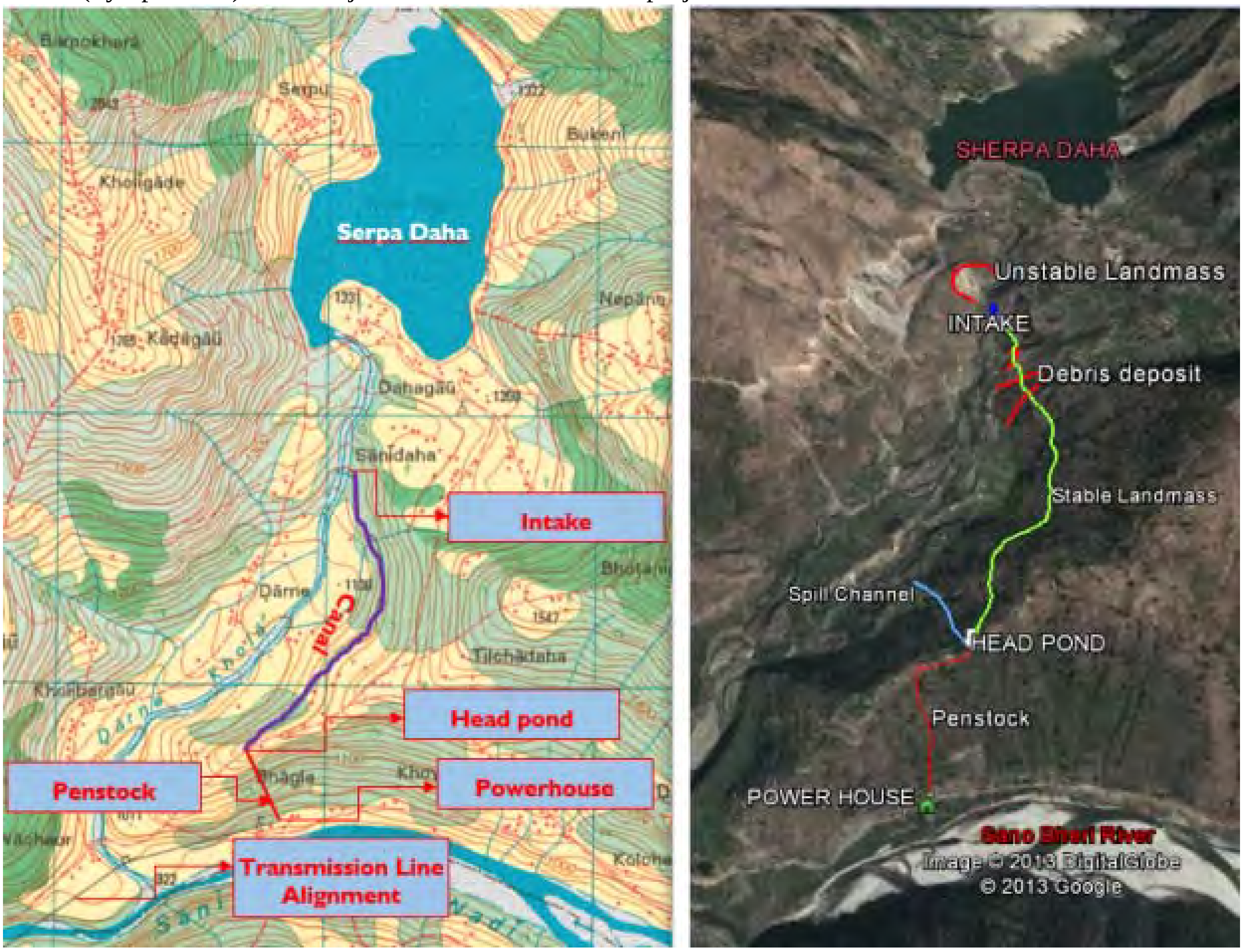



Figure 7-24 Project Location

### (2) Geology of the Project Area

Geologically, the project area belongs to the Midland Group of Lesser Himalaya of the Mid-Western Nepal and consists of sedimentary to low-grade metamorphic rocks. The main rock type in the project area is Limestone, dolomitic limestone and phyllie and phyllitic quartzite metasandstones and conglomerate beds. The limestone is fine grained, grey limestones and dolomitic limestones with thin intercalations of black to grey shale. The rock sequences near the project area can be divided into four lithological units.

(a)Ranimata Formation (Rm): Grey, greenish grey, gritty chioritic phyllie and phyllitic quartzite met sandstone and conglomerate beds with white massive quartzite in the upper and lower parts. Basic intrusions are frequent.

(b)Lakharpata Formation (Lk): Fine grained, grey limestone and dolomitic limestone with thin intercalations of black to grey shale. White dolomitic limestone purple and green shale at the top. Algal structures and stromatolites are present.

(c)Galyang Formation (Gl): Dark grey slates finely intercalated with grey calcareous slates and sandstones giving brown yellow and grey laminations oblique joint planes on weathering. Frequently dark grey to bluish grey fine grained limestone and dolomitic limestone of various sizes within the slates are found.

(d)Swat Formation (Saw): Grey to dark grey, carbonaceous crumpled shale with bands and lenses of fine grained fossiliferous limestone and ferruginous quartzite of the base.

1) Bed Rocks

LIMESTONE:

Limestone is found at the headworks area of the project. The limestone beds are moderately to highly weathered, bluish grey colored, fine grained, thinly foliated, closely jointed.

QUARTZITE:

A few quartzite outcrops are observed along the canal alignment. The quartzite beds are brown colored, medium grained, medium strong to strong, moderately weathered, thickly foliated, moderately spaced joints. Rock Quality Designation (RQD) of the rock mass is about 50%

SLATE:

Slate is found along the penstock alignment, just above the powerhouse. The bedrock is moderately to highly weathered, dark grey colored, fine grained, thinly foliated, closely jointed slate with small proportion of Quartzite. The rock breaks with the single blow of the geological hammer and Rock Quality Designation (RQD) is less than 25%. Attitude of bedrock (dip direction/dip angle): S55$^{o}$W/40$^{o}$.

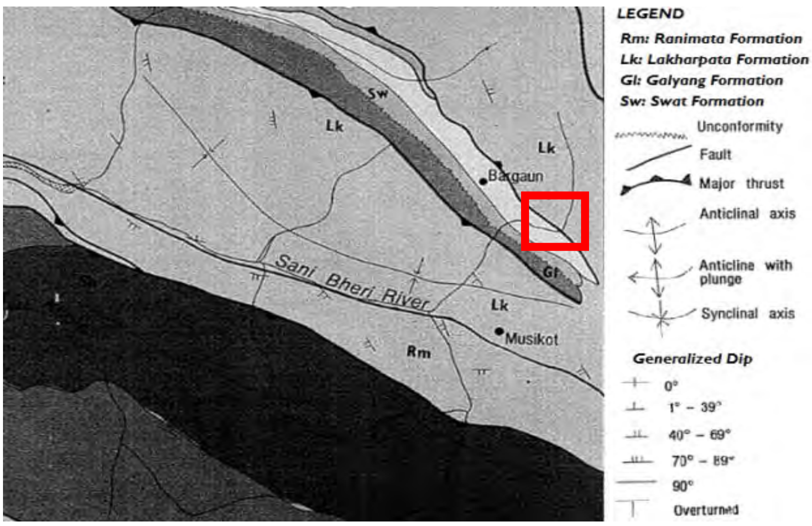



Figure 7-25 Geology of Project Area (Syarpu Daha, Rukum)

2) Surface Deposits

The main surface deposits within the project area are ;

- Alluvial soil
- Colluvial soil
- Residual soil

The low-lands of the project area are mainly composed of alluvial and colluvial soil whereas the soils in the upper hill area are composed of residual soil. Colluvial deposits are the major constituent at the start of the canal alignment. They are also present in the left bank along the landslide area. Alluvial deposits are seen in the low lands of the project area and mainly seen in power house area and extensively along the Sani Bheri and Darne River. Residual soil is present in the canal alignment and penstock alignment.

The alluvial terrace in the powerhouse area is made up of thick gravel deposit and somewhere residual soil are frequently used for settlement and agriculture fertile land. The deposits are thick and the base of the terrace is situated below the river bed. The colluvial deposits have slope varying from 30˚ to 45˚ and form the critical angle of repose whereas vertical scarps.

## (1) Engineering Geology of the Project Area

1) Headworks Area and Intake

The weir does not exist. The river channel width at the headworks area is about 15 m. The gradient of river is steep. Large boulders are accumulated in the river channel and on both the banks of the river in the headworks area. The diameter of the boulders is even larger than 5m. No fine materials were observed in the area. No bedrocks were observed in the immediate vicinity of the weir area.

A slide is observed on the right bank of river in the headworks area. Colluvial deposit is the major constituent of the right bank. Further upstream of the river in the right bank, bed rock exposures were observed. However, the bed rock present is moderately to highly weathered and heavily jointed with close joints. Rills are formed in the area. Smalls are formed in between. Bedrock is present in the left bank at about 100 m upstream of the headworks area also. Numerous cracks were observed in the rock mass, suggesting the unstable nature of slope as well.

Geologically the area is unstable. This may be due to the presence of a regional thrust in the near vicinity. A regional fault passes near the headworks area and hence the rock outcrops found in the near vicinity are highly jointed.

Syarpudaha, a large lake located at about 500 m uphill acts as a reservoir and is the source of water for the project. One remarkable fact is that the volume of water flowing at the headworks site was observed to be much higher than the water spills to the khola from the Syarpudaha, about 500 upsream from the HW site. A fair amount of water was also found disappear in the course in between. Water flows towards the site by infiltration into the pores suggesting that the pore space and or aperture of joint high in between these area.

Construction of weir in such large boulder accumulated area will be of major concern as permeability is expected to be high in the area. Seepage of water is expected from such deposits. The intake is present in the left bank where major flow of river is confined. Also, the discharge of the river is high and required volume of water can be diverted.

The gradient of river is very high in the headworks area. The high gradient river carries the rock fragments of unstable slope downstream. Hence, large sub angular to sum rounded boulder of diameter greater than 5m are found in the river channel. Due to the presence of large boulders in the headworks area and absence of fines in such a steep gradient river, it was not possible to dig any test pit at the area. Geo-physical investigation is recommended in the area to determine the depth and nature of the deposit.


Figure 7-26 Engineering Geological Condition of the Headworks Area

2) Canal Alignment

The canal alignment can be divided into two separated groups depending the stability of the slope on which it passes.

- *Unstable region (0+000 to 0+355)*

The first 40 meters of the canal runs parallel to the river consisting of the boulder deposit. A pier structure is constructed to cross a tributary afterwards. Then the canal passes into the unstable area. Few newly reactivated slide were observed in between. A slide of dimension about 50m x 60m is observed between the Chainage 0+160 and 0+210. The slide deposits consists of angular fragments of rock in a sandy silt matrix. While some portion of the channel is covered, some portion of the canal is still left open. The stability of the slope in the area will be a key issue, especially in the monsoon period. Slope stabilization means like installment of horizontal drains, limiting pore pressure in the slope-mass, construction of check dams in the slope and gabions walls at the base of the slope, all of these should be adopted in the area.

The Chainage between 0+210 and 0+290 is consists of angular fragments of large boulders of quartzite, limestone in a silty sand matrix. At some locations, Hill slope in the area is also higher than the angle of repose for such deposit. Hill slope in the slide area is S70$^{o}$W/46$^{o}$. Large boulders were found scattered up to the base of the slope between Chainage 0+290 and 0+355.

- *Stable region (0+330 to head pond)*

The Chainage 0+330 onwards lies on the stable slope. Rock outcrop was observed at some location. The attitude of bed is S80$^{o}$W/41$^{o}$ (dip direction/dip). Residual soil is the major soil type in the alignment. Hill slope of the area ranges between 30-40$^{o}$ in the area. Color of the residual soil is reddish brown in the upper reach whereas dark grey in near the head pond and penstock area. At locations, few large boulders were found scattered. The proportion of fines is much higher in the area.


Figure 7-27 Headworks Location and Canal Alignment


Figure 7-28 Support Pier between Chainage 0+000 and Chainage 0+100

Figure 7-29 Two Distinct Nature of Slide Deposits


Figure 7-30 Canal Alignment

3) Head pond

Morphologically, the head pond is located on a relatively flat ridge consisting of residual soil. The width of the flat land is about 7m. The ridge extends from NE to SW direction. The slope angle of the hill left to the head pond is steep and is covered by forest land. The slope to the right of the head pond ranges between 20 and 30 degrees and is currently cultivated.

Geologically, head pond area lies on the stable area. Residual soil is the main constituent of the head pond. Description of head pond is as follows;

*Composition: 80% fine 20% rock fragments*
*Roundness of Rock fragments: Angular*
*Plasticity: Medium*
*Dry strength: Medium*
*Moisture Content: Dry*
*Cementation: Weak to Medium*
*Consistency: Firm*
*Permeability: Medium to Low*

Figure 7-31 Head Pond

A spill way channel is constructed towards the northwest slope. The channel is composed of the residual soil deposits and is currently used for cultivation. The base of the spill way channel is degraded and water leaks through the wall and the base of the spillway channel.

Some collapsed slopes are reported to be activated due to the leakage from the spill way channel.

4) Penstock

Majority of the penstock alignment lies on forest area composing residual soil deposits. Rock outcrops are exposed only on the base of the slope near powerhouse area. The first 150m lies on the ridge between the slopes, afterwards descending down the slope. The residual soil on which the penstock alignment rests is composed of brownish grey to dark grey soil with low plasticity, low to medium dry strength, moist, homogeneous, firm and gritty clayey silt with some angular rock fragments. The thickness of the soil decreases as it descends down the slope. As the rocks dips into the slope, moderate hill-slope angle and presence of long rooted trees in the alignment, the penstock alignment is stable.

5) Powerhouse and Tailrace

The powerhouse is located on relatively flat flood plain deposit formed by the Sano Bheri River at Bhagle VDC. The thickness of the terrace is about 5-7m. The sediment log in the powerhouse area shows three visible river terraces. The upper deposit is of the least thickness and is composed of fine grained (sandy silt with fragments of slates) soils. The second terrace deposit comprises of sub-rounded to well-rounded boulders (<1 m dia.), cobbles, pebbles and gravels in sandy clayey silt matrix. The deposit contains 25-35% fine materials and 65-75% coarse materials. Permeability of such soil is expected to be high. The thickness of this deposit is about 2.5 meters. The third terrace deposit is composed of angular boulders in well cemented, dark brown colored, sandy silt matrix. Permeability of such soil is expected to be medium.

Rock outcrops were observed in the uphill side of the powerhouse area, where penstock alignment is located.

- *Attitude of rock (dip direction/dip angle): S55$^o$W/40$^o$*
- *Hill Slope: S25$^o$E/50$^o$-60$^o$*

Since the rock dips into the hill slope, instability in the slope is not expected.

Figure 7-32 Powerhouse and Penstock Alignment

Figure 7-33 Alluvial Terrace as seen in the River Bank below PH Area

## (2) Instability in the Project Area

One regional fault and unconformity lies within the project area. The first one-third area canal alignment lies on the unstable landslide area. Two landslides of distinct nature were observed near Chainage 0+140. The slope between the Chainage 0+000 and 0+330 is composed of colluvial deposits.


Figure 7-34 Instability Area

It is noted that 166 numbers of major and minor landslides including cut slope failures were recognized along the road from Sitalpati to Musikot alignment. These slides were observed to be shallow in depth, found in forest, dry cultivated land area and along the both sides of road and are unlikely to have been directly influenced by tectonic activities. Rock weathering, precipitation, surface and undercutting of slope by road cutting, loose materials on steep hill slope and groundwater were accounted for the slope failure. Presently, the slide condition is unstable due to the hanging blocks at the crown part of the slides, which may fall down after heavy rainfall.

### (3) Recommendation and Conclusion

- The weir will be founded on the large boulder deposits. Construction of weir for this size, project will be a hard task. If feasible, the depth and nature of the deposits is recommended to be determined from geo-physical analysis. Also, permeability between these deposits will be a major concern during the construction of weir. Permeability/ Infiltration Study is recommended in the headworks area before construction.
- The stability of the landslide between Chainage 0+160 and 0+210 is a key issue during the monsoon period. Slope stabilization means like installing horizontal drains, limiting pore pressure in the slope-mass should be adopted. The construction of check dams in the slope and gabions walls at the base of the slope are recommended.
- Covering of the canal at the unstable area is also recommended.

# 8. Summary of Quantities

The quantities for Micro-Hydropower Improvement Project in Bajhang, Bajura, and Syarpudaha are shown in Table 8-1 Diversion works, Table 8-2 Intake construction works, and Table 8-3 Rehabilitation works for existing structure.

Table 8-1 Diversion works

| Working Items | Unit | Bajhang | Bajura | Syarpudaha | Total |
|---|---|---|---|---|---|
| Clearing and stripping | $m^2$ | 3,128 | 1,024 | 1,652 | 5,803 |
| Excavation (common) | $m^3$ | 213 | 247 | 264 | 724 |
| Excavation (boulder) | $m^3$ | 53 | 62 | 66 | 181 |
| Extension existing temporary intake channel | $m^3$ | 146 | 131 | 154 | 431 |
| Gabion mattress (1st stage-1) | $m^3$ | 446 | 410 | 551 | 1,407 |
| Sandbag (1st stage-1) | $m^3$ | 180 | 149 | 194 | 523 |
| Gabion mattress (1st stage-2) | $m^3$ | 798 | 321 | 361 | 1,480 |
| Embankment with compacted backfill (1st stage-2) | $m^3$ | 817 | 296 | 404 | 1,517 |
| River flow diversion-1 (common excavation) | $m^3$ | 300 | 878 | 410 | 1,588 |
| Removal temporary intake | $m^3$ | 146 | 131 | 154 | 431 |
| Removal 1st stage cofferdam (2nd stage-1) | $m^3$ | 1,137 | 898 | 1,228 | 3,263 |
| River flow diversion (2nd stage-2) | $m^3$ | 200 | 200 | 200 | 600 |
| Gabion mattress (2nd stage-2) | $m^3$ | 248 | 96 | 156 | 500 |
| Sandbag (2nd stage-2) | $m^3$ | 100 | 40 | 60 | 200 |
| Removal 2nd cofferdam (2nd stage-3) | $m^3$ | 371 | 128 | 218 | 717 |

Table 8-2 Intake construction works (1)

| Working Items | | Unit | Bajhang | Bajura | Syarpudaha | Total |
|---|---|---|---|---|---|---|
| Earth Work | Clearing and stripping | $m^2$ | 1,138 | 551 | 801 | 2,490 |
| | Excavation (common) | $m^3$ | 1,391 | 651 | 1,002 | 3,044 |
| | Excavation (boulder) | $m^3$ | 341 | 157 | 243 | 741 |
| | Gravel bedding | $m^3$ | 86 | 45 | 67 | 198 |
| | Fill with cobble stone | $m^3$ | 233 | 123 | 149 | 505 |
| | Fill with random materials | $m^3$ | 63 | 35 | 40 | 138 |
| Concrete Works | Concrete (G) leveling | $m^3$ | 22 | 11 | 17 | 50 |
| | Concrete (E) for structure | $m^3$ | 1,222 | 751 | 925 | 2,898 |
| | Concrete (B) for block out | $m^3$ | 9 | 4 | 6 | 19 |
| | Formwork (F1) | $m^2$ | 1,086 | 663 | 786 | 2,535 |
| | Formwork (F2) | $m^2$ | 110 | 75 | 94 | 279 |

Table 8-2 Intake construction works (2)

| Working Items | | Unit | Bajhang | Bajura | Syarpudaha | Total |
|---|---|---|---|---|---|---|
| Concrete Works | Dowel bar D22,1.0m for contraction joint | nos. | 140 | 46 | 116 | 302 |
| | Bituminous coating for contraction joint | m2 | 101 | 35 | 84 | 220 |
| | Water swelling rubber sealing materials | m | 70 | 23 | 58 | 151 |
| | Reinforcing bar | ton | 32 | 21 | 26 | 79 |
| Miscellaneous Works | Gabion mattress | m3 | 923 | 519 | 739 | 2,181 |
| | Bar screen | m2 | 44 | 17 | 33 | 94 |
| | Stop log ( 2.0L,0.3H,0.3W) | nos. | 3 | 2 | 3 | 8 |
| | Geotextile mat ( including anchor pin) | m2 | 42 | 135 | 131 | 308 |
| | Weep hole, PVC-50mm,0.5m | nos. | 46 | 36 | 23 | 105 |
| | Steel pipe handrail(outdoor type) | m | 54 | 39 | 48 | 142 |
| | Traps (round bar $\phi$ 22) | nos. | 19 | 18 | 15 | 52 |
| | Wet rubble masonry | m2 | 230 | 84 | 96 | 410 |
| | Stone pitching | m2 | 780 | 427 | 584 | 1,791 |
| | Rock bolts (D25,2m) | m | 47 | 23 | 32 | 102 |

Table 8-3 Rehabilitation work for existing structure

| Working Items | Unit | Bajhang | Bajura | Syarpudaha | Total |
|---|---|---|---|---|---|
| Removal headrace concrete | $m^3$ | 21 | 9 | 32 | 62 |
| Removal masonry wall | $m^3$ | 63 | 155 | 94 | 313 |
| Removal of sediment | $m^3$ | 380 | 0 | 0 | 380 |
| Dismantle existing sand flush gate | Ls | 1 | 2 | 0 | 3 |
| Replacement sand flush gates | Ls | 2 | 2 | 1 | 5 |
| Wooden stop log | unit | 1 | 1 | 1 | 3 |
| Stop log guide metal | Kg | 34 | 41 | 30 | 105 |
| Gabion mattress (protection of waterway,slope) | $m^3$ | 113 | 600 | 624 | 1,337 |
| Tipping 5cm on existing structure | $m^2$ | 118 | 298 | 109 | 525 |
| Formwork (F2) | $m^2$ | 93 | 144 | 15 | 252 |
| Concrete(E) | $m^3$ | 23 | 65 | 9 | 97 |
| Reinforcing bar (30kg/m3) | kg | 690 | 1,920 | 270 | 2,880 |
| Wet rubble masonry | $m^3$ | 63 | 140 | 94 | 296 |
| Crack repairing work | M | 90 | 20 | 20 | 130 |
| Portable hand rake | Ls | 1 | 1 | 1 | 3 |

| Working Items | Unit | Bajhang | Bajura | Syarpudaha | Total |
|---|---|---|---|---|---|
| Painting on Penstock pipe | | See Metal works | | | |
| Replacement of saddle plate | kg | 0 | 592 | 118 | 710 |
| Excavation (common) | $m^3$ | 36 | 668 | 578 | 1,282 |
| Embankment with compacted backfill | $m^3$ | 0 | 41 | 198 | 239 |
| Geotextile mat ( including anchor pin) | $m^2$ | 62 | 130 | 1,457 | 1,649 |
| Sod facing | $m^2$ | 0 | 0 | 1,320 | 1,320 |
| Plaster mortal with chicken mesh | $m^3$ | 5 | 7 | 4 | 16 |
| Stone pitching | $m^3$ | 0 | 56 | 1 | 57 |
| Removal moss from waterway | $m^2$ | 0 | 1,540 | 840 | 2,380 |