No.

THE REPUBLIC OF VANUATU
Ministry of Lands, Energy, Environment,
Geology, Mines and Water Resources
Energy Unit

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
IMPROVEMENT OF POWER GENERATION
IN SARAKATA RIVER HYDROELECTRIC POWER STATION
IN
THE REPUBLIC OF VANUATU

JANUARY 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

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PREFACE

In response to a request from the Government of the Republic of Vanuatu, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Power Generation in Sarakata River Hydroelectric Power Station and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Vanuatu a study team from June 19 to July 16, 2006.

The team held discussions with the officials concerned of the Government of Vanuatu, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Vanuatu in order to discuss a draft basic design, and as this result, 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.

I wish to express my sincere appreciation to the officials concerned of the Government of The Republic of Vanuatu for their close cooperation extended to the teams.

January 2007

Masafumi Kuroki
Vice-President
Japan International Cooperation Agency

January 2007

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Improvement of Power Generation in Sarakata River Hydroelectric Power Station in the Republic of Vanuatu.

This study was conducted by Yachiyo Engineering Co., Ltd., under a contract to JICA, during the period from June, 2006 to January, 2007. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Vanuatu and formulated the most appropriate basic design for the project under Japan's Grant Aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Kiyofusa Tanaka
Project manager,
Basic design study team on the Project for
Improvement of Power Generation in Sarakata River
Hydroelectric Power Station
Yachiyo Engineering Co., Ltd.

SUMMARY

SUMMARY

① Overview of the Country

The Republic of Vanuatu (hereinafter referred to as "Vanuatu") is an island country consisting of some 80 islands which are spread over a distance of some 1,200 km from north to south in the western part of the South Pacific. Vanuatu has a population of approximately 215,000 (United Nations Population Fund 2006) and a total land area of approximately 12,000 km^2 which is similar to the size of Niigata Prefecture in Japan. The GNI per capita is US$ 1,600 (World Bank estimate in 2005). 20% of the total population live in Port-Vila, the capital on Efate Island, and Luganville on Espiritu Santo Island (hereinafter referred to as "Santo Island") where the Sarakata River Hydroelectric Power Station (the project site) is located.

② Background, History and Outline of the Requested Japanese Assistance

Small-scale agriculture is the main industry in Vanuatu and the few export products means a chronic deficit in the international trade balance. Up to around 1990, electricity was mainly generated by diesel engine generators using imported diesel oil, constituting a heavy burden on the national economy. Under these circumstances, the Government of Vanuatu adopted the breaking away from the dependence on oil as a priority target, formulated an energy programme primarily featuring a shift to hydroelectric power generation and made a request to the Government of Japan for the implementation of a project to build the Sarakata River Hydroelectric Power Station to supply electricity to Luganville. In response to this request, the Government of Japan implemented the Project to Construct the Sarakata River Hydroelectric Power Station on Santo Island (hereinafter referred to as "the previous project") in 1994 and 1995 as a grant aid project. Following the construction of this new power station with two 300 kW turbine generators (combined generating capacity of 600 kW), this power station supplied as much as 70% of the electricity supplied to Luganville in 1995, contributing to the breaking away from the dependence on oil for some time. However, the conspicuous growth of the power demand in the area in subsequent years made it impossible for the rated generating capacity of this hydroelectric power station to meet the peak power demand. This situation led to renewed dependence on diesel oil generation and the resulting increase of the diesel oil procurement cost began to oppress the economy of Vanuatu. To alleviate the situation, the Government of Vanuatu made a further request to the Government of Japan for the provision of grant aid for the installation of a new 600 kW hydraulic turbine generator at the Sarakata River Hydroelectric Power Station.

③ Outline of the Study Results and Contents of the Project

In response to this new request, the Japan International Cooperation Agency (JICA) dispatched the Preliminary Study Team (I) to Vanuatu in July and August 2004 to clarify the necessity, urgency and appropriateness of the requested cooperation to be implemented as a grant aid project. The Preliminary Study Team (I) confirmed that the Vanuatu side would conduct an EIA in view of the increased volume of river water intake and urgent countermeasures for the purpose of preventing damage by ground deformation to the ground around the intake water canal as preconditions for the implementation of a basic design study. In March 2006, the Preliminary Study Team (II) was dispatched to Vanuatu and confirmed that the Vanuatu side had already secured the land required for extension of the power station and that no serious environmental impacts would occur as a result of an increased river water intake volume. Meanwhile, the Preliminary Study Team (II) observed that even though the Vanuatu side was implementing work designed to restore the damaged ground around the intake water canal, the originally planned countermeasures were technologically insufficient because of the further worsening of the situation of ground deformation, making the urgent implementation of more fundamental countermeasures essential. As the canal in question was created by cutting a steep slope and is liable to the adverse impacts of loosened ground due to rainwater in the rainy season and earthquakes which occur regularly in the area, it was decided that permanent rehabilitation work would be included in the scope of Japan’s grant aid cooperation.

Following this decision, the Government of Japan decided to conduct the Basic Design Study and the JICA dispatched the Basic Design Study Team to Vanuatu for the period from 19th June to 16th July, 2006 to clarify the contents of the request, to discuss the details of project implementation, to conduct a project site survey and to gather relevant data and information.

On its return to Japan, the Basic Design Study Team examined the necessity, socioeconomic effects and relevance of the Project and compiled the Outline of the Basic Design describing the basic design and implementation plan for the optimal project. The JICA then dispatched the Basic Design Study Team to Vanuatu for the period from 30th October to 7th November, 2006 to explain the contents of the Outline of the Basic Design to the Vanuatu side.

The scope of Japan’s cooperation project which has been formulated based on the findings of the basic design study entirely covers the contents of the requested project. It incorporates the extension of the existing power house and the construction of a new penstock at the Sarakata River Hydroelectric Power Plant which was built under the previous project so that one new 600 kW hydraulic turbine generator can be installed. The Project also features the implementation of slope rehabilitation work and other urgent work for the ground supporting the intake water canal and other civil engineering structures damaged by heavy rain and earthquakes to achieve the same level of earthquake resistance as the existing civil engineering structures. The contents of the basic design for the Project, which have been finalised based on the field survey results and the results of discussions with the Vanuatu side, are outlined in the table below.

Item	Urgent Raceway Repair Plan	Power Station Extension Plan
Target Site	Sarakata River Hydroelectric Power Station in Luganville City on Santo Island	As left
Facility Construction Plan	Implementation of the following work for the existing Intake water canal and access road 1. Urgent canal repair work: one complete set Target : existing canal (some 830 m long) Contents : slope rehabilitation using rock bolts, reinforcement of the canal side faces by piling and backfilling of the deformed ground, etc. 2. Access road safety improvement work: one complete set Target : access road to the power station (approx. 100 m long) Contents : slope rehabilitation work using rock bolts, etc.	Implementation of the following work in association with the installation of the new No. 3 generator 1. Laying of penstock: one complete set (hydraulic pipes: approx. 40 m) 2. Tailrace improvement work: one complete set (concrete; for water discharge to Sarakata River) 3. Powerhouse extension work: one complete set ・ RC concrete two story ・ Building area : 117.32 m^2 ・ Total floor area : 226.22 m^2 ・ Overhead travelling crane (7.5 tons), lighting and other auxiliary equipment
Procurement and Installation of Equipment	-	Procurement and installation of the following equipment in connection with the installation of the new No. 3 generator 1. Hydraulic turbine generator: 1 set Hydraulic turbine : 660 kW or higher; horizontal shaft Francis turbine; 500 rpm; electric speed governor and frequency adjustment function; inlet valve; flywheel Generator : 3.3 kV; 750 kVA; 500 rpm; 0.8 pf 2. Auxiliary equipment: one complete set (3.3 kV distribution panel; station service transformer; DC power panel; low voltage distribution panel) 3. Main step-up transformer: 1 set (installed in the Sarakata River Hydroelectric Power Station premises, For power transmission: 3.3/20 kV, 750 kVA with protection and connection panel) 4. Step-down transformer for Sarakata River Substation: 1 set (for step-down operation: 20/5.5 kV; 1,500 kVA)
Procurement Plan	-	Procurement of the following items for the maintenance of the No. 3 generator 1. Maintenance tools: one complete set (special tools for the hydraulic turbine generator and instruments) 2. Spare parts: one complete set

④ Project Schedule and Estimated Project Cost

The estimated total project cost in the case of the implementation of the Project under the grant aid scheme of the Government of Japan is approximately ¥1,316 million (Japanese portion: approx. ¥1,227 million; Vanuatu portion: approx. ¥39 million). The principal work to be conducted by the Vanuatu side is the repair work of the inner face of the intake water canal (raceway). The planned work period for the Project is approximately 13 months for Phase I (Urgent Repair of the Intake Water Canal), including the detailed design and procurement/installation of equipment, and approximately 19.5 months for Phase II (Extension of the Hydroelectric Power Station).

⑤ Verification of the Relevance of Japan's Grant Aid Scheme

The organization responsible for the supervision and implementation of the Project is the Ministry of Land, Energy, Environment, Geology, Mines and Water Resources (MOL) while the Energy Unit of the MOL is responsible for the operation and maintenance of the new facilities/equipment. The Energy Unit manages the budget for the power sector and formulates plans for the power sector but has entrusted the operation and maintenance of the Sarakata River Hydroelectric Power Station to a private company. The staff members of this company who are responsible for the operation and maintenance of the said power station have acquired the necessary knowledge and skills for the operation, maintenance and repair of a hydroelectric power station through the OJT conducted under the previous project. Given the good operating and maintenance conditions of the existing generating facilities, it can be safely assumed that there is sufficient technical capability in Vanuatu to proceed with the Project in a satisfactory manner.

The size of the population which will direct benefit from the Project is approximately 20,000 islanders on Santo Island while Vanuatu's entire population of approximately 215,000 will also indirectly benefit from the Project due to the facilitation of local electrification using the Sarakata Fund. The increase of the generating capacity by 600 kW with the implementation of the Project will increase the reserve supply capacity. Accordingly, a stable power supply will be assured even if the operation of a generating unit is suspended for periodic inspection or due to a break down. The increase of the total generating capacity of the Sarakata River Hydroelectric Power Station to 1,200 kW means that this power station will meet the base load and will contribute to reducing the oil consumption due to the reduced operation of the diesel power station. The reduction of the oil consumption will increase the size of the Sarakata Fund, boosting the financial source for local electrification. Meanwhile, the reduced operating hours of the diesel power station will reduce air pollution and noise. The Project is, therefore, expected to have various positive effects and to contribute to the vitalisation of the Vanuatu economy as well as improvement of the basic living conditions for islanders. As such, the implementation of the Project with grant aid provided by the Government of Japan is judged to be relevant for the purpose of Japan’s grant aid scheme.

For the smooth and effective implementation of the Project and also for the realisation and continuation of its intended positive effects, the Vanuatu side should complete the following tasks.

(1) Proper implementation of the repair and maintenance of the civil engineering facilities and generating equipment required for hydroelectric power generation, including the repair of the inner face of the intake water canal.

(2) Establishment of a maintenance system with a view to conducting (i) the periodic inspection of the facilities to be improved under the Project and (ii) management of the water intake volume, etc. in an appropriate manner.

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The Project for Improvement of Power Generation in Sarakata River Hydroelectric Power Station in The Republic of Vanuatu

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ABBREVIATIONS

DAC	Development Assistance Committee
E/N	Exchange of Notes
FRP	Fiber Reinforced Plastics
GDP	Gross Domestic Product
IEC	International Electrotechnical Commission
ISO	International Organization for Standards
JCS	Japanese Electrical Wire and Cable Maker's Association Standards
JEAC	Japan Electric Association Code
JEC	Japanese Electrotechnical Committee
JEM	Standards of Japan Electrical Manufacturer’s Association
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
MOL	Ministry of Lands, Energy, Environment, Geology, Mines and Water Resources
O&M	Operation and Maintenance
OJT	On the Job Training

CHAPTER 1

BACKGROUND OF THE PROJECT

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In Vanuatu, only Port-Vila, which is the capital of the country where 20% of the total national population live, and the urban area of Luganville City on Santo Island have been electrified through the development of the power distribution system. As diesel power generation has been the main source of power, the cost of imported fuel oil has been a heavy burden on Vanuatu's national economy. To alleviate this burden, Japan implemented a grant aid project (the previous project) from 1993 to 1994 to build the Sarakata River Hydroelectric Power Station with a total output of 600 kW (300 kW generating unit x 2).

As a result of the previous project, power supply by the Sarakata River Hydroelectric Power Station to the Luganville power system on Santo Island, the target area of the present Project, accounted for some 70% of the total power supply, contributing to a reduction of the cost of the fuel oil used for diesel power generation. Meanwhile, the Government of Vanuatu started saving the net profit of the operation of the Sarakata River Hydroelectric Power Station, i.e. the amount remaining after deduction of the operation, management and other necessary costs from the income from power sales, named the Sarakata Savings Fund. This Fund has been used for the promotion of electrification in the Luganville area (including a subsidy for the electricity charge), promotion of the electrification of local areas through the installation of such independent power sources as photovoltaic power generation systems and various studies relating to the development of new power sources. With these efforts, the electrification rate in the Luganville area increased to 89% in 2003 from some 40% in 1994.

In the meantime, improvement of the electrification rate has pushed up the power demand which recorded annual growth of approximately 8% up to 2001. While the switch of large users to their own power generation resulted in a dip of the overall power demand for the power system in 2002, the power demand has resumed its growth at an annual rate of more than 7% since 2003, illustrating the noticeable growth of the power demand in recent years. However, the rated capacity of the existing Sarakata River Hydroelectric Power Station has been unable to meet the maximum power demand, making renewed dependence on diesel power generation necessary. Under these circumstances, the Government of Vanuatu made a request to the Government of Japan to provide a new grant aid for the installation of a hydraulic turbine generating unit (600 kW) at the Sarakata River Hydroelectric Power Station.

In response to this request, the Japan International Cooperation Agency (JICA) dispatched the Preliminary Study Team (I) to Vanuatu in July and August 2004 to check the necessity, urgency and appropriateness of the requested cooperation to be implemented as a grant aid project. The Preliminary Study Team (I) agreed with the Vanuatu side on the preconditions for the implementation of the basic design study. These were ① solution of the dispute regarding the leasehold of the land where the hydroelectric power station in question is situated, ② checking of the potential impacts on the natural environment due to increased water intake and ③ introduction of urgent countermeasures to prevent any potential damage by a landslide on the Intake water canal area from the intake to the hydroelectric power station. Subsequently, the JICA dispatched the Preliminary Study Team (II) to Vanuatu to confirm the response to these preconditions by the Vanuatu side.

The Preliminary Study Team (II) judged that the land issue (① above) would not hinder the progress of the Project despite it being contested in court as the MOL (Ministry of land, Energy, Environment, Geology, Mines and Water Resources) had deposited an amount of money to pay for the land with the consent of the land owner. The Preliminary Study Team (II) also confirmed that there were no factors which would have a serious impact on the natural environment (② above).

In regard to ③ - countermeasures to prevent landslide damage, the Vanuatu side had conducted the backfilling of cracks which had appeared along the route of the canal and also the laying of vinyl sheets to prevent the invasion of rainwater. However, it was confirmed that the urgent implementation of more fundamental countermeasures was necessary because of the technological limitations of the rehabilitation work which was believed to be sufficient by the Vanuatu side could not deal with the worsening situation. The canal in question was created by cutting the steep slope and was liable to the adverse impacts of loosened ground by rainwater in the rainy season and earthquakes which occur regularly in the area. Because of this, it was decided that permanent rehabilitation work would be included in the scope of the basic design study for the proposed Japanese grant aid project.

The contents of the original request which were confirmed at the time of the basic design are shown below.

(1) Urgent repair plan for the raceway: one complete set

(2) Hydroelectric power station expansion plan

① Installation of one new 600 kW hydraulic turbine generating unit: one complete set
② Installation of auxiliary equipment for the generating unit: one complete set
③ Installation of an additional penstock (between the head tank and the generating unit): one complete set
④ Extension of the power station building: one complete set
⑤ Installation of a new main step-up transformer (750 kVA): one complete set
⑥ Installation of a new step-down transformer (1,500 kVA) for the existing Sarakata River Substation: one complete set

CHAPTER 2

CONTENTS OF THE PROJECT

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2.1 Basic Concept of the Project

2.1.1 Higher Goal and Project Objective

In its National Development Plan, the Government of Vanuatu places emphasis on the promotion of employment and the development of the national economy, calling for the urgent implementation of countermeasures to develop infrastructure, including power supply, among others. While electrification through the development of the power system has so far been restricted to Port-Vila, the capital (on Efate Island), and the urban area of Luganville City, the project area, (on Santo Island), reliance on diesel generating units as the source of power generation used to constitute a heavy financial burden because of the need to import expensive fuel. To ease this financial burden, Japan implemented a grant aid project to construct the Sarakata River Hydroelectric Power Station (300 kW generating unit x 2) from 1993 to 1994. The subsequent conversion from diesel power generation to hydroelectric power generation has reduced the fuel cost and has greatly contributed to the economy of Vanuatu. Meanwhile, the Government of Vanuatu has been using the profit (the Sarakata Savings Fund) for the operation of this hydroelectric power station to facilitate the electrification of the Luganville area as well as other areas on Santo Island. The improved electrification rate has contributed to a better life for local people as well as the development of industries but the steadily growing power demand has made the power supply by the existing Sarakata River Hydroelectric Power Station insufficient. As a result, the use of the diesel power generation has increased and the sharp price rise of imported fuel is becoming a heavy pressure on the national economy. The higher goal of the Project is improvement of the international balance of payments through a reduction of the volume of imported fuel oil for diesel power generation based on an increased power supply capacity of the Sarakata River Hydroelectric Power Station as envisaged by the National Development Plan. Meanwhile, the objective of the Project is an increase of the power supply capacity of the said hydroelectric power station located in Luganville City on Santo Island in order to achieve stable power supply by hydroelectric power generation for Luganville City.

2.1.2 Outline of the Project

The Project aims at increasing the generating capacity of the Sarakata River Hydroelectric Power Station which was constructed under the previous grant aid project by installing the 600 kW No. 3 hydraulic turbine generating units as an addition to the existing No. 1 and No. 2 hydraulic turbine generating units (300 kW each). In addition, urgent repair work should be conducted for the Intake water canal which has been damaged by heavy rain, earthquakes and other reasons.

The components of this grant aid project consist of the construction of facilities and the procurement and installation of equipment as listed below.

(1) Intake Water Canal Repair Plan : one complete set

① Repair work of the Intake water canal area

② Work to improve the safety of the access road

(2) Hydroelectric Power Station Extension Plan : one complete set

① Construction of a penstock

② Construction and arrangement of the tailrace

③ Extension of the hydroelectric power station building for addition of Unit-3

④ Installation of a new hydraulic turbine generating unit (600 kW 1 set) and auxiliary equipment

⑤ Main step-up transformer (3.3/20 kV, 750 kVA 1 set)

⑥ Step-down transformer for the Sarakata River Substation (20/5.5 kV, 1,500 kVA 1 set)

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policies

2.2.1.1 Basic Policies

The Sarakata River Hydroelectric Power Station constructed under the previous grant aid project has a total output of 600 kW provided by two hydraulic turbine generating units (No. 1 and No. 2 generating units with 300 kW each). Since its commissioning, the station has supplied power in a stable manner through combined operation with the existing diesel power station. The power demand in Vanuatu shows an increasing trend along with growth of the GDP and there has been a master plan since the initial construction of this hydroelectric power station to eventually increase the maximum generating capacity to 1,200 kW with the addition of a 600 kW hydraulic turbine generating unit (hereafter referred to as “No. 3 generating unit”), the installation of which is planned under the present Project, so that the overall construction cost of this hydroelectric power station is highly economical. As such, the scale of the Intake water canal and other facilities is designed to match the final generating capacity.

In view of such arrangements, a new No.3 generating unit will be installed at the existing Sarakata River Hydroelectric Power Station and a range of equipments and facilities required for the operation of this new generator will be provided under the Project, while making the maximum use of the existing equipment and facilities. The capacity of this additional generating unit (600 kW) is determined on the basis of the power demand in the Project's target year, i.e. 5 years after its commissioning.

2.2.1.2 Policies Regarding the Natural Conditions

(1) Temperature and Humidity

According to the observation results at the Pekoa Airport Meteorological Station located near the Sarakata River Hydroelectric Power Station, the mean temperature and humidity in the area are 25.5°C and 83% respectively, indicating a general climate of a high temperature and high humidity in the area. Accordingly, careful consideration must be given to the design of the new generator and auxiliary equipment to prevent their malfunctioning due to condensation.

(2) Rainfall and Lightning

The mean annual rainfall in the area of approximately 2,250 mm is relatively high. The dry season (May – October) is clearly distinguishable from the rainy season (November – April). Cyclones causing stormy weather hit Vanuatu during the rainy season. The rainwater accompanying such storms penetrates cracks in the ground caused by earthquakes, etc. on the canal area as well as the access road of the Sarakata River Hydroelectric Power Station, aggravating such cracks. In view of this situation, careful consideration must be given to safety regarding the design of the civil engineering work against the canal damage. Careful attention must also be paid to preventing any adverse impacts of lightning strike on the equipment.

(3) Earthquakes

Vanuatu is situated in an earthquake zone and it is inferred that earthquakes are one cause of the cracks observed with the Intake water canal area and access road. For this reason, an aseismatic design will be adopted for civil construction and structures. Because of the absence of the design standards for civil construction and buildings in Vanuatu, the relevant Japanese standards will be used for the purpose of aseismatic design. Consequently, the design lateral seismic coefficient (kh) of 0.15 is adopted for civil construction, while the standard shearing force coefficient (Co) of 0.2 is adopted for building structures.

2.2.1.3 Policies Regarding the Socioeconomic Conditions

The Sarakata River Hydroelectric Power Station, i.e. the project area, is located far away from any urban area and the social infrastructure is not fully developed around the site. There are no accommodation facilities which engineers of the Japanese contractor can use as a permanent base. Careful consideration is, therefore, required in regard to finding safe accommodation during the construction period of the Project in view of the proper setting up of an emergency communication system. One possibility is to find accommodation in Luganville City.

2.2.1.4 Policies Regarding the Local Construction Industry and Local Procurement

There is more than one construction company and electrical contractor in Luganville City. However, none of the local companies possess the advanced technical skills required for the extension of the hydroelectric power station and the installation of the hydropower generating equipment, making the dispatch of engineers from Japan essential to provide technical guidance and to control the quality and schedule.

While such general construction materials as cement and aggregates are available in Vanuatu, the local procurement of such industrial products as hydraulic turbine generators and auxiliary equipment is practically impossible, making the procurement of these items from Japan necessary.

2.2.1.5 Policies Regarding the Use of Local Companies

No local company in Vanuatu has the technical know-how to conduct the installation of the planned equipment under the Project. However, some local companies do have engineers with suitable experience of civil engineering and building work and workers can be hired locally even if they do not have much experience of building a hydroelectric power station. Vehicles to transport workers can be locally procured fairly easily and the use of local companies as subcontractors for the civil engineering, building and electrical work is planned to reduce the overall project cost and to transfer skills. It must be stressed that work supervision by the Japanese contractor will be essential to ensure the achievement of the planned schedule and quality. Meanwhile, the procurement of construction machinery in Vanuatu is difficult. The large construction machinery to be used under the Project will be specially-designed construction machinery in view of its use for the reinforcement of the ground around the intake water canal.

2.2.1.6 Policies Regarding the Operation and Maintenance Capability of the Implementation Body

The hydroelectric power station constructed under the previous grant aid project in Vanuatu has been operated without any problems. The operation and maintenance system run by a private contractor under the supervision and guidance of the MOL Energy Unit has been well established. It is planned that the specifications of the hydraulic turbine generator and auxiliary equipment to be installed under the Project will not exceed those of the comparative equipment installed under the previous grant aid project. However, the existing generating unit was installed 10 years ago and new technologies which are mainly associated with the control system have since been developed. Moreover, each hydraulic turbine generator manufacturer has its own overhaul and re-assembly procedure which is part of the operation and maintenance regime for the hydraulic turbines and other components. For this reason, Japanese engineers will provide OJT on the operation, maintenance and inspection of the equipment during the construction period of the Project and the necessary spare parts, testing apparatus, maintenance tools and operation and maintenance manuals will be provided to ensure effective as well as efficient operation.

2.2.1.7 Policies Regarding the Scope and Grade of the Facilities and Equipment

In consideration of the various conditions described above, the scope, grade and technological level of the equipment to be procured and installed under the Project will be determined based on the following basic policies.

(1) Policies Regarding the Scope of the Facilities and Equipment

The target year of the Project is the fifth year from the planned year for the completion of the construction and installation work in view of the provision of stable power supply to the target area by the increased capacity of the existing hydroelectric power station. The minimum but necessary equipment and specifications will be adopted in connection with the construction of the civil engineering facilities and the procurement of materials.

In order to ensure an appropriate design in terms of technology and economy, the equipment specifications will be based on the relevant international standards as much as possible so that standard products can be selected for procurement. At the same time, the variety of products will be minimised to ensure the inter-changeability of equipment based on the minimum but necessary specifications.

(2) Policies Regarding the Equipment Grade

For the design of the generating facilities to be constructed and the equipment to be procured and installed under the Project, materials and equipment which match the operation and maintenance capability of the MOL Energy Unit which will be responsible for the operation and maintenance of the new facilities after their completion will be selected to ensure smooth operation and maintenance.

2.2.1.8 Policies Regarding the Construction Method, Procurement Method and Schedule

As the Project will be implemented in accordance with the grant aid scheme of the Government of Japan, the construction and other work must be completed within a single year. Given the fact that the work sites involves the riverbed and riverbanks, it is desirable for the work to take place in the dry season as much as possible to avoid labour disasters due to a sudden flooding in the rainy season. To ensure the completion of the Project within the planned schedule to realise the expected positive effects of electrification, the schedule plan must take such aspects as the inland transportation route, period and various administrative procedures, etc. into careful consideration while ensuring the harmony between the schedule for the work to be undertaken by the Japanese side and the schedule for the work to be undertaken by the Vanuatu side.

It is planned to conduct the repair work for the Intake water canal which has been damaged by natural disasters and other reasons in Phase 1 in view of its urgency and the work relating to the installation of the new hydraulic turbine generator will be conducted in Phase 2.

2.2.1.9 Policies Regarding Environmental and Social Considerations

According to the MOL Environment Unit, the Project, the scope of which includes the urgent repair of the canal, has been given the status of a natural disaster prevention project and it has been confirmed that no adverse impacts on the natural environment or social environment will occur as a result of the Project.

2.2.2 Basic Plan

2.2.2.1 Basic Conditions for the Project

(1) Mode of Operation of the Sarakata River Hydroelectric Power Station and Luganville Diesel Power Station

At present, power to the project area (Luganville City) is supplied by the Sarakata River Hydroelectric Power Station which was constructed under the previous grant aid project and the Luganville Diesel Power Station which is located in the city. After the commissioning of the planned new generator under the Project, it is planned to meet the city's power demand by three hydropower turbine generators (two existing and one new) as much as possible except at peak hours with a view to reducing the level of diesel oil consumption. Fig. 2.2-1 shows the basic mode of operation of the Sarakata River Hydroelectric Power Station and the Luganville Diesel Power Station. In the target year of 2014, the operation of the latter will be necessary between

08:00 and 24:00. The power demand in Luganville City to which the Sarakata River Hydroelectric Power Station supplies power does not show much seasonal fluctuation. For this reason, the mode of operation is primarily determined by the daily load curve which shows changes of the power demand during one day. The city has peak hours in the evening. As shown in Fig. 2.2-1 - Daily Load Curve, the maximum power demand is 1,200 kW between 00:00 and 08:00 hours and 1,600 - 1,900 kW between 08:00 and 24:00 hours.

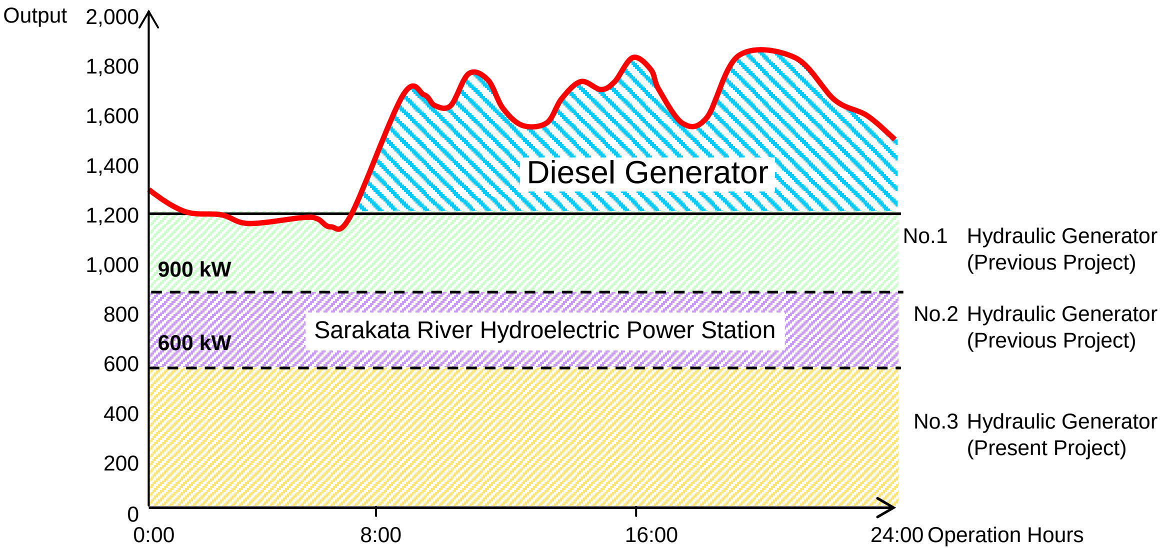


Fig. 2.2-1 Mode of Operation at the Sarakata River Hydroelectric Power Station and the Luganville Diesel Power Station (Forecast for the Target Year 2014)

Diesel generation with a quick response speed currently plays the function of adjusting the power supply in response to an increase/decrease of the power demand. After the commissioning of the No. 3 hydraulic turbine generator, this adjustment function should be transferred to the new hydraulic turbine generator as most of the power demand will be met by power supply by the Sarakata River Hydroelectric Power Station.

Based on the above consideration, the planned hydraulic turbine generator will have the following additional functions.

① Load and frequency adjustment function

② Function enabling the start up of the hydraulic turbine generator at the time of a power outage of the whole system

③ Function to enable power supply by the hydraulic turbine generator during light load hours at night which have so far been dealt with by the diesel generator

Careful consideration must be given to the quality of the electricity supplied in view of the fact that there has been a growing use of electrical appliances with a built-in computer. To ensure the supply of high quality electricity, a control system with an adjustment function corresponding to the envisaged system operation will, therefore, be installed.

(2) Power Demand Forecast and Capacity of the Planned Generator

The power demand (maximum demand) for the Luganville electric power system on Santo Island in Vanuatu recorded a high annual increase rate of approximately 8% between 1995 and 2001. In 2002, as such large users as a sawmill and palm oil plant switched to power supply by their own private power sources, the maximum power demand temporarily fell. Since 2003, however, the annual increase rate has returned to as high as more than 7%.

The power resources development plan for Santo Island up to 2015 only cites the extension of hydroelectric power generation under the Project as the source of additional power supply. Therefore, the scale of this new generating unit should be able to respond to the expected increase of the power demand in the coming years. The level of the power demand can be forecast based on the power demand growth rate as well as the GDP growth rate in the past. In the case of the Luganville power system, an annual growth rate of 7% which is the actual rate for the most recent years is adopted as the forecast annual growth rate of the maximum power demand up to 2007. In view of the facts that the electrification rate in the Luganville area was already as high as some 89% in 2004 and that the Luganville area is expected to be fully electrified by around 2008, the annual growth rate of the maximum power demand from 2008 onwards is forecast to be similar to the annual real GDP growth rate of 3% which is estimated by the IMF. Table 2.2-1 shows the demand forecast for the Luganville power system (with the No. 3 generator installed under the Project) while Table 2.2-2 shows the comparable forecast without the No. 3 unit.

As shown in Table 2.2-1, the maximum power demand in the target year of the Project (2014) is forecast to be 1,884 kW. Against this figure, the total generating capacity of the Sarakata River Hydroelectric Power Station serving the base load is 1,200 kW (approximately 64% of the maximum power demand). The operation of an additional diesel generator to service the peak load of the power system can provide a stable reserve supply capacity (approximately 740 kW), enabling stable power supply. A stable reserve supply capacity assumes a situation where the generating unit of the second largest capacity stops operation due to an accident or another reason when the generating unit of the largest capacity of the power system is suspended for periodic inspection or another reason. In this situation, the generating capacity above the maximum power demand is called “the stable reserve supply capacity”. When this stable reserve supply capacity is insufficient, the required supply capacity under the above-mentioned situation cannot be secured, resulting in a rejection of the load due to the temporary deterioration of the electricity quality (voltage and frequency). If the present Project is not implemented, the stable reserve supply capacity in the target year of 2014 will be extremely small at approximately 140 kW as shown in Table 2.2-2. Given the total generating capacity of the Sarakata River Hydroelectric Power Station (No. 1 and No. 2 units) of 600 kW which is equivalent to some 32% of the maximum power demand, it will be necessary for power supply operation to mainly rely on diesel generation.

In the case of a small power system in an island country such as Vanuatu, it is desirable for the capacity of a single generating unit of the principal generating facility to be 1/3 – 1/4 of the power demand for the entire power system from the viewpoints of efficiency, economical operation and economical maintenance of the generating facility. Given the forecast maximum power demand for the Luganville power system in the target year of 2014 of the Project of 1,884 kW, the appropriate generating capacity of the new unit is inferred to be approximately 600 kW.

Any design of a turbine generator must take heat loss at the generator into consideration. To be more precise, the planned energy output of the turbine generator must add the energy liable to heat loss to the required energy supply. For this reason, the generating capacity of the planned turbine generator under the Project is set at 660 kW.

Based on the above analysis, the additional installation of a new generating unit (600 kW) is judged to be appropriate from the viewpoints of the predicted balance of the power supply and demand and of the suitability of the generating capacity of a single unit in correspondence with the system capacity.

Table 2.2-1 Power Supply and Demand Balance of Luganville Power System on Santo Island (With New No. 3 Unit)

	Start Year	Result												Forecast								
		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Maximum Demand (kW)		**1,200**	**1,240**	**1,300**	**1,400**	**1,520**	**1,740**	**1,880**	**1,314**	**1,408**	**1,512**	**1,338**	**1,432**	**1,532**	**1,578**	**1,625**	**1,674**	**1,724**	**1,776**	**1,829**	**1,884**	**1,941**
Growth Rate (%)		-	3.3%	4.8%	7.7%	8.6%	14.5%	8.0%	-30.1%	7.2%	7.4%	-11.5%	7.0%	7.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
2. Generator Capacity (kW)		**3,140**	**3,440**	**3,440**	**3,440**	**4,354**	**4,327**	**4,301**	**4,165**	**4,130**	**4,094**	**4,059**	**4,025**	**3,990**	**3,957**	**4,523**	**4,490**	**4,457**	**4,424**	**4,392**	**4,360**	**4,329**
2.1 Luganville Diesel Power Station		**2,540**	**2,840**	**2,840**	**2,840**	**3,754**	**3,727**	**3,701**	**3,565**	**3,530**	**3,494**	**3,459**	**3,425**	**3,390**	**3,357**	**3,323**	**3,290**	**3,257**	**3,224**	**3,192**	**3,160**	**3,129**
No. 1 Unit 1000kw	2001	**-**	(No data for 1995 – 1998)		**-**	**0**	**0**	**1,000**	**990**	**980**	**970**	**961**	**951**	**941**	**932**	**923**	**914**	**904**	**895**	**886**	**878**	**869**
No. 2 Unit 1000kw	1999	**-**	**-**	**-**	**-**	**1,000**	**990**	**980**	**970**	**961**	**951**	**941**	**932**	**923**	**914**	**904**	**895**	**886**	**878**	**869**	**860**	**851**
No. 3 Unit 720kw	1992	**-**	**-**	**-**	**-**	**684**	**677**	**670**	**664**	**657**	**650**	**644**	**638**	**631**	**625**	**619**	**612**	**606**	**600**	**594**	**588**	**582**
No. 4 Unit 520kw	1994	**-**	**-**	**-**	**-**	**495**	**490**	**485**	**480**	**475**	**471**	**466**	**461**	**457**	**452**	**448**	**443**	**439**	**434**	**430**	**426**	**421**
No. 5 Unit 520kw	1990	**-**	**-**	**-**	**-**	**475**	**470**	**466**	**461**	**456**	**452**	**447**	**443**	**438**	**434**	**430**	**425**	**421**	**417**	**413**	**409**	**404**
Others (Withdrawn in 2001)	1966	**2,540**	**2,840**	**2,840**	**2,840**	**1,100**	**1,100**	**100**														
2.2 Sarakata River Hydroelectric Power Station		**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**	**1,200**
(1) Sarakata No. 1 Unit	1994	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
(2) Sarakata No. 2 Unit	1994	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
(3) Sarakata No. 3 Unit																600	600	600	600	600	600	600
3. Balance (kW) (2 – 1)		**1,940**	**2,200**	**2,140**	**2,040**	**2,834**	**2,587**	**2,421**	**2,851**	**2,722**	**2,582**	**2,721**	**2,593**	**2,459**	**2,379**	**2,898**	**2,816**	**2,733**	**2,648**	**2,563**	**2,476**	**2,388**
4. Output of Largest Unit (kW)		520	520	720	720	1,000	990	1,000	990	980	970	961	951	941	932	923	914	904	895	886	878	869
5. Guaranteed Output (kW) (2 – 4)		2,620	2,920	2,720	2,720	3,354	3,337	3,301	3,175	3,149	3,124	3,099	3,074	3,049	3,024	3,600	3,576	3,552	3,529	3,506	3,483	3,460
6. Reserve Capacity (kW) (5 – 1)		**1,420**	**1,680**	**1,420**	**1,320**	**1,834**	**1,597**	**1,421**	**1,861**	**1,741**	**1,612**	**1,761**	**1,642**	**1,517**	**1,447**	**1,975**	**1,902**	**1,828**	**1,753**	**1,677**	**1,599**	**1,519**
7. Output of 2nd Largest Unit (kW)		300	300	520	520	684	990	980	970	961	951	941	932	923	914	904	895	886	878	869	860	851
8. Stable Reserve Supply Capacity (kW) (6 – 7)		**1,120**	**1,380**	**900**	**800**	**1,150**	**607**	**441**	**891**	**781**	**661**	**819**	**710**	**594**	**533**	**1,071**	**1,007**	**942**	**876**	**808**	**739**	**668**
																< Planned Year of Project Completion>					< Target Year >	

Notes

(1) Average annual growth rate of the maximum power demand (UNELCO)

- 1995 – 2001 (Result) : 7.8%
- 2002 – 2004 (Result) : 7.3%
- 2006 – 2007 (Forecast) : 7.0% (based on the result for 2002 – 2004)
- 2008 – 2015 (Forecast) : 3.0% (based on the estimated real GDP growth rate of the IMF; 2005 – 2010, 3.0%/year)

(2) The rate of the annual deterioration of diesel generators is assumed to be 1%/year.

Table 2.2-2 Power Supply and Demand Balance of Luganville Power System on Santo Island (Without New No. 3 Unit)

		Result												Forecast								
	Start Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Maximum Demand (kW)		**1,200**	**1,240**	**1,300**	**1,400**	**1,520**	**1,740**	**1,880**	**1,314**	**1,408**	**1,512**	**1,338**	**1,432**	**1,532**	**1,578**	**1,625**	**1,674**	**1,724**	**1,776**	**1,829**	**1,884**	**1,941**
Growth Rate (%)		-	3.3%	4.8%	7.7%	8.6%	14.5%	8.0%	-30.1%	7.2%	7.4%	-11.5%	7.0%	7.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
2. Generator Capacity (kW)		**3,140**	**3,440**	**3,440**	**3,440**	**4,354**	**4,327**	**4,301**	**4,165**	**4,130**	**4,094**	**4,059**	**4,025**	**3,990**	**3,957**	**3,923**	**3,890**	**3,857**	**3,824**	**3,792**	**3,760**	**3,729**
2.1 Luganville Diesel Power Station		**2,540**	**2,840**	**2,840**	**2,840**	**3,754**	**3,727**	**3,701**	**3,565**	**3,530**	**3,494**	**3,459**	**3,425**	**3,390**	**3,357**	**3,323**	**3,290**	**3,257**	**3,224**	**3,192**	**3,160**	**3,129**
No. 1 Unit 1000kw	2001	-	(No data for 1995 – 1998) -	-	-	**0**	**0**	**1,000**	**990**	**980**	**970**	**961**	**951**	**941**	**932**	**923**	**914**	**904**	**895**	**886**	**878**	**869**
No. 2 Unit 1000kw	1999	-	-	-	-	**1,000**	**990**	**980**	**970**	**961**	**951**	**941**	**932**	**923**	**914**	**904**	**895**	**886**	**878**	**869**	**860**	**851**
No. 3 Unit 720kw	1992	-	-	-	-	**684**	**677**	**670**	**664**	**657**	**650**	**644**	**638**	**631**	**625**	**619**	**612**	**606**	**600**	**594**	**588**	**582**
No. 4 Unit 520kw	1994	-	-	-	-	**495**	**490**	**485**	**480**	**475**	**471**	**466**	**461**	**457**	**452**	**448**	**443**	**439**	**434**	**430**	**426**	**421**
No. 5 Unit 520kw	1990	-	-	-	-	**475**	**470**	**466**	**461**	**456**	**452**	**447**	**443**	**438**	**434**	**430**	**425**	**421**	**417**	**413**	**409**	**404**
Others (Withdrawn in 2001)	1966	**2,540**	**2,840**	**2,840**	**2,840**	**1,100**	**1,100**	**100**														
2.2 Sarakata River Hydroelectric Power Station		**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**	**600**
(1) Sarakata No. 1 Unit	1994	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
(2) Sarakata No. 2 Unit	1994	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
3. Balance (kW) (2 – 1)		**1,940**	**2,200**	**2,140**	**2,040**	**2,834**	**2,587**	**2,421**	**2,851**	**2,722**	**2,582**	**2,721**	**2,593**	**2,459**	**2,379**	**2,298**	**2,216**	**2,133**	**2,048**	**1,963**	**1,876**	**1,788**
4. Output of Largest Unit (kW)		520	520	720	720	1,000	990	1,000	990	980	970	961	951	941	932	923	914	904	895	886	878	869
5. Guaranteed Output (kW) (2 – 4)		2,620	2,920	2,720	2,720	3,354	3,337	3,301	3,175	3,149	3,124	3,099	3,074	3,049	3,024	3,000	2,976	2,952	2,929	2,906	2,883	2,860
6. Reserve Capacity (kW) (5 – 1)		**1,420**	**1,680**	**1,420**	**1,320**	**1,834**	**1,597**	**1,421**	**1,861**	**1,741**	**1,612**	**1,761**	**1,642**	**1,517**	**1,447**	**1,375**	**1,302**	**1,228**	**1,153**	**1,077**	**999**	**919**
7. Output of 2nd Largest Unit (kW)		300	300	520	520	684	677	980	970	961	951	941	932	923	914	904	895	886	878	869	860	851
8. Stable Reserve Supply Capacity (kW) (6 – 7)		**1,120**	**1,380**	**900**	**800**	**1,150**	**920**	**441**	**891**	**781**	**661**	**819**	**710**	**594**	**533**	**471**	**407**	**342**	**276**	**208**	**139**	**68**

< Planned Year of Project Completion> (2009)　　< Target Year > (2014)

Notes

(1) Average annual growth rate of the maximum power demand (UNELCO)

- 1995 – 2001 (Result) : 7.8%
- 2002 – 2004 (Result) : 7.3%
- 2006 – 2007 (Forecast) : 7.0% (based on the result for 2002 – 2004)
- 2008 – 2015 (Forecast) : 3.0% (based on the estimated real GDP growth rate of the IMF; 2005 – 2010, 3.0%/year)

(2) The rate of the annual deterioration of diesel generators is assumed to be 1%/year.

2.2.2.2 Policies Regarding the Civil Engineering Work

The planned civil engineering work under the Project primarily serves the operation of the No. 3 generating unit and consists of the construction of a penstock and a tailrace. The scope of this work includes countermeasures to urgently repair the presently damaged ground around the Intake water canal and the repair of the access road for the purpose of primarily ensuring safety during the project implementation period.

(1) Urgent Countermeasures for the Intake Water Canal and Access Road

The ground of the Intake water canal is currently damaged at the intake area, the middle section and the head tank area. Landslides and cracks on the shoulders are observed at the access road near the hydroelectric power station, suggesting a high potential for collapse during the passage of trucks transporting materials or other work vehicles. Therefore, the urgent implementation of countermeasures to restore road safety is required. The main causes of the ground deformation at the canal and access road are believed to be earthquake, heavy rain and the subsequent rise of the river water level. Therefore, the basic policy is to introduce the necessary measures taking the causes and present situation into consideration. The inner face of the canal shows some deterioration of the concrete. However, as any repair work of the inner face requires the temporary suspension of the operation of the canal for the drainage of water, it is planned that the Vanuatu side will conduct this work taking the operation of the hydroelectric power station and the power supply and demand trend into consideration (see Appendix 4).

The overall cost to be borne by the Vanuatu side, including the repair cost of the inner face of the raceway, is approximately VUV 39.8 million. As this figure represents only some 8% of the total amount of the Sarakata Savings Fund, it does not pose any problem.

Fig. 2.2-2 shows the damage situation of the Intake water canal and the access road.

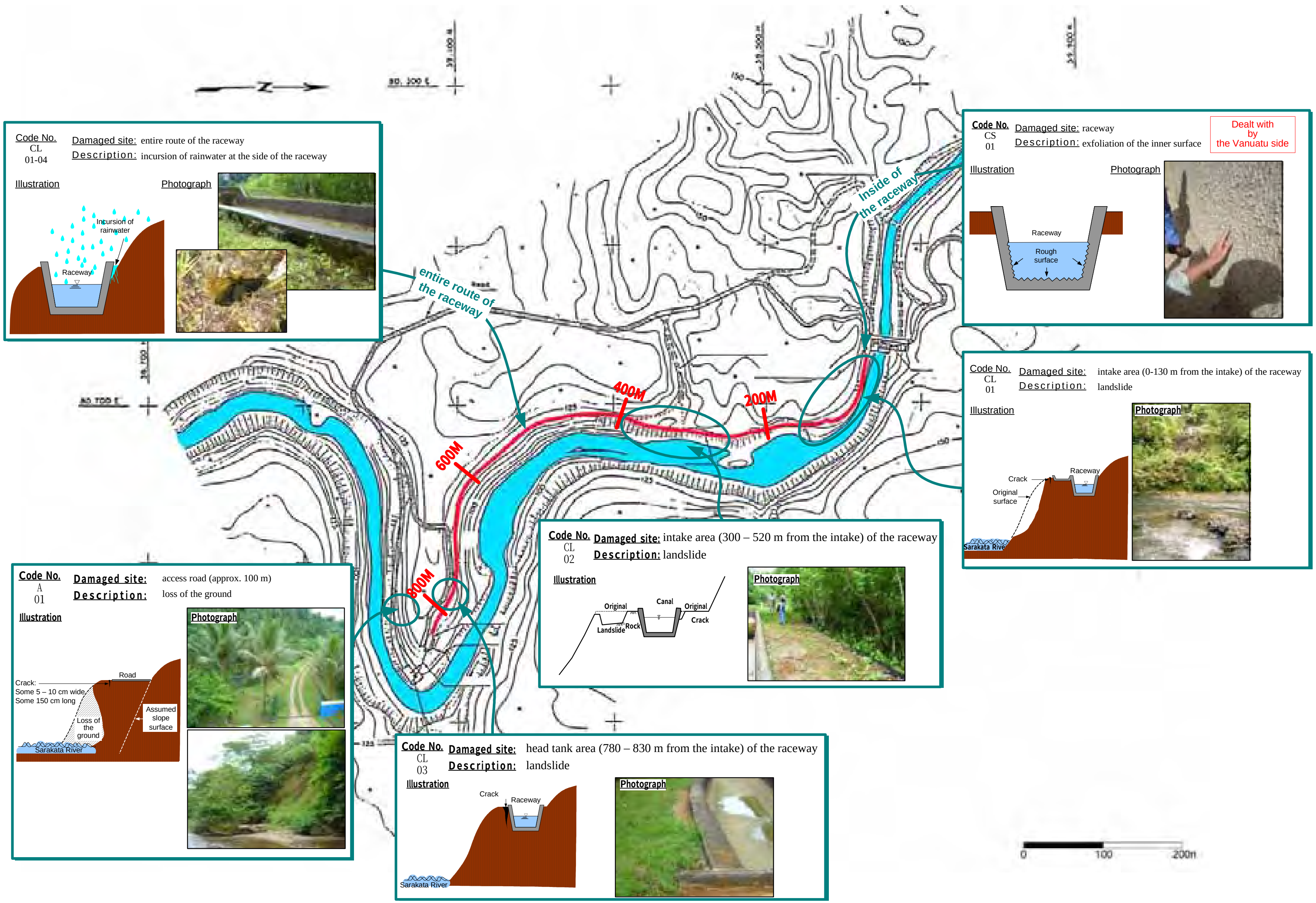


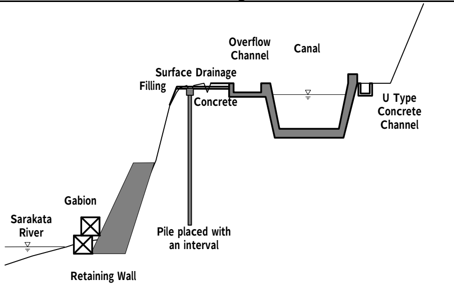
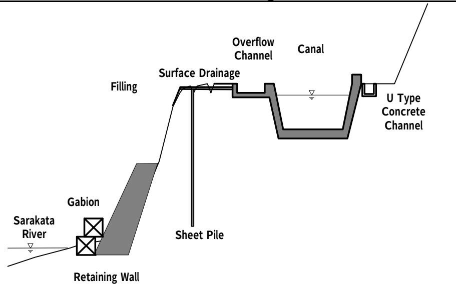
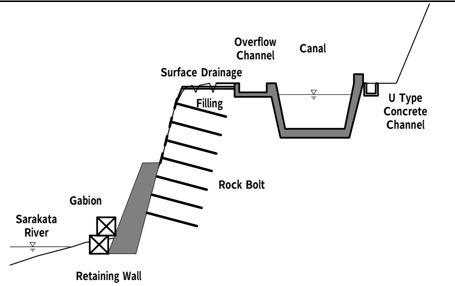
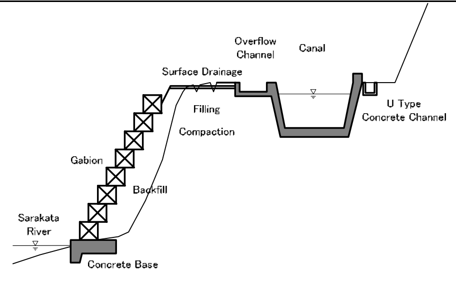
Fig. 2.2-2 Damage Situation of the Intake Water Canal and Access Road

(2) Selection of Countermeasures

The site survey found that the intake water canal had been constructed by cutting open a steep slope and that ground deformation, such as cracks, was occurring to the surrounding ground due to heavy rain and earthquakes, etc. in recent years. In addition, it can be inferred that such ground deformation is being accelerated by the incursion of rainwater into the cracks caused by earthquakes, etc.

There are two approaches to preventing the collapse of the intake water canal. One is direct prevention (prevention work) of the collapse and the other is the removal of the factors contributing to collapse. The former involves the use of piles and rock bolts, etc. to prevent the soil from collapsing. The latter involves the prevention of rainwater incursion into the ground. Because the ground deformation is caused by earthquakes and heavy rain, any countermeasures to prevent ground collapse must combine the above two approaches. Several methods exist to directly prevent a collapse and the suitable method must be selected in view of the situation of ground deformation and its causes as well as the conditions of the ground and structures. Table 2.2-3 compares the different methods.

Table 2.2-3 Comparison of Countermeasures

Method	Piling	Sheet Piling	Rock Bolts	Gabions
Illustration of the Work				
Outline	Piles are driven into the ground around the intake water canal to reinforce the ground. A boring machine is used as the base machine. The hammer pit is driven by the reciprocal movement of the piston caused by compressed air to dig a hole. Some space is required at the top section (side of the canal) to set up the machine.	Sheet piles are driven into the ground around the intake water canal to reinforce the ground. The sheet piles are driven by a pressure piling machine which travels along the sheet piles in place. The work can be conducted by a small crane to hoist the sheet piles. While the work cannot be conducted on hard ground, the combined use of a water jet machine makes this method applicable to ground of which the N value is up to approximately 80. Some space is required at the top section (side of the canal) to set up the machine.	Ground reinforcement materials (rock bolts) are inserted into the ground to reinforce the ground. Scaffolding is erected on the slope and a small boring machine is used to drill holes to insert reinforcing bars followed by the injection of grouting milk. As the work basically takes place on a slope, the work is difficult to implement on a long steep slope.	Gabions are placed at the collapsing site of the slope, followed by backfilling and compacting. The gabions are cubic-shaped wire cages filled by dry bed stones and crushed stones. They are often used to construct weirs for irrigation water. The embankments are protected by gabions piled on the slopes. The work starts at the bottom of the slope and involves the placement of gabions and backfilling in sequence.
Work Duration	Approx. 13 months	Approx. 9 months	Approx. 9 months	Approx. 9 months
Slope Protection Effect	Δ The piles are driven into the ground around the canal which the intention of securing the canal even if the slope is eroded.	X The sheet piles are driven into the ground around the canal with the intention of securing the canal even if the slope is eroded. Compared to steel pipes, the transportation volume of the materials is reduced. The use of sheet piles means that this method cannot be used for rock. The sheet piles may block the flow of rainwater in the ground and there is a risk of the entire structure collapsing due to the water pressure.	◎ This method is frequently used for slopes along a road or created ground. Intervals of some 1 m between the rock bolts should secure the slope. With the introduction of a concrete retaining wall, erosion by river water can be prevented.	Δ Gabions are frequently used for river protection in Japan. As local stones can be used, this method is suitable for urgent rehabilitation work. However, the use of gabions for the Project is difficult given that a height of more than 5 m is not recommended and that gabions are not used as permanent facilities in Japan (the ground height at the project site is more than 10 m).
Protection of Intake Water Canal	Δ As the piles are driven into the surrounding ground, this method has the effect of reinforcing the ground.	Δ As the sheet piles are driven into the surrounding ground, this method has the effect of reinforcing the ground. However, sheet piles stop the flow of rainwater through the ground even if a rainwater incursion prevention measure is employed. As a result, the entire structure may collapse and be washed away along with the soil.	O The intake water canal is constructed by placing concrete along the cut section of the slope. The structure of the canal is maintained as the ground behind the concrete walls provides support. The planned work focuses on the slope to secure the stability of the ground, thereby protecting the canal.	Δ This method is unsuitable for the permanent protection of the intake water canal.
Conclusions	Δ Apart from the use of a heavy machine, the transportation of the steel pipes, etc. is expensive. Suitable space for delivery and for the placement of the machine is required.	X The transportation cost is high. Suitable space for delivery and for the placement of the machine is required. There is a risk of collapse due to the pressure of rainwater.	O The stability of the surrounding ground can be secured and the cost-benefit effect is high. While the required space for working is normally small, the application of this method to a long steep slope is difficult due to the large scale of the required scaffolding.	X While the materials can be locally procured, the application of this method is difficult for slopes while the piling height of the gabions exceeds 5 m. The river width is narrowed by the gabions.

Based on the comparison results in Table 2.2-3, slope protection work using rock bolts is judged to be the most effective. The reasons are further explained below.

The prospect of delivery a heavy machine to the project site is limited because of the loss of soil supporting the intake water canal and the restricted work space available at the intake and side of the canal. The selection of the rock bolt method is, therefore, based on not only comparison of the cost and the technical issues involved but also on the likelihood that the work can be smoothly implemented within a limited work period.

(3) Civil Engineering Facilities Accompanying the Installation of the New No. 3 Generating Unit

As part of the work to install the new No. 3 generating unit (600 kW), the following work will also be conducted.

・ Installation of the penstock
・ Improvement of the tailrace

(2) Applicable Standards

As Vanuatu has no standards for the design of civil engineering facilities, the relevant Japanese standards will be used.

2.2.2.3 Policies Regarding the Building Plan

(1) Basic Policies

The building which houses the existing generators is designed to be able to accommodate a further generator to increase the overall generating capacity to 1,200 kW in the future as envisaged by the previous project. However, the existing hydraulic turbine room is not large enough for the installation of the planned 600 kW hydraulic turbine generator under the Project. In addition to the necessary space for installation, maintenance space to allow the overhaul and re-assembly of the generator is also required. All of the existing buildings have a RC structure and no signs of the degradation of the structural strength, such as concrete cracks and separation, are observed. Based on the above analysis, the following basic policies are adopted for the building plan.

① The existing powerhouse will be extended at the southwest side by 9.4 m to secure the installation space for the No. 3 generating unit and maintenance space. The span and height of this extended section will be the same as those of the existing building. The anchor reinforcing bars attached to the existing building for the purpose of extension are too corroded to be used. In addition, the structural characteristics of the existing building are not fully understood. Therefore, the extension section will be attached to the existing building using expansion joints.

② The finish of the new building is planned to be as similar as possible to that of the existing building to create a sense of harmony.

③ As the basement pit structure for the No. 3 generating unit has already been constructed under the previous project, this will be used as long as its functioning is not problematic.

(2) Applicable Standards

As Vanuatu has no building design standards, the relevant Japanese standards will be used for the structural design of the buildings.

2.2.2.4 Policies Regarding the Hydropower Generating Equipment

(1) Basic Policies

The hydraulic turbine generator to be installed under the Project is designed based on the following basic policies.

① The scope of the hydropower generating equipment will be the minimum but necessary equipment to simplify the generating system.

② Durability, safety and a high corrosion-resistance will be taken into full consideration in the selection of the hydropower generating equipment in view of its use for public power supply.

③ Auxiliary equipment will be the same models as that used for the existing generators as much as possible to achieve reliable operation and maintenance.

④ The planned hydraulic turbine generator will be designed to allow its independent operation and initial line charging so that frequency and voltage regulation, etc. can be conducted without relying on the diesel power station.

⑤ The hydraulic turbine generator will be able to operate at a light load (approximately 40%) as it is necessary for the hydroelectric power station to meet the power demand in the Luganville area without relying on the diesel power plant.

(2) Applicable Standards and Units

For the design of the Project, such international standards as IEC and ISO and Japanese standards will be used for the main equipment functions in consideration of compatibility with the existing equipment in Vanuatu. The International System of Units (SI) will be used for the units.

① IEC : applied to the main functions of electrical goods in general

② ISO : applied to units

③ JIS : applied to industrial products in general

④ JEC : applied to electrical products in general

⑤ JEM : as above

⑥ JCS : applied to electrical wires and cables

⑦ Hydraulic gate and penstock standards : applied to steel penstock

⑧ Other relevant Japanese and international standards : applied to electrical installation work in general

2.2.2.5 Outline of the Basic Plan

Table 2.2-4 outlines the basic plan for the Project based on the basic design policies described earlier (2.2.1).

Table 2.2-4 Outline of the Basic Plan

Item	Canal Repair Plan	Power Station Extension Plan
Target Site	Sarakata River Hydroelectric Power Station in Luganville City on Santo Island	As left
Facility Construction Plan	Implementation of the following work for the existing Intake water canal and access road 1. Urgent canal repair work: one complete set Target : existing canal (approximately 830 m long) Contents : slope rehabilitation using rock bolts, reinforcement of the canal side faces by piling and backfilling of the deformed ground, etc. 2. Access road safety improvement work: one complete set Target : access road to the power station (approx. 100 m long) Contents : slope rehabilitation work using rock bolts, etc.	Implementation of the following work in association with the installation of the new No. 3 generating unit. 1. Laying of penstock: one complete set (hydraulic pipes: approx. 40 m) 2. Tailrace improvement work: one complete set (concrete; for water discharge to Sarakata River) 3. Powerhouse extension work: one complete set ・ RC concrete two story ・ Building area : 117.32 m^2 ・ Total floor area : 226.22 m^2 ・ Overhead travelling crane (7.5 tons), lighting and other auxiliary equipment
Procurement and Installation of Equipment	-	Procurement and installation of the following equipment in connection with the installation of the new No. 3 generating unit 1. Hydraulic turbine generator: 1 set Hydraulic turbine : 660 kW or higher; horizontal shaft Francis turbine; 500 rpm; electric speed governor and frequency adjustment function; inlet valve; flywheel Generator : 3.3 kV; 750 kVA; 0.8 pf 500 rpm 2. Auxiliary equipment: one complete set (3.3 kV distribution panel; station service transformer; DC power panel; low voltage distribution panel) 3. Main step-up transformer: 1 set (installed in the Sarakata River Hydroelectric Power Station premises, For power transmission: 3.3/20 kV, 750 kVA with protection and connection panel) 4. Step-down transformer for Sarakata River Substation: 1 set (for step-down operation: 20/5.5 kV; 1,500 kVA)
Procurement Plan	-	Procurement of the following items for the maintenance of the No. 3 generating unit. 1. Maintenance tools: one complete set (special tools for the hydraulic turbine generator and instruments) 2. Spare parts: one complete set

2.2.2.6 Civil Engineering Facilities

(1) Urgent Countermeasures for the Existing Intake Water Canal

It is believed that countermeasures to rectify the deformed ground are urgently required for the existing canal. Landslides along the route of the canal can be classified into three sites, i.e. ① the intake area, ② the intermediate area and ③ the head tank area, based on the location and actual situation. The plan for the urgent canal area repair will aim at securing the stability of the canal against the possible collapse of the surrounding ground of the canal. Table 2.2-5 outlines the urgent countermeasures to stabilise the ground along the existing canal based on the current situation of the ground and the underlying concept of the envisaged countermeasures.

As shown in this table, the existing Intake water canal was constructed by cutting a steep slope and cracks and landslides have occurred due to heavy rain, earthquakes and an increased level of the river water.

As it is inferred that the landslides are progressing due to the incursion of rainwater into the cracks caused by earthquakes, etc., the urgent countermeasures will primarily focus on the proper drainage of rainwater. The test pit and boring survey results have confirmed that the ground along the canal has sufficient strength to support the canal except for some areas in the intermediate area.

The basic policies for the urgent countermeasures for improvement of the ground along the existing canal are explained in connection with each type of ground deformation confirmed.

①	Landslides	:	landslide prevention measure, rainwater incursion prevention measure and river bank erosion prevention measure if a landslide is being caused by river bank erosion
②	Cracks	:	filling and rainwater incursion prevention measure
③	Depression and subsidence	:	reinforcement of the ground (reinforcement by means of filling, compacting and/or piling, etc.) and rainwater incursion prevention measure

The eradication of weak sites along the entire route of the canal is also necessary.

The concrete measures to be introduced are slope reinforcement using rock bolts, etc. as a landslide prevention measure, the installation of ditches and drainage pits as a rainwater incursion prevention measures, the installation of levees as a river bank erosion prevention measure and piling at some sites with a low N value, which is the indicator for the strength and compactness of the ground, in the immediate area of the canal.

The basic design concept for the landslide prevention measure mentioned above is to provide the target ground with the same level of resistance to earthquakes as the existing and new civil engineering structures (weir, anchor block and powerhouse, etc.) of the Sarakata Hydroelectric Power Station. As the civil engineering structures of the said power station have an aseismatic design suitable for areas prone to relatively large-scale earthquakes in Japan, they have maintained a healthy state up to the present.

Basic Design Drawings C-01 - C-06 show the planned methods to deal with the situation at each site.

(2) Safety Measures for the Access Road

Collapse of the ground and cracks have been confirmed at the existing access road, making it essential to introduce measures designed to ensure the safety of work vehicles transporting equipment. Given the existence of landslides and large cracks, the landslide prevention measure will be applied based on the same principle adopted for the intake area of the canal for the purpose of preventing ground deformation and erosion (see Table 2.2-5).

The underlying concept for the countermeasures to improve the ground of the canal area and access road where ground deformation is observed is outlined in the following table.

Location	Raceway				Access Road
	Intake Area	Intermediate Area		Head Tank Area	
Distance	0 - 150 m	300 - 360 m	360 - 500 m	780 - 830 m	0 - 150 m
Ground Situation	・Landslide ・Crack	・Depression ・Crack (mountain side)	・Subsidence	・Crack	・Landslide ・Crack
Main Causes	・Earthquake; heavy rain; increased river water level	・Earthquake; heavy rain	・Earthquake; heavy rain	・Earthquake; heavy rain	・Earthquake; heavy rain; increased river water level
Required Countermeasures	・Landslide prevention ・Rainwater incursion prevention ・River bank erosion prevention	・Ground reinforcement ・Rainwater incursion prevention	・Ground reinforcement ・Rainwater incursion prevention	・Rainwater incursion prevention	・Landslide prevention ・River bank erosion prevention

Basic Design Drawings C-07 show the planned methods to deal with the situation.

(3) Tailrace

The tailrace is a facility to prevent ground erosion by water discharged from the outlet so that the water used for power generation can be safely returned to the river. For this purpose, the tailrace will have concrete foundations primarily aimed at preventing ground erosion while gabions will be installed to control the velocity of the discharged water. Erosion of the tailrace ground has currently been confirmed at the No. 1 and No. 2 generating units of the Sarakata River Hydroelectric Power Station. As this tailrace will serve all three generating units, including the No. 3 unit to be newly installed under the Project, the entire tailrace will be improved under the Project. The location of the tailrace is shown on Basic Design Drawing L-01.

(4) Penstock

The penstock for the new generating unit will be made of steel as in the case of the existing No. 1 and No. 2 units. The design of the penstock is required to ensure its structural stability against its own weight as well as acting internal and external pressures. This steel penstock will also be protected to prevent conspicuous deterioration due to the natural conditions in Vanuatu. The planned specifications of the penstock are given below.

Material	:	steel (SS 400)
Inner diameter	:	1,200 mm
Thickness	:	≧ 6 mm

(5) Foundations for Penstock (Anchor Blocks and Supports)

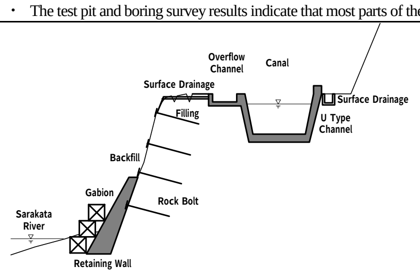
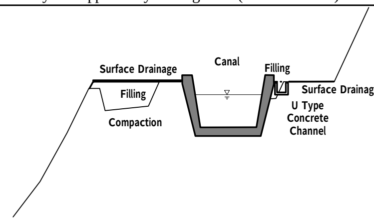
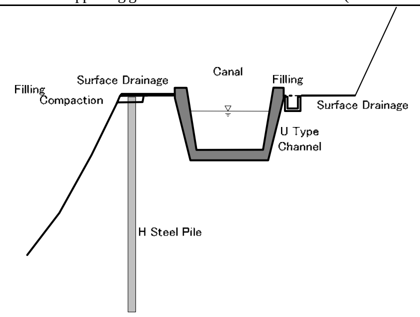
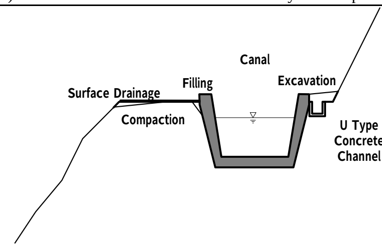
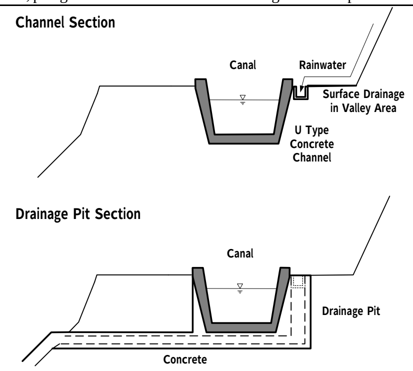
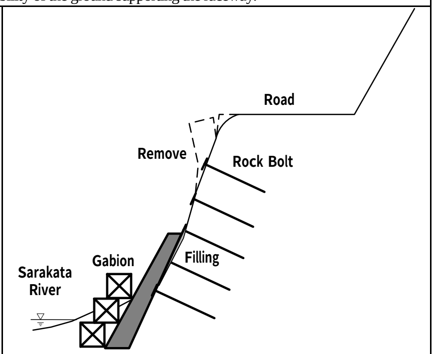
The foundations for the penstock will be designed to ensure that it has a stable structure, preventing any falling, sliding or sinking of the penstock due to the acting load. The location of the penstock is shown in Basic Design Drawing L-01.

(6) Repair of the Inner Face of the Intake Water Canal (Undertaking by the Vanuatu Side)

The repair of the inner face of the canal can be conducted in a number of ways, including the pasting of FRP and a thin coating of resin mortar. The most suitable repair method should be selected in consideration of the need not to reduce the cross-sectional area of the water channel, to use a material which is highly resistant to yearly changes and to be economical. The most common method to meet these needs is a thin coating of the inner face with resin mortar.

The water quality analysis results for Sarakata River (Appendix 11) indicate a much higher (4 - 5 times) concentration of hydrogen carbonate ion (154 mg/L) and calcium (36.8 mg/L) than the corresponding average value for Japanese rivers (31 mg/L and 8.8 mg/L respectively). As hydrogen carbonate ion dissolves the calcium contained in cement, the selection of a high strength non-shrink polymer cement mortar containing a special fibre is desirable as the type of mortar to be used for the planned repair work.

Table 2.2-5 Urgent Measures to Improve the Ground Around the Existing Intake Water Canal

No.		CL-01	CL-02		CL-03	CL-01-04	A-01
Location		Intake area	Intermediate area		Head tank area	Mountain side of the raceway	Access road
Distance (from the intake)		5 – 135 m (130 m)	300 – 360 m (60 m)	360 – 520 m (160 m)	780 – 830 m (50 m)	0 – 830 m (830 m)	100 m from the gate for the powerhouse
Situation (state of deformation)	Photograph	 			 		 
	Explanation	・ Partial loss of the ground ・ Crack	・ Subsidence	・ Subsidence	・ Crack ・ Gap between the ground and the structure	・ Gap between the ground and the structure	・ Partial loss of the ground ・ Crack
Inferred main causes		Heavy rain (March, 2005; 950 mm); earthquake (Jan., 2001: MS7.1); rise of the river water level (March, 2004; water depth of 4 m at the power station)					
Necessity for improvement measures		Apart from some sections, the structural stability of the raceway is provided by the ground. However, landslides have been in progress due to severe natural phenomena (heavy rain, earthquakes and rise of the river water level) in recent years. At the intake area in particular, the distance from the structure to the crack is 90 m while that from the structure to the landslide area is only approximately 2.0 m. Urgent countermeasures are accordingly necessary to secure the stability of the raceway.					The crack has reached the roadside while partial loss of the ground has been confirmed. The implementation of safety measures is necessary to ensure the safe passage of work vehicles.
Ground conditions (test pit)						-	-
		Mostly gravel mixed with clay and sand with some clay spots	Mostly oceanic limestone although the intercalation of clay is found at the lower level	Outcropping of oceanic limestone with the distribution of gravel mixed with clay and sand on the valley side	Gravel mixed with clay and sand	-	-
Height of the ground from the river bed		5 – 15 m	≥ 20 m	≥ 20 m	≥ 20 m	-	5 – 10 m
Underlying concept of envisaged countermeasures		・ At the intake area where partial loss of the ground and a crack are observed, the stability of the slope will be improved using a retaining wall and rock bolts to control any further loss and collapse of the ground. ・ Measures to drain rainwater will be implemented along the entire route of the raceway. At sites where subsidence is observed, filling and compaction of the ground will be conducted. ・ The test pit and boring survey results indicate that most parts of the raceway are supported by stable ground (value of N ≥ 30) but the value of N of the supporting ground is less than 30 at one section (420 m – 500 m) in addition to a short distance from the raceway to the slope. At this section, piling will be conducted to reinforce the ground to improve the stability of the ground supporting the raceway.					
Improvement measures							
		・ Surface protection and gabions (to combat river bank erosion) ・ Rock bolts (ground protection) ・ Surface drainage work (to combat erosion by rainwater) ・ Filling and compaction to eliminate the weak section ・ Work length: 130 m	・ Surface drainage work (to combat erosion by rainwater) ・ Filling and compaction ・ Work length: 50 m	・ Surface drainage work (to combat erosion by rainwater) ・ Piling (reinforcement of the ground near the raceway: 80 m) ・ Filling and compaction ・ Work length: 160 m	・ Surface drainage work (to combat erosion by rainwater) ・ Filling and compaction ・ Work length: 50 m	・ Rainwater drainage system (to combat erosion by rainwater) ・ Work length: 830 m	・ Surface protection and gabions (to combat river bank erosion) ・ Rock bolts (ground protection) ・ Filling and compaction to eliminate the weak section ・ Work length: 100 m

2.2.2.7 Building Plan

(1) Plan Contents

In view of the fact that the building to be constructed under the Project is an extension to an existing building, the span and floor height will match those of the existing building. Another essential point is to plan that the entire building, including the new extension, uniformly functions. The details of the planned extension to the existing powerhouse are as follows.

Structure and scale	:	RC two storys
Type of foundations	:	spread foundation type independent footings
Area	:	building area of 177.32 m^2; total floor area of 266.22 m^2

(2) Site and Facility Layout Plan

As the building site, including the part designated for the No. 3 unit, was prepared under the previous project, the new extension will be planned in accordance with the existing layout plan. As part of the work to improve the tailrace under the Project, steps from the ground level of the building to the tailrace will be constructed to provide an access passage for the purpose of tailrace maintenance.

(3) Main Functions and Building Plan of the Facilities

1) Generator Room

The generator room will house the No. 3 generating unit and its auxiliary equipment and will be given sufficient space to allow easy equipment inspection and maintenance. Given the measurements of the generator of approximately 8.5 m in length, 2.8 m in width and 3.0 m in height, the required length of the building extension is approximately 9.4 m provided that maintenance space of some 4.5 m wide is secured at the side of the generator. The existing building has a RC wall to the side to be extended and this wall will be dismantled to allow the extended section to function integrally with the existing section.

An overhead crane (manually-operated monorail crane) which is capable of lifting up to 7.5 tons will be installed for the purpose of repairing and replacing heavy components of the generator.

2) Electric Room

The electric room will have 3.3 kV distribution panels, the position of which will be carefully planned for its easy inspection and maintenance. As the first floor has no space for the installation of the electric panels which will be necessary due to the addition of the new generating unit, the new extension will be a two story building with the distribution panel installed on the second floor.

3) Staircase

The staircase from the first floor to the second floor will be a major structure because of the floor height. A steel frame structure will be employed for this structure in view of better workability. The staircase will be located in the generator room to avoid its deterioration or damage due to the external weather conditions.

(4) Floor Area and Facilities of Each Room

Table 2.2-6 Floor Area

(Unit: m^2)

Room	Existing Section	Extended Section	Total	Facilities
1F Generator Room	115.20	62.12	177.32	Lighting; ventilation
2F Monitoring Room	39.32	-	39.32	Lighting; air-conditioning
2F Conference Room	23.68	-	23.68	Lighting
2F 3.3 kV Distribution Panel Room	-	25.90	25.90	Lighting; air-conditioning

(5) Specifications of the Main Structural Parts

Table 2.2-7 Specifications of Main Structural Parts

Structural Part	Specifications
Foundations	RC spread foundations
Earth floor; cable pit	RC
Floor on the first floor	RC
Pillars, beams and walls	RC
Staircase	Steel frame

(6) Finish

1) External Finish

Table 2.2-8 External Finish

Part	Finish
Roof	Waterproof coating + protective concrete (80 mm)
Pillars, beams and walls	Concrete base + resin paint finish

2) Internal Finish

Table 2.2-9 Internal Finish

Room	Part	Finish
1F Generator Room	Floor	Concrete trowel finish; dustproof coating
	Walls	Exposed concrete
	Ceiling	Exposed concrete
2F Monitoring Room	Floor	Concrete trowel finish; dustproof coating
	Walls	Exposed concrete; EP coating
	Ceiling	Exposed concrete; EP coating
2F Conference Room	Floor	Concrete trowel finish; dustproof coating
	Walls	Exposed concrete; EP coating
	Ceiling	Exposed concrete; EP coating
2F 3.3 kV Distribution Panel Room	Floor	Concrete trowel finish; dustproof coating
	Walls	Exposed concrete; EP coating
	Ceiling	Exposed concrete; EP coating

(7) Cross-Sectional Plan

The generator room will have a sufficient height to hoist components with the 7.5 ton overhead crane which will be installed for the purpose of turbine and generator maintenance. The cross-section will be large enough to allow some 2 m clearance for hoisting operation of the crane.

(8) Structural Plan

1) Main Frame of the Building

The main frame of the extension building will be made of RC as in the case of the existing building.

2) Foundation Structure

The boring survey results indicate the existence of a loose cohesive soil layer underneath the some 1 m thick top soil layer at the planned site for the extension building. A cohesive soil layer mixed with small gravel lies below GL -3 m. The N value of this layer is 15 or higher. For the foundations of the new building, spread foundations using this layer as the supporting layer are planned.

(9) Building Services Plan

The building services for the main rooms are described below. No alteration will be made to the existing building.

1) Lighting and Power Sockets

In principle, indoor lighting will be provided by fluorescent lamps. In the case of the generator room, wall-mounted lighting will be installed to match the layout of the lighting fittings in the existing building. In regard to outdoor lighting, the minimum number of outdoor lighting fittings will be installed along the main inspection route. The standard illuminance will be 200 lux in the floor surface of the generator room, 500 lux at the desk top in the monitoring room and 300 lux at the desktop in the office. For other rooms, these reference illuminances will be used where appropriate. Single phase 220 V power sockets (earthed) will be installed in each room. The generator room will be provided with extra three phase 380 V power sockets (earthed).

2) Air-Conditioning System

A separate type air-conditioning system will be installed in the 3.3 kV distribution panel room.

3) Ventilation System

A ventilation system (wall-mounted with an external hood) will be installed in the upper section of the generator room as in the case of the existing building.

4) Fire-Fighting Equipment

ABC fire extinguishers (10 kg type) will be provided in the extended section of the generator room and the 3.3 kV distribution panel room for initial fire fighting.

5) Overhead Crane

An overhead crane (monorail crane) (hoisting capacity: 7.5 tons) will be installed for inspection and maintenance of the hydraulic turbine and generator components.

6) Lightning Rod

A lightning rod will be installed on the extended section of the powerhouse.

(10) Foundation Plan

Appropriate foundations and a cable pit will be provided for the hydraulic turbine, generator, auxiliary equipment and electrical equipment, etc.

2.2.2.8 Hydroelectric Power Generation Equipment Plan

(1) Underlying Concept for the Selection of the Hydraulic Turbine Generator

The civil engineering facilities for the hydroelectric power station have already been constructed under the previous project. As such, the water level of the head tank and the water level of the tailrace are already determined and cannot be altered. Accordingly, it is necessary for the design of the new hydraulic turbine generator to refer to the existing facilities.

The planned capacity of the No. 3 generating unit is double the capacity of each of the hydraulic turbine generators installed under the previous project. Assuming that the loss of the head in the penstock and the discharge loss in the tailrace are similar to those of the existing generators, the effective head of the No. 3 unit is set at 27.3 m which is 0.5 m less than the effective head adopted by the previous project (27.8 m) as the water level of the tailrace for the No. 3 unit is set at 0.5 m higher than that for the existing No. 1 and No. 2 generating units. The existing Intake water canal is designed on the basis of a maximum water consumption by the No. 3 generating unit of 2.9 m^3/sec and, therefore, this value is adopted for the present Project.

The specific speed of the hydraulic turbine based on the above conditions is 206 assuming a turbine speed of 500 rpm. This value is similar to 213 of the 300 kW hydraulic turbines installed under the previous project, offering a good cavitation characteristic as in the case of the No. 1 and No. 2 units currently in operation ("cavitation" means air bubbles occurring inside the hydraulic turbine and is believed to cause corrosion of the turbine). The runner and guide vane will be made of stainless cast steel as in the case of the previous project to maintain the anti-cavitation characteristic.

As in the case of the previous project, the mechanism to operate the guide vane which regulates the inflowing water to the hydraulic turbine will use an electric servo motor which does not require the oil pressure system. The inlet valve will be an electric butterfly inlet valve. Simplification is also an important feature of the generator as a brushless exciter and oil-less bearings will be used to minimise the necessity for inspection and maintenance. Moreover, a control unit which has a frequency regulation and other necessary functions will be installed and the generator will have a coaxial flywheel. A line charging function will be made available in the case that it is necessary for the No. 3 generating unit to operate independently.

(2) Transforming Equipment

1) Power House Transforming Equipment at the Sarakata River Hydroelectric Power Station

As part of the installation of the new No. 3 generating unit under the Project, one main step-up transformer (3.3/20 kV, 750 kVA) required for the transmission of power to Luganville City will be installed at the Sarakata River Hydroelectric Power Station. Since the 20 kV distribution panel for transmission, the 20 kV distribution panel installed by the Vanuatu side at its own expense has built-in capacity to deal with the electric power generated by the No. 3 hydraulic turbine generator planned under the Project. This panel will, therefore, be commonly used for the new generator. However, a new protection and connection panel will be procured under the Project for the connection to the existing 20 kV circuit breaker panel.

2) Step-Down Transformer at the Sarakata River Substation

The Sarakata River Substation located in Luganville City has the function of receiving power from the Sarakata River Hydroelectric Power Station via a 20 kV transmission line and stepping down to 5.5 kV for distribution to the city. Although this substation has one transformer (800 kVA), the capacity is only sufficient to serve the existing hydraulic turbine generators installed under the previous project. This situation makes expansion of the transforming capacity of the substation necessary following the planned installation of a new generator under the Project. Because of the difficulty of parallel operation of two transformers, there should be a single step-down transformer of which the capacity corresponds to the maximum power demand. For this reason, the existing transformer will be replaced by a new 1,500 kVA substation transformer.

This new transformer is of outdoor type and will be installed at the currently vacant space on the premises of the Sarakata River Substation.

(3) Scope of Supply of Equipment for Hydroelectric Power Generation

The scope of equipment procurement for hydroelectric power generation is shown in Table 2.2-9. The one-line diagrammes for the Sarakata River Hydroelectric Power Station and the Sarakata River Substation, the layout plan for the Sarakata River Hydroelectric Power Station, the plan for the powerhouse of the Sarakata River Hydroelectric Power Station and the cross-section of the powerhouse at the Sarakata River Hydroelectric Power Station are shown in Basic Design Drawings E-01, L-01, M-01 and M-02 respectively.

Table 2.2-10 Scope of Supply of Equipment for Hydroelectric Power Generation

Equipment	Quantity	Specifications		
① Turbine	1 set	Type	:	horizontal shaft Francis turbine
		Maximum output	:	≧ 660 kW (maximum output by this single turbine)
		Effective head	:	27.3m
		Water volume	:	2.9 m^3/sec
		Speed	:	500 rpm
		Material	:	stainless cast steel for the runner and guide vane (same as the previous project: SCS-5 for the runner and SCS-1 for the guide vane)
		Inlet valve	:	1,000 mm Dia, electric butterfly valve (with cone pipe), AC or DC operated
		Speed governor	:	electric speed governor (with PMG), frequency regulating function
		Servo motor	:	electric servo motor (DC operated)
		Other	:	operable with a 40% load or higher
② Synchronous generator	1 set	Type	:	horizontal shaft air-cooled revolving-field type, 3.3 kV, 750 kVA, 500 rpm, 12 poles, power factor of 0.8, 50Hz
		Exciter	:	brushless AC exciter
		Automatic voltage requlator		
		Separate flywheel		
		3.3 kV cable and others		
		Other	:	possession of a function to deal with fluctuations of the system load, capable of line charging
③ 33 kV distribution panel	1 set	Main control panel: with meters and switches ・ When the in-house AC supply is lost, the guide vane is closed by the DC power source. ・ With an automatic synchronising device and capable of independent start-up function		
		Protective relay panel for the generator (installed inside the circuit breaker cubicle)		
		3.3 kV circuit breaker cubicle		
		Circuit breaker	:	VCB 3.6 kV, 600 A, surge absorbing type
		3.3 kV disconnecting switch cubicle		
④ Station transformer	1 set	3.3 kV/380 - 220 V, 50 kVA, mould type, stored in the cubicle		
⑤ Low voltage distribution panel	1 set	380 - 220 V, installed at the back of the main panel		
⑥ DC power source	1 set	More than 30 AH with a floating charging device		
⑦ Main transformer	1 set	Outdoor oil-filled self-cooling type, 3.3/20 kV, 750 kVA, three phases, 50 Hz, Δ -Y		
		Protection and connection panel (including protective device) for the main transformer, installed inside the existing concrete house		
⑧ Step-down transformer for the substation	1 set	Outdoor type	:	20 kV/5.5 kV, 1,500 kVA, three phase, 50 Hz, oil-filled Y - Δ
		With an automatic tap changer (on the high voltage side) (including a operating power source)		
		20 kV and 5 kV cables, accessories		

(4) Maintenance Tools and Spare Parts

Under the Project, the Japanese side will procure the maintenance tools required for the proper operation and maintenance of the No. 3 generating unit and spare parts to support the operation of the unit for two years.

Table 2.2-11 Maintenance Tools and Spare Parts to be Provided Under the Project

Item	Description	Quantity
① Maintenance tools	(1) Tools for the overhauling and assembly of the turbine	1 set
	(2) Simplified noise meter	1 set
	(3) Simplified vibration meter	1 set
	(4) Simplified speed meter	1 set
	(5) Phase rotation meter	1 set
	(6) Insulation resistance tester (megger)	1 set
	(7) Multi-raster	1 set
	(8) Clamp meter	1 set
② Spare parts	(1) Packings and O-rings, etc. for the turbine	100%
	(2) Bearings for the hydraulic turbine generator	1 set
	(3) Limit switches for the inlet valve	1 each
	(4) Pressure, negative pressure and shaft temperature gauges	1 each
	(5) Printed circuit board for control (CPU)	1 set
	(6) Servo driver	1 set
	(7) Lamps and fuses	100%
	(8) Relays and MCCBs	1 each
	(9) Silica gel	100%

2.2.3 Basic Design Drawings

The basic design drawings for the facilities and equipment covered by the scope of the Project are listed below.

1. Urgent Repair Plan for Intake Water Canal

1.1 General

C-01 Countermeasures for Landslides

1.2 Civil Engineering Work

C-02 Landslide Protection in Intake Area
C-03 Landslide Protection in Middle Area (1/2)
C-04 Landslide Protection in Middle Area (2/2)
C-05 Landslide Protection in Head Tank Area
C-06 Drainage System for Rainwater
C-07 Protection in Access Road Area

2. Hydroelectric Power Station Expansion Plan

2.1 General Plans

G-01 General Layout Plan
E-01 Oneline Diagramme

2.2 Equipment Plans

M-01 Sarakata River Hydroelectric Power Station: Plan of Powerhouse
M-02 Sarakata River Hydroelectric Power Station: Cross-Section of Generator & Turbine

2.3 Building Plans

B-01 Sarakata River Hydroelectric Power Station: Finishing Schedule
B-02 Sarakata River Hydroelectric Power Station: Plans and Section
B-03 Sarakata River Hydroelectric Power Station: Elevation
B-04 Sarakata River Hydroelectric Power Station: Fitting Schedule

B-05 Sarakata River Hydroelectric Power Station: Foundations, Beam Plan

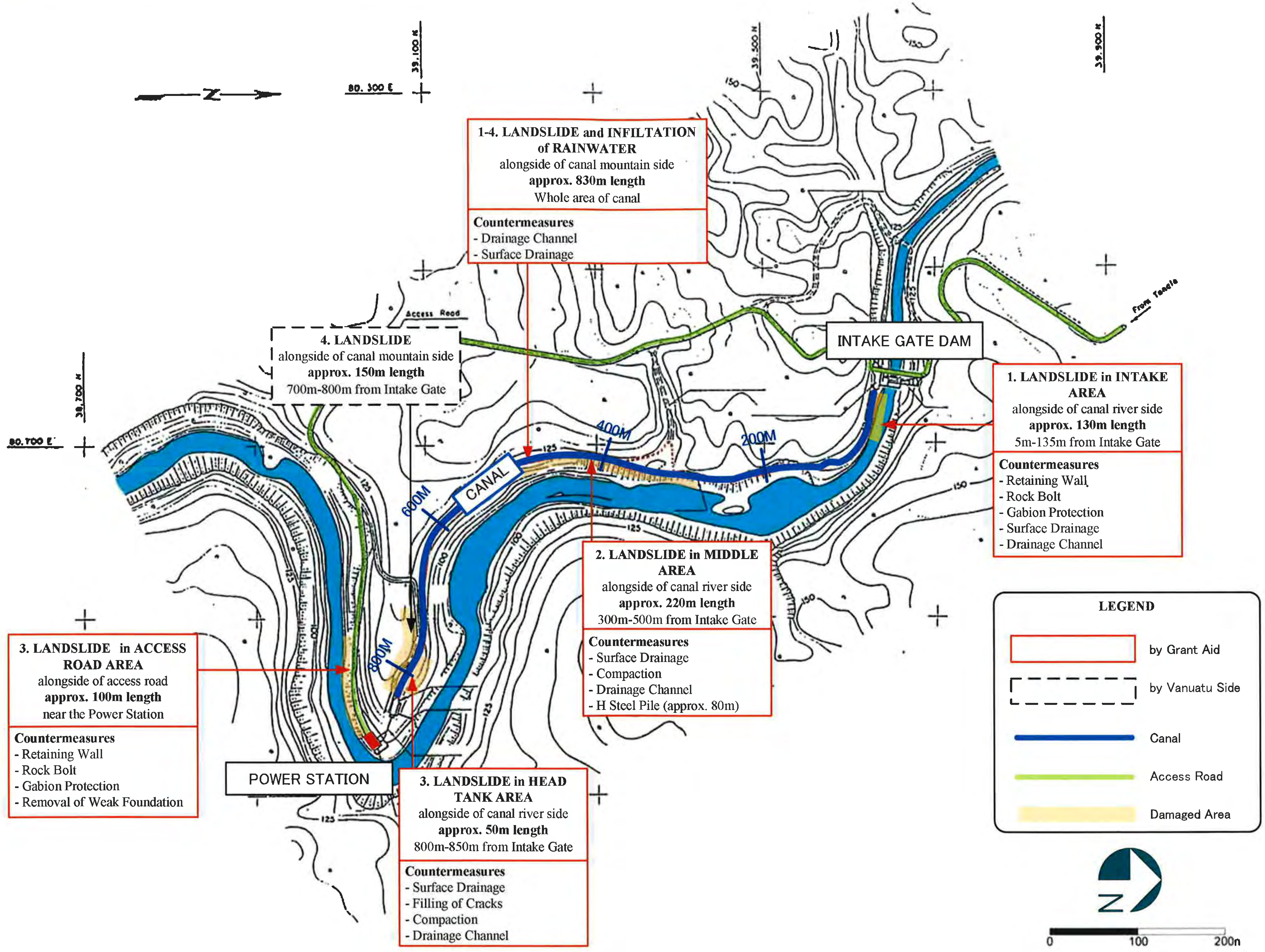
B-06 Sarakata River Hydroelectric Power Station: Framing Elevation

2.4 Civil Engineering Plan

L-01 Sarakata River Hydroelectric Power Station: Layout Plan

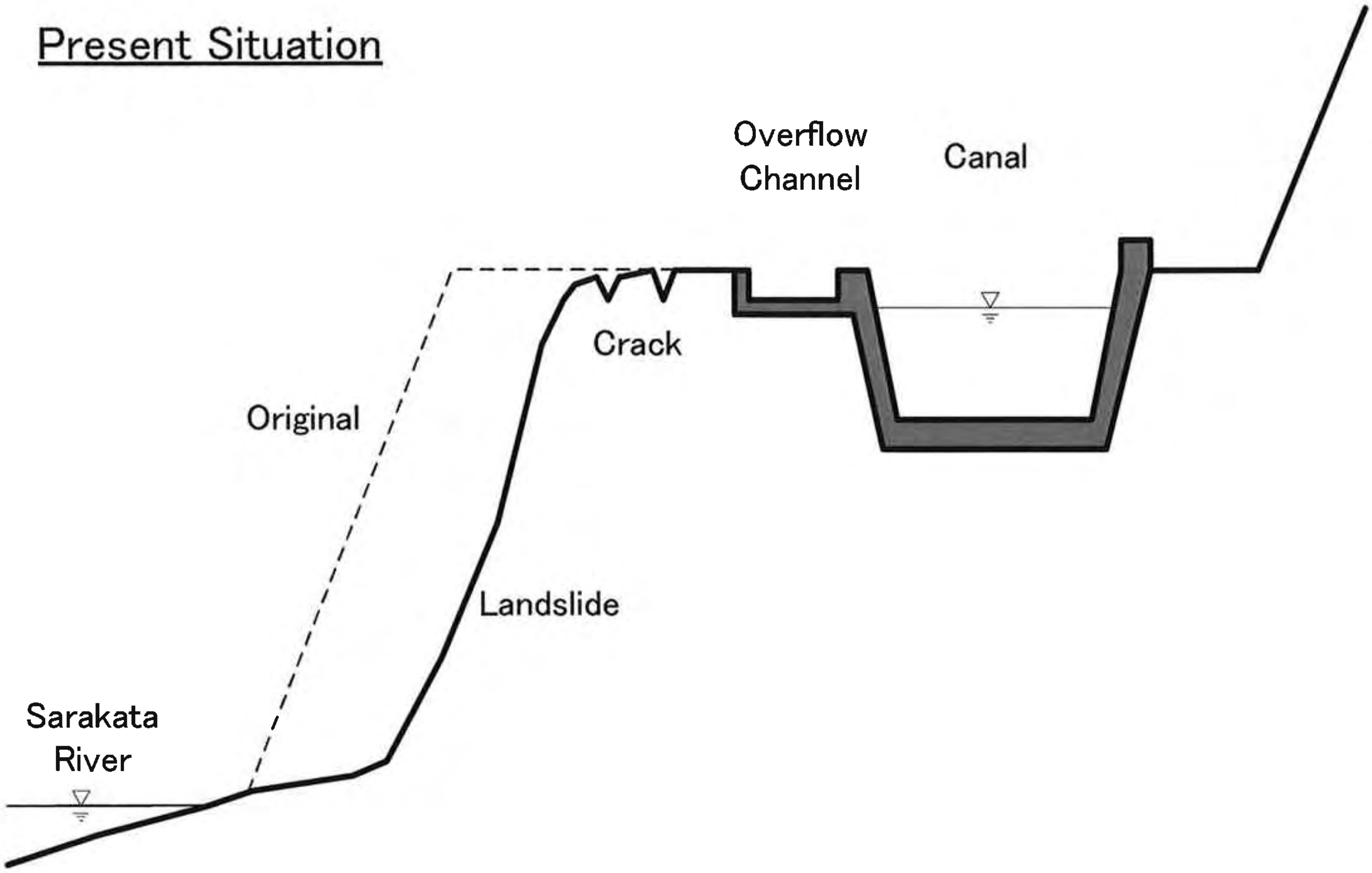
2.5 Sarakata River Substation Expansion Plan

S-01 20 kV Step-Down Existing Sarakata River Substation: Layout Plan

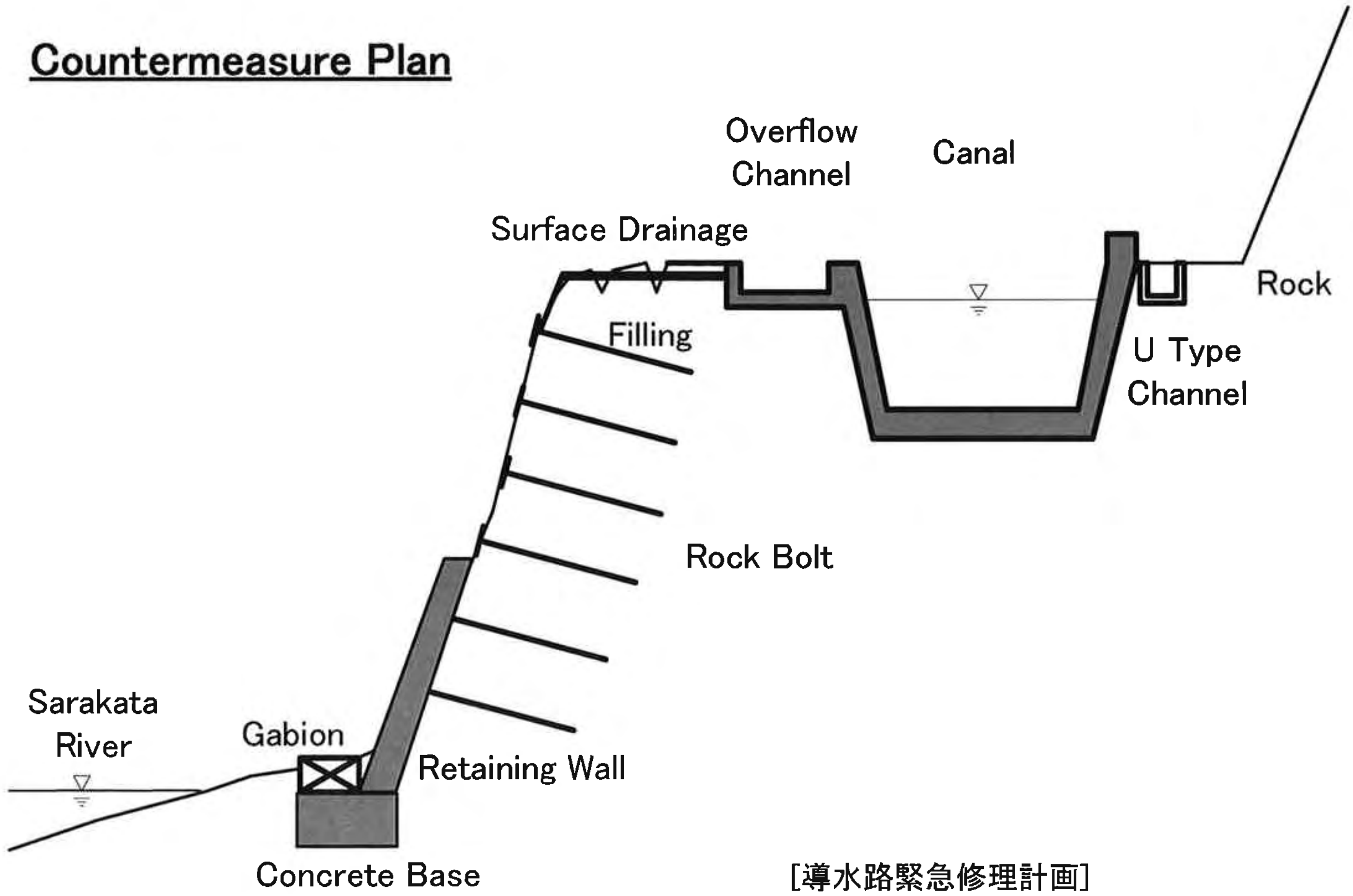


[導水路緊急修理計画]
C-01 地盤変状対策全体図
Countermeasures against Landslides

Present Situation



Countermeasure Plan

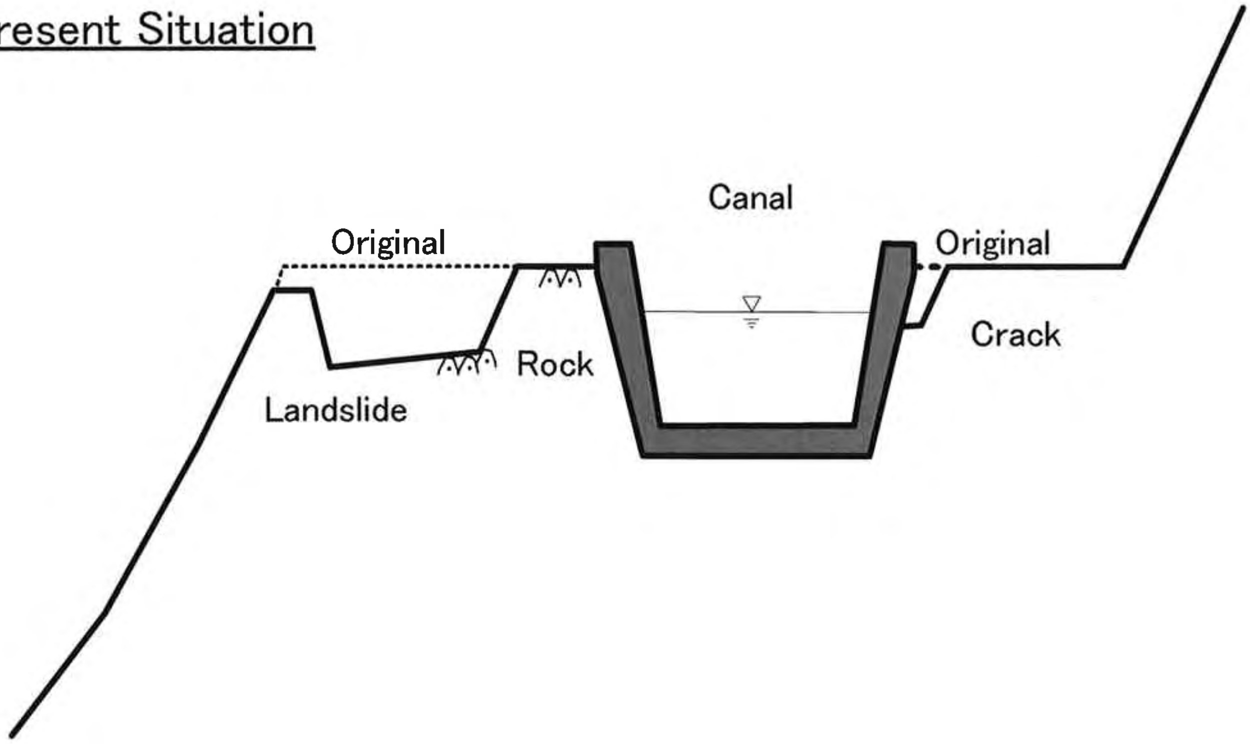


[導水路緊急修理計画]

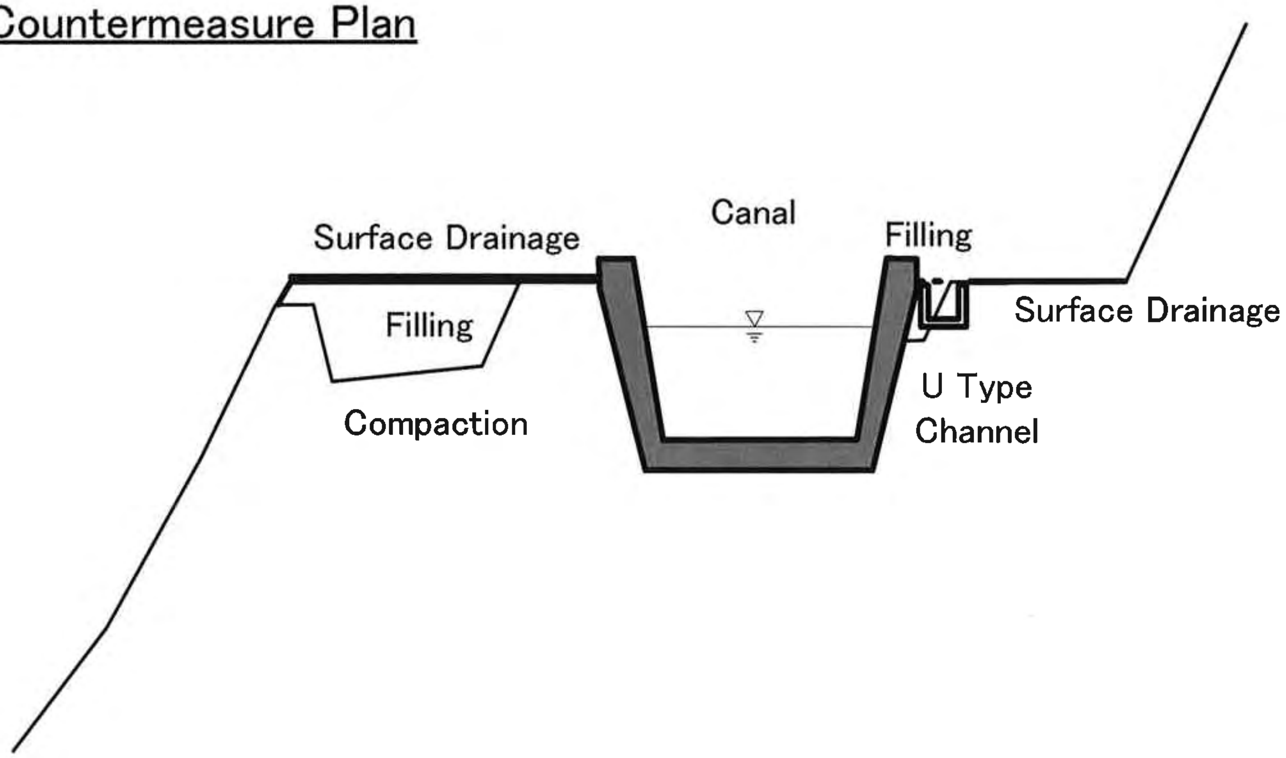
C-02 取水口地盤変状対策

Landslide Protection in Intake Area

Present Situation

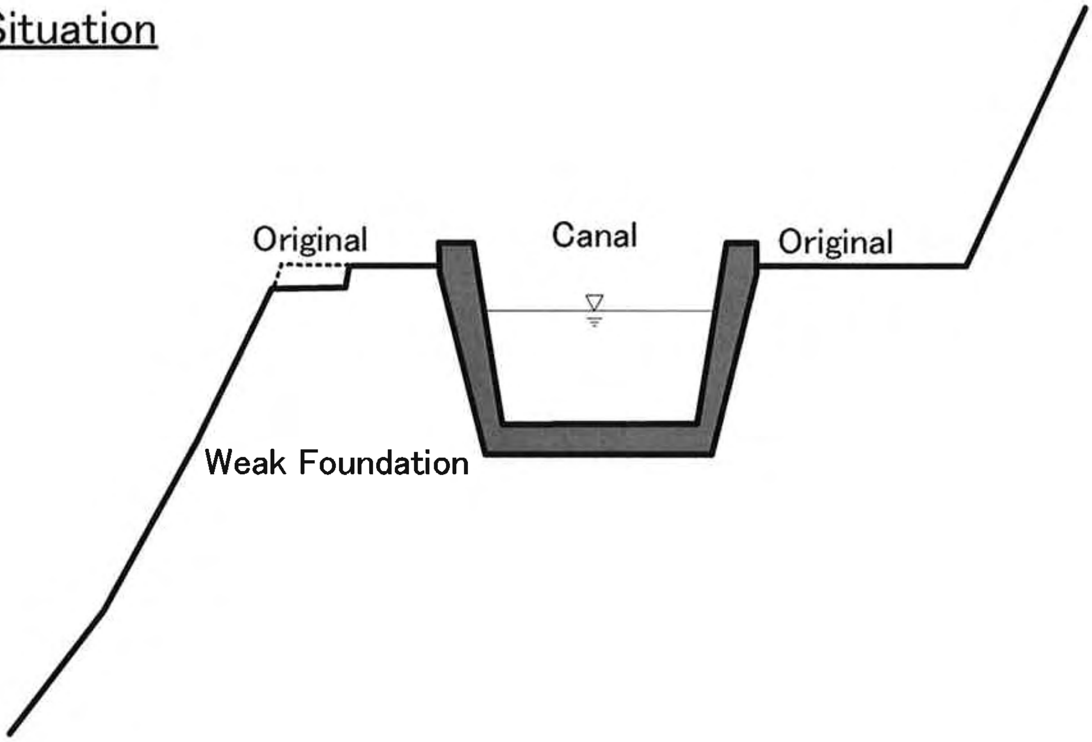


Countermeasure Plan

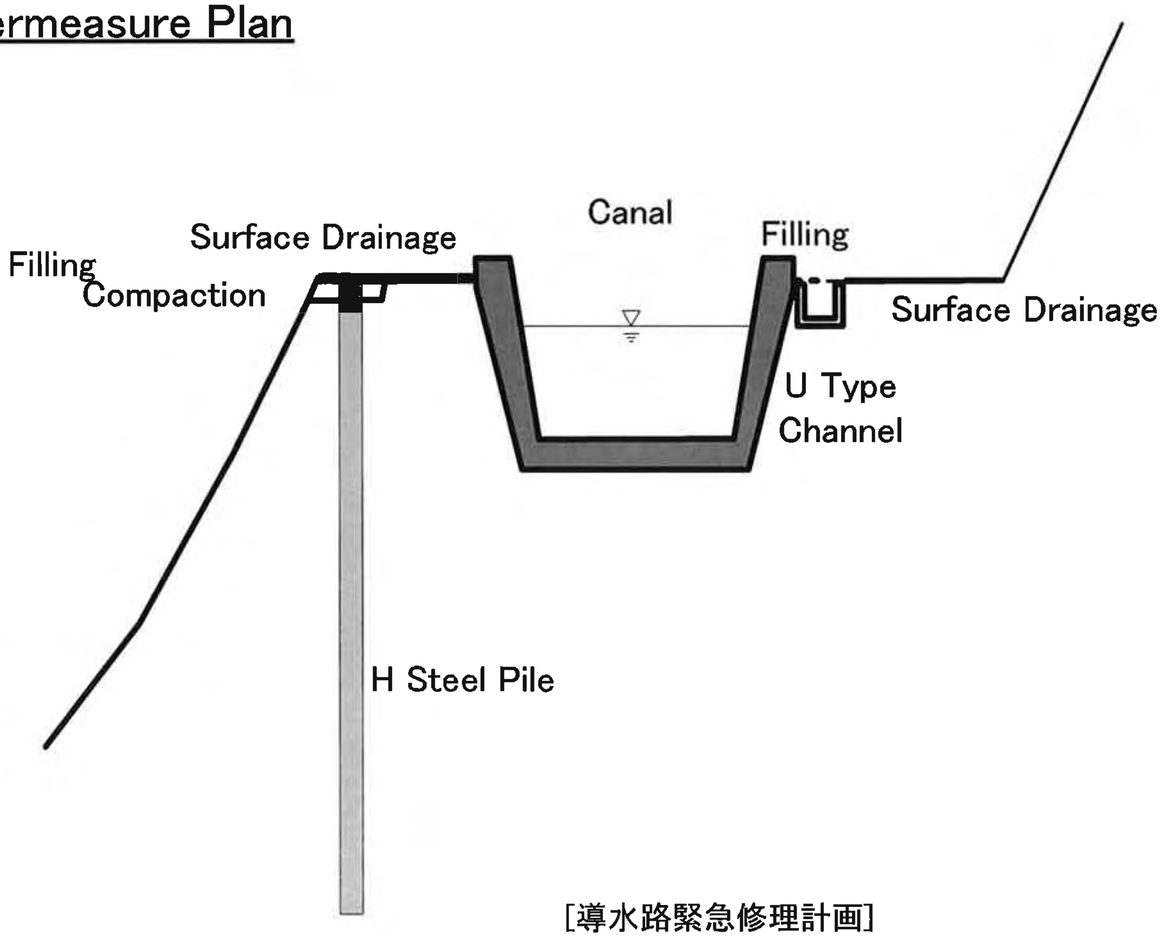


[導水路緊急修理計画]
C-03 中間部地盤変状対策-1/2
Landslide Protection in Middle Area-1/2

Present Situation

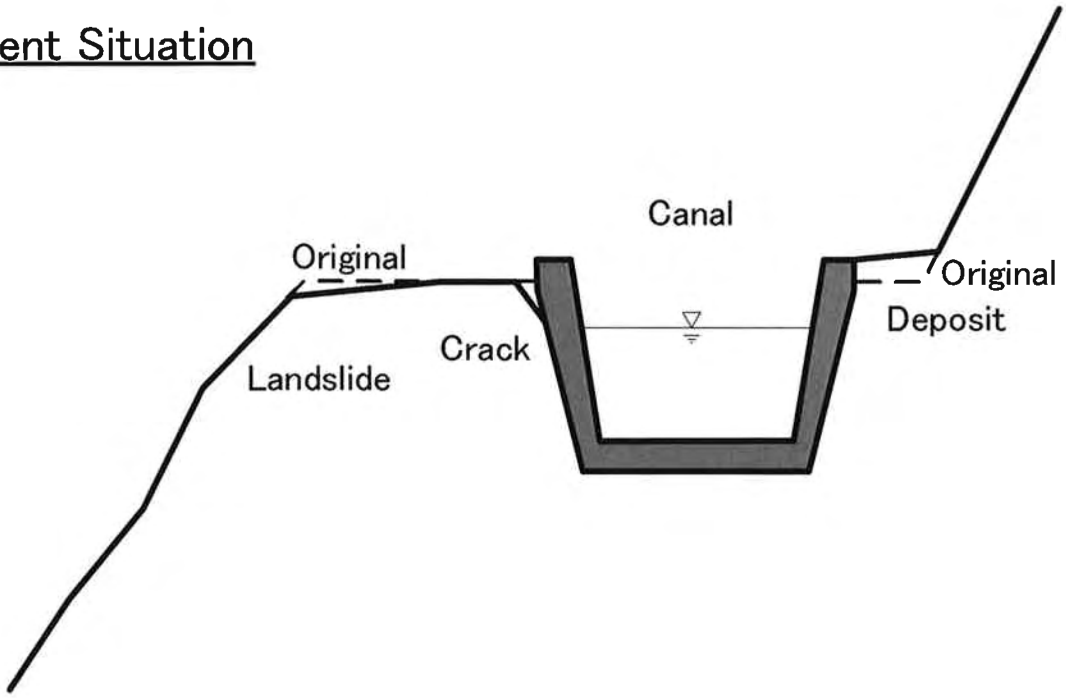


Countermeasure Plan

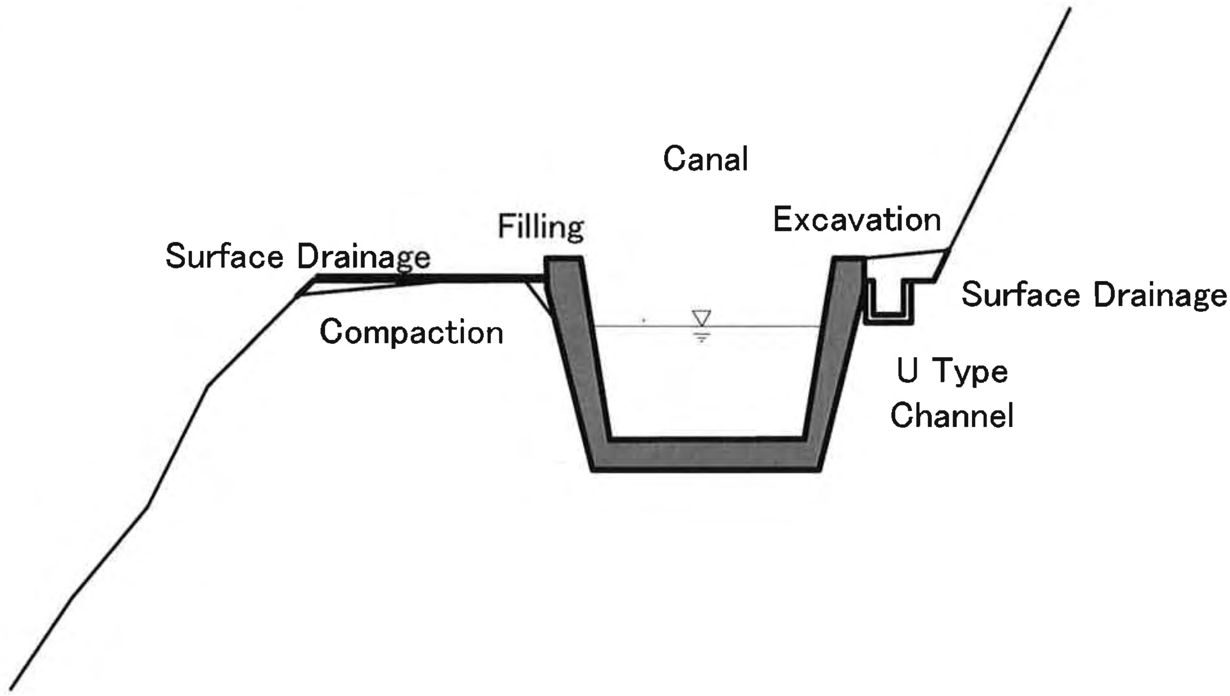


[導水路緊急修理計画]
C-04 中間部地盤変状対策-2/2
Landslide Protection in Middle Area-2/2

Present Situation

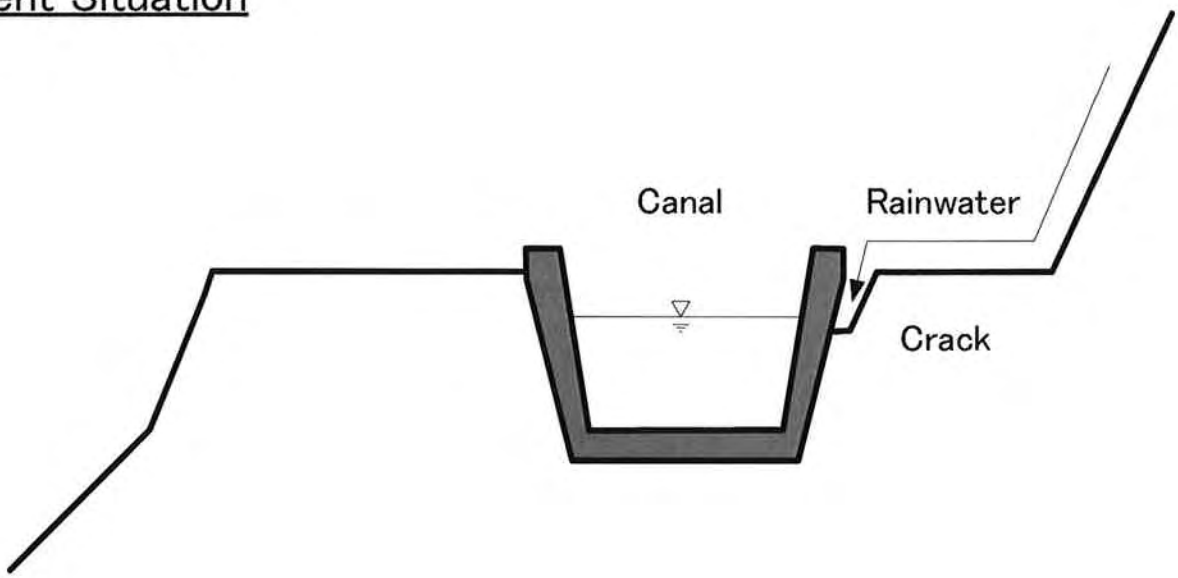


Countermeasure Plan



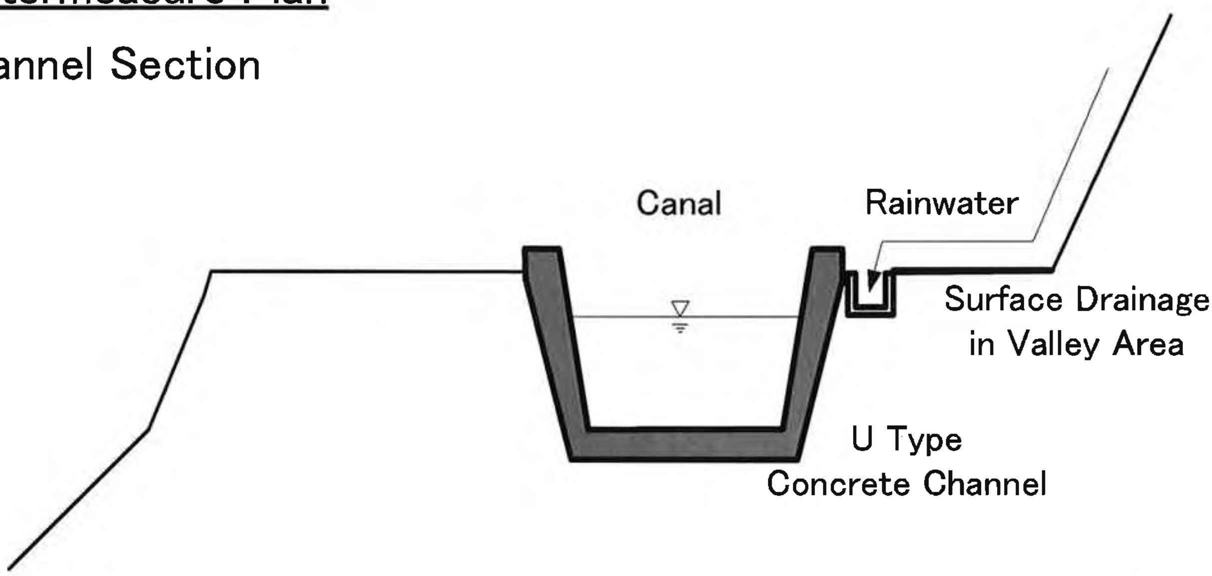
[導水路緊急修理計画]
C-05 ヘッドタンク部地盤変状対策
Landslide Protection in Head Tank Area

Present Situation

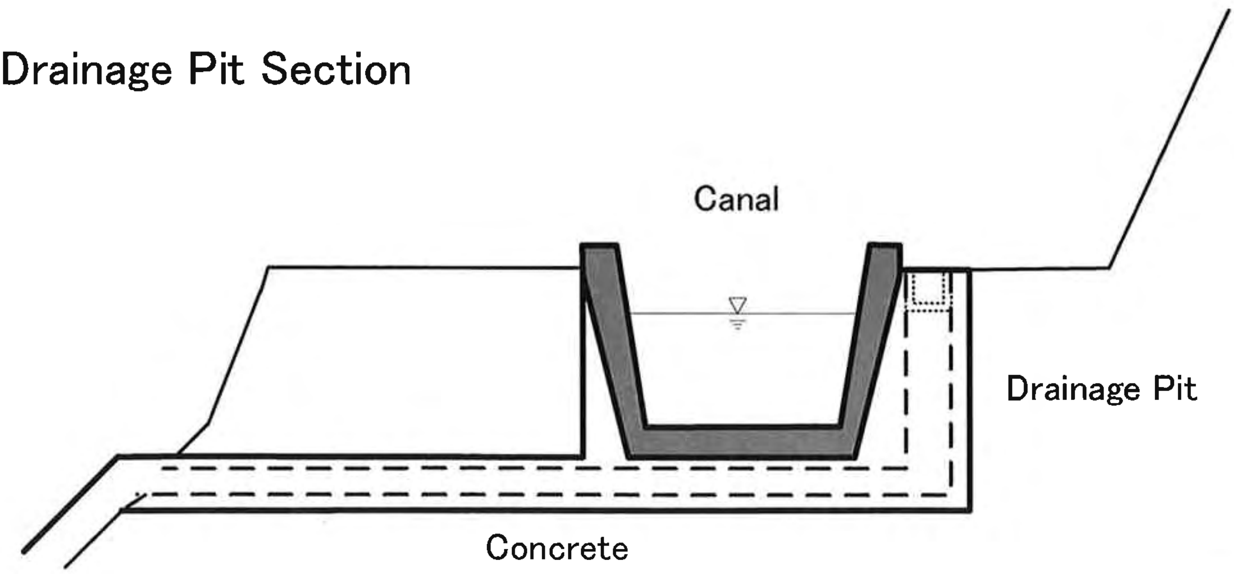


Countermeasure Plan

Channel Section

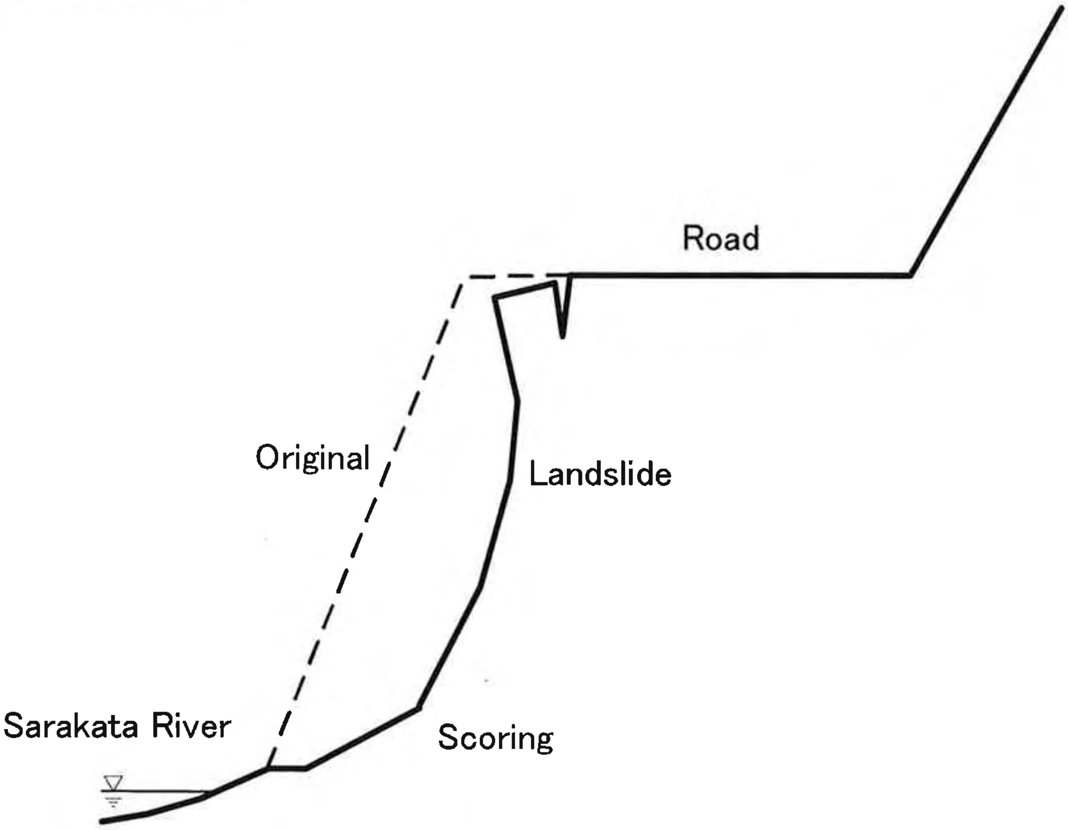


Drainage Pit Section

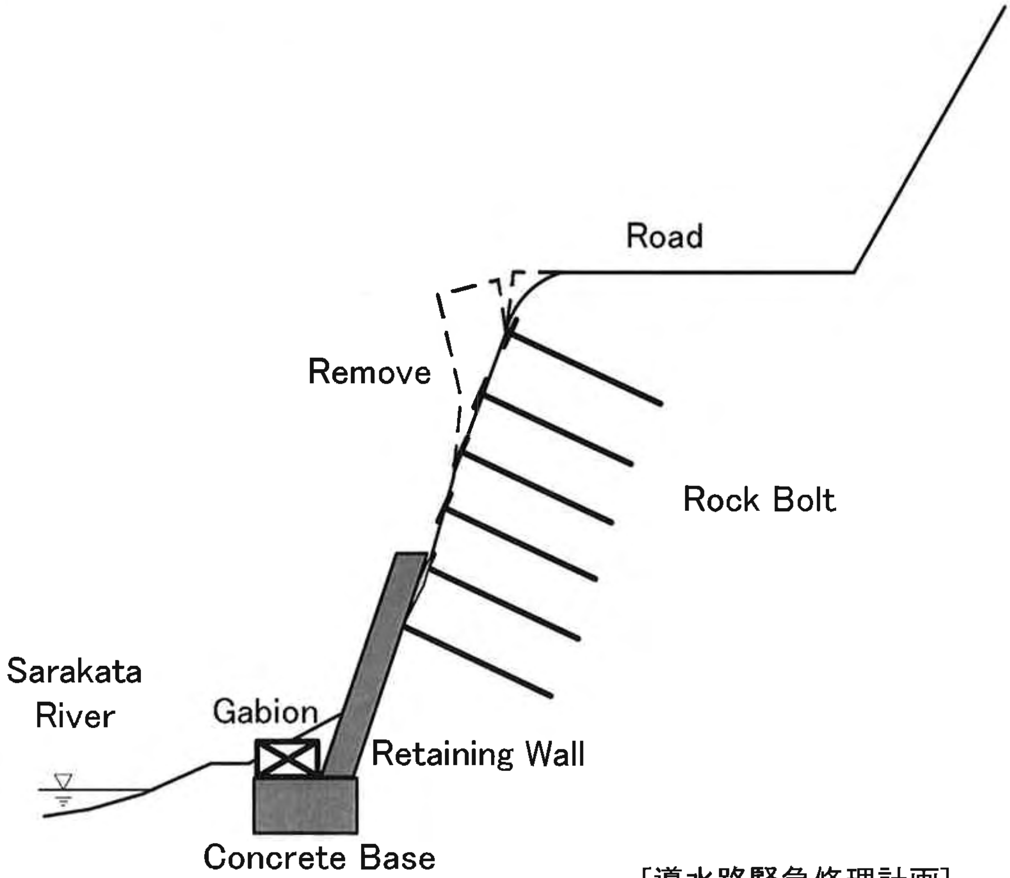


[導水路緊急修理計画]
C-06 雨水排水対策
Drainage System for Rainwater

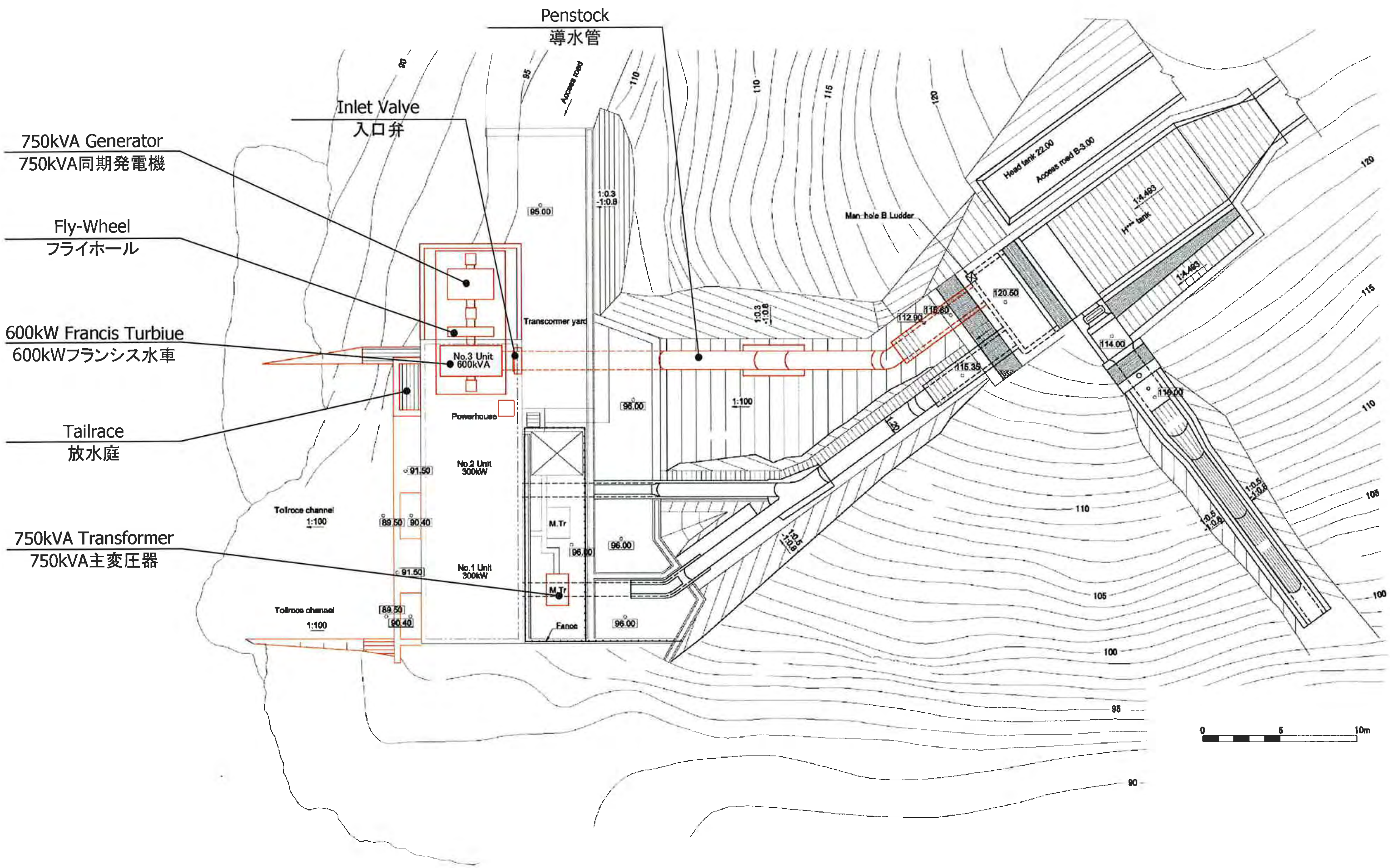
Present Situation



Countermeasure Plan



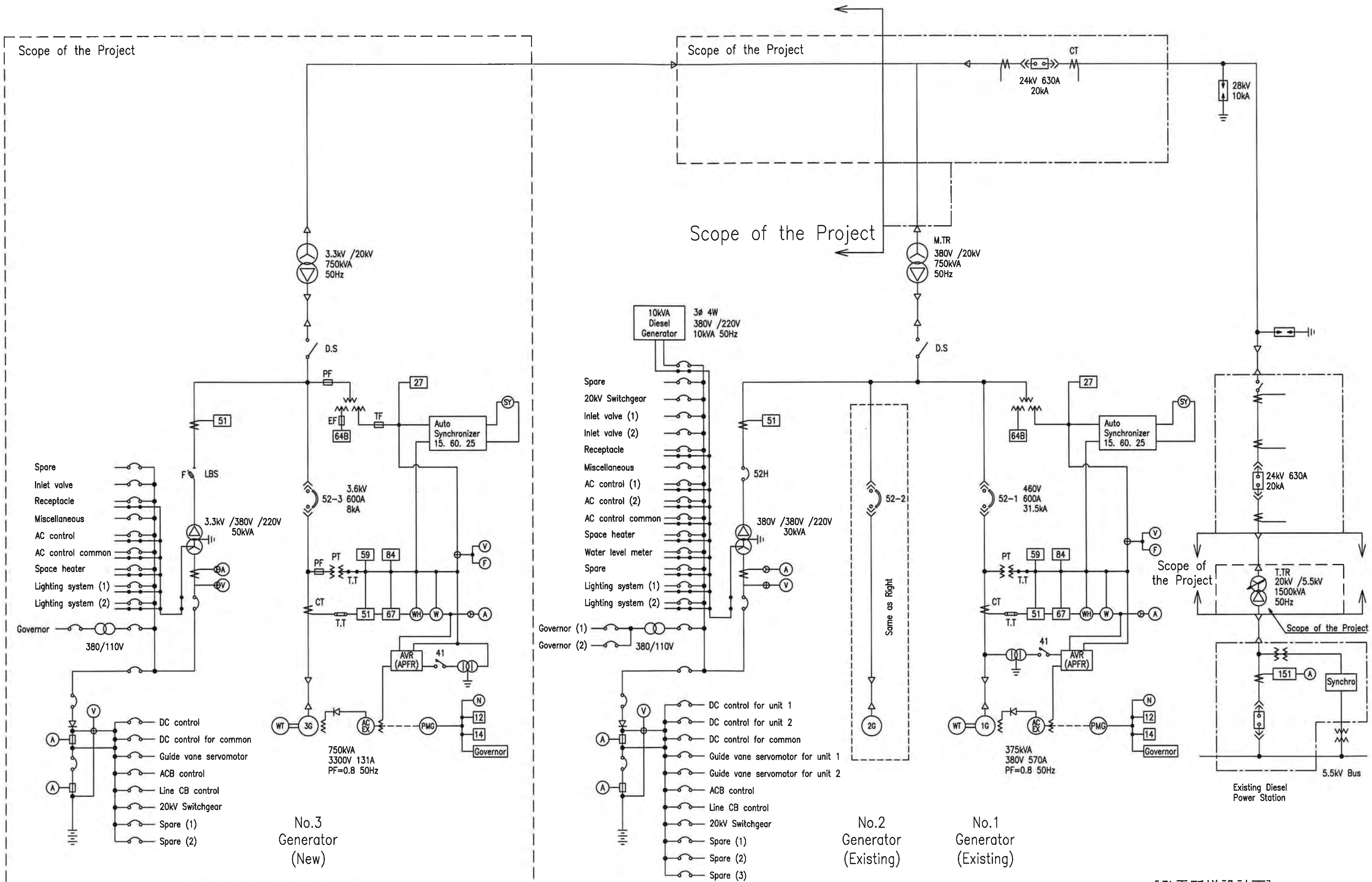
[導水路緊急修理計画]
C-07 アクセス道路復旧対策
Protection in Access Road Area



[発電所増設計画]

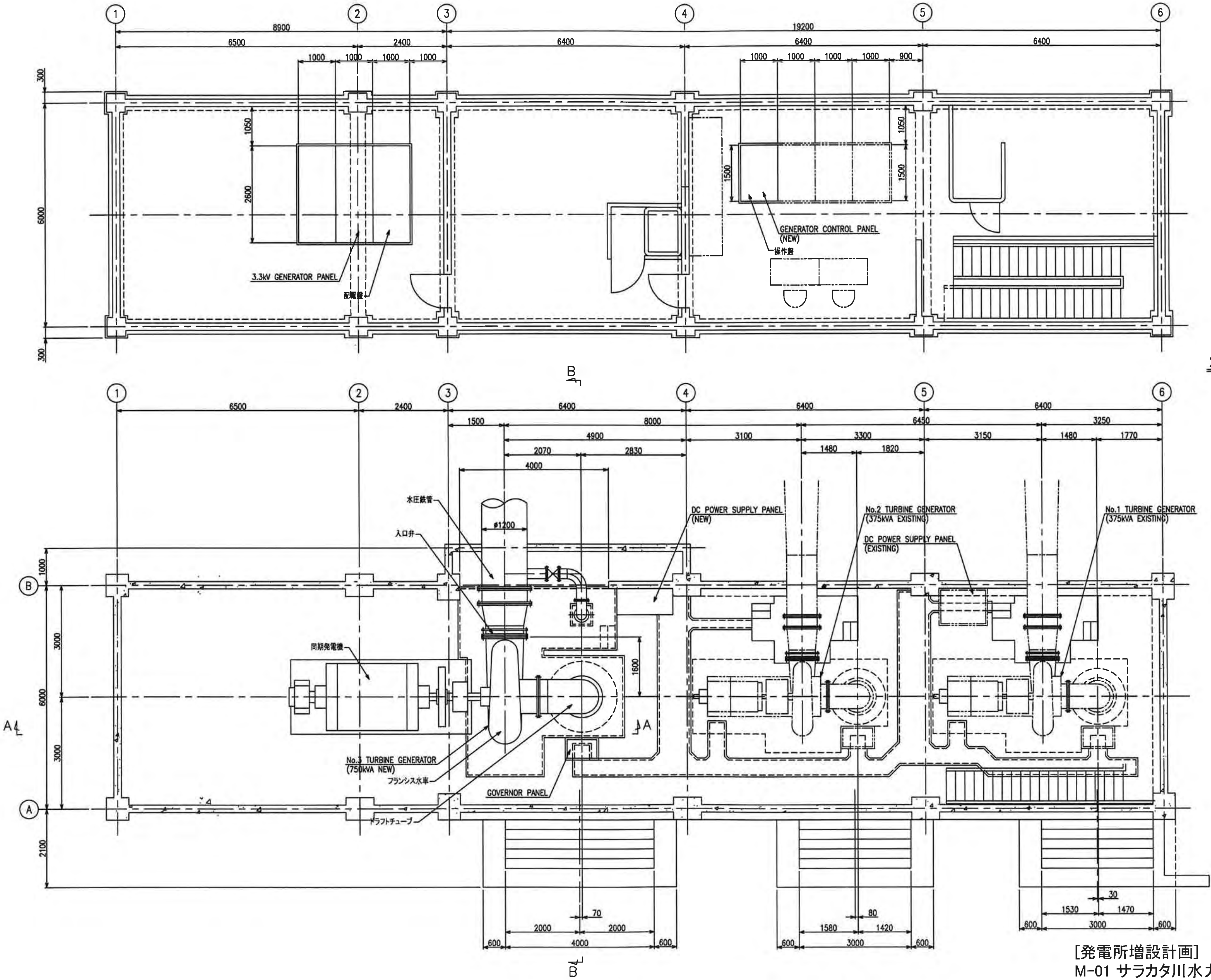
G-01 全体配置図

General Layout Plan

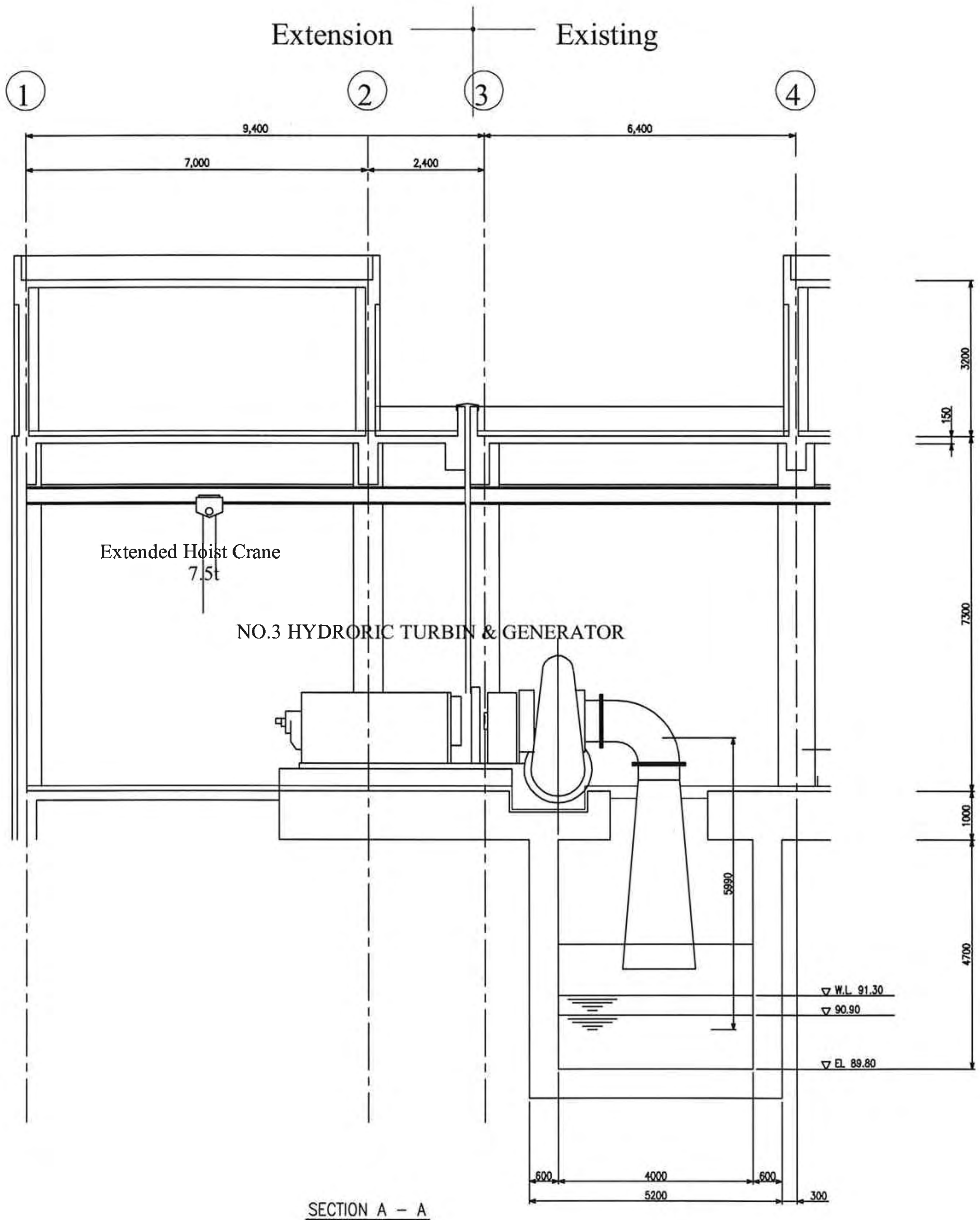


NEW CONSTRUCTION

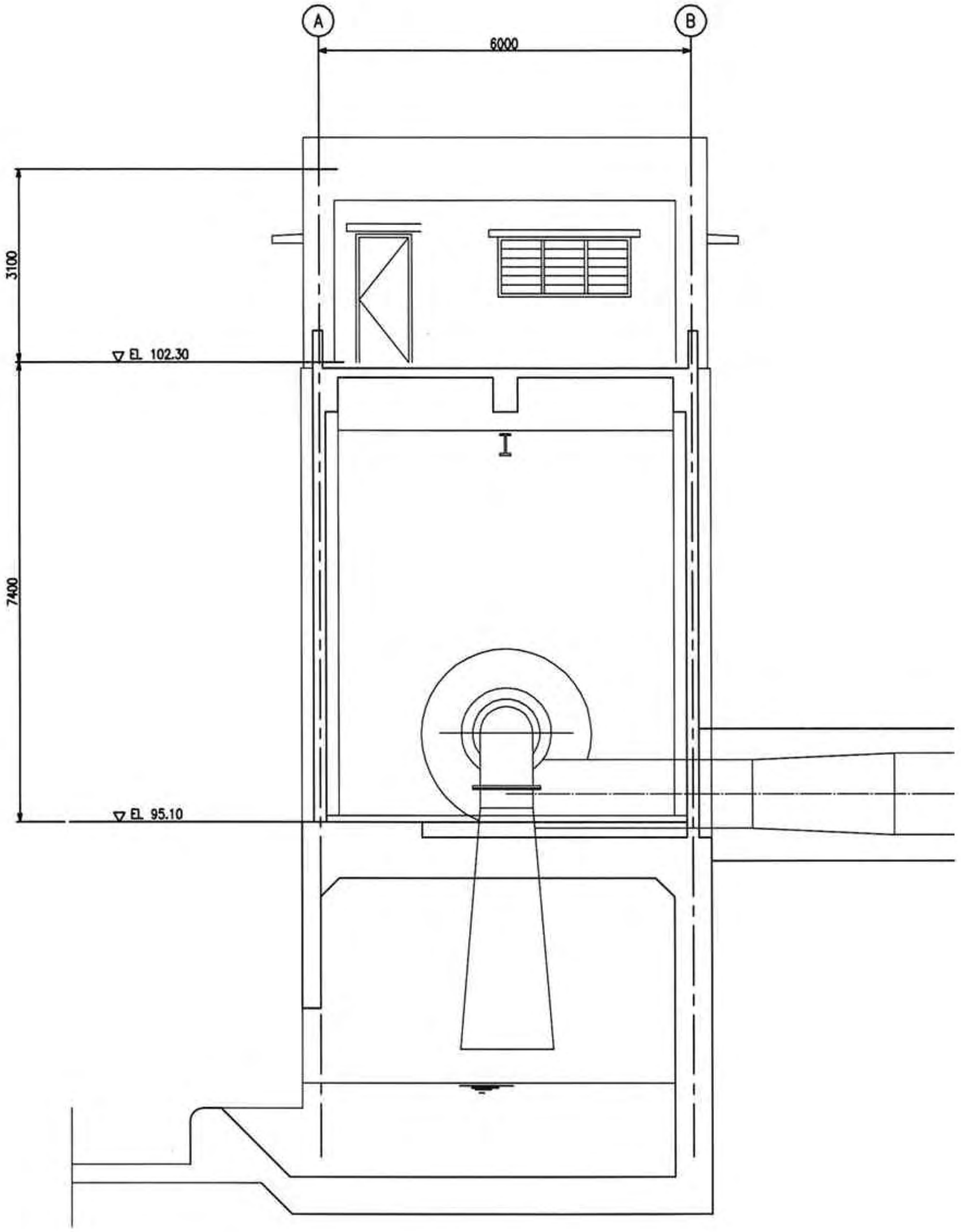
[発電所増設計画]
E-01 単線結線図
Oneline Diagram



[発電所増設計画]
M-01 サラカタ川水力発電所 機材配置平面図
Sarakata River Hydroelectric Power Station
Plan of Powerhouse



SECTION A – A



SECTION B – B

[発電所増設計画]

M-02 サラカタ川水力発電所 機材配置立面図

Sarakata River Hydroelectric Power Station

Cross Section of Generator & Turbine

EXTERIOR FINISH SCHEDULE

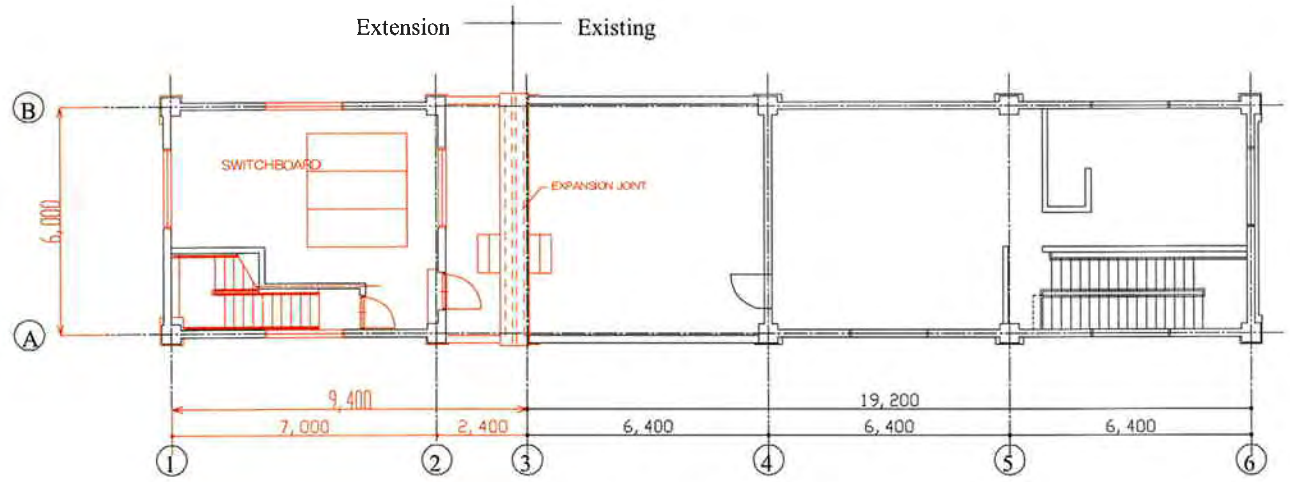
				REMARKS
ROOF	COVERING CONCRETE WITH WIREMESH FILM WATERPROOFING CONCRETE STEEL TROWEL	ROOF DRAIN	CAST IRON	
PARAPET	INSIDE : EXPOSED FILM WATERPROOFING OUTSIDE : CONCRETE REPAIR PAINT FINISH O.P.	RAIN LEADE	PVC PIPE ⌀ 100	
EXTERIOR WALL	CONCRETE REPAIR PAINT FINISH O.P. BASEBOARD : CONCRETE REPAIR , PAINT FINISH O.P. (DIFFERENT COLOR H=1500)	OTHERS	LIGHTNING SYSTEM	
CANOPY	TOP : CONCRETE STEEL TROWEL PAINT FINISH O.P. BOTTOM : CONCRETE REPAIR PAINT FINISH O.P.			
FITTING	ALUMINIUM WINDOW STEEL DOOR			

INTERIOR FINISH SCHEDULE

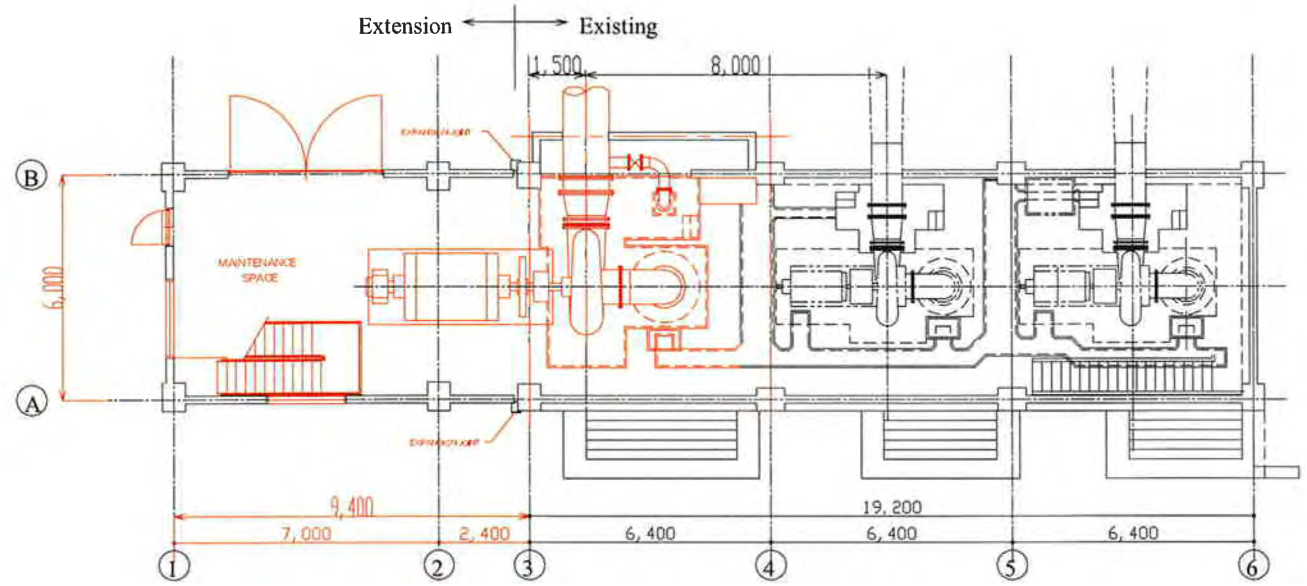
ROOM NAME	FLOOR	BASEBOARD	WALL	CEILING	REMARKS
GENERATOR ROOM	CONCRETE STEEL TROWEL ANTI DUST PAINT FINISH	EXPOSED CONCRETE REPAIR	EXPOSED CONCRETE REPAIR	EXPOSED CONCRETE REPAIR	ADDITIONAL CABLE PIT MOVEMENT EXISTING STEEL DOOR (4000W X 3000H)
MAINTENANCE SPACE	CONCRETE STEEL TROWEL ANTI DUST PAINT FINISH	EXPOSED CONCRETE REPAIR	EXPOSED CONCRETE REPAIR	EXPOSED CONCRETE REPAIR	NEW STEEL STAIR, VENTILATING FAN
SWITCHBOARD(CONTROL) ROOM	CONCRETE STEEL TROWEL ANTI DUST PAINT FINISH	CONCRETE REPAIR PAINT FINISH E.P	CONCRETE REPAIR PAINT FINISH E.P	CONCRETE REPAIR PAINT FINISH E.P	AIR CONDITIONER

[発電所増設計画]
B-01 サラカタ川水力発電所 仕上表
Sarakata River Hydroelectric Power Station
Finishing Schedule

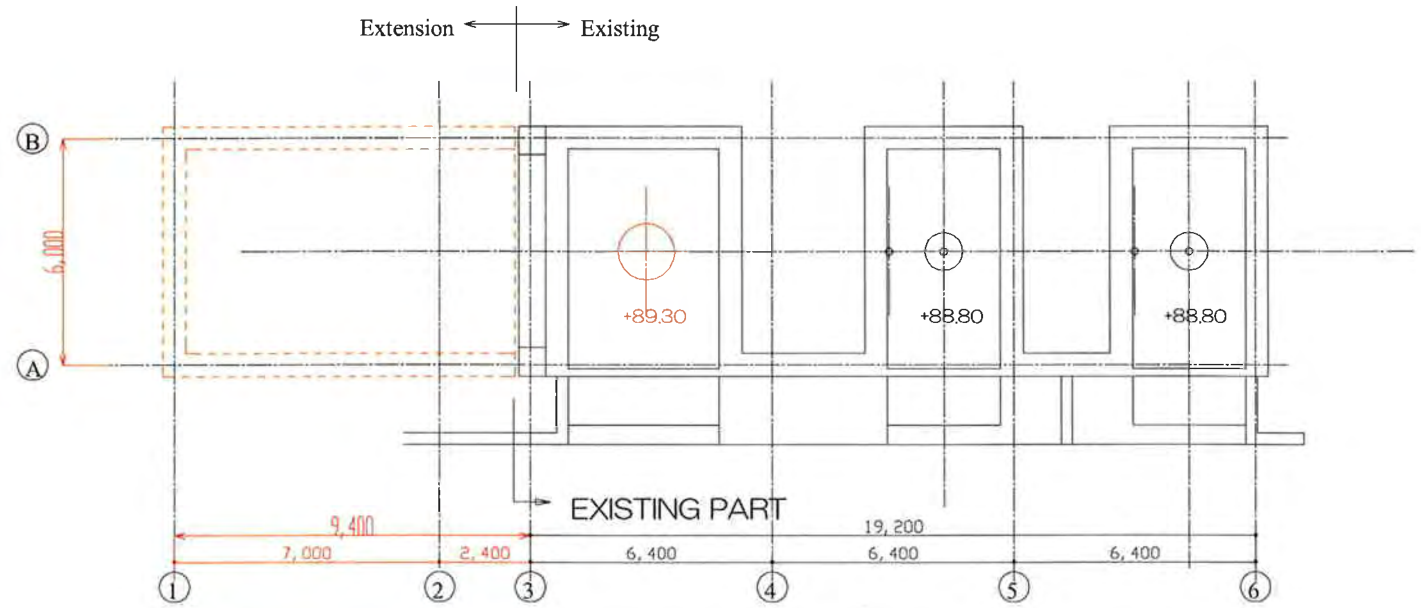
S:1/200



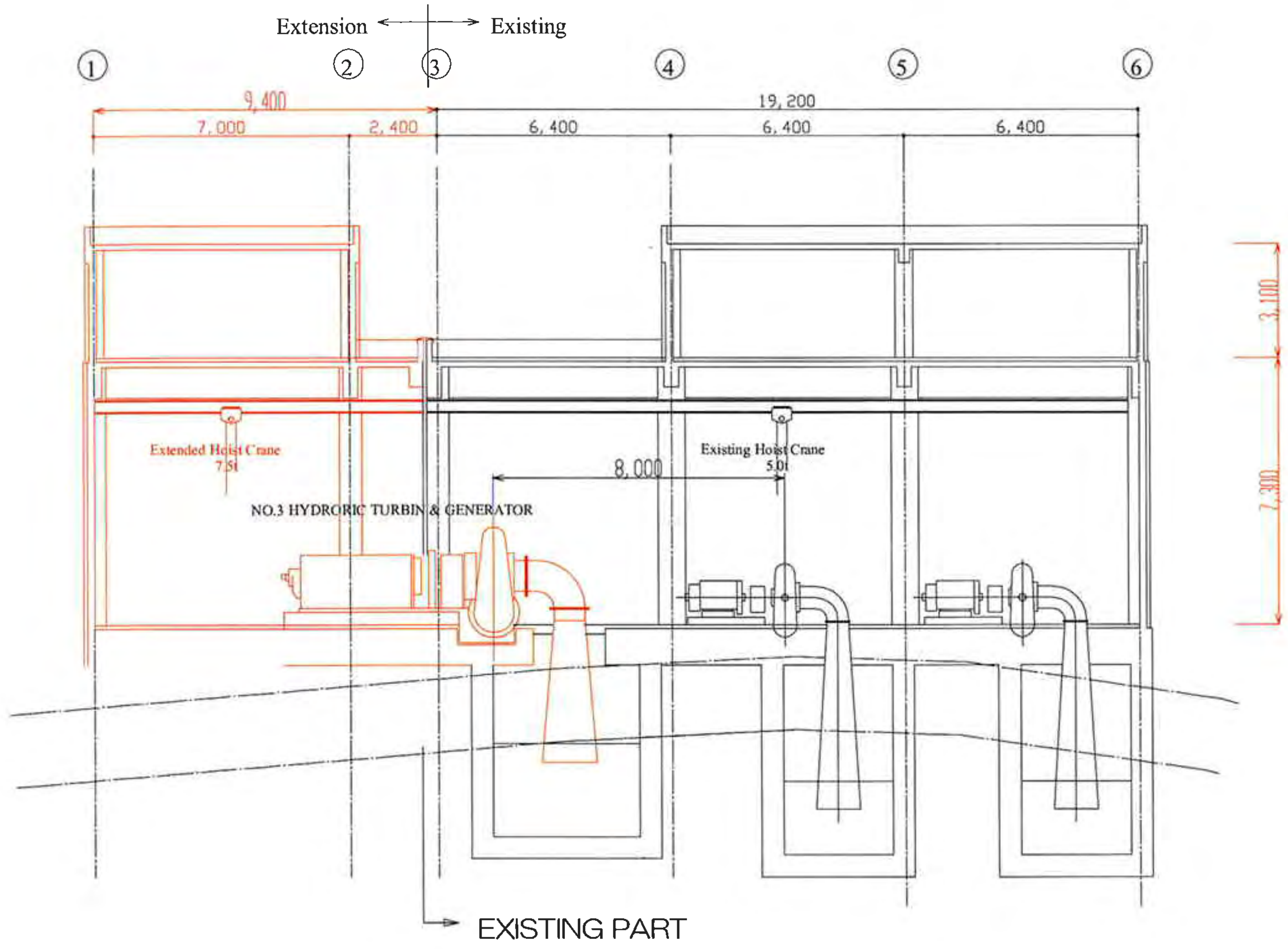
2nd FLOOR PLAN 1/100



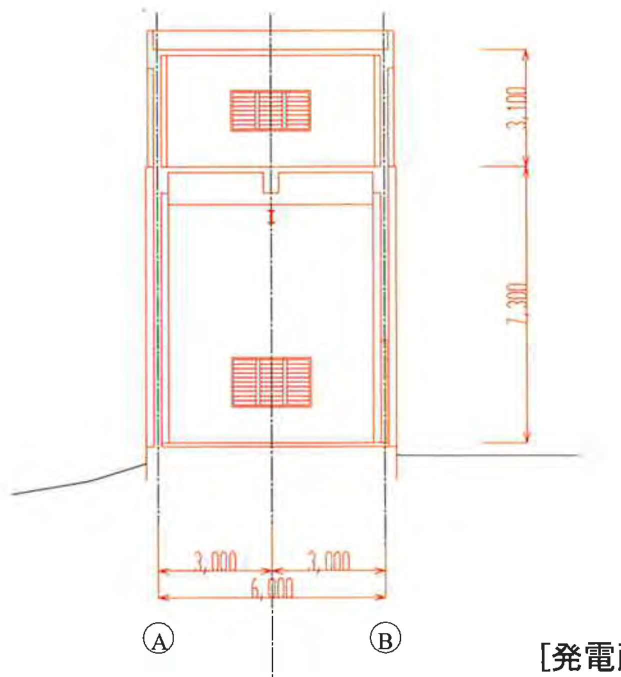
1st FLOOR PLAN 1/100



UNDERGROUND STRUCTUTE PLAN 1/100



SECTION - 1 1/100



SECTION - 2 1/100

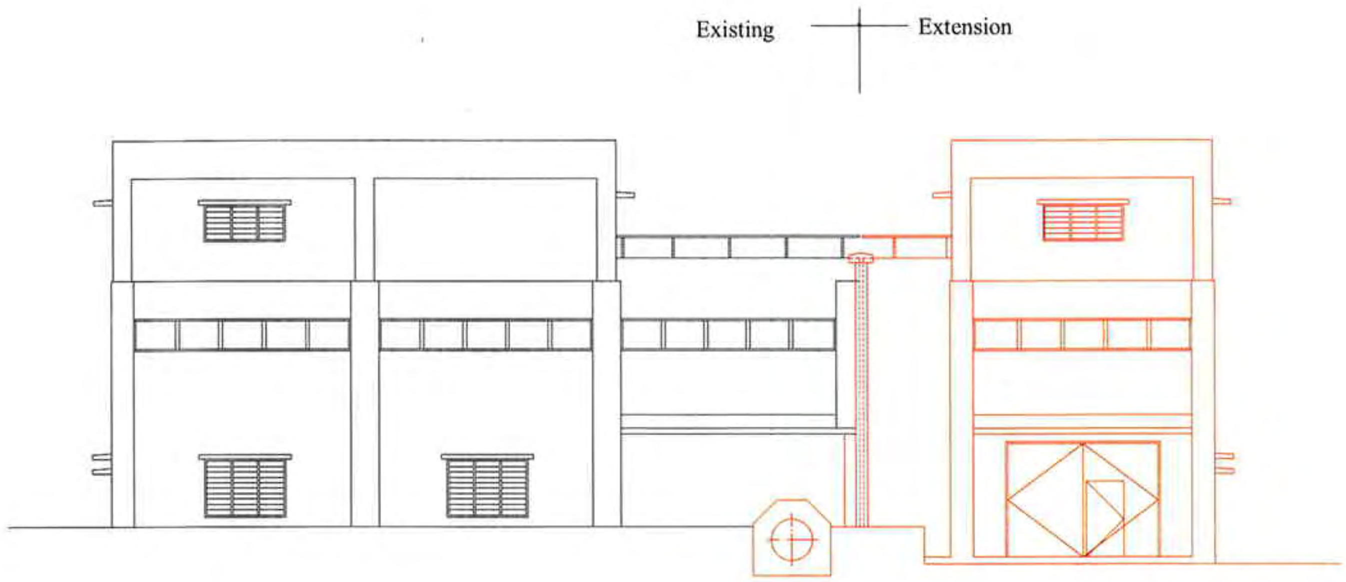
[発電所増設計画]

B-02 サラカタ川水力発電所平面図、断面図

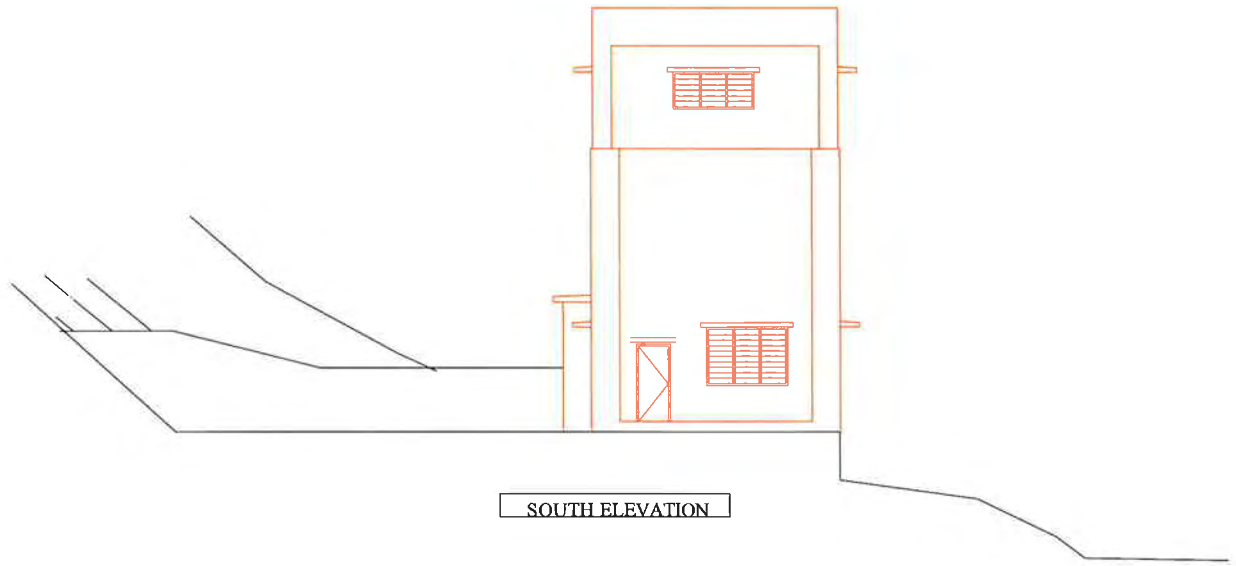
Sarakata River Hydroelectoric Power Station

Plan and Section

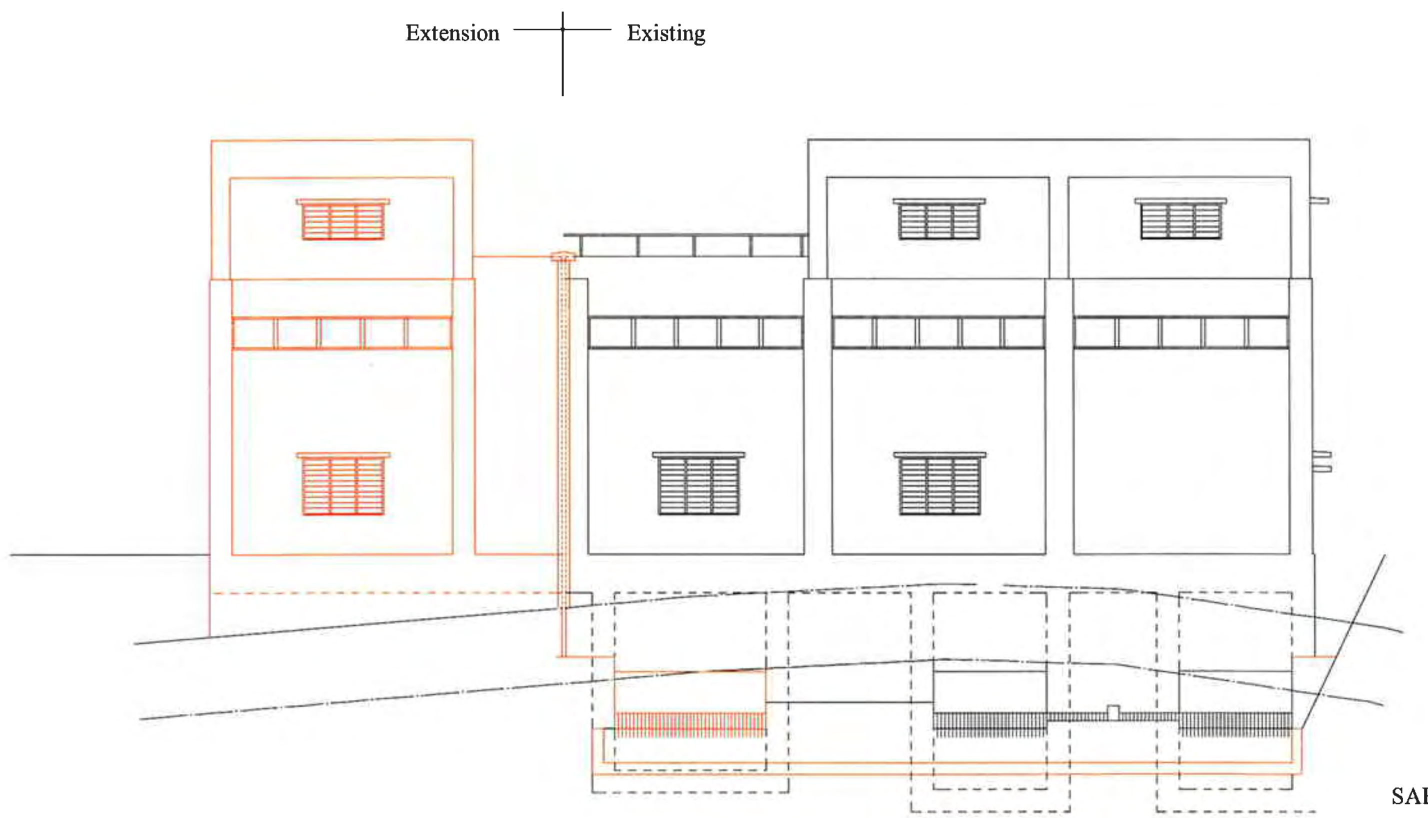
S:1/200



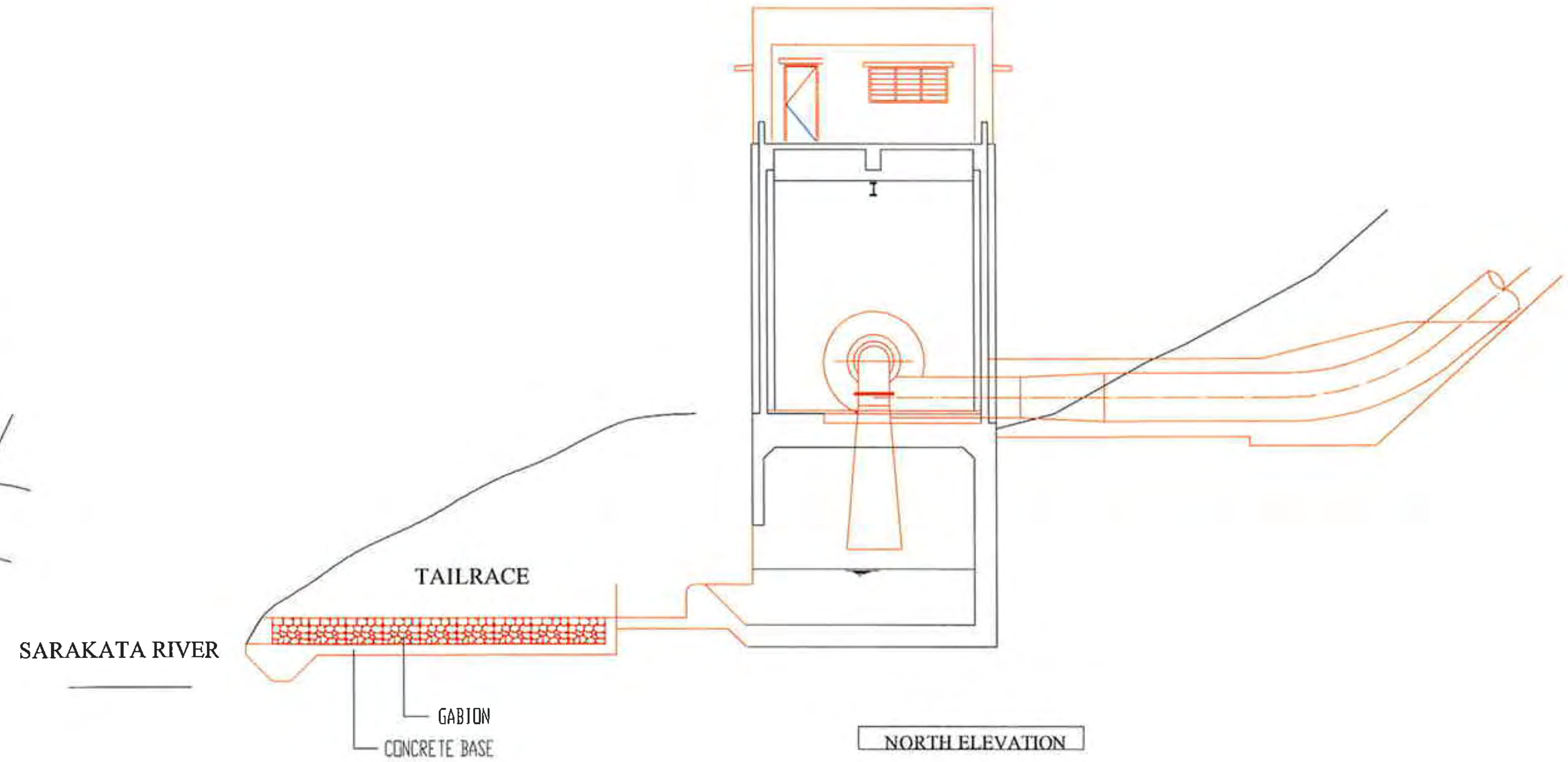
WEST ELEVATION



SOUTH ELEVATION

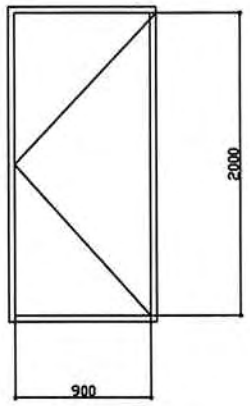
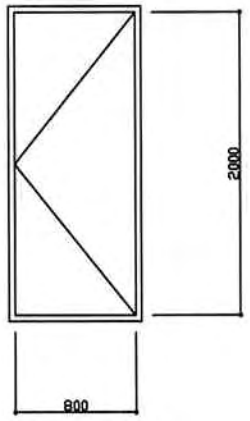
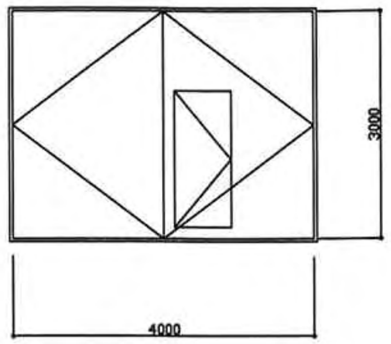
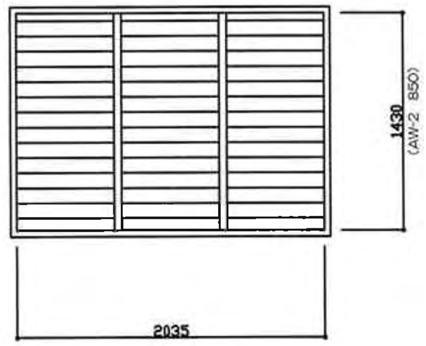
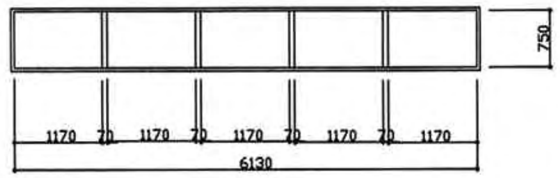


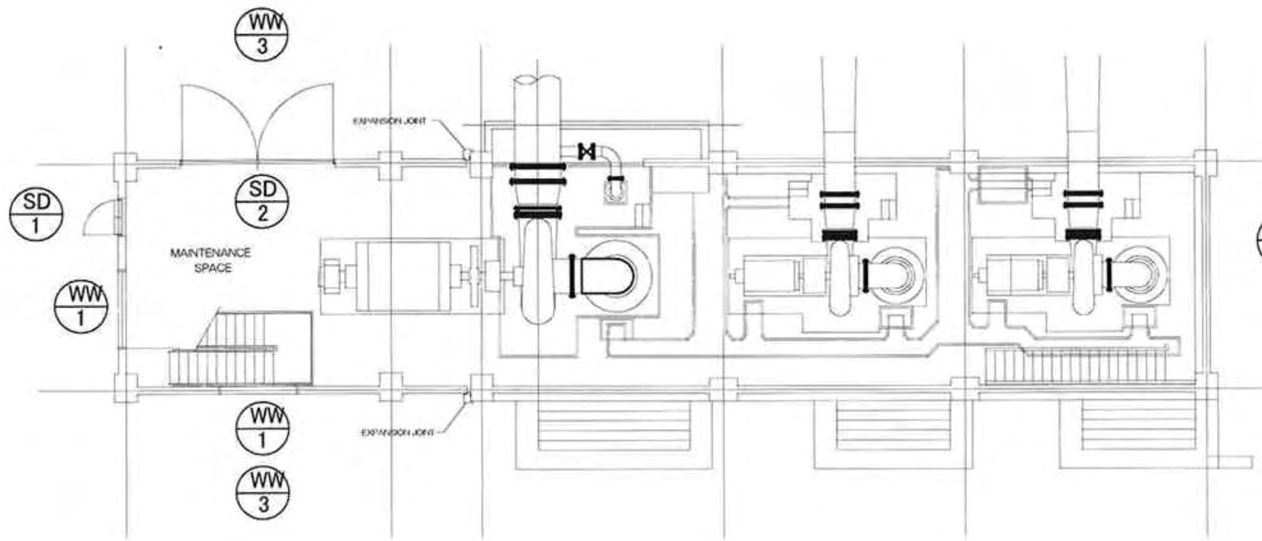
EAST ELEVATION



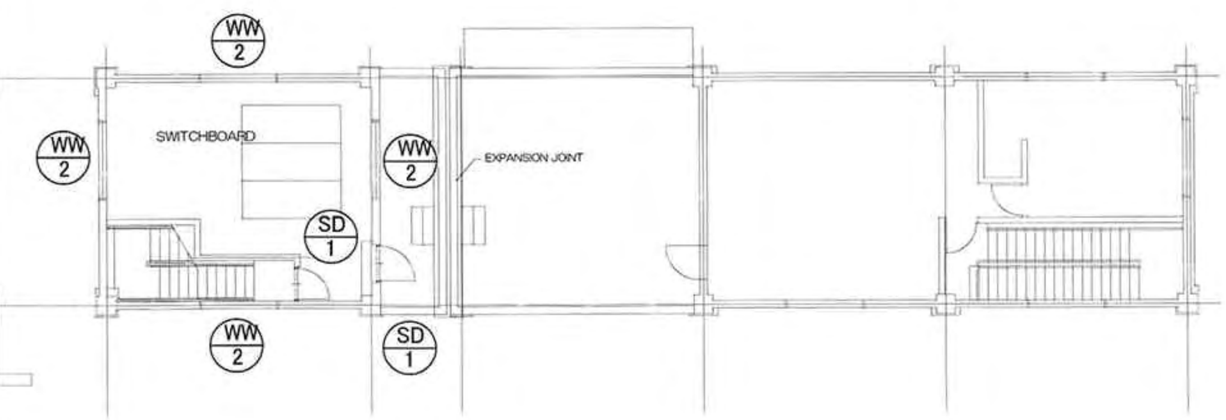
NORTH ELEVATION

[発電所増設計画]
B-03 サラカタ川水力発電所 立面図
Sarakata River Hydroelectric Power Station
Elevation
S:1/200

SYMBOL / UNIT	SD 1 — 2	SD 2 — 1	SD 3 — 1	WW 1 — 2, WW 2 — 4	WW 3 — 2
FIGURE					
TYPE	SINGLE SWING FLASH DOOR	SINGLE SWING FLASH DOOR	DOUBLE SWING FLASH DOOR	LOUVERBOARD WINDOW	FIXED WINDOW
MATERIAL / FINISH	STEEL / OIL PAINT	STEEL / OIL PAINT	STEEL / OIL PAINT	WOOD / OIL PAINT	WOOD / ANDOIC OXIDE COATING
GLASS	———	———	———	POLISHED WIRED GLASS 6.8	POLISHED WIRED GLASS 6.8
HARDWARE	DEAD LOCK, LEVER HANDLE HINGE,DOOR CLOSER	DEAD LOCK, LEVER HANDLE HINGE,DOOR CLOSER			
REMARKS			REMOVED EXISTING DOOR		

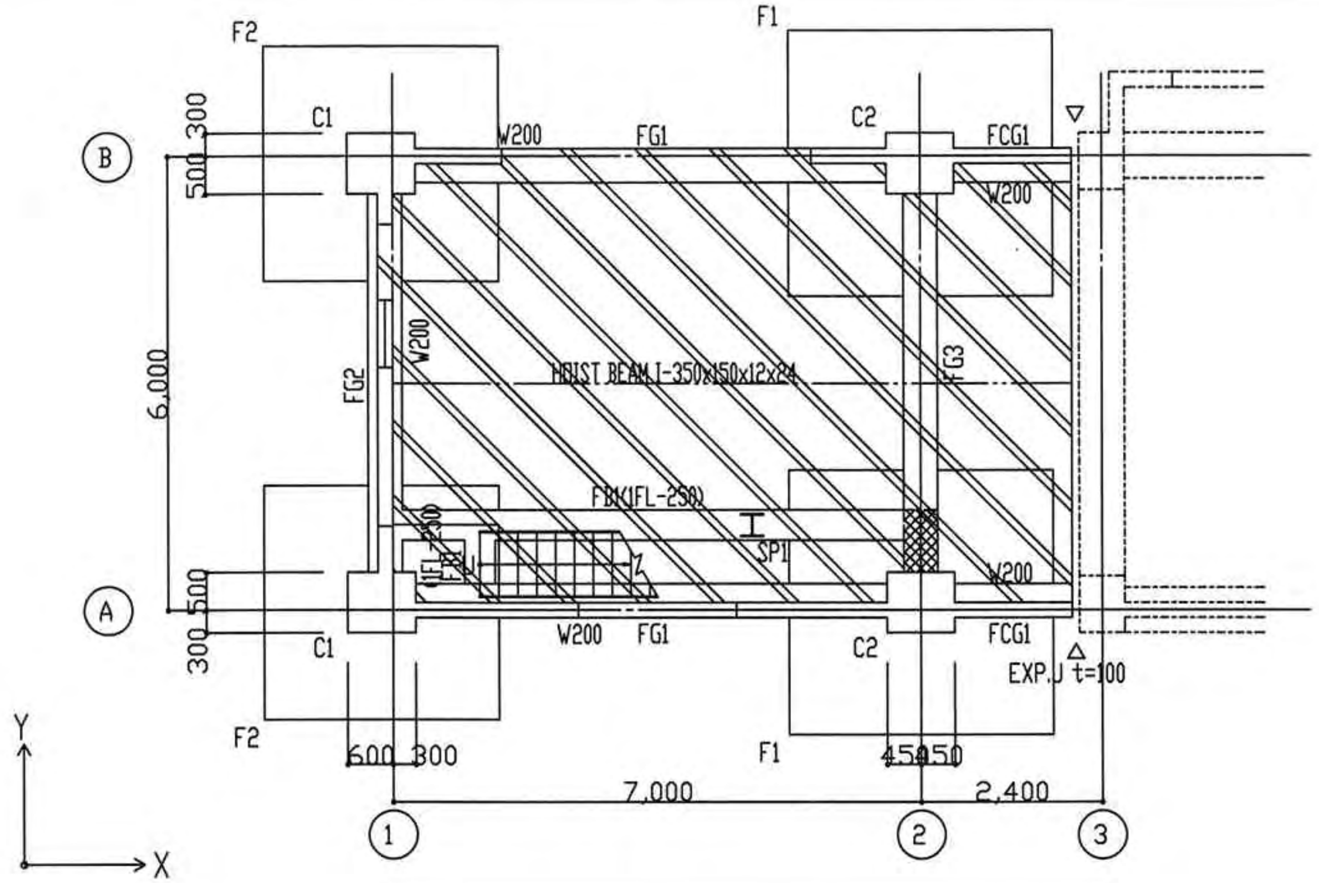


1st FLOOR PLAN 1/100

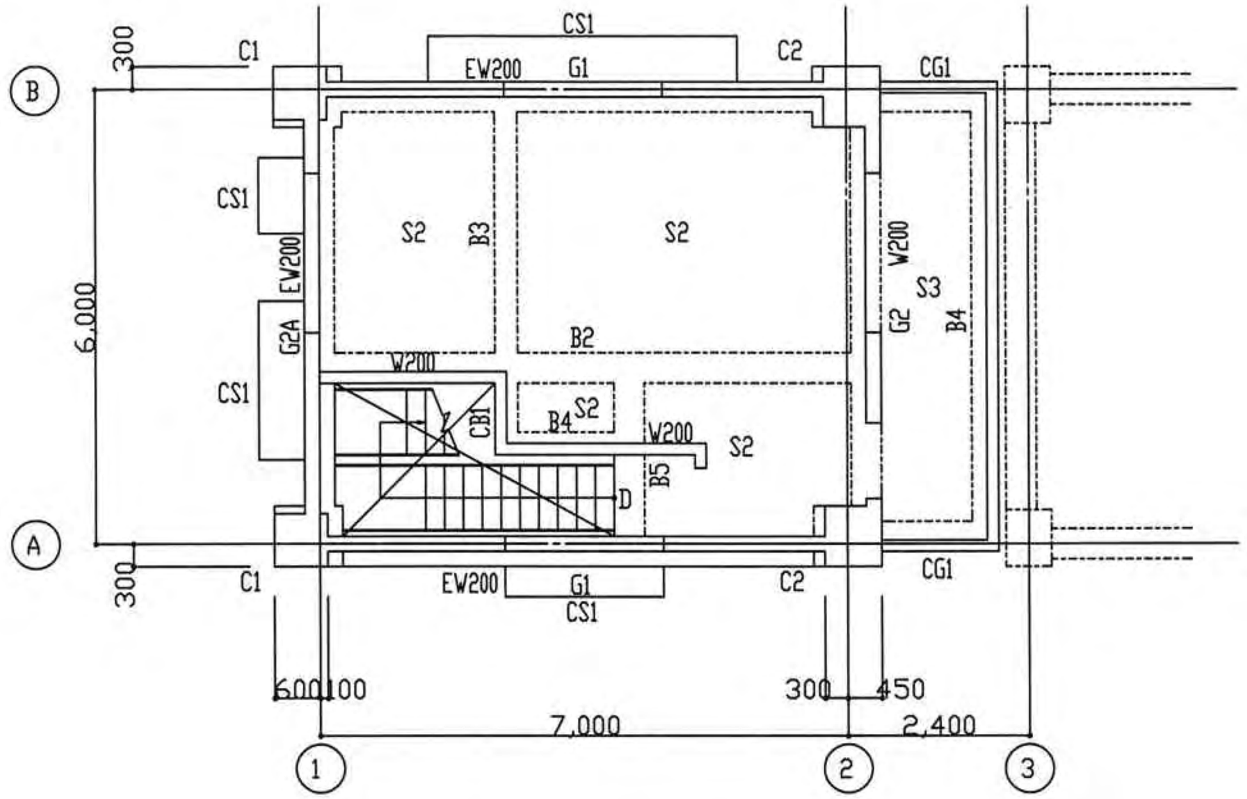


2nd FLOOR PLAN 1/100

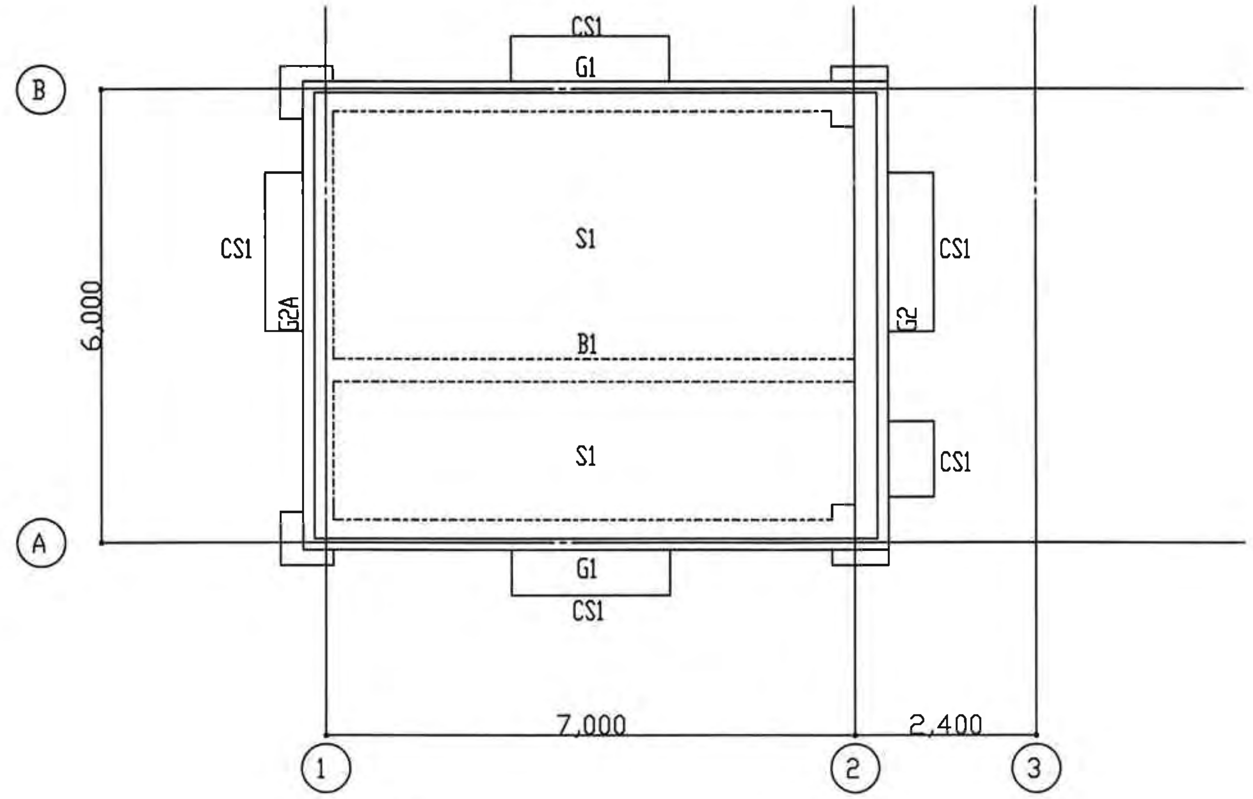
[発電所増設計画]
B-04 サラカタ川水力発電所 建具表
Sarakata Hydroelectric Power Station
Fitting Schedule
S:1/50, S/200



FOUNDATION&1ST FLOOR FRAMING PLAN S=1/100



2ND FLOOR FRAMING PLAN S=1/100



ROOF FLOOR FRAMING PLAN S=1/100

GENERAL NOTES

1) INDICATED REINFORCED CONCRETE SLAB-ON GRADE

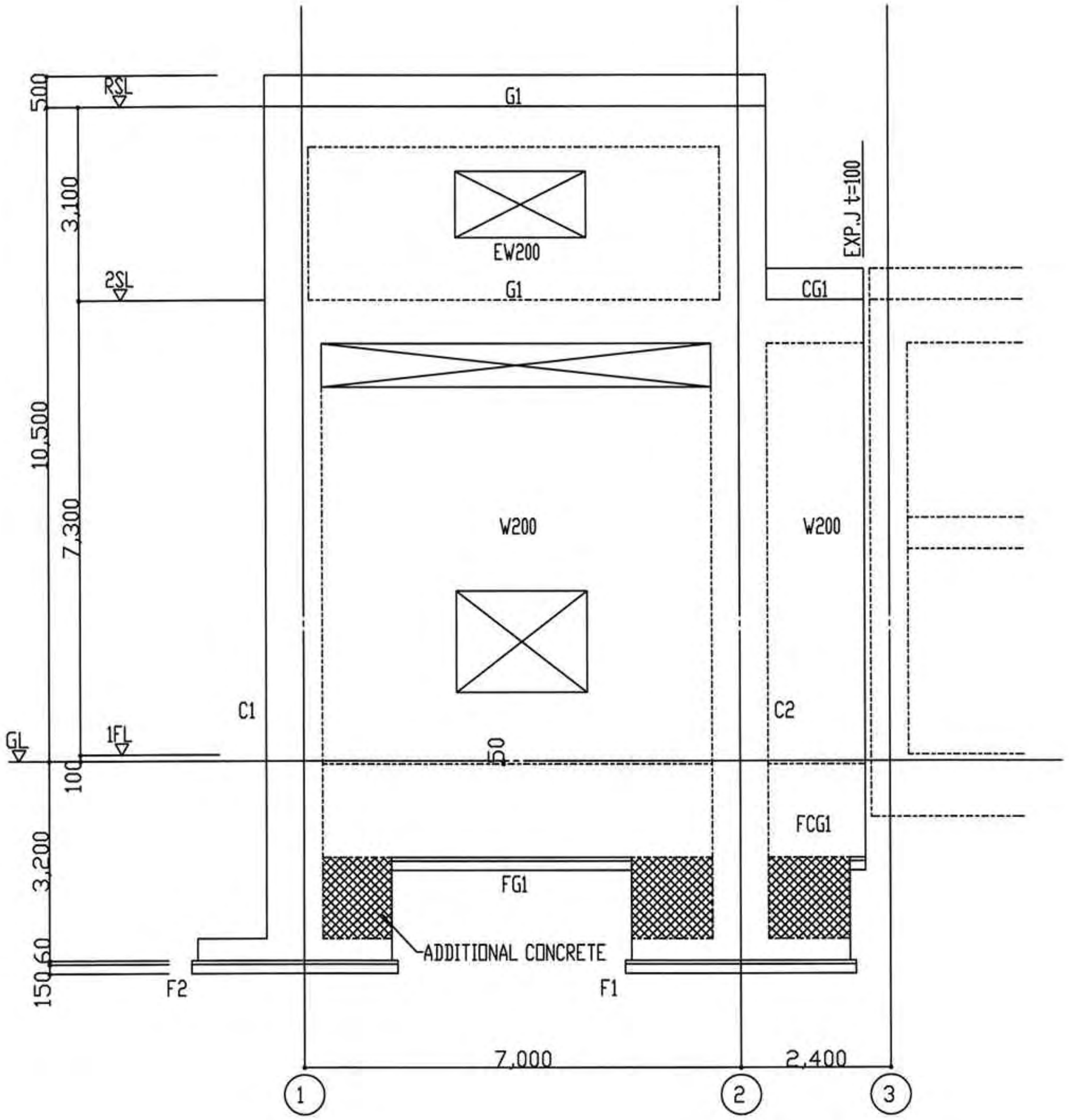
2) INDICATED ADDITIONAL CONCRETE

3) STEEL MEMBER
SP1:H-300×300×10×15 BASE.P-19 A.BOLT:4-M20
SCB1:H-200×100×5.5×8

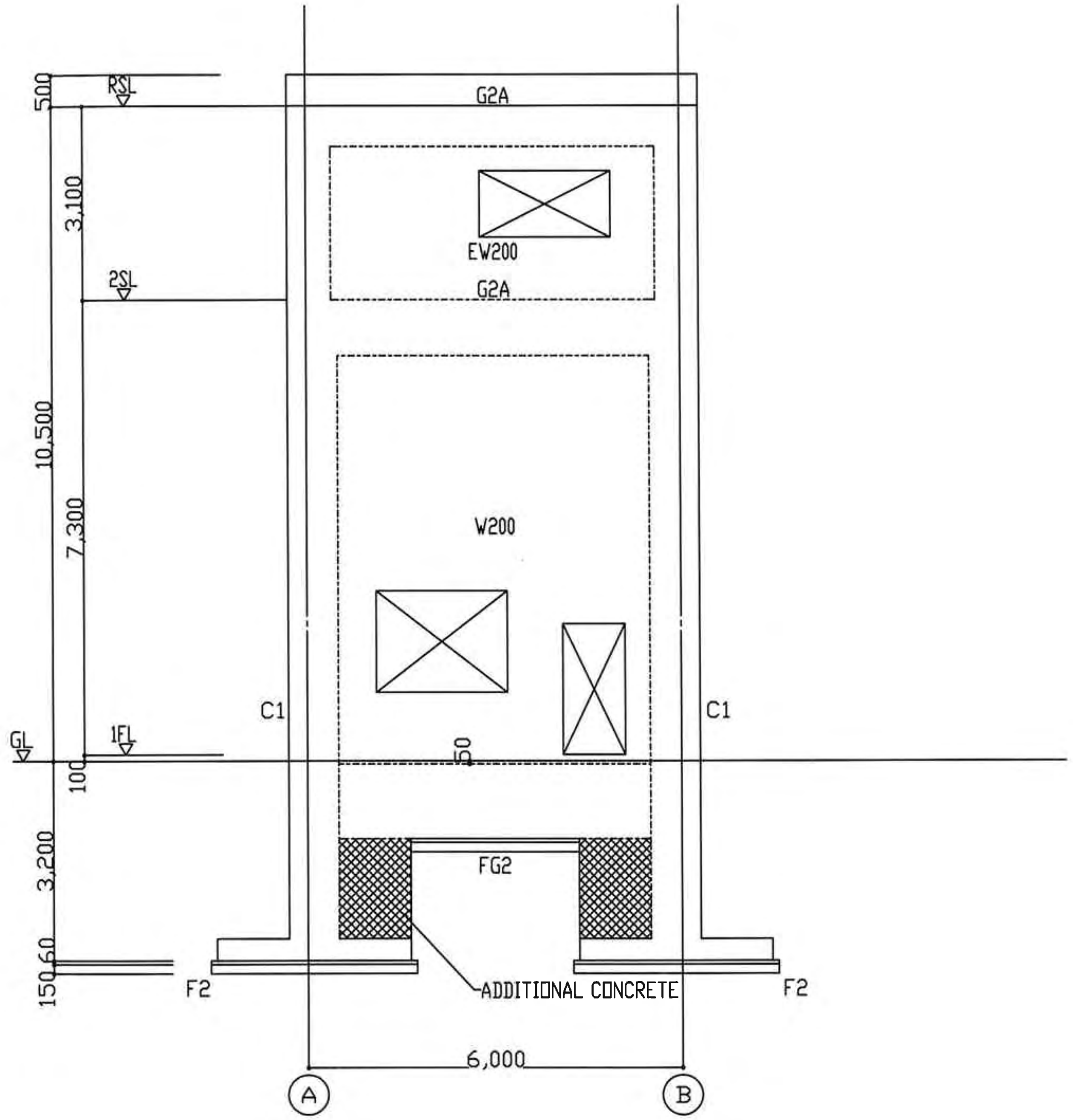
MATERIAL UNLESS OTHERWISE NOTED	
CONCRETE	Fc=21N/㎟
RE-BAR	D10-D25:295A
STEEL	SS400
BOLT	SS400

[発電所増設計画]
B-05 サラカタ川水力発電所 基礎・梁伏図
Sarakata Hydroelectric Power Station
Foundation , Beam Plan

S:1/100



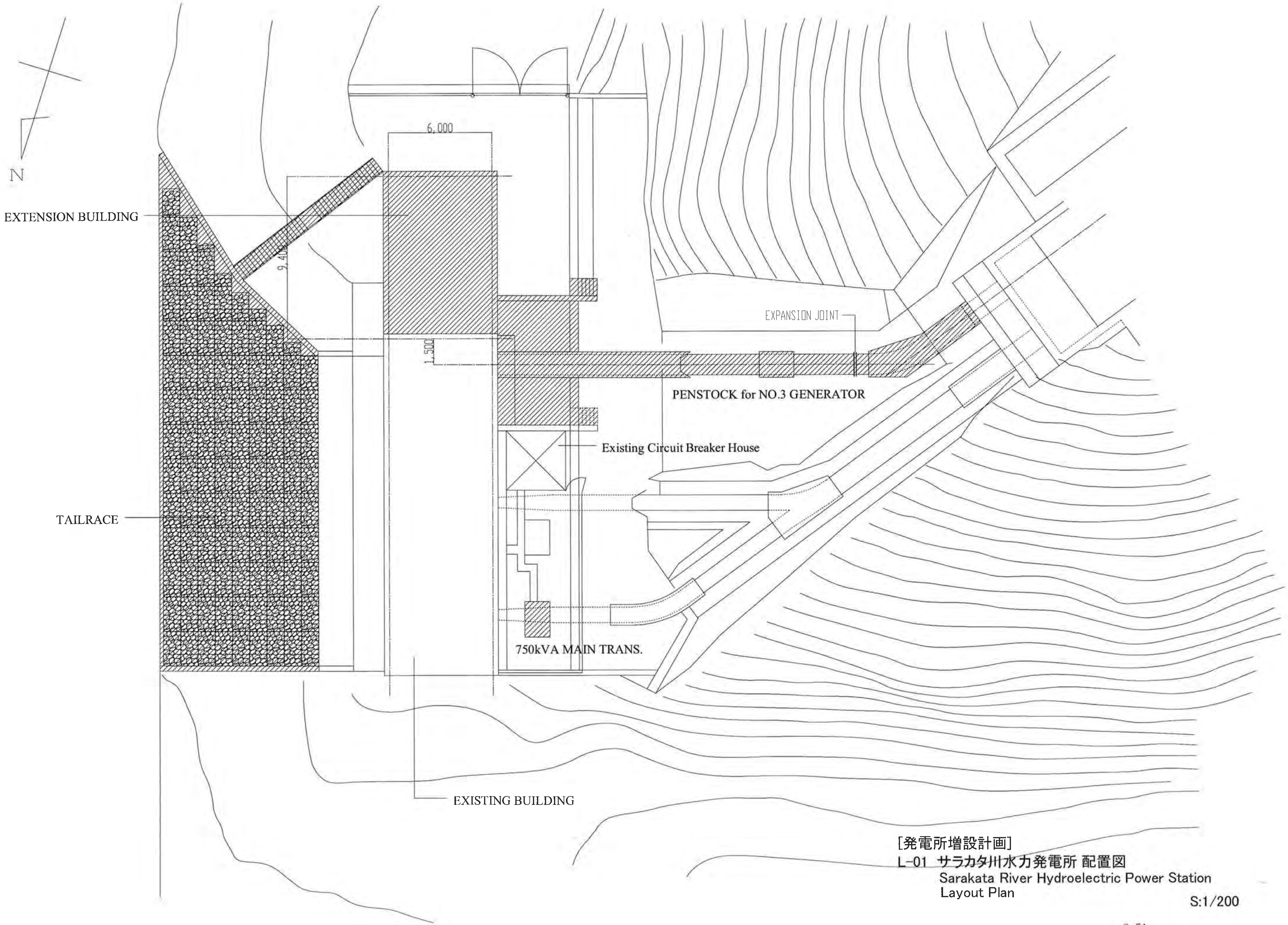
A LINE FRAMING ELEVATION S=1/100



1 LINE FRAMING ELEVATION S=1/100

[発電所増設計画]
B-06 サラカタ川水力発電所 軸組図
Sarakata Hydroelectric Power Station
Framing Elevation

S:1/100



[発電所増設計画]

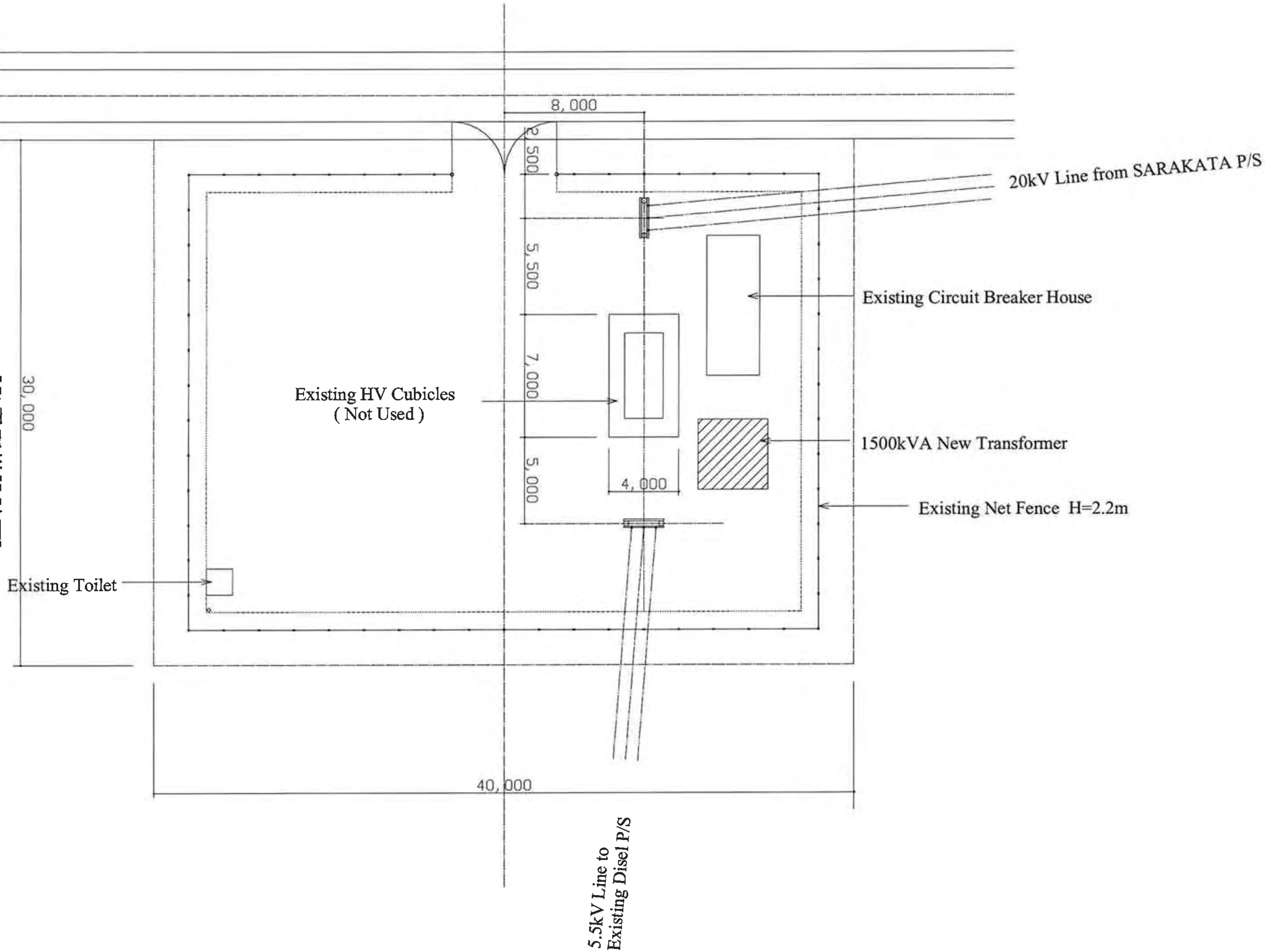
L-01 サラカタ川水力発電所 配置図

Sarakata River Hydroelectric Power Station

Layout Plan

S:1/200

[発電所増設計画]
S-01 20kV サラカタ既設変電所 配置図
20kV Step-Down Existing Sarakata Substation
Layout Plan
S:1/300



2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

As the Project aims at expanding an existing hydroelectric power station which requires a high level of technical capability, the implementation of the Project in accordance with the grant aid scheme of the Government of Japan is judged to be appropriate. Accordingly, the Project will be implemented with the exchange of the E/N between the Government of Japan and the Government of Vanuatu after approval of the Project by the former. Important points for the implementation of the Project are described below.

(1) Project Implementation Body

The organizations responsible for the supervision and implementation of the Project on the Vanuatu side are listed below.

① Supervising Ministry : Ministry of Lands, Energy, Environment, Geology, Mines and Water Resources (MOL)

② Implementation Body : MOL, Energy Unit (EU)

It is planned that the Energy Unit (the implementation body) will receive assistance from the Public Works Department for the implementation of the Project.

It will be necessary for both the supervising ministry and the implementation body to select a person to be responsible for the Project. This person will act as a window for the Vanuatu side and will closely liaise and consult with the Japanese Consultant and Contractor. The selected person will also be required to fully explain the contents of the Project to staff members of the related organizations to obtain their cooperation.

(2) Consultant

The Japanese Consultant will conclude a consultancy (design and supervision) agreement with the Energy Unit of the MOL and will conduct the detailed design work (preparation of the tender documents) and the procurement and supervision work (agent for the tender, procurement and supervision) for the Project.

(3) Contractor

The Contractor will be responsible for the construction/delivery of the facilities and equipment which meet the specifications stipulated in the tender documents by the stipulated date and for the necessary construction work for equipment installation.

The Contractor will also be responsible for after-service, such as the supply of spare parts and the repair of breakdowns, after the completion of the Project.

(4) Necessity for the Dispatch of Japanese Engineers

As the planned equipment for procurement under the Project requires a high level of technical skill for installation as well as post-installation adjustment and testing, etc., the dispatch of Japanese engineers to Vanuatu will be necessary for the purpose of quality control, technical guidance and schedule control.

Meanwhile, the Energy Unit of the MOL has entrusted the operation and maintenance of the existing hydraulic turbine generators to a private company and its technical staff members possess the basic technological knowledge and skills. Because of this, no special technical problems regarding equipment operation and maintenance are anticipated. However, it is believed that local engineers are unfamiliar with the operation and maintenance requirements when the manufacturer and equipment configuration differ from those of existing equipment. The dispatch of Japanese engineers from the equipment manufacturers will, therefore, be necessary to provide technical guidance on operation and maintenance at the time of the installation of the newly procured equipment.

2.2.4.2 Implementation Conditions

(1) Local Construction Industry, etc.

Although construction companies and electrical contractors exist in Luganville City where the Sarakata River Hydroelectric Power Station is located, no local company has the advanced technological capability required for the planned facility construction work as well as equipment installation work under the Project. Accordingly, Japanese engineers will be dispatched to Vanuatu to provide technical guidance and quality/schedule control at the time of construction/installation.

(2) Use of Local Equipment and Materials

Locally available equipment and materials will be used as much as possible.

2.2.4.3 Scope of Work, Demarcation

The Japanese side will implement safety measures during the work, such as the implementation of countermeasures to stabilise the ground along the canal and to protect the slope along the access road at the side of the power station.

The Japanese side will bear the cost of the procurement and installation of the power generating equipment while the Vanuatu side will bear the cost of the removal or repair of the existing equipment which is necessary for the Japanese work to proceed. Table 2.2-11 shows the division of work (draft) between the two sides.

Table 2.2-12 Division of Work Between the Japanese Side and the Vanuatu Side

Work Item	Division of Work		Remarks
	Japan	Vanuatu	
(1) Urgent countermeasures to stabilise the ground along the canal and safety measures for the access road	○		
(2) Procurement of the generating equipment	○		
(3) Inland transportation of the generating equipment	○		
(4) Installation of the generating equipment	○		Including the installation/improvement of the penstock and tailrace
(5) On-site testing and on-site adjustment after installation	○		
(6) Repair of the inner face of the canal and relocation of the bridge on the canal (as required)		○	・To be completed prior to the commencement of the Japanese work to install the equipment ・Reporting of the implementation status of the Vanuatu side's work to the Japanese side
(7) Access road repair work and protection of the slope on the mountain side of the canal		○	As above
(8) Removal of the 20 kV outdoor circuit breaker panel at the Sarakata River Hydroelectric Power Station		○	To be completed prior to the commencement of the Japanese work to install the equipment (installation of the main transformer for the Project by the Japanese side at the cleared site)
(9) Disposal area for the soil		○	The soil excavated will come out at the implementation of the Project

Note : ○ indicates the side responsible for the work.

2.2.4.4 Consultant Supervision

(1) Basic Work and Procurement Supervision Policies

The Consultant has the obligation to organize a project team to be responsible for the implementation of the Project and to smoothly proceed with the detailed design and work supervision in accordance with the guidelines for Japan's grant aid scheme and the contents of the basic design.

The Consultant will also dispatch specialist engineers in line with the progress of such work as civil, building and equipment installation, on-site testing and on-site adjustment, etc. in order to ensure schedule control, quality control, completed work amount control and safety control in accordance with the respective plans. Moreover, the Consultant will also have the obligation to conduct the pre-shipment inspection of the equipment for the purpose of preventing post-delivery equipment problems in advance.

The important points for work/procurement supervision are described below.

1) Schedule Control

The Consultant will conduct weekly as well as monthly progress checks while demanding that the Contractor abide by the time limit clearly indicated in the agreement. If the Consultant foresees any delay of the work, he will issue the Contractor with a warning, requesting the latter to submit and implement a remedial plan. Comparison between the planned schedule and the actual work progress will mainly be based on the following items.

① Quantity of the work completed (civil work, building work and quantity of the manufactured equipment by the manufacturers and quantity of the actual shipment made)

② Quantity of the equipment and materials delivered

③ Work efficiency and actual number of engineers, technicians and workers at work

2) Quantity and Completed Work Amount Control

The Consultant will supervise the Contractor in regard to the following items to ensure that the manufactured, delivered and installed equipment and constructed facilities meet the quality and completed work amount clearly indicated in the contract documents. If the check results suggest that there is a possibility that the required quantity or completed work amount will not be met, he will immediately demand that the Contractor correct, change or modify the situation.

① Checking of the equipment specifications

② Checking of the shop drawings and equipment specifications

③ Witnessing of the factory inspection or checking of the factory inspection results

④ Checking of the installation manuals

⑤ Checking of the trial operation, adjustment, testing and inspection manuals for the equipment

⑥ Supervision of the on-site installation work and witnessing of the trial operation, adjustment, testing and inspection of the equipment

3) Safety Control

The Consultant will hold full discussions with the safety manager of the Contractor with a view to preventing any on-site accidents to workers as well as injuries or accidents involving third parties during the construction period. The important points for safety control at the site are listed below.

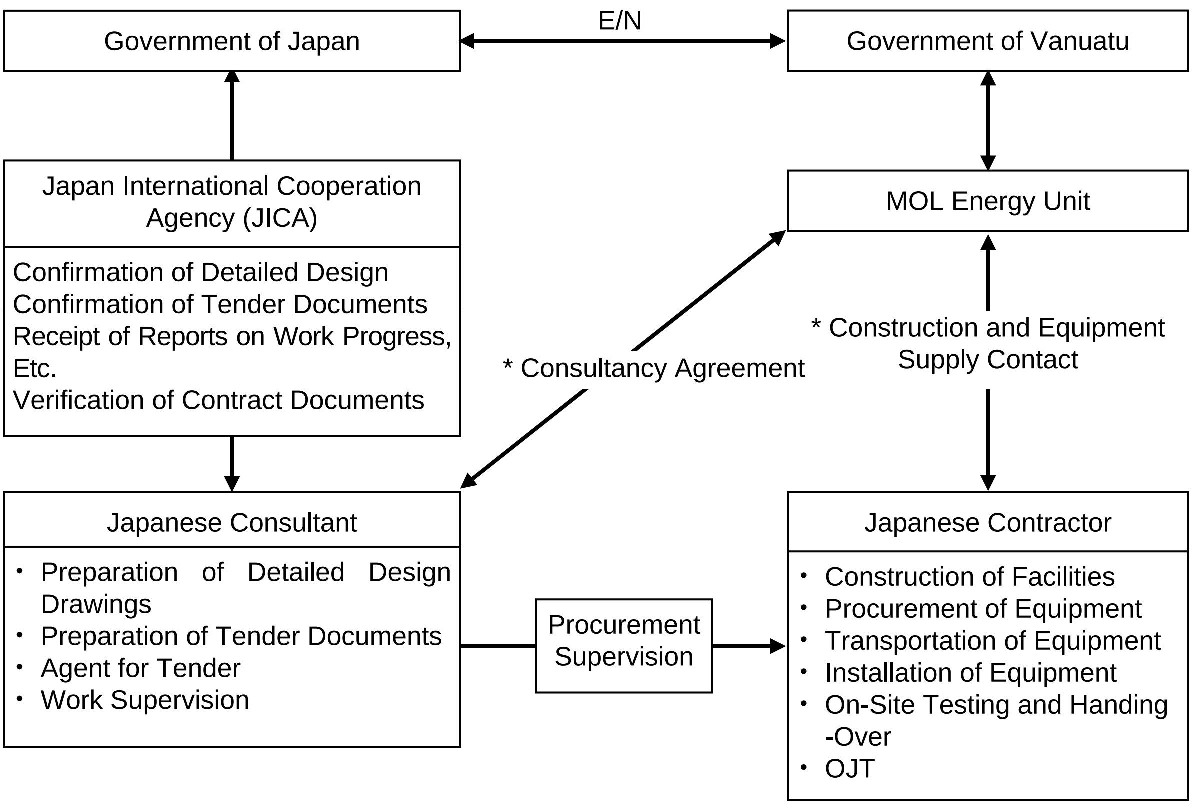
① Establishment of safety control rules and appointment of a person responsible for work safety (safety manager)

② Introduction of travelling routes for work vehicles and transportation machinery, etc. and the strict enforcement of slow driving on the site

③ Enforcement of welfare measures and days off for workers

(2) Project Implementation System

Fig. 2.2-3 shows the project implementation regime, i.e. the relationship between the parties involved in the implementation of the Project.



* The consultancy agreement and contractor agreement must be verified by the Government of Japan.

Fig. 2.2-3 Project Implementation Regime

(3) Work Supervisor

In addition to the procurement and delivery of the equipment and the construction work the Contractor will also be responsible for the equipment installation work which will be conducted by a local subcontractor. The Contractor must, therefore, ensure that the subcontractor strictly observes the requirements set forth in the contractor agreement regarding the work schedule, quality, amount of work completed and safety. For this purpose, the Contractor will dispatch engineers with experience of similar work overseas to the project site to provide guidance and advice for the subcontractor.

2.2.4.5 Quality Control Plan

The Consultant will check the compliance of the procured equipment with the technical specifications clearly indicated by the tender documents by means of conducting pre-shipment factory inspection. During the construction/installation period at the site, proper quality control will be conducted in accordance with the quality control standards included in the manuals.

2.2.4.6 Equipment and Materials Procurement Plan

Such main equipment as the hydraulic turbine, generator and generator control panel to be procured under the Project will, in principle, be procured in Japan. The circuit breaker panel and transformers will also be procured in Japan. The protection and connection panel (to be installed in the existing concrete house) will be imported from DAC to Japan and adjusted for protection relay of transformer due to the need for it to be compatible with the existing panels because of its installation along side the existing panels.

It is assumed that such civil engineering materials as rubble stones, coarse aggregates and fine aggregates will be procured in Vanuatu. In the case of reinforcing bars, those imported from ASEAN countries are readily available in Vanuatu. The procurement prospect of construction machinery in Vanuatu and Japan is possible. Temporary materials, such as the H-section steel and metal deck, etc., used for reinforcement of the intake weir bridge must be procured early as these will be used at the beginning of the work. These will be procured in Japan in view of the ease of procurement and reliability of the products.

The procurement sources for the equipment and materials to be used for the Project are listed in Table 2.2-13. The planned equipment for the Project will be procured in Japan.

Table 2.2-13 Procurement Sources

Item		Procurement Source	
		Vanuatu	Japan
1.	Generating unit		
1.1	Hydraulic turbine; generator; control panel		○
1.2	Transformer; electrical panel		○
1.3	Circuit breaker		○
2.	Civil engineering materials		
2.1	Rubble stones	○	
2.2	Coarse aggregates	○	
2.3	Fine aggregates	○	
2.4	Cement	○	
2.5	Reinforcing bars	○	
2.6	H-section; metal deck (temporary materials)		○
3.	Construction machinery		
3.1	Hydraulic crane (*)	○	○
3.2	Dump truck	○	
3.3	Bulldozer; backhoe (*)	○	○
3.4	Giant breaker	○	
3.5	Engine compressor		○
3.6	Boring machinery		○
3.7	Concrete mixer		○
3.8	Engine generator		○
3.9	Truck (with crane)		○

Legend (*) Large type: Japan

2.2.4.7 Transportation Plan

Such main equipment as the hydraulic turbine, generator and electric panels, etc. will be procured in Japan while the protection and connection panel will be procured in Europe because of the question of measurements and compatibility with the existing connection panels. Procurement in Vanuatu will be restricted to civil engineering materials. Such neighbouring countries as Australia, New Zealand and Fiji, etc. are considered to be the main sources for construction machinery but certain machinery, such as that used for the work to insert rock bolts, may be procured in Japan in consideration of economy, convenience and technical reliability.

(1) Port Facilities

Port Santo located in Luganville City will be used as the port of landing for the equipment, civil engineering materials and construction machinery to be procured under the Project.

(2) Maritime Transportation Route

There is a regular monthly shipping service from Japan to Port Santo.

- Japan → Port Santo : monthly service by container ship; travelling time of approximately one month

(3) Inland Transportation

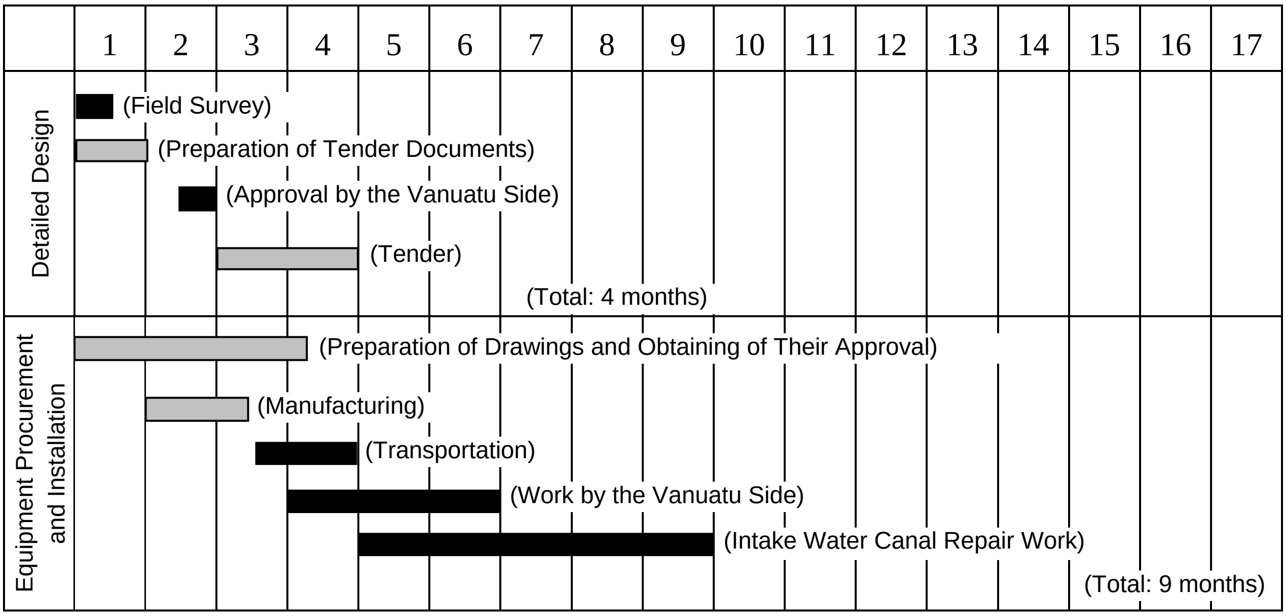
Inland transportation will take place from Port Santo to the Sarakata River Hydroelectric Power Station (distance of approximately 27 km) using the existing road. Although some sections of the road near the project site are poor with pot holes, etc., these will be repaired by the Vanuatu side prior to the commencement of the Project.

The bridge above the intake weir on the power station premises was constructed with the previous assistance but no record exists regarding its design load. Simple calculation based on the relevant drawings in the previous documents suggests that the piers can withstand a compressive load of more than 50 tons while the bridge floor can withstand a bending load of approximately 10 tons. According to the construction company which constructed this bridge, the maximum live load experienced by this bridge above the intake weir was a 0.6 m^3 backhoe (total weight of approximately 10 tons) and it has been found that the delivery of heavy machinery at the time of the previous project used the temporary bridge. Under the present Project, a 25 ton class hydraulic crane (total weight of approximately 25 tons) and a dump truck carrying rubble stones and aggregates for the concrete and gabions (live weight of approximately 10 tons and a total weight of approximately 15 tons) will, in principle, use the existing bridge and their loads will be supported by piers. Meanwhile, the bridge floor will be reinforced to withstand a load of up to 30 tons during the construction period. Given the fact that there is no nearby road around the intake, it will be necessary to construct a sloping temporary road along the left bank from the front of the present intake dam to the riverbank access point for the delivery of heavy machinery and materials to the river site. For the construction of this temporary road, it is planned to dig out some of the soil and to establish a surplus soil yard on the power station premises.

There is evidence of a collapse of a approximately 100 m shoulder section of the access road from the gate area of the powerhouse as the shoulder has a crack (approximately 20 m long). Because this is the only road available for the transportation of equipment, materials and construction machinery, etc., the repair of this access road will be included in the scope of the Project to ensure a safe transportation route.

2.2.4.8 Implementation Schedule

(Phase I) Urgent Repair Plan of Intake Water Canal



(Phase II) Hydroelectric Power Station Expansion Plan

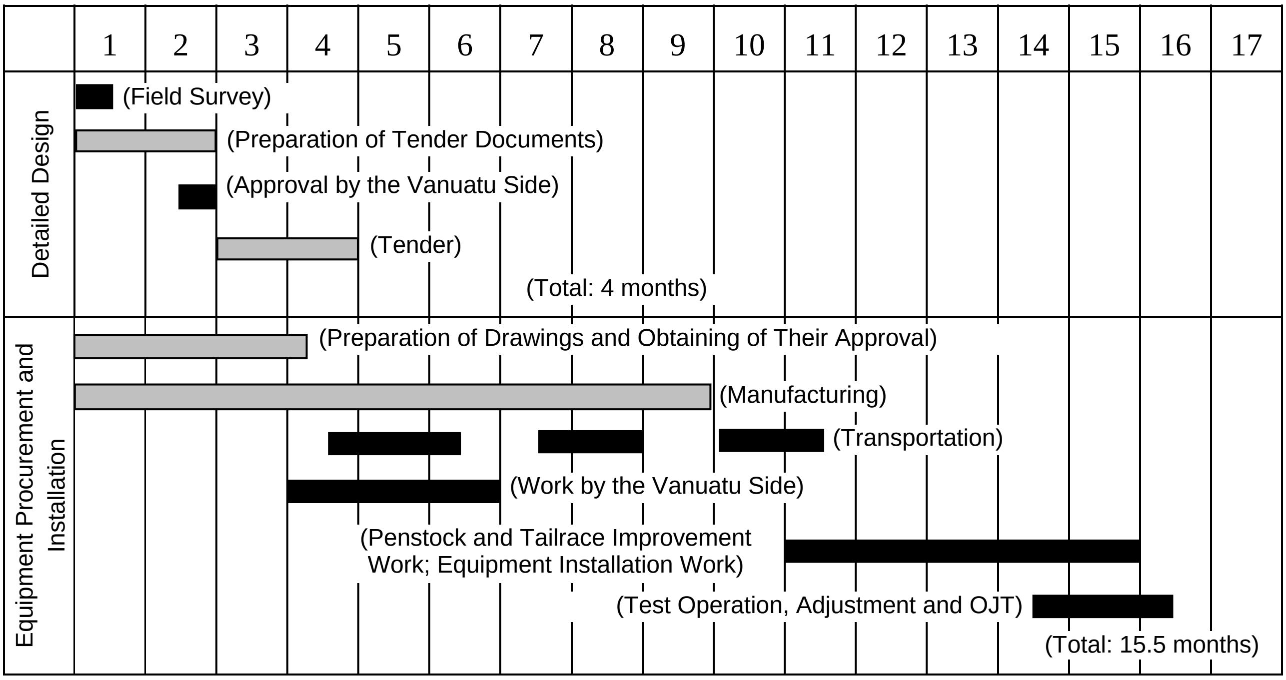


Fig. 2.2-4 Project Implementation Schedule

2.3 Obligations of Recipient Country

The Vanuatu side will be responsible for the following matters in addition to its obligation of work shown in 2.2.4.3 Division of Work.

(1) Provision of necessary data and information for the Project

(2) Ensuring of the speedy unloading, customs clearance and tax exemption of the products required for the Project at the port and airport of landing in Vanuatu

(3) Accordance of Japanese nationals whose services may be required in connection with the supply of products and services under verified contracts such facilities as may be necessary for their entry into Vanuatu and stay therein for the performance of their work.

(4) Exemption from customs duties, internal taxes and other fiscal levies which are normally imposed on a Japanese corporation or Japanese nationals in Vanuatu in respect to the supply of products and services under verified contracts

(5) Bearing of the commission of a Japanese bank for banking services based on the banking arrangements

(6) Bearing of all expenses other than those to be borne by the Japanese grant aid necessary for the execution of the Project

(7) Assignment of exclusive counterpart engineers and technicians for the Project in order to transfer operation and maintenance techniques under the Project and to witness the inspection of the equipment and materials procured for the Project

(8) Proper and effective use and maintenance of all equipments provided and installed under the Japanese grant aid

(9) Provision of proper disposal sites for excavated soil, waste water and waste oil discharged during the work period

(10) Repair of inner face of the raceway and relocation of the bridge on the canal (as required)

(11) Repair of the access road and protection of the slope on the mountainside of the Intake water canal

(12) Removal of the 20kV outdoor distribution panel at the Sarakata River Hydroelectric Power Station

2.4 Project Operation Plan

2.4.1 Operation and Maintenance System

For the Energy Unit of the MOL to perform its duty as a power provider, procurement and renewal based on its own budget and the power demand in Vanuatu is essential. Accordingly, the maintenance plan for the equipment, etc. to be procured under the Project will consider the periodic renewal of equipment as shown in Table 2.4-1.

Packings and other items which are assumed to wear very quickly will be replaced every year. Bearings and auxiliary relays, etc. will be replaced every five years in view of their physical life expectancy. Such main components as the runner and guide vane, etc. will be replaced 10 – 15 years after the commencement of their use based on their condition found at the time of periodic inspection, taking their depreciation period into consideration. Insulation of the generator coil will also be required for preventive maintenance in regard to short circuiting accidents, etc. and the yardstick for replacement is set at 10 years.

Table 2.4-1 Equipment Maintenance Plan

Timing of Replacement	Subject Part/Component	Budget Amount (Approximate)	Remarks
Every year	Packings; O-rings; shaft seals, pipe flange packings; others	VUV 4 million	Suspension of operation for two months will be necessary in the dry season
Every 5 years	Bearings; indicators; meters; printed circuit boards, etc. for control; auxiliary relays; fuses; others	VUV 10 million	As above
10 – 15 years	Guide vane; links; generator insulation; runner; others	VUV 50 million	As above

2.4.2 Regular Inspection

Recent technological innovations, including the introduction of electric servo motors to replace hydraulic apparatus, have simplified as well as improved the reliability and durability of equipment. The number of equipment breakdowns has, therefore, been steadily decreasing. Because of this, the inspection/maintenance interval has generally become longer.

Nevertheless, it is still important to conduct daily and periodic inspection to ensure the effective use of equipment for a long period of time. This inspection is particularly important for a body like the

Energy Unit of the MOL which cannot afford frequent equipment replacement due to financial constraints. The establishment of the minimum but necessary maintenance standards for the daily and periodic inspection is, therefore, essential to prevent equipment breakdown. Table 2.4-2shows the subject items for the daily and periodic inspection of the equipment to be procured under the Project and the instruments required to conduct such inspection.

Table 2.4-2 Equipment Inspection Items and Required Instruments

Type of Inspection	Inspection Item	Required Instruments
Daily inspection	Visual inspection of meters and fault displays, etc. and checking of any water leakage	Tool set
	Visual inspection of civil engineering facilities and their surrounding areas	-
Six monthly inspection (characteristic test)	Checking of the characteristics of the control system and hydraulic turbine; vibration; coil insulation	Vibration meter; gauges; insulation-resistance tester; others
	Control system; protective relays	Digital tester; relay tester; others

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

The estimated total project cost in the case of the implementation of the Project under Japan's grant aid scheme will be ¥1,316 million, based on the estimation conditions listed below and its breakdown into the Japanese portion and the Vanuatu portion are described next. This cost estimate is provisional and would be further examined by the Government of Japan for the approval of the Grant.

(1) Cost to be Borne by the Japanese Side: approx. ¥1,277.2 million

Item			Amount (¥ million)	
(1) Phase 1 work	Facility	Work for the Intake water canal, etc.		536.4
(2) Phase 2 work	Facility	New penstock and the power house building extension work, etc.	181.4	634.3
	Equipment	Procurement and installation of a turbine generator and other equipment	452.9	
(3) Design and Supervision Fee				106.5
Total				1,277.2

(2) Cost to be Borne by the Vanuatu Side: VUV 38.2 million (approx. ¥39 million)

1) Repair of the inner face of the raceway:
VUV 24.5 million (approx. ¥25 million)

2) Repair of the surface of the access road (gravelling, etc.):
VUV 4.9 million (approx. ¥5 million)

3) Prevention of sediment inflow to the raceway from the mountain side slope
(erection of the retaining fence for an 80 m section on the mountain side in the head tank area):
VUV 8.8 million (approx. ¥9 million)

Note: The above costs are the minimum funding requirements to implement the Project.

(3) Estimation Conditions

1)	Date of estimation	:	November, 2006
2)	Foreign exchange rate	:	VUV 100 = ¥102.02 US$ 1 = ¥116.72
3)	Work period	:	as shown in the work schedule
4)	Others	:	The Project will be implemented in accordance with the Guidelines for Japan's Grant Aid and the estimated project cost does not mean the upper limit of the grant aid referred to in the E/N.

2.5.2 Operation and Maintenance Cost

For the Energy Unit of the MOL to continually provide an electricity supply service in a healthy manner in the years to come, renewal of the equipment to be procured and installed under the Project at reasonable intervals will be essential. Accordingly, the maintenance plan should take the periodic equipment renewal cost referred to in 2.4 in addition to the maintenance cost of the existing and new equipment into consideration.

The equipment to be procured under the Project will commence operation in 2009 and the annual expenditure is estimated here based on the assumption that the cost of the renewal of the main parts/components (approximately ¥100 million), which will become necessary after approximately 10 years' operation, will be saved as a reserve. The total cost of procuring spare parts for the three generating units at the power station in question is assumed to be VUV 15 million.

The sources for this reserve will be the electricity charge and reduction of the fuel cost for diesel generation. The fuel cost for diesel generation has shown a tendency to steadily increase every year and the cost of diesel oil is assumed to be VUV 83.7/litre. An electricity charge of VUV 40/kWH is adopted as the target level of the electricity charge. The expenditure items and the calculation basis are shown in Table 2.5-1.

Based on the above conditions, contribution to the Sarakata Fund which is the reserve fund for the equipment renewal in 10 years' time, including equipments provided under the present Project, will be steadily made. With an increase of power demand, additional savings on the deisel cost will be made in 2015. If the electricity charge remains at the same level, the amount of surplus is expected to be boosted further.

Table 2.5-1 Estimation of the Operation and Maintenance Cost

No.	Item	2005 (Result)	2010 (One Year After Commissioning)	2015 (One Year After Target Year)	Remarks
1	Generated energy per Year (kWH)	6,645,200 (100.00%)	7,703,631 (100.00%)	8,930,620 (100.00%)	
2	Diesel (kWH)	3,654,871 (55.00%)	1,745,668 (22.66%)	2,402,456 (26.90%)	
3	Hydroelectric (kWH)	2,990,349 (45.00%)	5,957,963 (77.34%)	6,528,164 (73.10%)	Operation suspended for approx. two months every year for inspection
4	Sale of Electric Energy				
(1)	Energy sold (kWH)	6,069,839	6,983,432	8,095,711	
(2)	Sales income (VUV)	169,955,492	195,536,092	226,679,922	Unit price: VUV 40/kWH x 70%
5	Generation Cost				
(1)	Diesel				
	Fuel (VUV)	88,757,080	42,392,857	58,342,671	Consumption rate: 0.29 litres/kWH
	Lubricating oil (VUV)	12,918,507	6,170,239	8,491,719	Consumption rate: 0.03 litres/kWH
	Spare parts (VUV)	5,482,307	2,618,503	3,603,683	
(2)	Hydroelectric				
	Spare parts (VUV)	5,000,000	15,000,000	15,000,000	
(3)	O & M cost (VUV)	20,000,000	25,000,000	25,000,000	
(4)	Contribution to Sarakata Fund (VUV)	10,000,000	20,000,000	20,000,000	
(5)	Total (VUV)	142,157,894	111,181,599	130,438,074	
	Balance: 4(2)–5(5) (VUV)	27,797,598	84,354,493	96,241,848	

VUV 100 = ¥102.02 (June 2006)

CHAPTER 3

PROJECT EVALUATION AND RECOMMENDATIONS

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3.1 Project Effects

The main expected effects of the Project when implemented are described below.

(1) Direct Effects

Present Situation and Problems	Improvement Measures Under the Planned Project (Assistance)	Effects of the Project and Degree of Improvement
The ground around the existing canal has partially eroded, causing the risk of a collapse of the canal. Urgent measures are required.	Rainwater drainage work and slope protection work, etc. will be conducted for the ground in question to stabilise the ground.	Water supply to the Sarakata River Hydroelectric Power Station will be secured, making the safe and continual operation of the power station possible.
The high dependence on diesel power generation has increased the financial pressure on the Government of Vanuatu due to an increase of diesel imports.	The new No. 3 hydraulic turbine generator (600 kW) will be installed as an addition to the existing two generators (300 kW each).	The total capacity of the Sarakata River Hydroelectric Power Station will increase to 1,200 kW. As a result, it will provide the base load, contributing to a reduction of diesel oil consumption.
		The increased generation capacity by 600 kW (No. 3 unit) will increase the reserve supply capacity, making the provision of a steady power supply possible when the operation of a turbine generator is suspended for periodic inspection or due to a breakdown.

(2) Indirect Effects

Present Situation and Problems	Improvement Measures Under the Planned Project (Assistance)	Effects of the Project and Degree of Improvement
While expansion of the coverage of local electrification is necessary, the growing dependence on diesel power generation has led to financial difficulty to maintain the service.	As above	The reduced expenditure for diesel oil will increase the contribution to the Sarakata Fund, boosting the financial source for local electrification.
Increasing operation hours of the diesel power plant causes further air pollution and noise in the surrounding area		The shortening of the operating hours of the diesel power station will reduce the risk of air pollution and noise.

3.2 Recommendations

The Vanuatu side should complete the following tasks to ensure the realisation and continuation of the positive effects of the Project.

(1) The appointment and appropriate assignment of engineers must be conducted without delay so that the proper operation of the new generating unit will continue after the handing over of the new facilities to the Vanuatu at the project site.

(2) The necessary funds in the form of the Sarakata Fund, etc. for the procurement of repair parts and others should be saved from the surplus income to ensure the proper maintenance of the new generating unit and auxiliary equipment to be installed under the Project.

(3) The existing canal should be properly maintained in order to maintain the proper operation of the new generating unit at its output level. For this purpose, the inner face of the canal should be repaired prior to the commencement of the operation under the Project and the canal should be properly maintained and repaired (if necessary) thereafter.