National Drainage and Irrigation Authority

Ministry of Agriculture

The Republic of Guyana

IMPLEMENTATION REVIEW STUDY REPORT ON THE PROJECT FOR THE REHABILITATION OF THE EAST DEMERARA WATER CONSERVANCY(Ⅱ) IN THE REPUBLIC OF GUYANA

October 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

SANYU CONSULTANTS INC.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the implementation review study for the project named “The Rehabilitation of East Demerara Water Conservancy (Ⅱ)” and conducted the field survey during the period of 5th ~26th March, 2013.

In the field survey, the study team carried out site survey and had a series of discussion with the concerned government staff and also made efforts to fully grasp the current state of the project site. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute not only to the promotion of the project and to the enhancement of friendly relations between our two countries. Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Guyana for their close cooperation extended to the survey team.

I sincerely hope that this report will contribute not only to further promote this project, but also to serve for further development of close relationship between two countries.

Finally, I would like to express my sincere appreciation to their close cooperation extended to the survey team.

October 2013

Shokichi SAKATA
Director General
Financial Cooperation Implementation Department
Japan International Cooperation Agency

SUMMARY

1. Outline of the Republic of Guyana

The Republic of Guyana (hereinafter referred to as “Guyana”) has the total population of 762,300 (as of 2013, National Statistical Authority). Its territory, extending over 215 thousand km2, is divided into fertile coastal plain along the coast of the Atlantic Ocean, low hilly zone in its hinterland, tropical rain-forest of inland zone and plateau savanna zone.

The coastal plain forms the lowland occupying 6% of the overall territory area, with the average elevation of minus 2m below the sea level. However, about 90% of national population and 50% of agricultural production are concentrated in this plain.

Climate is classified, according to Keppen’s climatic zoning, into tropical rain-forest, tropical monsoon and tropical savanna. Annual mean precipitation ranges 2,300mm in the coastal plain while as much as 3,000mm in the tropical rain forest zone. Average yearly temperature in Georgetown is 27.3℃ with a narrow annual temperature fluctuation.

Total GDP of Guyana amounts to 570,770 million G$（2,850 million US$ and per capita GDP is about 748,700 G$(3,740US$) (According to World Bank website)） . The growth rate of average substantial GDP during the period from 2007 to 2012 stood at 4.5%, indicating a steady economic development. GDP is composed of the primary industries with a share of 18.7%（where agriculture accounts for 13.7%）, the secondary ones with a share of 27.7% and the tertiary ones sharing 57.5% (National Statistical Authority).

2. Background, Rationale and Outline of Grant Aid Cooperation

Guyana has launched policies for applying measures towards impact of recent increased annual precipitation and rising mean tidal water level caused by climatic change in “the state strategic policy for adapting the state to climatic changes (2002)”. Under this policy, it implements disaster prevention policies mainly concentrated on sea-coastal dike through the assistance by World Bank and Inter-American Development Bank. In addition, National Drainage and Irrigation Authority (hereinafter referred to as NDIA), Citizen’s Disaster Prevention Committee, River and Ocean Defense Division, Land Survey Committee intend to promote “low-carbon development strategy (September, 2009)”. “Poverty Alleviation Strategic Paper (2002)” also noted that consolidation of drainage and irrigation facilities is indispensable to secure economic growth of Guyana.

The East Demerara Water Conservancy (hereinafter referred to as EDWC) is located at

the south of the capital, Georgetown, constructed in 19th century, mainly of the embankment with the length of about 65km, consisting of such facilities as embankment, canal in the conservancy, reservoir, discharge outlet and intake, and these have been under the control of NDIA.

The catchment area of EDWC is measured at about 580km^2, while the water storage surface area is measured at around 460km^2. EDWC has a flood controlling function by regulating the volume of flood water flowing into the metropolitan area during spells of torrential rain, while it serves as water sources irrigating about 17,900ha of farmland located around it and also for supplying potable water in the area (accounting for about 40% of the total water source for around 360 thousand, target population of water supply), thus playing a key role of water supply for multi-purpose use in the metropolitan sphere.

However, its water storing function against the recent amplified rainfall intensity that may have been brought about by the influence of climatic change has not been sufficient, resulted in frequent flood damages in 2005, 2006 and 2009. Above all, in the flood experienced in 2005, the stored water spilled out over several points of the northern embankment of EDWC. During this flood period, measures were taken to release water to the Mahaica River, but these resulted in large-scale flood-inundation in its downstream watershed area. Also a large-scale inundation took place in the metropolitan area due to insufficient capacity of the pump drainage. About 40% of the metropolitan population had suffered damages from this inundation with the economic loss equivalent to around 60% of national GDP.

Suffering from a heavy damage by this disaster, the government of Guyana requested United Nations to dispatch disaster evaluation coordinating team. United Nations Disaster Assessment and Coordination (hereinafter referred to as UNDAC) compiled its study result (February 2005) in a report “Geotechnical and Hydraulic Assessment of the East Demerara Water Conservancy Dam”, in which it presented from short-term to medium term Action Plan.

In pursuance of this Action Plan, the Government of Guyana not only carried out “Reservoir Adaptation Project” under WB assistance, but also requested grant aid to Japan for rehabilitating the embankment and its appurtenant facilities. Responding to this request, JICA conducted “Preparatory Survey (I) on the Rehabilitation of the East Demerara Water Conservancy” in July-November 2009, then “Preparatory Survey (II) on the Rehabilitation of the East Demerara Water Conservancy” during the period of October 2010 ~ September 2011, and implemented a grant aid in 2012 in which provides fund for procurement of equipment necessary for urgent rehabilitation works of EDWC.

After the implementation of grant aid in 2012, further implementation of grant aid project aiming at rehabilitation of facilities as proposed under the Rehabilitation of the East Demerara Water Conservancy (II) was decided and after signing of Exchange of Notes (E/N) and Grant Agreement (G/A) on September 6, 2011, the detailed design had been commenced.

However, the original consulting firm withdrew from the services for the bidding and construction supervision stages. This project implementation study was then carried out for the purposes to confirm the following items toward the project implementation at the earliest.

- Changes in site conditions
- Review in detail on the detailed design including cost estimate and implementation schedule
- Final cost estimate and updated implementation scheduling

Based on the background and proceedings as mentioned above, JICA dispatched the subject study team for project implementation study to Guyana during the period March 3 – 26, 2013. This Project conforms to the dam rehabilitation project that the Government of Guyana has been promoting, and shall have not only the aspect coping with the climatic change but also bring the actual effect of supplying water resources constantly and decreasing the flood damages to the metropolitan sphere and the surrounding lowland.

3. Outline of the Study Result and Contents of the Project

Through conducting the survey, the study team confirmed such changes prevailing since the previous survey as caused by the progresses attained by the WB Reservoir Adaptation Project as well as the situation of the embankment protection works (With a certain period after the flood).

(1) Outline of study result and design policy

(a) Intake facilities

As the result of the site survey, it was identified that the main body of intake facilities have structural defects and in some cases intake facilities have become “weak points of the embankment”. As regards such intake facilities, the thorough rehabilitation by replacement of the existing facilities to new ones, shall be implemented.

- Due to the fact that the main canal of Ann’s Grove Intake is crossed by Hope/Dochfour Canal, the inlet shall be shifted to the right bank of the Hope/Dochfour Canal. While, a full rehabilitation of Shanks Intake was judged to be inevitable and it was planned that the

inlet of Ann's Grove Intake shall be newly constructed together with the Shanks Intake.

- In the proposed sites for the revetment rehabilitation, it is surely confirmed that the existing wooden-pile revetments become rotten and lost sometimes; but the embankment slope or the ground surface behind them maintain their shape and remain stable. Therefore the slope protection work shall be adopted the method suitable for the current situation, and rehabilitated the place with high urgency and necessity as priority.

(b) Discharge facilities

As to discharge facilities, "Improvement of discharge capacity" is considered as priority in examining the targets of the rehabilitation.

(2) Target facilities for the rehabilitation/reconstruction

Taking into account the relative importance and necessity of rehabilitation of the facilities, the following priority order is given in rehabilitating/reconstructing the facilities requested by Guyana as shown in the following Table-2 through the review results as indicated in the Table-1.

Table -1 Review on Necessities for Rehabilitation

Facility Name	Contents at the time of preparatory survey	Results after reviewal
Maduni Sluice	-Rehabilitation of the existing sluice gate -Rehabilitation of revetments on both inlet and outlet sides -Rehabilitation of embankment -Construction of rear embankment	-Rehabilitation of the existing sluice gate -Rehabilitation of slope protection for inlet side to keep slope stable and protection. (including treatment for rear embankment) -No need for outlet side due to Self supported ground
Sara Johanna Sluice	-Rehabilitation of revetment on inlet side -Replacement of drainage pipe	- The plan shall be reviewed so as to give the priority improving the canal capacity directly. - Rehabilitation of flume canal The range and scale of revetment works shall be reviewed.
Ann's Grove Intake	-Rehabilitation of revetments both on inlet and outlet sides -Improvement of embankment filling	-Rehabilitation together with the Shanks Intake -Burying the existing pipe with concrete
Hope Intake	-Rehabilitation of guide channel to intake -Rehabilitation of revetments both on inlet and outlet sides -Extension of intake mouth -Improvement of embankment filling	- New construction of intake -Burying the existing pipe with concrete

Facility Name	Contents at the time of preparatory survey	Results after reviewal
Annandale Intake	-Partial rehabilitation of intake gate -Rehabilitation of revetments both on inlet and outlet sides -Construction of rear embankment	-no need for rehabilitation of intake gate because leakage from the gate is allowable -Rehabilitation of revetment on inlet side (including treatment for rear embankment) but no need for outlet side where the slope is self-supported with coverage of vegetation
Nancy Intake	-Rehabilitation of revetments both on inlet and outlet sides -Construction of rear embankment	-Rehabilitation of slope protection for inlet side to keep slope stable and protection. (including treatment for rear embankment)
Shanks Intake	-	New construction of intake -Burying the existing pipe with concrete

Table -2 Structures to be rehabilitated/reconstructed and their priority order

Facility	Target of rehabilitation	Priority rank
Shanks Intake (Ann's Grove Intake)	New construction of the entire intake facility（Backfilling of the existing facilities）	1
	Treatment of existing Ann's Grove intake facilities	
Hope Intake	New construction of the entire intake facility（Backfilling of the existing facilities）	2
Sara Johanna Sluice	Rehabilitation of the concrete flume	3
	Rehabilitation of the slope protection works	5
Maduni Sluice	Replacement of the sluice gate	4
	Rehabilitation of the slope protection works（Including the shaping of the embankment）	6
Nancy Intake	Rehabilitation of the slope protection works（Including the shaping of the embankment）	7
Annandale Intake	Rehabilitation of the slope protection works（Including the shaping of the embankment）	8

(3) Construction method to be applied

With regard to the application method, initially, the ground improvement method and the soil cement method were proposed in consideration of soil properties around facilities to be rehabilitated. However, the Guyana side showed a strong intention to be adopted the conventional methods. In addition to this responses, the study team re-examined the possibility of application of these methods in Guyana including environmental considerations, and sustainability, etc., and decided to modify the methods to be adopted in the Project to the followings.

(a) Rehabilitation of intake facilities

In case of Shanks Intake and Hope Intake which shall be newly constructed, the intake conduit traversing and buried in the embankments is deemed to be 'the buried structure onto the soft ground'. In Japan, "flexible structural system" that can absorb the deformation caused by the foundation settlement shall be provided to such structures, or "the soil improvement method (ground conditioning method) shall be applied.

Also, the conduit and the retaining walls shall be designed to have longer lengths than the existing ones so as to secure the higher safety against the seepage flow in and around the structures; and the backfill shall be done by using the soil-cement to secure the impervious of the backfill itself and the surrounding portion of the conduit.

(b) Sara Johanna outlet facility

The existing concrete flume installed on the water way toward the Sara Johanna regulation gate, also functioning as piers of the wooden bridge to the plywood company's premise, is so narrow that it becomes a bottleneck to the water flow. This concrete flume shall be replaced to a wider one to improve the discharge capacity of the canal.

(c) Slope protection works around intake structures and sluice structures

Field survey results indicate that wooden piles and sheet-piles have been rotten, while no abnormal conditions are observed on concrete walls. Hence, soil-cement is to be adopted for slope protection work taking durability/ economy into consideration.

(4) Soft component (Technical Assistance)

Soft components are to be modified partly in accordance with the results of site survey and the review results on design policy.

(a) Preparation for setting up the EDWC operation plan of keeping the water level low during flood period

While attaining substantially fast progresses in rehabilitation project for EDWC, operation manual for discharge (Sluice) facilities are yet to be compiled in a way to meet the actual situation. It is necessary, therefore, to secure safety standard in the facilities operation through improvement its operation; For this sake, technical know-how for setting up the EDWC operation plan of keeping the water level low during flood period will be introduced and basic data collection for formulating its operation plan will be conducted.

4 Project evaluation

Taking into account the project benefits as confirmed through the project implementation review study, the subject project is evaluated as a project which can contribute to stabilization of livelihood and improvement of living condition of the people residing at the downstream area of EDWC in the form of, and the project is considered suited to implementation at the soonest.

Moreover, introduction of the operation method of “safety dam management of keeping the water level low during flooding”, which is planned for soft component and aimed at safety enhancement of dam management, is evaluated as having significance in response to climate change such as the impact of sea level rise and the increase tendency of intensity rainfall.

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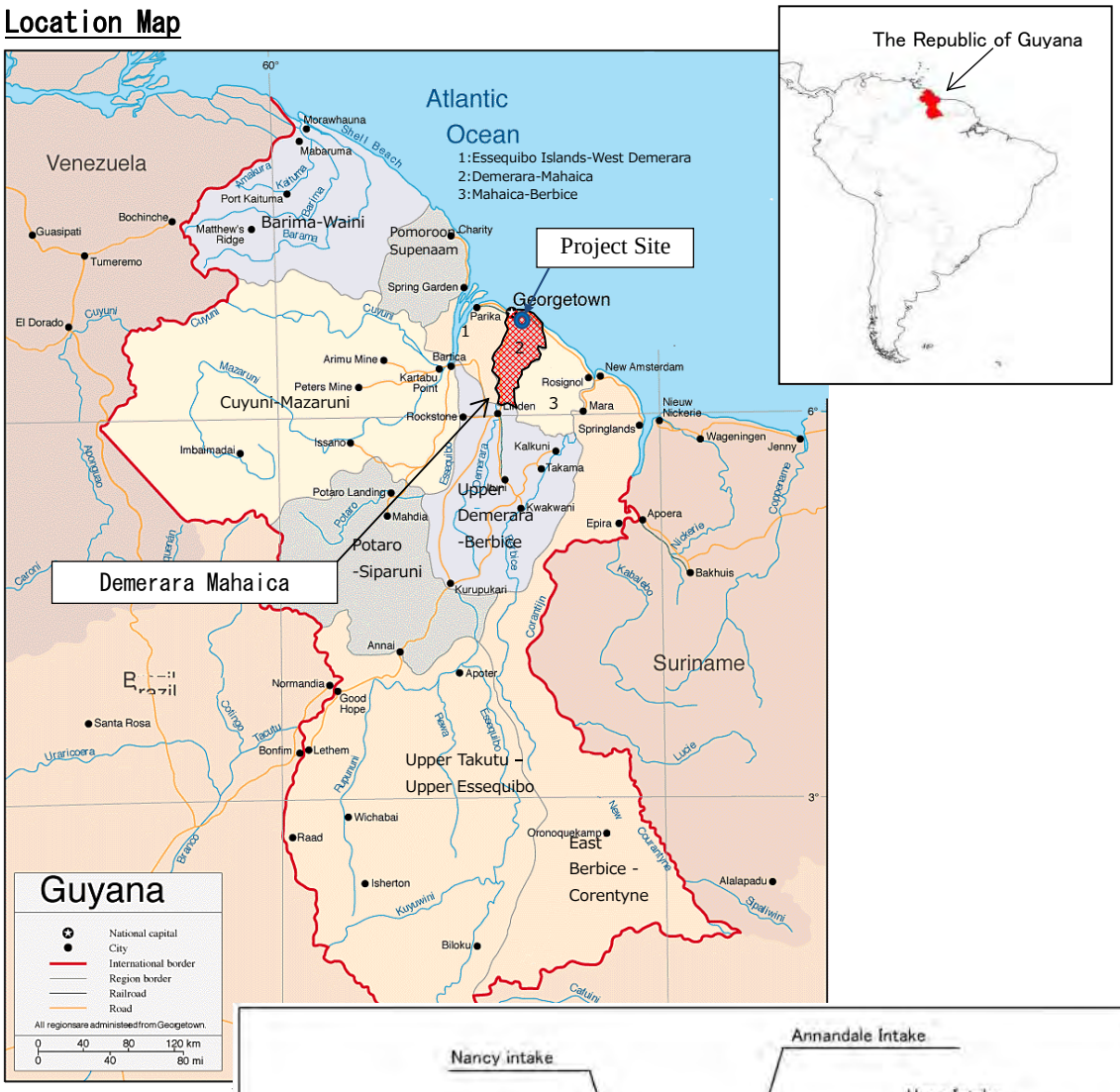
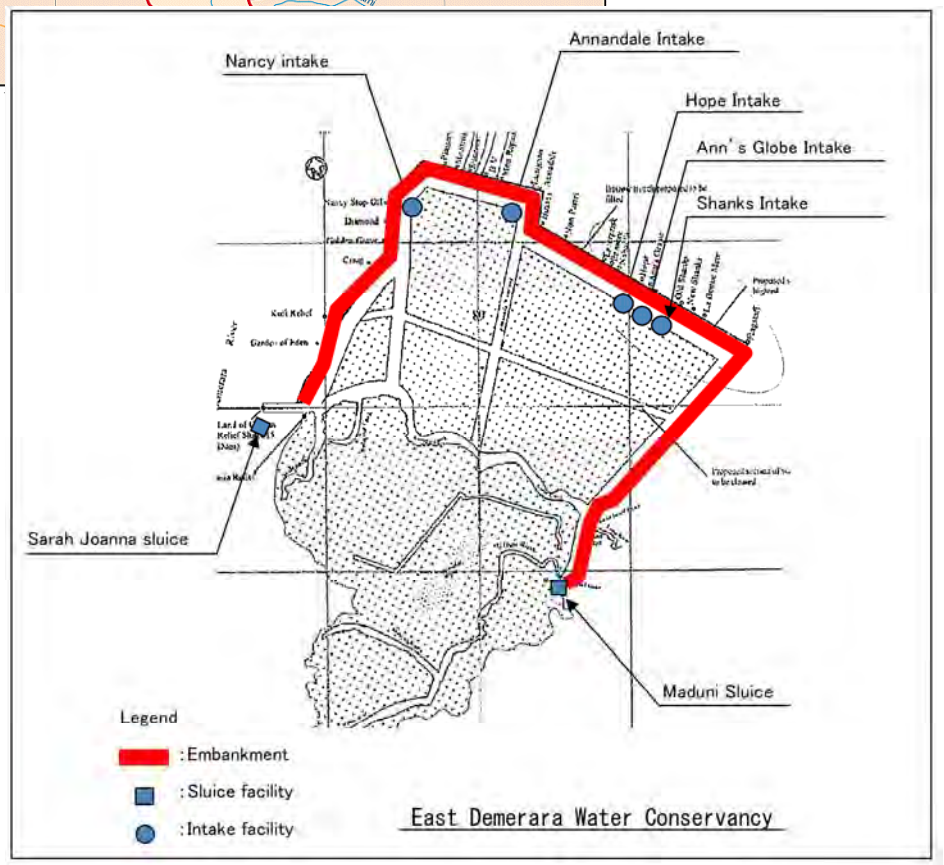
Abbreviations

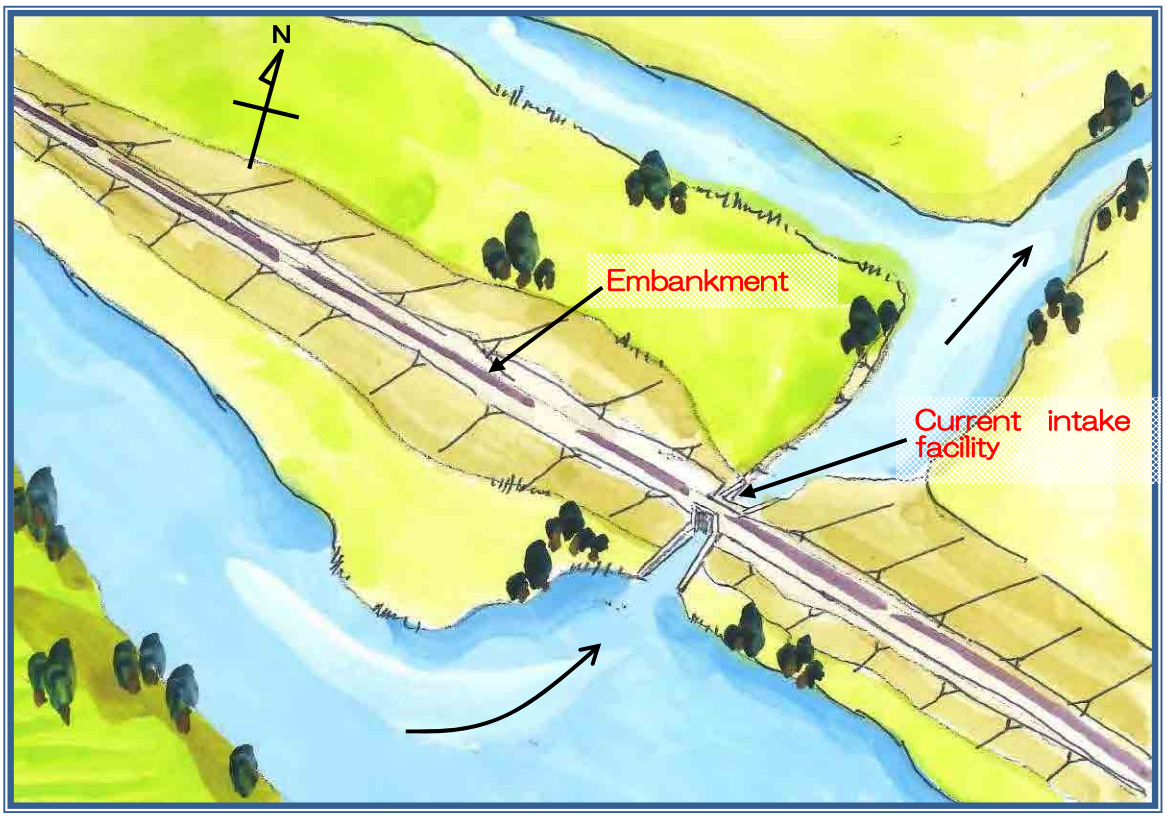
ASTM	American Society for Testing and Materials
BS	British Standard
CAP	Conservancy Adaptation Project
DEIA	Detailed Environmental Impact Assessment
EDWC	East Demerara Water Conservancy
EIA	Environmental Impact Assessment
EMD	Environmental Management Department
EPA	Environmental Protection Agency
GD	Georgetown Datum
GWI	Guyana Water Inc.
HYDROMET	Hydrometeorology Department
IDB	Inter-American Development Bank
JICA	Japan International Cooperation Agency
LCDS	Low Carbon Development Strategy
MOA	Ministry of Agriculture
MSL	Mean Sea Level
NDC	Neighborhood Democratic Council
NDIA	National Drainage and Irrigation Authority
NDS	National Development Strategy
NFMS	National Flood Management Strategy
RDC	Regional Democratic Council
SEEC	Strategic Emergency Engineering Committee
UNDAC	United Nations Disaster Assessment and Coordination
UNDP	United Nations Development Program

Location Map

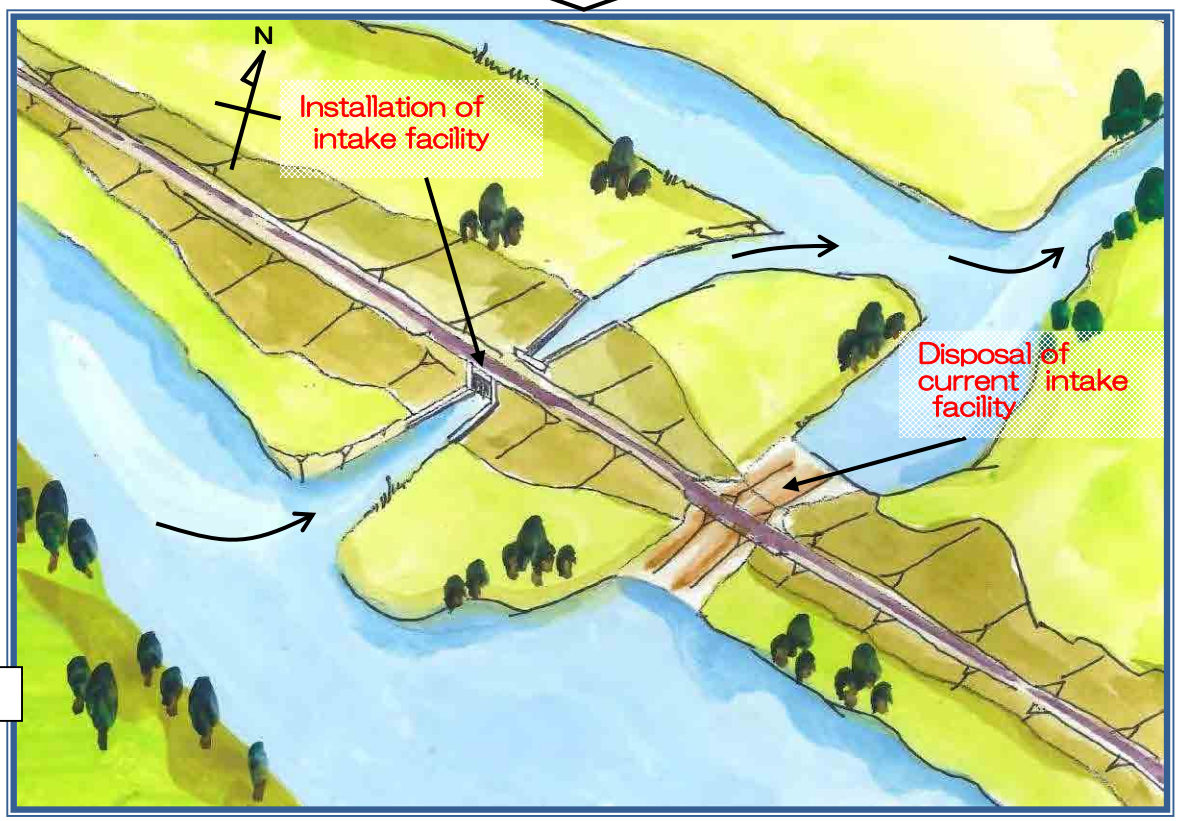




Perspective



Current facility



Perspective (after rehabilitation)

Chapter 1 Background of the Project

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1-1 Background of the Project

Japan International Cooperation Agency (JICA) carried out the preparatory study on the project "The Rehabilitation of East Demerara Water Conservancy" in 2009, in response to the request by Guyana to Japan made in 2008 on the grant supply of construction machinery and equipments including ultra-long arm excavators and also on the assistance for the rehabilitation of appurtenant facilities for improving the discharge capacity and the structural safety, and identified the contents of the request as follows:

Component 1: Procurement of Equipment
Machinery and equipment for urgent rehabilitations of East Demerara Water Conservancy:

- Ultra-long arm excavators - 8 Nos.
- Pontoons (with a storage bin for excavated soil) - 2 Nos.

Component 2: Rehabilitation of appurtenant facilities
East Demerara Water Conservancy; Rehabilitation of Intake and Sluice facilities:

- Intake facilities; 4 sites (Ann's Grove, Hope, Annandale and Nancy)
- Sluice facilities; 2 sites (Maduni and Cuhnia)

Through detailed studies and discussions with NDIA on the components above which had been done as a part of the preparatory study in September 2011, the Cuhnia Sluice was replaced to the Sara Johanna Sluice as the target of the rehabilitation. The prehistory of this change is as follows.

- The discharge canal of Cuhnia Sluice was diverted and connected to the Sara Johanna discharge canal at the time of the national highway construction.
- Since then, the latter portion of the old Cuhnia discharge canal has been kept buried.
- The intention of NDIA was to restore the buried portion and increase the discharge capacity of the Cuhnia Sluice.
- Restoring requires a large scale construction of bridge or culvert to the national highway; and the preparatory study team judged it difficult considering the budget condition.
- NDIA requested the rehabilitation of Sara Johanna discharge canal in place of the Cuhnia Sluice; and the both sides agreed to this change.

Later, the component 1 was implemented as the grant supply of ultra-long arm excavators and pontoons in 2012 under the project "the Rehabilitation of the East Demerara Water Conservancy".

After the implementation of grant aid in 2012, further implementation of grant aid project aiming at rehabilitation of facilities under the Rehabilitation of East Demerara Water Conservancy (II)

was decided and through signing of E/N and G/A on September 6, 2011, subject detailed design had been commenced.

However, the consulting firm in charge of the subject Project (II) detailed design withdrew from the services for the bidding and construction supervision stages. This project implementation study was then carried out for the purposes to confirm the following items toward the project implementation at the earliest.

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This Project conforms to the dam rehabilitation project that the Government of Guyana has been promoting, and shall have not only the aspect coping with the climatic change but also bring the actual effect of supplying tap water and irrigation water constantly and decreasing the flood damages to the metropolitan sphere and the surrounding lowland.

1-2 Natural Conditions

(1) Topography/ geology

Topography of Guyana is roughly divided into four zones, namely, low coastal plain that is fertile lowland along the coast of the Atlantic Ocean, low hilly zone covered by white sand behind the plain (Hilly sand and clay region, the basement of which consists of clay formations), inland rain-forest zone (Rain forested region) and plateau savanna zone (Interior savannah).

The coastal plain occupies a narrow area along the coast, accounting for only 6% of the territory area. Its basement mainly consists of clay and its average elevation is lower than the sea level by 2 meter. However, about 90% of the 800,000 state population lives in this plain where administrative organization, agriculture and other industrial activities have been concentrated.

Low hilly zone extends behind and in parallel with the coastal plain like a belt, covered with vegetation. This zone accounts for 25% of the territory area and well known by rich deposit of bauxite ore.

Interior savannah zone accounts for about 6% of the territory area with a vegetation dominated

by grasses and shrubs. Rain forested region is vast dense-forest zone extending from central lowland area to 4 mountain ranges located along Brazilian border in the south, accounting for about 63% of the territory area. Its basement under jungle vegetation consists of well-weathered laterite, but its basal rocks including that of interior savanna zone consist of the oldest rocks in the world, or those of pre-Cambrian origin.

East Demerara Water Conservancy Dam has been constructed at northern half of the coastal plain. The ground elevation of the dam at the coastal side is measured at about GD.52 feet {GD: Georgetown standard elevation, GD = MSL (mean sea level) + 1.8 feet}, and the basement found around the dam consists of 3 layers, namely, white clay with a thickness of 1 meter or so covering the ground surface, beneath it a peat layer called Pegas lies with a thickness of 5 meter or so and a grey-bluish clay layer lies at the bottom. The boundary of peat layer and clay layer at the bottom, with a thickness of around 2 meter forms a transient part of these two layers (information obtained from a constructor engaged in Crown Dam Rehabilitation work).

The grey-bluish clay layer found at the bottom of basement is changed into pale brown clay layer from the point located at 10km upstream of the northern side dyke, while the dyke of the eastern side located in further upstream side of the northern one, probably constructed with this pale-brown clay, forms a rigid embankment bearing pale brownish color. It is presumed that this layer is a terminal part of clay formation forming low hilly zone (hard clay that resists penetration of piles). The upstream basin of this dam extending over the inland area, located at 50 ~ 60 km from the coastal line, has low hilly {with the elevation of GD.20m or so（≒GD.64 feet）} or flat topography and its surface is covered with white sand where vegetation like that found in savannah develops.

In the coastal zone from Georgetown to Mahaica, sand collected from this area is exclusively used as aggregates of concrete where the distance of sand carriage reaches 100km in some cases.

Fig. 1-2-1 Satellite imagery of the East Demerara Water Conservancy
（Guyana, Socio-Economic Assessment of the Damages and Losses caused by the January-February 2005 flooding /Economic Commission for Latin America and the Caribbean (ECLA) /Mar. 2005）

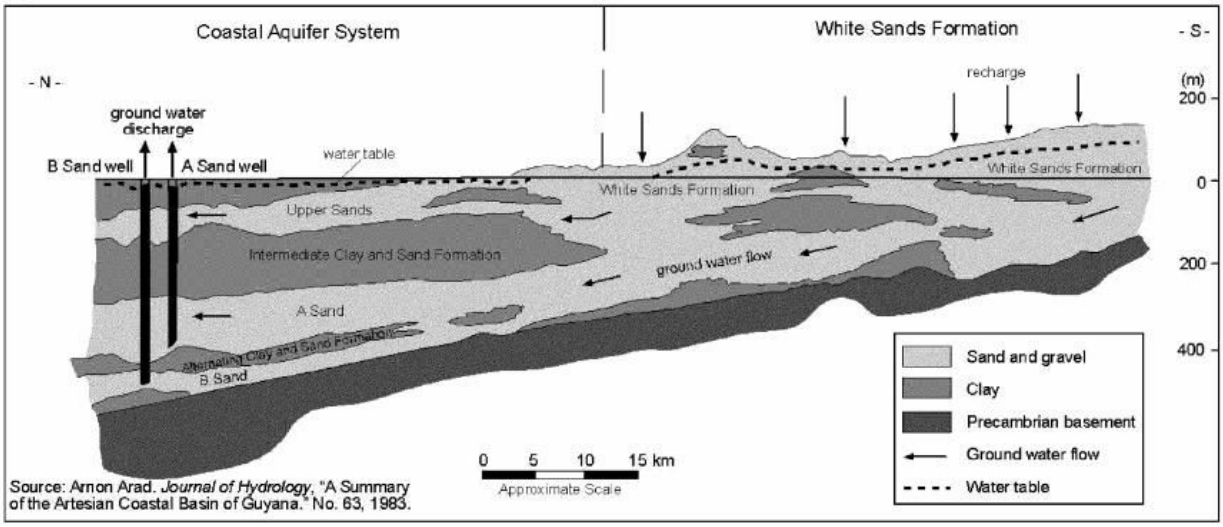


Fig. 1-2-2 Estimated geological vertical section in and around Georgetown
（Water Resources Assessment of Guyana, US Army Corps of Engineers (1998)）

Also, volcano is not found in Guyana, nor deposited soils of volcanic origin.

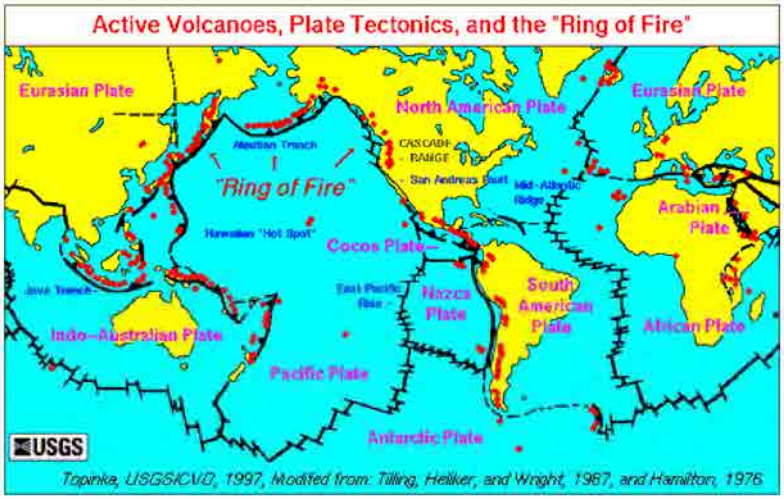


Fig.1-2-3 Guyana and volcanoes (<http://vulcan.wr.usgs.gov/home.html>)

As to earthquakes, Guyana is classified into "Low Hazard" according to the hazard map by UN, where even at maximum only about 1/10 of the quake strength as much as that takes place in Japan is assumed.

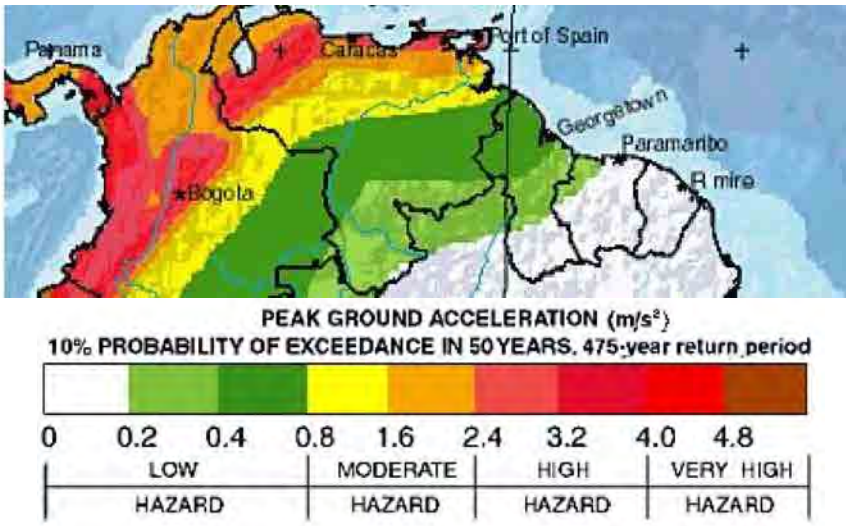


Fig. 1-2-4 Earthquakes in Guyana
(Seismic Hazard Map of the World By Global Seismic Hazard Assessment Program (GSHAP), UN /1992~1999)

(2) Meteorology

Climate in Guyana is classified according to Keppen's climatic zoning as Af（tropical rain-forest) - Aw（tropical monsoon）- Am（tropical savanna）(refer to Fig.1-2-5).

Annual mean precipitation ranges 2,300mm in coastal plain, 1,600mm in savanna zone and 3,000mm in tropical rain forest zone. Atmospheric temperature changes with a range of 34℃-16℃

and that of inland, higher elevation zone shows cooler temperature range. According to a scientific constant bulletin, the climate in Georgetown is characterized by annual mean precipitation: 2,314.3mm and annual mean atmospheric temperature: 27.3℃(during the period of 1971-2000).

Besides, the territory of Guyana develops in a range of 2° - 8° in latitude which is largely overlapped with equatorial windless zone located in 5° - 10° of north latitude. The north-easterly trade wind rises from northern side and the south-westerly one blows from southern side into this zone. In the coastal plain, the former gently blows from sea side to leeward bringing about gentle climate with refreshing air. In this concern, the equatorial windless zone often serves as a cradle of hurricanes because ascending air flow takes place, induced by both trade winds blowing into it, however, as far as Guyana itself is concerned, it remains in a calm zone without any influence of hurricanes (refer to Fig.1-2-5).

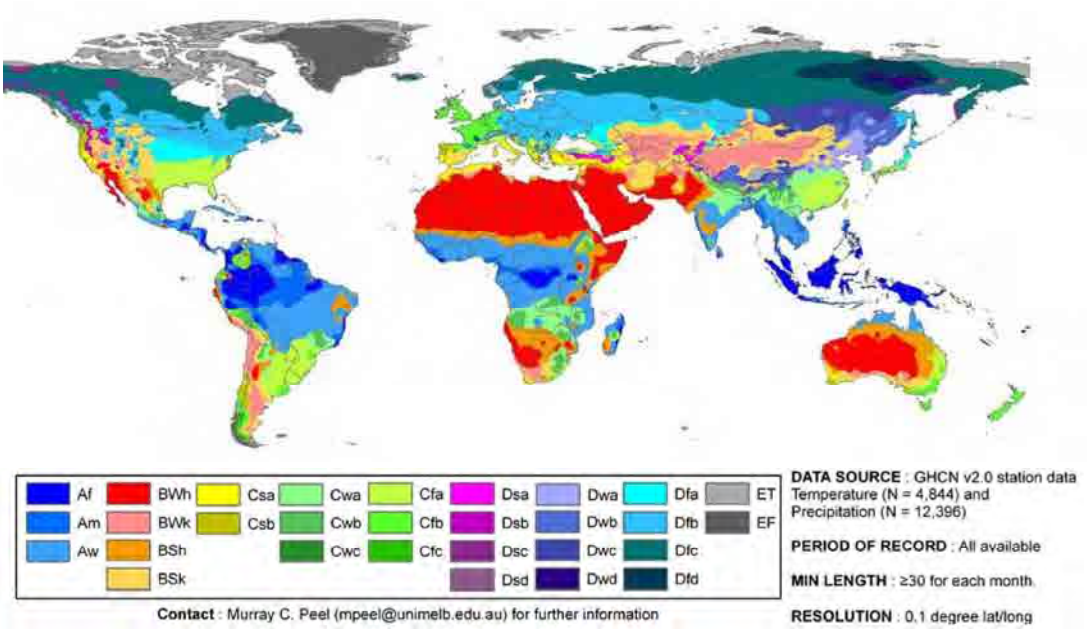


Fig.1-2-5 Keppen's climatic zoning
(http://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification

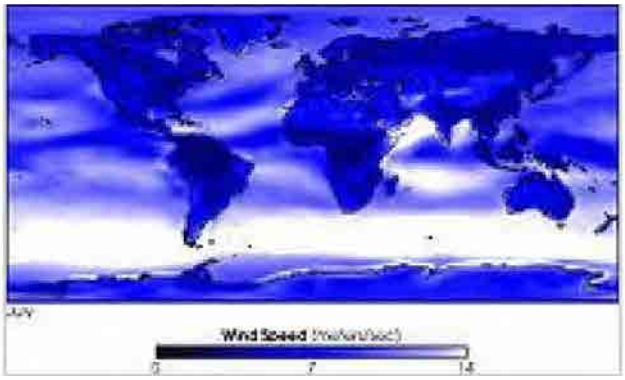


Fig.1-2-6 Map of the world wind distribution (in July)
(http://ja.wikipedia.org/wiki/%E3%83%95%E3%82%A1%E3%82%A4%E3%83%AB:Wind_speed_climatology.j

(3) Rainfall

It is said that in Guyana the influence of climate change has been dramatically arising in various fields in nature since 1980 (referred to Office of Climate Change; www.icds.gov.gy). As for the rainfall, the declining tendency of the annual total rainfall and contrarily the increasing tendency of the rainfall intensity are pointed out. Fig. 1-2-7 shows the analyzed results of rainfalls for 34 years from 1974 to 2008 observed at Cane Grove observatory at the east of the Flagstaff office. Here, the increasing trend appears clearly in annually maximum consecutive 3-day rainfall and in annually maximum consecutive 7-day rainfall; in latter's case, that is said to have a tight relationship with flood events, the increasing rate is 3.5 % per year.

(4) Hydrology

One of the salient features of East Demerara Water Conservancy lies in the larger rate of reservoir area to its catchment area, that is to say, the conservancy has the reservoir area of 460km^2 at its full-water level against the catchment of 580km^2 according to the report in the preparatory study for cooperation in 2009. Since such a conservancy itself has a function of storing rainwater (retention effect), the phenomenon of huge amount of rainwater collected by the streams in its watershed flowing into it as flood water and bringing a rapid rise of the water level does not take place. The water level rising pattern is very simple, the increment of the level reaches 1,000mm if rain precipitates at the rate of 1,000mm. It follows that the most

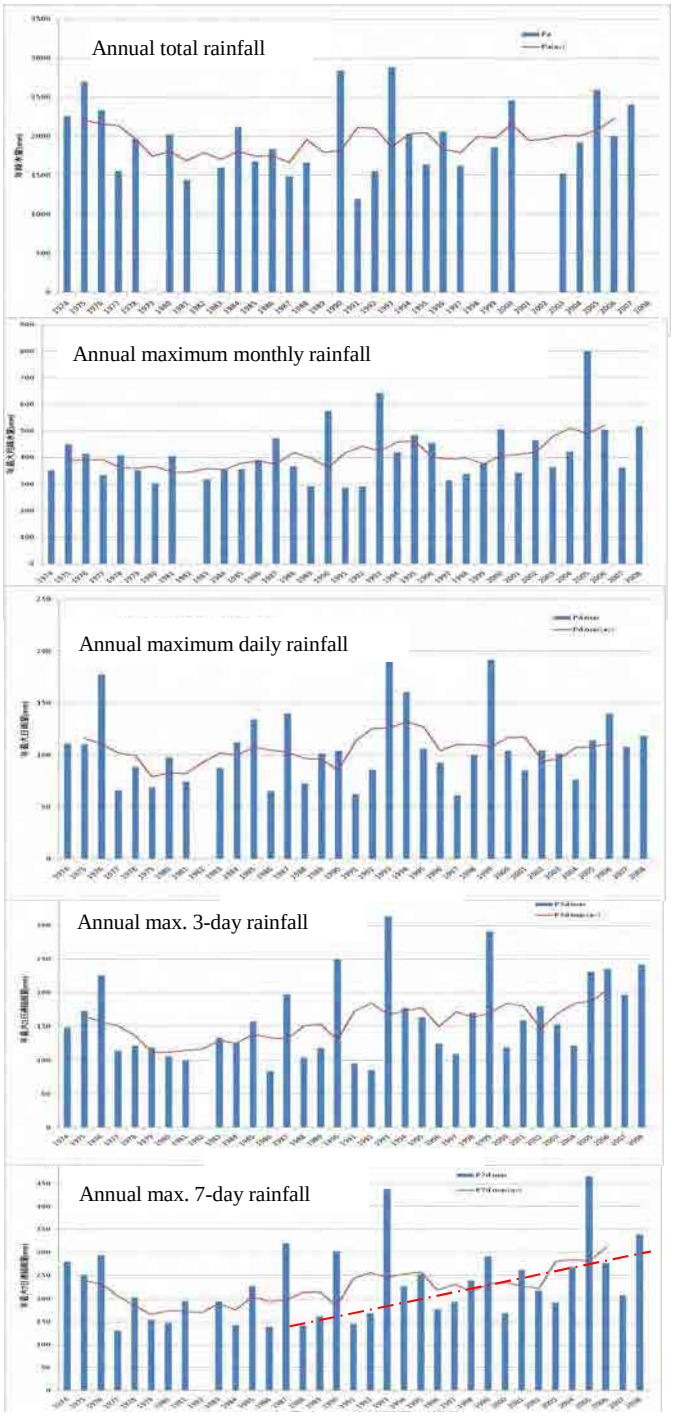


Fig. 1-2-7 Changes in rainfall
(the achievement of the preparatory study by JICA (2008), rainfall analysis based on HYDROMET data provided by Ministry of Agriculture)

effective measures against flood is a water-level operation where the water level is lowered by 1,000mm, for example, just before the predicted occurrence of heavy rain. In this context, it is important to vest the enough discharge capacity and to formulate a rational water level operation rule based upon a statistical analysis.

The conservancy is composed of a land part where palm trees thrive (about 10% of the conservancy), wet land zones consisting of isles of floating grasses and excavated parts as canals. Isles of floating grasses accounting for the most part of the conservancy have a thickness of about 1 meter, some part of which can bear the human weight. Water under floating grasses is about 30cm-50cm deep, contains much organic humus, and seems to be lack of circulation. Because of the difficulty of assuming the water movement in these floating grasses' area, it is impossible to estimate an accurate volume of stored water in the conservancy. Judging from such state of poor circulation, it is highly possible that the most of available water is equal to the inflow from Lama River and Maduni River

As to water storage level in the conservancy, the UN report mentioned in 2005 that the water level at the point of Flagstaff was higher by about 1 meter than that at the point of Land of Canaan during the flood period. On the other hand, according to the interview in this study, the observed water levels on 25th March were 55.10 GD feet at Lama, 55.45 GD feet at Flagstaff and 55.85 GD feet at Land of Canaan, and these results were difficult to understand when considering the relative locations and the water flow directions. Hereinafter, it will be necessary to check benchmarks and water level gauges.

(5) Water quality

According to the report of "Preparatory Study on the Rehabilitation of the East Demerara Water Conservancy" issued in November 2009, water quality of the dam was tested with Litmus papers. The result of the testing was reported as follows:

- Water quality in the conservancy (sampled in the canal) was fairly acidic, measured as pH4.5 - pH5 as of the late October at the stored water level of around 55 feet. At times acidity changed to around pH6.0, influenced by the rainfall or the increase of inflow into the conservancy.
- Water in a pool at the downstream side of the embankment was highly acidic, as high as pH3.0.

1-3 Environment and Social Consideration

(1) Procedures related to environmental and social consideration

Basic environmental law in Guyana has been Environmental Protection Act No. 11 of 1996 promulgated in 1996, and Environmental Protection Agency (EPA) was established based on this act. In 2000, Environmental Protection Regulations 2000 was proclaimed.

Environmental Impact Assessment Law of Guyana was proclaimed on 5th June 1996 and mended in 2001. EPA performs prevention of public pollution and approves development actions. Besides, it has competence of supervise/ monitor surrounding environment as need arises.

Articles related to Environmental Impact Assessment (EIA) are stipulated in the part 4 of the Environmental Protection Act, of which Environmental Management Department (EMD) is in charge. How this rehabilitation project is positioned in this act is shown in Table 1-3-1.

Table 1-3-1 Stance of this project on the Environmental Protection Act

Item	Contents
Target item	Including risk of disaster
Screening organization	Environmental Protection Agency（EPA）
Implementing agency	National Drainage and Irrigation Agency（NDIA）of Ministry of Agriculture
Other related persons	Expert(s): who is (are) designated by EPA to appraise reports submitted to EPA
Procedural flow	1. NDIA delivers information concerned to EPA 2. Expert(s) appraise(s) the necessity of performing Detailed Environmental Impact Assessment （DEIA） within 12 days through the information 3. In the case that DEIA is required, expert(s) of assessment provide(s) at the expense of NDIA 4. Plans of environment conservation and environment monitoring prepared by NDIA as well as opinions of inhabitants/ local chamber/assembly on these plans are submitted to EPA. 5. The expert(s) appraise(s) relevance/ feasibility of the plans by DEIA 6. Based on the views of the expert(s), EPA makes decision on the implementation of the planned project.

In implementing this project, NDIA must provide application form of environmental approval by means of the format of EPA, and it has to submit it with land-ownership document, documents of agreement by the related local persons including NDC, design drawings/ documents of the project and application fee etc. EPA shall judge the necessity of the Detailed Environmental Impact Assessment

through examining the application form, executing the field survey and the screening.

(2) Screening

Since this project comprises rehabilitation of the existing sluices and intake facilities, and small-scale earth works in the adjacent places to these facilities and all these do not include any large-scale work, no detrimental or serious impact to environment is assumed. However, because of the fact that stored water in EDWC has been used as the water source of the tap-water in Georgetown that accounts for 40% of the source, it is relevant to deem this project as category "B" in the environmental category of "environment and social consideration guideline by JICA (April 2004)". (Category "B" is defined as a cooperation project of which undesirable impact to environment and society is considered small as compared with that of category "A". Therefore, the project categorized as "B" is in general considered affecting only the site itself and it gives limited irreversible impact, so the impact is coped with ordinary measures).

(3) Scoping

Scoping was performed by means of the environmental matrix shown in Table 1-3-2 in which items assumed to give impact to environment were selected. Taking account of the current situations in the project area, items that covered wide range of aspect and were considered to have the possibility of impact were extracted. In rank "B", assessment to the influence was applied, and in rank "C", situations assumed were to confirm with or without the influence, the extension of the influence, and the assessment to the influence if necessary. The assessment was made in three categories, namely, social environment, natural environment, and contamination.

Table 1-3-2 Scoping Check List

No.	Item of impact	rank	Explanatory Note
【Social Environment】			
1	Non-voluntary inhabitant transfer	D	Because this project aims at rehabilitation of the existing facilities, land acquisition or inhabitant's compulsory transfer never takes place.
2	Local economy such as employment and livelihood means	D	Though a part of employment environment would be improved, its impact is limited because of the project scale being small. No possibility of arising impact from the project on such local economy factors as employment/ livelihood is anticipated.
3	Land use and utilization of local resources	B	Because of the stable supply of irrigation water enabling more aggressive land use, the project may give some impact on land use and utilization of local resources though the impact is not so big.
4	Social-related capitals and social organizations such as local decision-making	B	Supply of irrigation water is stabilized on one hand, necessity arises to arrange each other the distribution of irrigation water, on the other hand. In this regard, there is possibility that the project generates impact on social

No.	Item of impact	rank	Explanatory Note
	mechanisms		organizations
5	The existing social infrastructure and social services	B	The existing bridge is going to be renewed in the rehabilitation work of Sarah Joanna cana. Impact arises from this work to related private enterprises, but the scale of the impact will be limited because traffic blockage is not accompanied with the work.
6	Poverty strata/ aborigine/ ethnic minorities	D	Though there is an aborigine village at the upstream of Maihaca River, it is located out of the watershed of EDWC, so that there is no possibility of impact being brought on poverty strata/ aborigine/ ethnic minorities.
7	Biased occurrence of damages or conveniences	D	Since all the inhabitants living in and around the project area shall be helped from suffering from flood damages, possibility of impact arising with biased occurrence of damages or conveniences is not assumed.
8	Cultural heritages	D	Because no object has been registered as cultural heritage in and around EDWC, possibility of generating any impact on cultural heritages is not assumed.
9	Antagonistic rivalry on interests	D	Improved safety against floods brought about by the rehabilitation leads to less discharging opportunity from Lama and Maduni Sluices, eventually orienting toward solution of conflict/ rivalry between inhabitants in the basin of Mahaica River and those in Georgetown and its surroundings
10	Water use/ water right and usufruct right	B	Ann's Grove Intake shall be integrated with Shanks Intake. Accompanying with this integration, necessity arises to arrange the water distribution between both beneficiaries.
11	Public hygiene	D	Since reduced risk of flood damages by the project leads to the reduction of contagious diseases likely occurring during inundated period, there is possibility of inducing impact on public hygiene, but negative impact seldom arises.
12	Disaster, contagious diseases such as HIV/AIDS	D	The period of rehabilitation work is confined to the dry season and Guyana belongs to equatorial windless zone, so that some disaster risk during the project implementation is negligibly small.
【Natural Environment】			
13	Topography/ geology	D	Because of limited scale of the work, no possibility is assumed of impact arising on the local topographic or geological conditions.
14	Soil erosion	D	Planned area of the work is limited in scale and in marshy flat land only where any vertical erosion fostered by rainwater shall not arise. No possibility of soil erosion.

No.	Item of impact	rank	Explanatory Note
15	Groundwater	D	The intake facility is constructed by cast-in-place concrete. But the negative impact to groundwater and lake water is not assumed because there is no elution of the alkali from the concrete after curing.
16	State of lakes / ponds and rivers	D	
17	Sea coast/ open sea	D	Since work sites are located far from the coast and the open sea, no possibility of impact arising is assumed.
18	Plant, animal, bio-diversity	D	No specified plant/animal to be protected is found in and around EDWC, in addition the range of the project is confined to limited area, thus no possibility is assumed of any impact arising to plants etc.
19	Meteorology	D	The exhausted gas is to be emitted from machinery/ equipments used in the work, but because of its limited scale, possibility of negative impact arising is not assumed.
20	Scenery	D	Because the scale of the work is small, no possibility is assumed of generating impact to the scenery.
21	Global greenhouse effect	D	The exhausted gas is to be emitted from machinery/ equipments used in the work, but because of its limited scale, no possibility of inducing impact on the global warming is assumed.
【Pollution】			
22	Air pollution	D	Although exhausted gas is assumed emitting from machinery/ equipments used in the work, no possibility of bringing about impact to air pollution is assumed because of the limited scale of the project.
23	Water pollution	B	Excavation work is executed, but taking account of the work inside the space surrounded with sheet piles, the limited scale of the work, flow velocity inside the canal in the reservoir being small, and ingredient of the turbid water settling down before its expansion, no possibility of water pollution arising is likely to happen. Nevertheless, as to the site of Nancy, since it is the source of tap-water, it is required to monitor during the work.
24	Soil pollution	D	The negative impact will be not assumed because backfilling is carried out with the soil excavated from surrounding.
25	Wastes	D	Though wastes are partly produced from the work, possibility of negative impact arising from the resulted wastes is not assumed because of its limited scale of the work.
26	Noise and vibration	D	Noise and vibration are emitted from construction machinery, but no house is found in and around the sites of construction. There is no possibility of impact arising as far as noise and vibration are concerned.

No.	Item of impact	rank	Explanatory Note
27	Ground subsidence	D	Factors that cause settlement of the ground are pumping of groundwater and new, additional increase of load on the ground. In this project, excavation and back-filling are carried out, but the increase of load onto the ground is very small so that the ground subsidence is negligible.
28	Vile-smelling odor	D	Because no work is included that emits unpleasant odor, there is no possibility of generating impact of unpleasant odor to the surrounding.
29	Sediments on canal bed	D	Sediments on the canal bed might be disturbed through the temporary piling works as a water stopper, but they shall be settled down soon so that there is no possibility of negative impact remaining.
30	Accident	B	Ultra-long arm excavators, crane etc are used in the work. Works done on the pontoons by using these machines are common in this project. Therefore, it is imperative to pay thorough attention for preventing accidents brought from these works.
The overall evaluation		D	

Evaluation rank）A：Serious impact exists, B：Some impact may happen, C：Extent of the impact is not known, D：Almost no impact arises.

(4) Principal measures to avoid/ alleviate environment/ social impacts

Measures to avoid/alleviate environmental/social impacts ranked “B” are shown in Table 1-3-3 as follows.

Table 1-3-3 Measures to avoid/alleviate environment/social impacts with the evaluation rank B

No	Item	Measures to avoid/ alleviate impact
3	Land use and utilization of local resources	・Hold meetings to exchange opinions with local inhabitants prior to the project implementation ・Grasp the state of activities of water user’s association, and when necessity arises facilitate relevant adjustment
5	The existing social infrastructure and social services	・Consult with related private constructors（Barama Company Limited）prior to the project implementation to explain contents of the planned work and to get his agreement ・Explain how to provide yard for storing construction materials and reach consensus ・Install sign-boards to awake attentions during the construction period
10	Water use/ water right and usufruct right	・Hold meetings to exchange opinions with local inhabitants prior to the project implementation。 ・Grasp the state of activities of water user’s association, and when necessity arises facilitate relevant adjustment
23	Water pollution	・Thoroughly carry out such temporary works as enclosing the work space with sheet-piles etc ・Strive for perfect management of such construction materials as cements and for complete treatment of surplus/ residual wastes
30	Accident	・Provide safety instruction at the construction sites and perfectly keep the workers out of the working range of heavy excavators and cranes

		・In case of handling the cement powder, enforce the workers putting on the dust-trapping mask ・Oblige those engaged in the construction work to wear helmet ・Establish safety regulations at each construction site covering the above mentioned safety measures

(5) Monitoring plan

Monitoring shall be carried out as shown below on the particularly important items among those shown in Table 1-3-4.

Table 1-3-4 Monitoring plan on important items of environment and social impacts

No	Item	Monitoring plan
23	Water pollution	・Monitoring on the following items shall be carried out during the period of rehabilitation works at Nancy Intake which is the intake point of the potable water ● pH ● transparency
30	Accident	・Regularly check the state of observance of safety regulations

1) Standard level of water pollution

Monitoring item	Unit	Measured value (median)	Measured value (maximum)	Standard level of Guyana	Criteria referring to international standard	Remarks (Measurement point, frequency, technique)
pH	-	6.5	8.5	-	EPA(USA) *1	At the outlet of Nancy Intake, at 10 :00AM every-day throughout the construction period
Turbidity	NTU*2		*3	-	EPA(USA)	The same as above

*1 EPA: (US Environmental Protection Agency)

*2 NTU: (Nephelometric Turbidity Unit)

*3 Larger value in those of measured one prior to the start of works or of the standard 5

2) Standard value of monitoring the extent of soil pollution

Monitoring item	Unit	Measured value (median)	Measured value (maximum)	Standard level of Guyana	Criteria referring to international standard	Remarks (Measurement point, frequency, technique etc))
pH	-	-	-	-	-	Measurement of pH of standing water after mixing soil with cement powder during the construction period, 1 sample / day

(6) Overall evaluation of the project on Environment and social consideration

The extent of the environmental and social impact is considered light because of its small scale work. In addition, it can be evaluated that the impact can be controlled to a low level by taking measures of avoiding and alleviating its influence under the monitoring based on the monitoring plan.

The evaluation mentioned above was also approved in the consultation with EPA during the study; and as a conclusion, it was judged that DEIA was not necessary in this project.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Purpose

In Guyana, rehabilitation works for each facility of East Demerara Water Conservancy (EDWC) have been carried out according to the action plan presented in the report "Geotechnical and Hydraulic assessment of the East Demerara Water Conservancy dam" by Joint UNEP/OCHA Environment Unit of UNOAC published in February 2005. This action plan recommends to complete the EDWC embankment rehabilitation works, rehabilitation of appurtenant intake facilities installed on the embankment, new construction of a discharge canal from EDWC to the Atlantic Ocean, thorough rehabilitation of the existing sluice facilities, renovation of pumping facilities installed along the sea coast, and formulation of a draft Action Plan on flood disaster management etc. by the year of 2015. This UNDAC report issued in 2005 is regarded as the superior plan of this project.

Besides, rise of atmospheric temperature and decline of precipitation have been predicted in the northern part of South America including Guyana in many models dealing with the future prospect of climatic change. From this view point, EDWC has a primary importance as a source supplying water stably during the dry season to farmlands and the capital area. In order to maintain EDWC functional, it is necessary to raise the structural stability of its embankment and appurtenant facilities. For this purpose, the construction equipment was procured under "The Project for the Rehabilitation of The East Demerara Water Conservancy", the project under Japan's Grant Aid, and "The Project for the Rehabilitation of The East Demerara Water Conservancy (II)" has been planned for the rehabilitation of the embankment.

"The Project for the Rehabilitation of The East Demerara Water Conservancy (II)" is the project focusing to enhance the structural safety of the appurtenant facilities (sluice/intake facilities).

2-1-2 Project Outline

This project is to be implemented to attain the objectives as noted above through rehabilitating those appurtenant facilities in the EDWC. After the due rehabilitation of intake and sluice facilities coupled with the adequate O & M activities provided, it is expected to avail stable supply of domestic as well as irrigation water and possible alleviation of flood damages by the improved flood control capacity.

Appurtenant facilities included for rehabilitation under the project are as follows.

-Sluice facility;	2 Numbers (Maduni and Sara Johanna)
-Intake facility;	4 Numbers (Shanks, Hope, Annandale and Nancy)
	*Ann's Grove is to be merged with Shanks Intake

The above project outline can be sorted out as in the Table 2-1-1 when classified in relation with the project objectives.

Table 2-1-1 Summarized Project Outline

Narrative Summary	Objectively Verifiable Indicators	Means of Verifications	Important Assumptions
Overall Goal Through upgrading the flood control capacity of EDWC, the national capital sphere can be secured with stable water resources with less flood damages.	1) Flood damages can be lessened for downstream watershed (About 350 km2 for about 300,000 people). 2) Irrigation water supply for the downstream farm land of 17,900 ha can be stabilized. 3) Stable water supply for the capital area (0.36 Million people, equivalent to 40 % of the total population) can be secured.	-Project annual report -Records of water distribution -Records of flood damages	
Project Purpose Stability of the EDWC embankment can be remarkably improved.	Even water level rises up to the Flood water level, no damages on the embankment will occur.	-Record of water level in EDWC -Repair records for EDWC -Surrounding area monitoring records	Adequate facility operation and safety monitoring are practiced with enough budget allocated.
Outputs Stability of the appurtenant facilities targeted for rehabilitation can be reinforced and the intake and sluice capacity be improved.	Each incidental facilities exhibit predetermined function. Damaged appurtenant facilities as weak points of EDWC may be lessened. Sluice capacity can be improved. The intake facility can function normally.	-Records of sluice gate opening/closing -Records of intake gate opening/closing -Surrounding area monitoring records -Repair records on appurtenant facilities	Adequate facility operation and safety monitoring are practiced with enough budget allocated.
Activities -Rehabilitation of 2 sluice facilities -Rehabilitation of 4 intake facilities -Technical transfer related to the reservoir management method with the concept of limiting water level during flood period	Inputs		Pre-conditions
	Japanese side [Rehabilitation of appurtenant facilities] [Human resources] Contractor, Consultant, Procurement Management Agent [Project cost] Construction cost, Construction supervision cost	Guyana side [Human resources] Engineers, Technicians Operators, Labors [Project cost] Cost of operation and management Bank payment fee Testing apparatus	Signing of E/N and G/A. (Completed)

2-1-3 Results of Field Survey and Review on the Japanese Assistance

2-1-3-1 Original Plan of the Japanese Assistance

As of the preparatory study report, the following appurtenant facilities and their associated structures were originally planned as the targets of rehabilitation.

Table 2-1-2 Facilities planned as the targets of rehabilitation

Name of the facility	Contents of rehabilitation
Intake facility	
Ann's Grove Intake	• Rehabilitation of intake gate • Rehabilitation of the wooden pile revetment at both inlet and outlet sides • Replacement of the surrounding embankment
Hope Intake	• Installation of grooves for the inlet gate • Rehabilitation of the wooden pile revetment at both inlet and outlet sides • Extension of the retaining wall at the inlet mouth • Replacement of the surrounding embankment • Cutoff work for preventing the piping phenomenon
Annandale Intake	• Partial rehabilitation of inlet gates • Rehabilitation of the wooden pile revetment at both inlet and outlet sides • Embankment work around the facility
Nancy Intake	• Rehabilitation of wooden pile revetment at both inlet and outlet sides • Construction of rear embankment
Sluice facility	
Maduni Sluice	• Replacement of the sluice gate • Rehabilitation of wooden pile revetment at both inflow and outflow sides • Rehabilitation of the embankment • Construction of rear embankment
Sara Johanna Sluice	• Rehabilitation of wooden pile revetment at inflow sides • Relocation of the drainage pipe

2-1-3-2 Field Reconnaissance

(1) Ann's Grove Intake

Part	Conditions
Main body	A bent on the gate spindle（PH 2-1-1）
Wooden pile revetment	Almost normal except the left side of the inlet mouth (The disordered row of piles does not mean necessarily the aging condition because of the piles being not driven straight into the hard ground.)（PH 2-1-2）
Surrounding embankment	A step caused by a land slide extends on the upstream side embankment crest. (PH 2-1-4)
Operation	The gate has been out of use for the last 3 years. Leakage water through the opening and the foundation - an old pipe left in the foundation – has been used as irrigation water. (PH 2-1-3)

PH 2-1-1 Bent of the spindle

PH 2-1-3 Canal flow maintained by leakage water

PH 2-1-2 Revetments at the inlet mouth

PH 2-1-4 Step, cracks and inclined revetments

(2) Hope Intake

Part	Conditions
Main body	At present, normally functioning without problems（PH2 -1-5, PH 2-1-7）
Wooden pile revetment	Almost normal at the both upstream and downstream sides（The disordered row of piles does not mean necessarily the aging condition because of the piles being not driven straight into the hard ground.）（PH 2-1-7, PH 2-1-8）
Surrounding embankment	Complementary filling on the crest has quite recently completed. The portion provided with the wooden pile revetment is limited and filled slopes at the upstream side are steep.(PH 2-1-5, PH 2-1-6)
Operation	The downstream side is in marshy condition, and the canal extends from there. (PH 2-1-9) The Gate is operated 4 times a year by the staff of the Flagstaff Office（at the beginning of the dry season and the wet season）.

PH 2-1-5 Embankment crest and the spindle

PH2-1-6 Wooden pile revetment at the inlet mouth

PH 2-1-7 Wooden pile revetment at the upstream side

PH 2-1-8 Wooden pile revetment

PH 2-1-9 Marshy condition, and the canal

(3) Annandale Intake

Part	Conditions
Main body	At present, normally functioning without problems (see PH 2-1-10)
Wooden pile revetment	The wooden pile revetment can be hardly seen at the upstream side, and the slope looks stabilized by the natural vegetation (see PH 2-1-11). At the downstream side, tall concrete retaining walls are installed (see PH 2-1-12). Surrounding portions consist of a stable ground slope covered by vegetation (see PH 2-1-13).
Surrounding embankment	No symptom of sliding is seen on the embankment slopes (see PH 2-1-11).
Operation	The gate is operated 4 times a year by Guyana Sugar Corporation (at the beginning of the dry season and the rainy season). Small amount of leakage comes out through an opening of the gate, which is utilized by farmers cultivating cash crops.

PH2-1-10 Spindle attached to the gate

PH2-1-11 Condition at the upstream side

PH2-1-12 Retaining walls at the outlet

PH2-1-13 Ground slope covered by vegetation

(4) Nancy Intake

Part	Conditions
Main body	At present, normally functioning without problems (see PH 2-1-14)
Wooden pile revetment	Concrete retaining walls are installed at the surrounding portions of the inlet mouth. Wooden pile revetments were once installed on the tail portions, but now leave almost no trace of existence (see PH 2-1-15).
Surrounding embankment	No symptom of sliding is seen on the slopes of embankments/grounds (see PH 2-1-15).
Operation	The gate is daily operated by the staff of the Flagstaff Office. Water is conveyed to the waterworks for the tap-water of Georgetown.

PH2-1-14 Gate operation and the retaining walls

PH2-1-15 Debris of the revetment and vegetation on the slope

(5) Shanks Intake

Part	Conditions
Main body	At present, functioning almost normally without problems, though there is a doubt in future operation due to the inclined spindle. (see PH 2-1-16)
Wooden pile revetment	Revetment works at the upstream side are rather irregular with having only temporary treatments (see PH 2-1-17). Disturbed condition is not seen in the downstream side revetment, but the range of revetment coverage is quite limited (see PH 2-1-19).
Surrounding embankment	Crest of the embankment has narrow width because it has been dwindled (see PH 2-1-18). At the right hand point of about 20m distant from the inlet, a terrace was formed as a result of sliding over the slope of upstream side (see PH 2-1-20).
Operation	The gate is operated by the staff of Flagstaff Office four times a year. This facility is the most important headwork in northern irrigation network, and downstream canal is of a large scale (see PH 2-1-21).

PH2-1-16 Gate functions without problems

PH2-1-17 Revetment at the inlet mouth

PH2-1-18 Lean and narrow embankment crest

PH2-1-19 Revetment at the outlet mouth

PH2-1-20 Steps caused by sliding

PH2-1-21 Wide canal extending downward

(6) Sara Johanna Sluice

Part	Conditions
Sluice gate	The sluice facility consists of two culvert channels, 3.1m in width and 2.7m in height respectively, with a wooden gate for each culvert (see PH 2-1-22). These dimensions may be decided for the discharge capacity of this sluice so as not to under-run the one of Cuhnia Sluice when considering the support piers of the Cuhnia regulation gate being placed 5.6m apart (see PH 2-1-22). Gates and winch systems normally function.
Wooden pile revetment	No slope protection works is observed other than a small scaled revetment at the upstream right bank. Banks of both sides of the canal are covered with vegetation, and their slopes remain stable (see PH 2-1-23).
Upstream canal	The canal is about 15m wide and about 300m long and connected to the Cuhnia canal. The waterway and the slopes are completely covered by water weeds. Dredging and cleaning are necessary (see PH 2-1-24). A wooden bridge is found in the middle part, a bit upstream side of this canal; below the bridge, there is a concrete flume of which side walls are used as the bridge pedestals. The width of this flume is only 2.7m so that this portion most likely becomes the bottleneck of the canal and decreases its discharge capacity (see PH 2-1-25).
Downstream canal	Water weeds thrive in the canal, lowering flow capacity of the canal. Collapse etc is not seen on both banks of the canal (see PH 2-1-26).


PH2-1-22 Culvert channels, gates and winch systems

PH2-1-22' Piers for winching the Cuhnia regulation gate

PH2-1-23 Canal condition at the upstream of the Johanna regulation gate

PH2-1-24 Connecting canal

PH2-1-25 Wooden bridge and the narrow concrete flume

PH2-1-26 Canal condition at the downstream of the regulation gate

(7) Maduni Sluice

Part	Conditions
Concrete wall	Concrete wall is well functioning (see PH 2-1-27).
Outlet gate	Considerable leakage is found at wooden gate (see PH 2-1-28), and the extent has remained as it was in 2009.
Wooden pile revetment	Wooden sheet piles over water surface in the wooden pile revetment at the upstream side have almost been decayed (see PH 2-1-29). A training wall of wooden piles has been installed at the downstream side, but it has already been almost decayed (see PH 2-1-30). Nevertheless, in both upstream and downstream sides of this facility, filled backside slope and slope on the rock mass have been stabilized.
Surrounding embankment	Filling earth is clayey nature, well compacted and stabilized (see PH 2-1-31).

PH2-1-27 Gate and the retaining walls

PH2-1-28 Leakage condition through the gate

PH21-29 Rotten wooden sheet piles and the self-standing embankment slope

PH2-1-30 Rotten wooden sheet piles and the stable ground surface

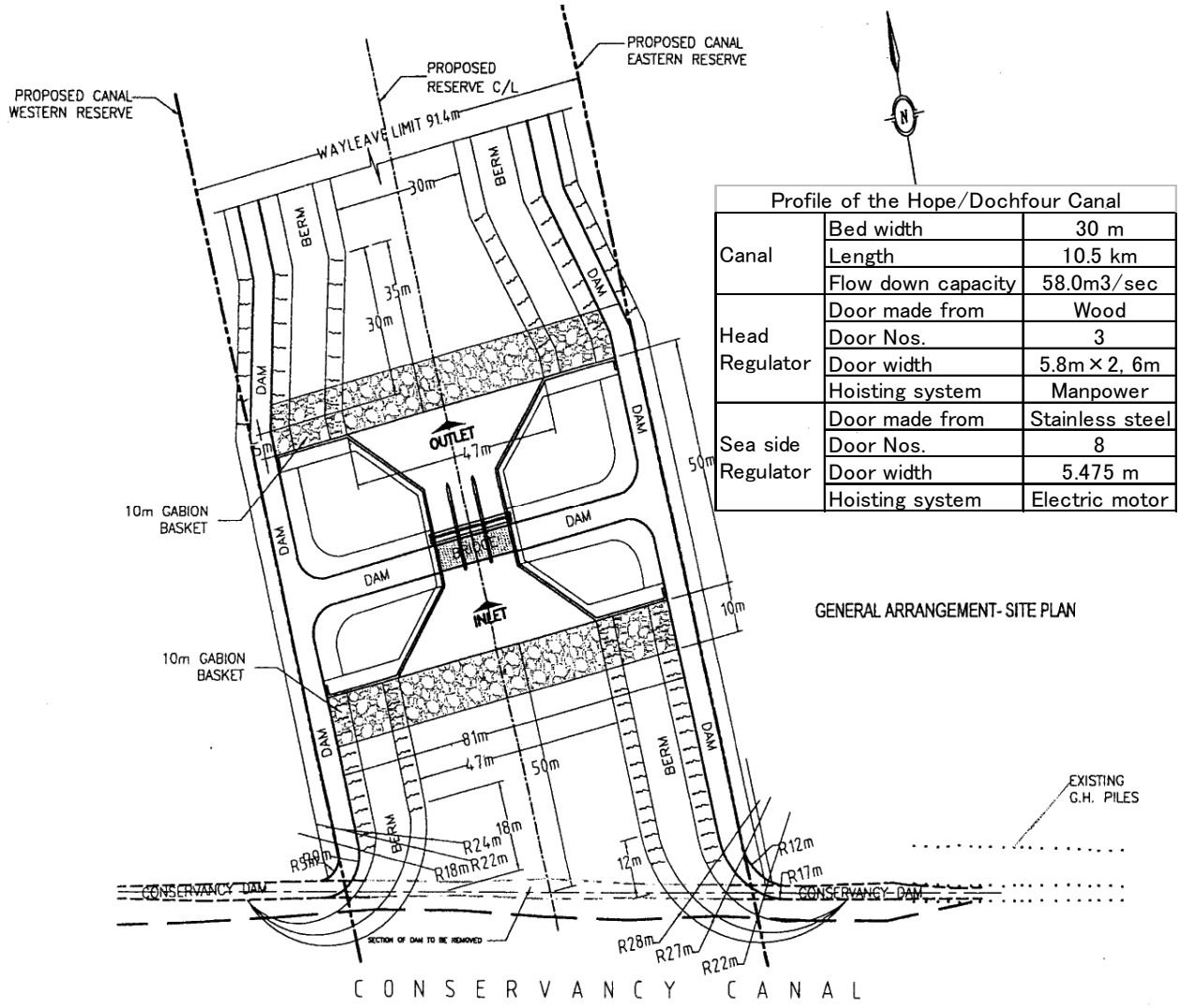
PH2-1-31 Embankment surface composed of well-compacted clayey soil

(8) Influence of Hope/Dochfour Canal Project

(a) Outline of the project

According to an official bulletin of the Government of Guyana, the canal construction work was started in 2010 and is scheduled to be completed by the end of 2013. The canal dimensions are as follows with the appurtenant facilities as noted.

-Canal length	10.5 km
-Width of canal bottom	30 m
-Regulator (Reservoir	3 wooden gates
-Regulator (Coastal)	8 steel gates



Profile of the Hope/Dochfour Canal		
Canal	Bed width	30 m
	Length	10.5 km
	Flow down capacity	58.0m3/sec
Head Regulator	Door made from	Wood
	Door Nos.	3
	Door width	5.8m×2, 6m
	Hoisting system	Manpower
Sea side Regulator	Door made from	Stainless steel
	Door Nos.	8
	Door width	5.475 m
	Hoisting system	Electric motor

Fig.2-1-1 Plan of the sluice at the conservancy

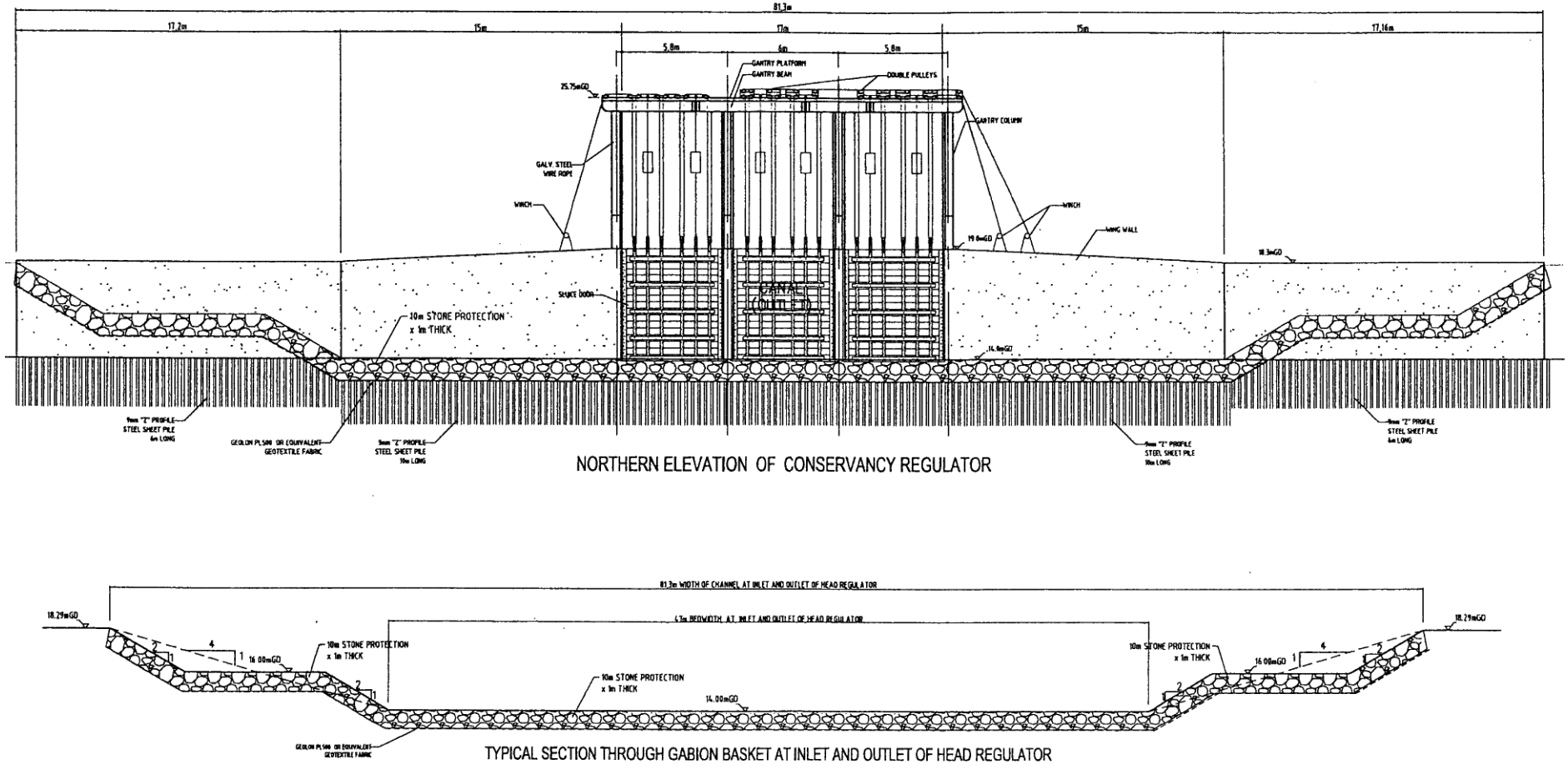


Fig. 2-1-2 Front view of the sluice at the conservancy

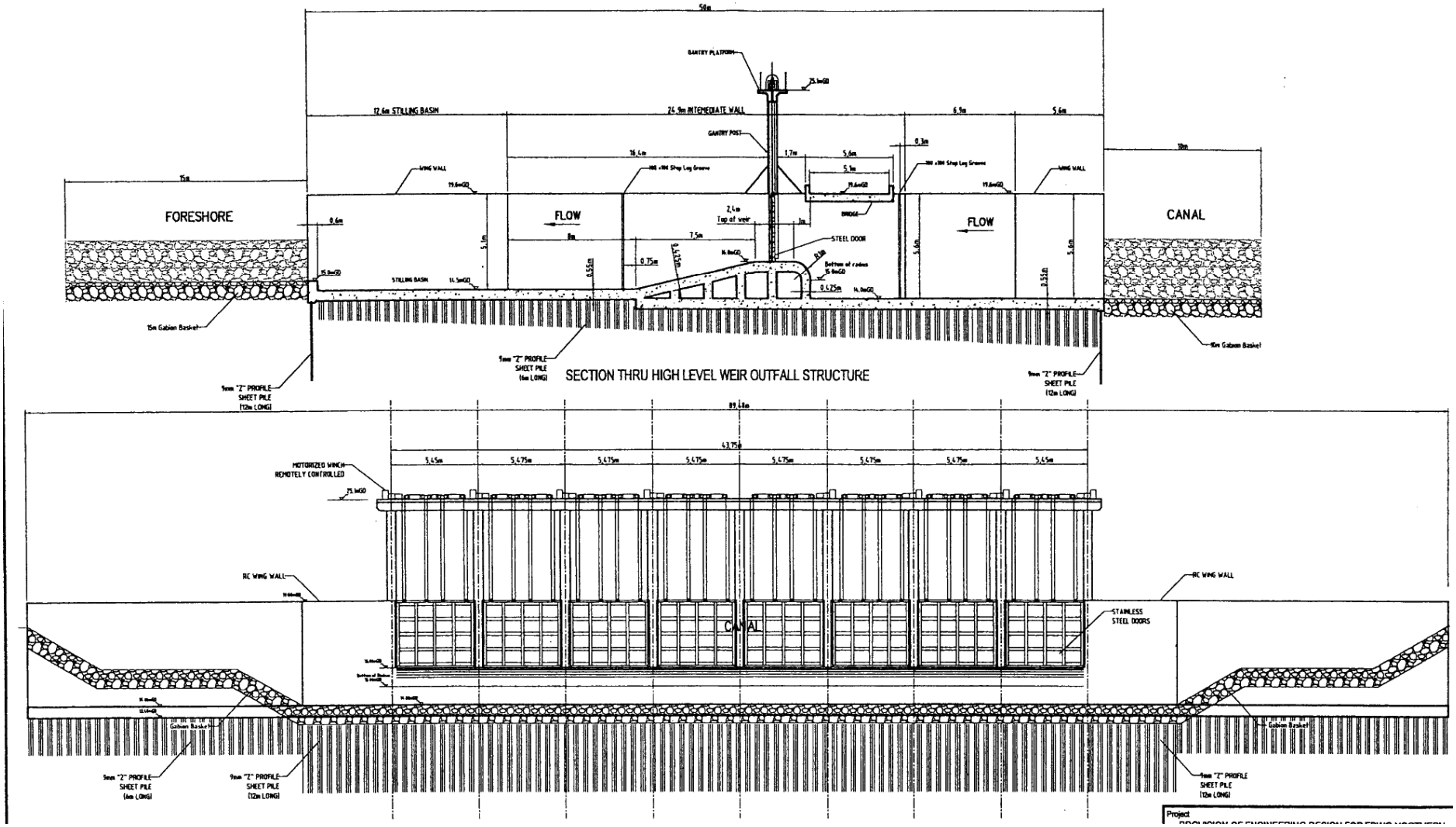


Fig. 2-1-3 Schematic diagram of the regulation facility at the sea coast

(b) State of the construction works

PH2-1-32 Downstream view at 2.3 km point from the national highway

PH2-1-33 Upstream view at 2.3 km point from the national highway

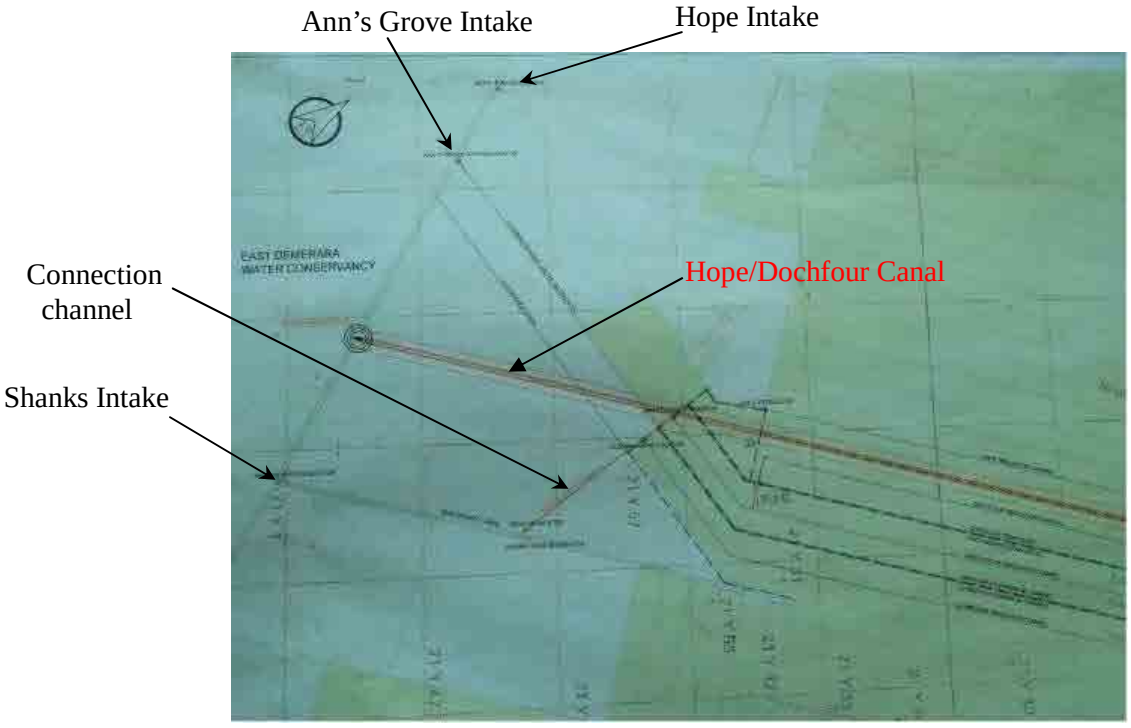
PH2-1-34 Shape arrangement work of the dike at its midway point on the alignment

PH2-1-35 Canal excavation and the stockpile of the embankment materials at the point about 2 km from the conservancy

PH2-1-36 Pile driving works as the foundation treatment for the sluice structure at the beginning of the canal

(c) Influence of Hope/Dochfour Canal in the design of the Project

At the time of the preparatory study for EDWC, construction of Hope/Dochfour canal was planned already but it was under the field survey this time the details of the plan was duly confirmed. As the result, it was found out that the main canal of Ann's Grove Intake is cut/separated by the alignment of the Hope/Dochfour canal immediately after its starting point (see PH 2-1-37) and there is no reason of rehabilitating the Ann's Grove Intake facility at the present location as originally planned under the said preparatory study. After being cut by the Hope/Dochfour canal due to the presently on-going construction works, the downstream main canal of Ann's Grove can not take water from the Ann's Grove Intake and receives instead the diverted water from the Shanks Intake main canal. There are two opinions among the NDIA engineers, one is to construct a new independent intake facility for Ann's Grove on the right bank side of the Hope/Dochfour canal and the other is to construct the intake facility in parallel with the Shanks Intake facility which is also in need of a thorough rehabilitation. The latter is considered adequate taking into account the Shanks Intake's necessity of rehabilitation and the need of new excavation for the connection canal in the former case.



PH2-1-37 Relationship between each intake and Hope/Dochfour canal

2-1-3-3 Rehabilitation history of Intake Facilities

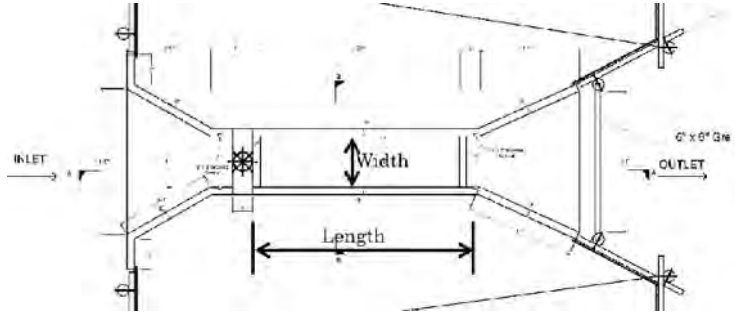
Table 2-1-3 Summary of the interview result on the rehabilitation history of intake facilities

Intake Name	Remarks
Shanks	Two years ago, problems of leakages caused by piping phenomena, depressions of the revetment and cracks on the embankment crest occurred; and rehabilitation works were carried out at that time. Similar troubles appeared several times in the past and rehabilitation works had been carried out repeatedly.
Ann's Grove	Rehabilitation works were carried out including the main body of intake in 2000. On this occasion, a part of the conduit was left without choking treatment under the constructed culvert channel, and later this pipe has been serving as a leaking route. Three years ago, a gate trouble happened and the gate has been un-operational since then.
Hope	Two years ago, rehabilitation works of the gate, the spindle of the gate and the revetment around the inlet mouth of the intake were carried out. Problems of the leakage by piping phenomena occurred several times in the past and the rehabilitation works were done each time.
Annandale	In 2003, this intake was rehabilitated thoroughly including the concrete facility. After that, the problem of the spindle bending occurred once and the spindle was subsequently changed; after that any kind of troubles have not occurred.
Nancy	Rehabilitation works of the wooden pile revetment were implemented in 1996. Replacements were done in 2003 for the gate, the spindle and the winching handle. In this occasion, the old wooden gate was renewed by the steel gate. Since then, no problem has followed. Including older time before 2003, collapse of the embankment or the ground slope has never happened.

2-1-3-4 Study of identifying dimensions of current facilities of head-works

Table 2-1-4 Summary of the survey for identifying dimensions of existing intake facilities

	Shanks Intake	Ann's Grove Intake	Hope Intake	Annandale Intake
1.Demension				
Width	1.0m	1.4m	1.2m	1.4m
Length	3.0m	3.4m	3.0m	4.3m
Conduit /Diameter	Pipe / unknown	Pipe / 800mm	Pipe / unknown	Pipe / 1,200mm
Gate	Wooden	Wooden, 6.4 cm thick	Wooden, 5 cm thick	Wooden
2.Water Depth	In front of the gate: 3.1m At the Revetment foot:1.8m	—	—	—
3.Revetment works				
Inlet	Degradation due to aging. Inclined.	Left side : inclined Right side : not inclined	Old , but not inclined	Not inclined
Outlet	Small scale, not deteriorated	Not exist, slopes are stable	Not deteriorated, firm	Not exist, slopes are stable
4.Embankment	Right side : a line of step caused by depression or sliding	Left side: sliding movement	Stable, but crest width is narrow	stable
5.Downstream Waterway	Width; 16m	Width; 6～7m	Width; 5～6m after a pond	Width; 7～8m



2-1-3-5 Confirmation of conformance between the current conditions and the plan

Rehabilitation plan	Current conditions	Conformance	Recommendation
Ann's Grove Intake Improvement of revetments at the inlet and outlet mouth, and the embankment	Ann's Grove Intake can not work as usual because of the Hope/Dochfour Canal cutting the Ann's Grove Canal at its throat.	The current conditions and the plan do not match up.	Ann's Grove Intake must be moved to the right bank side of the Hope/Dochfour canal line and construct another gate in parallel with the Shanks Intake.
Shanks Intake During the preparatory study, the facility was in a condition immediately after the rehabilitation works.	The embankment around the intake facility has been repeating the leakage failure due to piping. The narrow embankment crest seems to be flushed off and request the thorough rehabilitation.	Shanks Intake was not on the list of rehabilitation. The current conditions and the plan do not match up.	It is adequate to rehabilitate Shanks Intake thoroughly in parallel with Ann's Grove Intake.
Hope Intake Door guide Revetments, inlet and outlet Extension of the conduit Embankment quality Anti-piping works	The Hope Intake looks stable at this moment. But it has the history of repeated leakage failures due to the piping phenomena in the past.	The current conditions and the plan match up.	The plan is adequate but somehow seems to be not perfect. Also there is not 100 percent assurance for the anti-piping works to be effective. It is better to carry out the thorough rehabilitation.
Annandale Intake Door, partially Revetments, inlet and outlet Additional embankment	All the facilities and embankment are stable. Since the thorough rehabilitation in 2003, no problems have occurred except the spindle bending once.	Match up partially.	Give the last priority of rehabilitation to Annandale Intake. Provide the revetment at upstream side to keep slope stable and protection.
Nancy Intake Revetment installation Additional embankment	The revetment was installed in 1996 and has already decayed completely. But the slopes behind are stable.	Match up partially.	Provide the revetment at upstream side to keep slope stable and protection.
Maduni Sluice Door, renewed Revetments, inlet and outlet Rehabilitation of embankment Additional embankment	The revetment works have already been decayed. But the steep slopes behind the revetment reman stable. And the embankment is composed of clayey soils and sound. On the sluice door, there are leakages.	Match up partially.	Renew the sluice door. Provide the revetment at upstream side to keep slope stable and protection.
Sara Johanna Sluice Revetments, inlet and outlet Drainage pipe	The existing revetment covers the partial area only. In other area, the slopes are self-sustained and stable. There is a narrow concrete flume in the connection waterway.	Match up partially. The canal requires improving the capacity.	The plan shall be reviewed so as to give the priority improving the canal capacity directly. The range and scale of revetment works shall be reviewed.

2-1-3-6 Necessity of the rehabilitation after the completion of the Hope/Dochfour canal

(1) Maduni Sluice

The Maduni Sluice has two functions; one is the emergency spillway function and the other is the regulating function between the Maduni River and the conservancy, that is to say the water is led through the sluice from the Maduni River into the conservancy at the time of the conservancy water level descending down due to the drought.

Regarding the former function “emergency spilling”, as the report “The Design of the East Demerara Water Conservancy (EDWC) Northern Relief: Hope/Dochfour, December 2009” pointed out the possibility of flood occurrence, over topping of the conservancy dam, under the condition of heavy rain with more than 1,000 year probability attacking the conservancy, it is considered for the Maduni Sluice to be used as the emergency spillway that is opened only at the time of “national scale catastrophe”.

Based on these two points of view, the rehabilitation of the Maduni Sluice is considered to be necessary.

(2) Sara Johanna Sluice

The relationship between the rehabilitation of the Sara Johanna Sluice and the rehabilitation of the Cuhnia Canal is considered as follows.

It is assumed that the water surface level at the branch point would descend as the two waterways can provide with a larger flowing down capacity; thus descended water surface at the branch point makes the hydraulic gradient between the Cuhnia Sluice and the branch point larger. By increase in hydraulic gradient, the flowing down capacity of the whole waterway increases. Therefore, rehabilitation of the Sarah Johanna waterway is effective to improving its flowing down capacity even if the Cuhnia Canal is constructed.

It is assumed that the rehabilitation of the Cuhnia Canal and the Sara Johanna Sluice is considered to be necessary based on the design report of the Hope/Dochfour canal as shown above. Such a recognition would be understandable considering the situation that the additional height of the conservancy dam, the height between the design flood water level (58.5 feet DG) and the dam crest (59.0 feet DG), is only 0.5 feet, i.e. 15 cm where not less than 1.0 m of additional height must be provided even for a small irrigation pond in Japan.

To this end, it can be said that the flood countermeasures for such reservoir as EDWC depends on the available allowance of drainage capacity of the sluice facilities.

2-1-3-7 Crown Dam and Hope/Dochfour Canal

The field reconnaissance was carried out with an expectation that the rehabilitations of intakes on the northern conservancy dam might become unnecessary if the Crown Dam can function as the conservancy dam in place of the existing one as the line of extension from the Crown Dam to the Hope/Dochfour Drainage Channel looks to be an alternative to the existing conservancy dam located in front of them in the map (refer to the figure below).

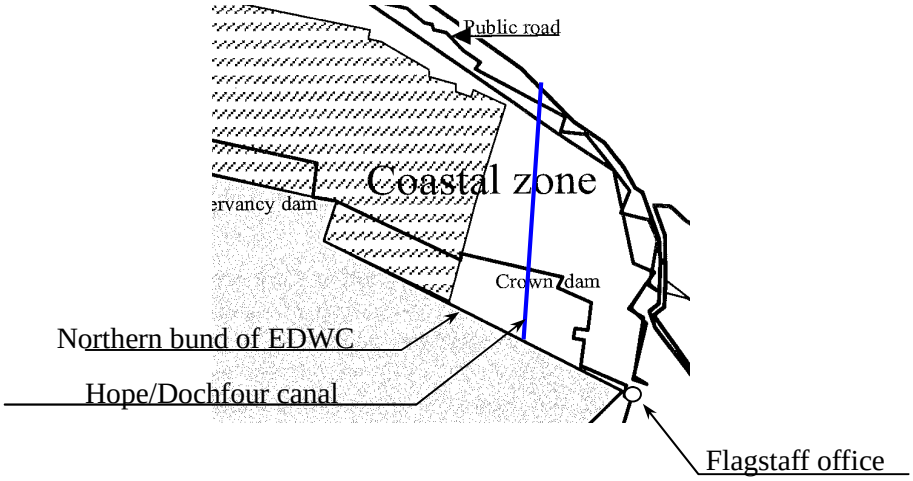


Fig. 2-1-4 Location of the Crown Dam and the Hope/Dochfour canal

In Guyana, all the old roads in rural area are not called “road” but called “dam” or “trail”. The Crown Dam is confirmed as the road and its surface elevation is lower than the crest elevation of the conservancy dam and the Hope/Dochfour Drainage Channel. The conclusion is that the Crown Dam can not function as the conservancy dam in place of the existing one.

PH 2-1-38 Crossing point of the Crown Dam and the Hope/Dochfour canal

2-1-3-8 Review of the original rehabilitation plan and priority

Since the existing rehabilitation plan is to be reviewed within the fixed amount of the entire construction cost, each component will be given the priority as below.

From the necessity of the existing designs, the influence derived from the construction of the Hope/Dochfour canal is quite significant where rehabilitation of Ann's Grove Intake at the existing location does not make sense. Also, as to Shanks Intake, which was not listed as the target of rehabilitation at the preparatory study in September 2011 due to the fact that the intake was rehabilitated by Guyana by that time. However, the Shanks Intake is considered as one of target to be rehabilitated taking into account the lean/narrow embankment crest, bent spindle and repeated rehabilitation works in the past etc. Considering these two points, the thorough rehabilitation of Shanks Intake in parallel with Ann's Grove Intake shall be given with the top priority.

Judging from the survey result on the past records of rehabilitation works mentioned in 2-1-3-3 and that of the site measurement of dimensions of the existing facilities as stated in 2-1-3-4, the cause of rehabilitations done repeatedly in the past for the Shanks/Hope Intake facilities is assumed to be the narrow width of the embankment crest of only 3 m. So, it is adequate to carry out the thorough rehabilitation also to the Hope Intake facilities.

The wooden pile revetment has two functions, one is to sustain the unstable slope of the embankment and the other is to protect the embankment slope from the wave's erosive action. In case of the embankment slope being stable, the latter function only is pursued. In EDWC where the maximum waves are the ones caused by the motorboat, the influence of wave action is small so that the priority of the revetment becomes low.

As for Annandale Intake, the facilities function without any problems, and also since the former rehabilitation in 2003 no problem has been occurred. Taking this into account, the matter to be considered is only the sustainability of the wooden pile revetment so that the priority is judged to be low.

Table 2-1-5 Targeted appurtenant facilities for rehabilitation and their priority order

Facility	Target of rehabilitation	Priority rank
Shanks Intake① (Ann's Grove②)	New construction of the entire intake facility（treatment of the existing facilities）	1
	Treatment of existing Ann's Grove intake facilities	
Hope Intake③	New construction of the entire intake facility（treatment of the existing facilities）	2
Sara Johanna Sluice ⑦	Rehabilitation of the concrete flume	3
	Rehabilitation of the slope protection works	5
Maduni Sluice ⑤	Replacement of the sluice gate	4
	Rehabilitation of the slope protection works（Including the shaping of the rear embankment）	6
Nancy Intake ⑥	Rehabilitation of the slope protection works（Including the shaping of the rear embankment）	7
Annandale Intake ④	Rehabilitation of the slope protection works（Including the shaping of the rear embankment）	8

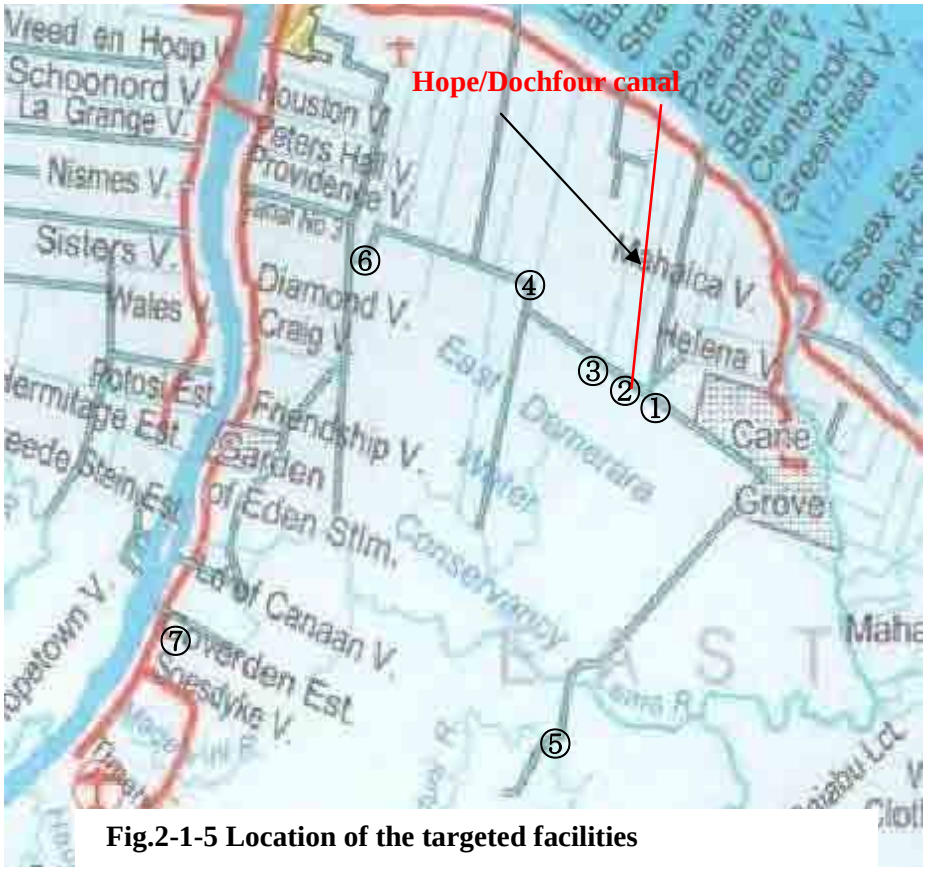


Fig.2-1-5 Location of the targeted facilities

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic policy

Basic policy of this Project is summarized in the following table.

Table 2-2-1 Basic policy of rehabilitating appurtenant facilities

No.	Item	Principle
1	Contents of the Japanese Assistance	To determine the scope & contents of the target of cooperation in the light of the objective of the superior program and the project based on the recognition to the significance of grant aid cooperation
2	Adjustment with the content of assistance by other donors	To coordinate with the facilities/parts of rehabilitation which have been the targets of on-going or scheduled projects by other donors.
3	Adjustment of the work with rehabilitation works of the Conservancy	To adjust materials/ works/ processes between this Project and the rehabilitation works implemented at the same time by Guyana or by the assistance of other donors so as not to cause any obstacles or inconveniences of these works.
4	Implementation of Soft Component	To implement Soft Component programs so as to effect in optimum outcomes from the subject grant aid project undertaking.

In the superior program, “Geotechnical and hydraulic assessment of the East Demerara Water Conservancy dam (Joint UNEP/OCHA Environment Unit)” as the report compiled in February 2005, basic goal has been set on “Improvement of/ increased safety of the Water Conservancy dam against floods”. For this sake, i.e. as the means to reach this goal, “strengthening of embankment by dissolving the shortage of free board” and “improvement of/ increased discharge capacity” has been suggested in the report.

Along with the line of this suggestion, the rehabilitation of intake facilities corresponds to the former, namely in the meaning of the rehabilitation eliminating the possibility of damage occurrence caused by the facilities located on the embankment; and the rehabilitation of sluice facilities corresponds to the latter in the literally meaning. When confirming these aspects, the Shanks Intake has been taken up at the top of the priority order; and prioritizing of other components has been done one by one.

As to the adjustment/coordination of the contents of assistance by other donors/rehabilitation works by other projects, there found two adjustment cases, the Hope/Dochfour canal project and the Cuhnia canal rehabilitation project. Concerning the former, the Study Team identified that the rehabilitation of Ann’s Grove Intake facility at the present location is to be cancelled and necessity arises to rehabilitate it through shifting the facility to the right bank of the canal, thus it is judged reasonable and proper to newly construct it side by side with Shanks Intake. As regards the latter, it is pertinent to rehabilitate Sara Johanna canal in parallel with the rehabilitation of Cuhnia canal, and no problem arises from doing so.

In connection with the rehabilitation works for EDWC, the embankment works being undertaken focus on the crest elevation at GD. 60.0 feet, which is composed of the designed crest elevation at GD. 59.0 feet plus 1.0 feet additional embankment height for subsistence allowance. Taking this into consideration, the subject design shall be adjusted properly. Concerning the construction works and the scheduling, it is noted that the rehabilitation of EDWC reservoir embankment is of lines nature while the works for appurtenant facilities are of dots nature and it is necessary to make necessary coordination so as to give higher priorities for the works of dots nature, appurtenant facilities. As to the material stockyards, it is necessary to make some coordination but for the equipment it is not necessary as the contracted constructor in charge for the appurtenant facilities will provide by themselves independently.

2-2-1-2 Selection of rehabilitation method for appurtenant facilities

(1) Foundation improvement method by soil cement

According to the results of field survey, the necessities of new Hope and Shanks intake facilities and the extension of Sara Johanna sluice were confirmed. In addition to the project cost increase due to the impact of exchange rate fluctuations of Yen-Dollar, a new component of construction effects the increase of the project cost.

When facilities are built on soft foundation, necessary measures for ground subsidence are taken to prevent from adverse effects (load increase, leakage problem etc.) to the facilities. The existing Hope Intake has leakage failures from the surrounding of its facility. This cause is assumed that the pile foundation method was applied to measure for ground subsidence of the facility.

Taking into account these circumstances, it was proposed for the project cost reduction, (i) the foundation of intake facilities was achieved subsidence reduction and increased the strength of it by foundation improvement method, (ii) the revetment works around intake facilities were modified from the wooden pile method planned in "Preparatory Survey" to the soil cement method.

The foundation improvement method and the soil cement method have the advantages of keeping certain level in quality of work and low construction cost because the methods have no requirement of special technology and machinery. In addition, since the correlation between the improvement strength of foundation and cement mix proportion had been confirmed from the blending tests of soil cement method conducted during "Preparatory Survey" of the year of 2009, it was also an advantage that construction period could be shortened to omit the blending tests during construction. Moreover it was considered that this method would be spread through the technology transfer by the soft component.

Since it was possible to implement all the components of rehabilitation works by the adoption of the above-mentioned method, the consultant team explained the rehabilitation plan by these methods to the Guyana side in August 2013 after the re-calculation of the project cost.

However, after the above-mentioned explanation in August 2013, the Guyana side strongly showed the following intentions for the rehabilitation plan, so it was necessary to revise the foundation treatment method and the slope protection method.

(i) The contents of component including the new construction of Hope and Shanks intake facilities and their priority are acceptable.

(ii) The contents of foundation improvement method and soil cement method have an understanding. However, it is not adopted in this project because the methods are not commonly employed in Guyana.

(iii) Pile foundation method should be adopted for foundation treatment of concrete structures, and cut-off piles should be installed at the upstream and downstream end of concrete structures as leakage control.

(iv) Slope protection method should be selected the appropriate type in consideration of economic efficiency, stability and durability.

(2) Evaluation of foundation improvement method

In regard to the problem of hexavalent chromium with the ground improvement method by the soil cement, according to the results of consultation with expert of the ground improvement method during “Preparatory Survey (I) on the Rehabilitation of the East Demerara Water Conservancy in the Republic of Guyana (November 2009)”, it was concluded that there is no problem of hexavalent chromium from the following reasons.

(i) Adsorption - reduction action of surrounding soil is large enough for elution of hexavalent chromium.
(ii) If hexavalent chromium is eluted from improved soil, its movement is controlled by the action of the soil.
(iii) Since elution of hexavalent chromium is not promoted unless a large amount of water penetrates into the improved soil, there is no impact on the surrounding environment.
(iv) In cohesive soil, possibility of excess of Japan's standard value is only about 4%. It is judged that there is little elution of hexavalent chromium by making an earth coverage.

In addition, as a judgment of the consultant from the examination on measures for design, construction and geological properties, it was concluded that there is no problem of hexavalent chromium elution with ground improvement method.

• In general, it is easy eluted with volcanic ash clay containing a large amount of clay minerals significantly inhibit the formation of hydrates. However, since there is no volcano in Guyana, volcanic ashy soil which hexavalent chromium is easily eluted does not exist. For the reason

of this, the impact on the environment is very small.

- The improved soil by earth coverage method is employed to take necessary measures against the elution of hexavalent chromium.
- By ensuring the water-stopping around the structure of intake facilities, to prevent the inflow of a large amount of water penetration for an improved soil and suppress the elution.

However, sufficient measures for hexavalent chromium will be taken during construction in order to address the technology transfer on ground improvement method through soft component, on the other hand, EWDC has become a drinking water source in the capital of Georgetown. It is necessary to confirm the hexavalent chromium by the elution test. Further, it can be judged whether there is no adverse effect on water quality by the soil cement which will be employed for slope protection for EWDC. For this reason, the tests will be planned to execute in Japan.

Ground improvement is to mix cement in soil and raise the cohesion between the soil particle by a hydration reaction and increase strength of the ground. Sometimes the generation of the hydrate is obstructed under the influence of clay minerals and organic component of soil targeted for the improvement, and the sexivalent chrome which was not fixed by a hydrate may elute it on this occasion.

The ground improvement method in Japan has the reference value provided for the elution of hexavalent chromium by law, and there are regulations on environmental impact. Portland blast-furnace slag cement, which is to reduce the elution of hexavalent chromium, is used as common measures.

On the other hand, in consideration that the equipment and/or testing laboratories for the elution test of hexavalent chromium is not provided, and status of enacting the relevant legislation in Guyana, the present system will not be established to to assess and regulate the risk of hexavalent chromium.

Silica cement and ordinary Portland cement is easy to procure in Guyana. However, it is difficult to obtain blast furnace cement in Guyana. It is possible to perform the hexavalent chromium measures in Guyana, but imported cement is required. However, in consideration that the local contractors will undertake the construction work in this Project, materials to be utilized for the project might be limited to obtain in Guyana. Therefore, the use of materials which is difficult for procurement in their own country can be an obstacle to the spread of construction method in future and the increase of construction costs.

From the above reasons, in order to widespread the soil improvement techniques in Guyana, it is necessary to prepare the regulation system including the elution test of hexavalent chromium in order to to reduce the risk. Further, if blast furnace cement is easy to obtain, the method becomes sustainable because the impact on the environment is small and the construction cost is also an inexpensive. In present stage, it is judged that the ground improvement method would not become rapidly widespread in Guyana.

Therefore, it is judged that the adopting of ground improvement method by cement in Guyana is not appropriated in consideration of the intent of Guyana side and the sustainability of future technologies.

(3) Review of the improvement method

The ground improvement method changes to the pile foundation method in consideration of the wishes of Guyana and the environmental impact by the improvement. As a result, using a soil cement method for slope protection is also changed to another method.

2-2-1-3 Target appurtenant facilities for rehabilitation

The targets of rehabilitation and their locations are shown in Table 2-1-5 and on Fig. 2-1-5.

2-2-1-4 Design Policy

(1) Intake facilities

(a) Foundation treatment

Since pile foundation is generally applied as the foundation treatment of intake facilities in Guyana, wooden sheet piles with depth of 4.5m are installed at the upstream and downstream ends of concrete bottom slab as the measures during ground subsidence for piping phenomenon.

In consideration of the circumstances in Guyana, besides the installation of cut-off wall at the intake portion, pile foundation method shall be applied as the foundation treatment.

(b) Extension of conduit pipes and retaining walls

The length of conduit pipes installed in the existing intake facilities is short, in many cases is as same as the embankment crest width. This is the reason why the wooden pile revetment is provided as the supporting/fixing works to the embankment slopes. The short length of the conduit pipes, which brings the short seepage path along the conduit, incomplete work of the wooden pile revetment and its poor durability makes the embankment/foundation condition around the intake facility unstable. The intake facility shall become durable and has a long lifespan in case of the conduit pipe being given a long enough length, the long enough concrete retaining walls being installed, and surrounding embankment/foundation being kept stable.

(c) Consideration of embankment/backfill material around the intake facilities

Since it is difficult to obtain a good soil material such as appropriate quality and water content around a job site, earth material produced on the site shall be used., As adequate compaction of soil by heavy machinery is too difficult in consideration of the soft foundation and the properties of the embankment material, it is not expected the enough strength (adhesion) of the embankment. For the above matter, it is necessary to consider to the specifications of the facilities and the revetment.

(2) Wooden pile revetment

The wooden pile revetment has two functions. One is to support the unstable embankment slope or the soil block under sliding, and the other is to protect the slope surface from wave's erosive action. The rehabilitation plan of EDWC is mainly composed of new construction of the intake facility and wooden pile revetment work with excavation and backfilling of embankment, backfilling the back of revetment work. Thus, it is required two functions with the stabilization of embankment and the erosion measures. In consideration of the economy and the durability, wood pile revetment method shall be adopted.(refer to Table 2-2-3)

2-2-1-5 Design criteria, construction method and selection of materials/equipment

Application of design criteria, construction methods and selection of materials/equipment shall follow the way shown below.

Table 2-2-2 Application fundamentals from design to construction

Item	Remarks
Design criteria	To apply standards adopted in Guyana, such as BS, ASTM etc. Besides, in case that it is difficult to follow these, JIS standard is applied to. Individual specifications are explicitly described in design documents.
Design method	To apply criteria/guidelines etc utilized in Guyana, (such as allowable stress). In case of the method being used conventionally due to lack of suitable standard/guideline and some inconvenience arising from its application, Japanese standards are temporarily adopted.
Parts/material and specifications of detailed part of member	To follow what are specified in the standard design drawings or design reference documents. Materials and quality management method etc shall be adopted based on the specifications and rules in BS, ASTM. Verification on whether currently practiced anti-rust method or measures are taken shall be made on steel products.
Loading condition	To apply the load based on design standards/guidelines adopted by relevant institutions in Guyana
Construction machinery	To select machinery which can be procured in Guyana, also can satisfy the requirements on design/ construction work
Construction method	To adopt the construction method which contractors in Guyana can perform by means of construction machinery available in Guyana
Material procurement	In principle, to use materials which are procurable in Guyana

2-2-1-6 Management, operation and maintenance

Appurtenant facilities rehabilitated by this Project are subject to the dimensional inspection and the total completion inspection just after their finish of construction, and then delivered to NDIA. Management, operation and maintenance of these facilities shall be carried out directly by the management office of EDWC under the supervision of the EDWC Management Committee.

The Japanese Consultant in charge of construction supervision shall confirm the quality of works/method and repairing records completed in the past in Guyana. If necessary, the Consultant

shall recommend to NDIA for the record-keeping methods in order to execute the inspection, operation and management for the appurtenant facilities smoothly and effectively.

2-2-2 Construction Plan

2-2-2-1 Rehabilitation of intake/sluice facilities

(1) Shanks (Ann's Grove) Intake and Hope Intake

(a) Positioning of the facilities

These are the intake facilities to be renewed. The construction works are carried out during the dry season, when the irrigation water is required. The new intake facilities shall be constructed beside the existing one through which the irrigation water shall be taken and supplied to the farmlands without giving any influence of water lacking to the farmers. The water conduit of existing ones shall be closed after construction of the new one.

In this context, taking account of water evacuation from the work area during the construction period, it is one idea to install it outside the conservancy (downstream of the existing embankment). But in this case, it would become a problem for the newly constructed embankment around the intake facility to cause the settlement of foundation. Here, from the view point of avoiding the occurrence of settlement problem, the position of the facility newly constructed shall be chosen on the line of the cross-section of the existing embankment, where the facility shall be constructed on the open space obtained through its excavation and the additional increase of load shall not occur by the backfill around the facility.

(b) Longitudinal and cross-sectional form

As found in the historical record of rehabilitation, the rehabilitations have been done repeatedly in the past to those intake facilities where the crest width of the dam, i.e. the conduit length, is narrow/short to be 3.0 m. In consideration of the embankment crest being 3.5m～4.0m wide usually and of the intake construction portion tending to become the weak/vulnerable point of the embankment because of the intake facility itself being a foreign body for the embankment, it is adequate to give the enough width of 4.5m to the embankment crest of the intake installed portion. Furthermore, longitudinal and cross-sectional dimensions are determined by the reference to the standard design drawing of intake facility in Guyana.

The wood pile revetment work is continuously placing to the facility as the earth retaining at the time of backfill of intake facility.

In order to prevent the seepage path of facilities near future, it takes measure such as the installation of sheet piles at the upstream and downstream ends of intake facility, providing a cut-off wall to the intake portion, and the installation of wooden sheet piles to a sufficient depth.

(c) Supporting type of the facility

For the pile foundation type, the subsidence of the pile itself sometimes is not matched with the

subsidence of surrounding ground, as a void space appears at the under portion of the facility, the pile foundation is, in principle, capable to support only vertical force by the pile. In this area, the specifications and the placement of the piles shall be determined, without taking into account the load sharing on the lower ground with the intake facility, as to support vertical force by pile.

The pile foundation can be classified into a friction pile and a bearing pile whether it is considered of the bearing force of a pile edge or not, however, the bearing piles are generally desirable in order to prevent displacement of the foundation for long-term.

For the bearing piles, the edge of pile is necessary to ensure the required depth of penetration for a favorable support layer. A favorable support layer, in the case of clay layer, has N-value with about 20 or more and unconfined compressive strength with 0.4N/mm^2 or more. (refer to "Pile Foundation Design Handbook (January 2007)" (Japan Road Association) P.118)

From the results of drilling investigation in EDWC, the upper surface elevation of a good clay layer of N-value with about 20 appears at EL.3.0m near the lowest positions. This is about 15m down from the dam crest. Since the wood pile material of 15m in length is available to obtain in Guyana, the bearing piles shall be adopted for the Project.

(2) Rehabilitation of gate（Maduni Sluice）

The wooden gate of Maduni Sluice shall be replaced to the new one because of the leakage through the old one having been gradually increasing. Other equipments such as the winch system shall be untouched as they are operational without troubles.

(3) Rehabilitation of the narrow flume under the wooden bridge in Sara Johanna

The existing narrow flume 2.7m wide shall be replaced to the new one wider than the culvert channel at the downstream Sara Johanna regulation sluice.

The cross-sectional shape of this new one shall be similar to that of the downstream channel, provided with two connected culvert channels considering the length and the vulnerability required as the bridge. In addition, the treatment of its foundation shall be adopted by the pile foundation as well as the intake facility.

2-2-2-2 Rehabilitation of slope protection works

(1) Slope protection works installed at Nancy Intake, Maduni Sluice and Annandale Intake

(a) Basic policy

No collapse of slope has ever appeared as collated in the repair records, however, it is considered that the function of intake facility would be dropping near future by sediment due to the erosion around the inlet. For this reason, the scope of rehabilitation work for revetment shall be decided clearly in order to maintain this function.

The priority sites for rehabilitation are as follows.

(i) reservoir side is given a high priority to rehabilitation (the channel of downstream side of intake has enough width and no steep, and also its cross section is wide. Thus, urgency is low)

(ii) the vicinity of the intake facility is given the second priority (because the effect of flowing water is larger at the inlet of the intake)

Hydraulic calculation for the flow in the downstream canal is as follows.

When, normal full water level is at GD 57.5 feet, inlet of intake facility is at diameter φ4feet (about 1,200 mm), (Tube bottom and GD45.00ft, tube center GD45.0 +2 feet = GD47.00);

Intake discharge $Q=CA\sqrt{2g\frac{H}{2}}$

Where, Q: intake discharge (m^3 / s)

C: coefficient of discharge (generally 0.62)

A: conduit cross-section area (m^2) A = 1.22 / 4 × π = 1.13m^2

g: gravitational acceleration (L = 9.8m/s^2)

H: water depth from the surface to conduit center (m)

H= GD57.5-GD47.0 = 10.5feet = 3.20m

$Q=0.62\cdot 1.13\sqrt{2\cdot 9.8\frac{3.20}{2}}=3.9m^3/s$

When, the bottom width of downstream canal: 7m, average longitudinal slope of canal I = 1/500, the velocity is as follows.

From Q = A · V, V = Q / A

$V=\frac{1}{n}R^{\frac{2}{3}}I^{\frac{1}{2}}$

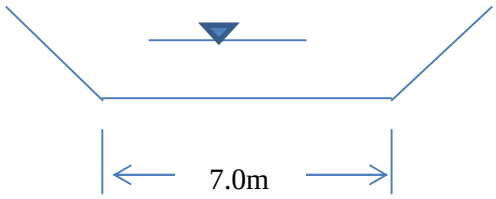
Where, A: flow cross-sectional area (m^2), V: velocity (m/s), n: coefficient of roughness 0.025 (no vegetation), R: hydraulic radius (m) R = A / s, I: longitudinal slop of canal

From the result of the calculation, water depth in the downstream side of the intake channel at the time of 50cm, velocity is 1m/s, therefore, it is satisfied for the allowable velocity in the earth canal of clay layer. (Land improvement business plan design criteria "channel work", Ministry of Agriculture, Forestry and Fisheries Rural Development Bureau P.153). In addition, since water is always filled up inside of the downstream canal, then this controls the velocity as water cushion, thus, it is judged that there is no problem of erosion of the banks of canal.

Hydraulic engineering examination for the downstream canal

Discharge	Area	Hydraulic radius	Slope	Width of canal	Uniform Water level	Velocity	Coefficient of roughness	Longitudinal slope

Q	A	R	1:m	B	h	v	n	I
(m^3/s)	(m^2)	(m)		(m)	(m)	(m/s)		1/I
3.90	3.74	0.4	1.0	7.0	0.499	1.04	0.025	500.0



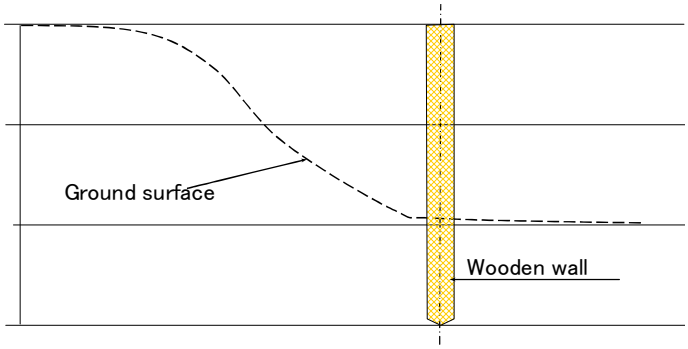
(b) Comparative examination of slope protection methods

1) Slope protection methods

The following three methods are to be examined.

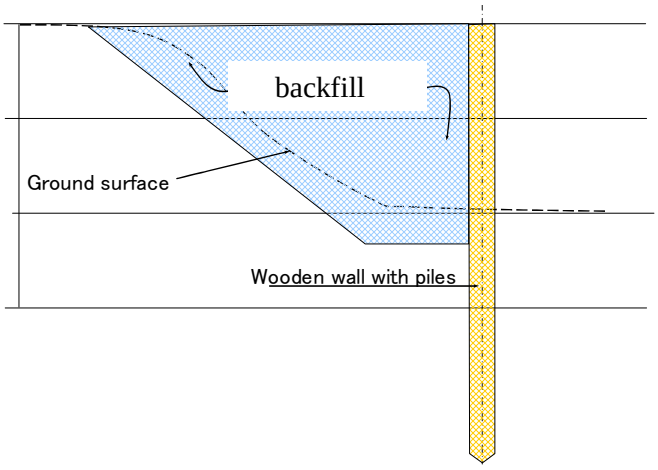
(i) Wooden wall protection method

Wooden wall protection is provided along the toe of the existing slope. It can block waves to reach the slope so that the vacant space between the wall and the slope is left as it is.



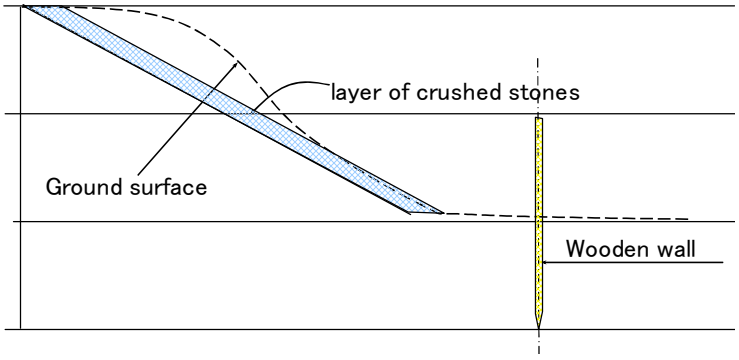
(ii) Wooden wall with piles and backfill protection method

New wooden wall shall be installed near the existing wooden piles in the bank, and the space between the wooden wall and the slope surface is backfilled by soil provided from a job site. Since the earth pressure acts to the wall from the back, the revetment work shall be applied by wooden wall with pile method.



(iii) Crushed stone protection method

The ground surface of the existing bank shall be shaped at the inclination of 1 to 1.5. Crushed stones are spread on the slope at the thickness of about 20cm. If the construction of crushed stone ranges between the dam crest (59.0 feet G.D.) and the minimum reservoir level (53.5 feet G.D.) minus 0.3m, the height of slope protection wall shall be 2.3m.



2) Comparative examination/ adopted construction method

Since the three methods mentioned above, they were examined under the condition of cofferdam construction method for dry work.

From the following reasons, wooden wall with piles and backfill protection method is to be adopted.

- Though the wooden wall protection is excellent in terms of economy, problems would arise from the view point of durability. Further, it is not possible to effectively utilize the space in the wood pile back.
- In case of the wooden wall with piles and backfill protection, the construction cost would be expensive but the space between the wall and the slope backfilled would be effectively utilized together with stabilizing slope. This method does not require special construction technology and has many results of construction in this area.
- The crushed stone protection has advantage in the construction cost per 10m including transportation costs, but there is a concern about durability and less achievement of construction.

Table 2-2-3 Summary of comparing examination on various slope protection work

Method / Item	Wooden wall protection		Wooden wall with piles and backfill protection		Crushed stone protection	
Landscape	×	Weeds thrive in between the slope and wooden wall, which brings the deterioration of landscape and water quality, and then foul odor.	△	Just after the completion of the work, landscape is excellent. However, once the wooden wall becomes rotten, it becomes bad by and by.	○	Finishing of the surface of the protection work is easy. The protection work would fit in the surrounding landscape.
Stability of slope	○	The protection work does not bring any load to the slope and any affect to the slope stability.	○	Since the soil backfilled brings new load to be affected, the slope shall be stable by the construction of wooden wall.	○	The load condition on the slope shall not be changed and the stability shall be scarcely affected by this construction.
Workability / facility	○	The facility is simple and the construction is easy.	△	It is necessary to be considered for the construction during rainy season because of including the earth work.	△	The workability of crashed stone is easy. But all the materials must be transported long way from outside.
Durability	×	About 15 years or so.	○	The soil backfilled becomes to be function as vegetation base.	△	The crushed stones are not stable around a pier because they are not fixed.
Achievement	×	None	○	Many results in EDWC	×	None
Economic Feasibility (per 10m of construction)	○	Cofferdam work: 20,000G$×5m×10m=1,000,000G$ Revetment work:40,000G$/m2×5m×10m =2,000,000G$ (Materials + Construction) Barge: 46,000G$×30days=1,380,000G$ Tug boat: 46,100G$×30days=1,383,000G$ Crane:80,700G$×30days=2,421,000G$ Total cost: 6,801,000G$	×	Cofferdam work: 20,000G$×5m×10m=1,000,000G$ Revetment work:60,000G$/m2×5m×10m =3,000,000G$ (Materials + Construction) Excavation &backfill: 1,600G$×10m2×10m=16,000G$ Barge: 46,000G$×50days=2,300,000G$ Tug boat: 46,100G$×50days=2,305,000G$ Crane:80,700G$×30days=2,421,000G$ Back-hoe: 52,600G$×20days=1,052,000G$ Total cost:12,094,000G$	△	Cofferdam work: 20,000G$×5m×10m=1,000,000G$ Revetment work:40,000G$/m2×2m×10m =800,000G$ (Materials + Construction) Crushed stones backfill: 18,500G$×0.8m2×10m=148,000G$ Barge: 46,000G$×50days=2,300,000G$ Tug boat: 46,100G$×50days=2,305,000G$ Crane:80,700G$×30days=2,421,000G$ Back-hoe: 52,600G$×20days=1,052,000G$ Total cost:10,026,000G$
Overall Evaluation	△	This method has an advantage of the economical point, but it is little result.	○	Since construction cost is a bit expensive, the scope of work for construction is considered. However, this method is adopted for the Project in consideration of many results and the excellent stability of slope.	×	Construction cost is a bit expensive and the method has no achieved in EDWC in the past. The stability of slope is scarcely affected because the stones is not fixed.

(2) Slope protection work at the upstream of Sara Johanna regulation sluice

Both banks of the canal at the upstream of the regulation sluice consist of excavated slopes or embankment slopes. The soils on these banks are clayey and highly adhesive, so that the slopes are stable and self-supported. However, slope protection work shall be adopted as measures for erosion. As to the left bank of which top serves as a community road, the revetment work by wooden pile with self-supported type shall be furnished in consider with safety measures. Further, the revetment work shall be placed the canal side (front side) slightly from the existing one, so that the road shall be possible to utilize during construction.

2-2-2-3 Disposal of the existing facilities

(1) Treatment of the Shanks, Ann's Grove, and Hope intake facilities

These existing intake facilities have the past experiences of repeated repairs due to the occurrence of piping phenomenon, so that the treatment to these facilities shall be adequately conducted to eliminate the occurrence of these events. It is the most complete way to remove these facilities and replace them with the embankment. However, for this it is necessary to enclose the work area by installing temporary sheet piles, which invites the high cost of construction. Therefore, the following measures shall be conducted.

(i) The existing intake facilities have the sequence of events of water leakage from the foundation, but it is too difficult to cut off the seepage path which is present in the soil. However, it is possible to reduce the amount of reliably leakage by installing wooden sheet piles at the upstream and downstream of the intake, so that this is to prevent for piping phenomenon in future.

(ii) For pipe culvert, no abnormal situation has occurred such as leakage from pipe culvert by the collapse of the dam crest, however, it is necessary to block the leakage when the intake gate is closed. For this reason, the inside of pipe culvert shall be filled with concrete and cement milk. During construction, after the removal of intake gates, it is difficult to reuse them because each one has different size. Thus, they can be used as mold frame.

(2) Treatment to the defect at the upstream edge of the embankment crest (reference)

This defect shall be rehabilitated as a part of daily maintenance works by NDIA. Here, the fundamental points considered in the rehabilitation work shall be presented.

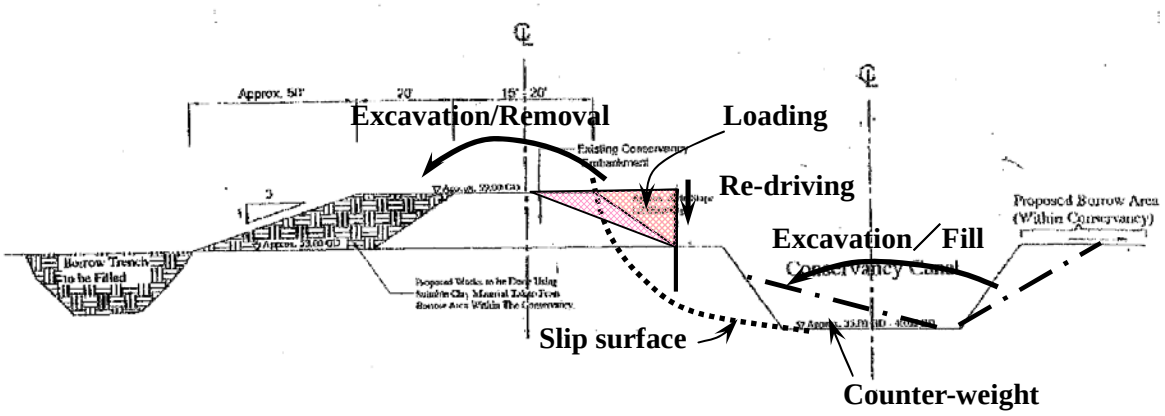
The part where sliding takes place and a extension of step appears is somehow provided with the wooden pile revetment and has the widened embankment crest. The figure bellow shows such situations. According to this figure, it is assumed that the red colored portion filled up to the crest level with soil functioned as the increased load and pulled a trigger of sliding assisted by the canal excavation. There are several countermeasures against land sliding; for example, the load removal method, the counter-weight embankment method, and the pile restraint method are listed up in the order of simplicity and economy of the works.

Here, the following countermeasures are recommended to be conducted in order.

(i) As the load removal method, the colored portion in the figure shall be excavated and moved to the downstream side.

(ii) As the counter-weight embankment method, the slope shoulder of the canal at the reservoir side shall be excavated and the soil shall be moved to the slope foot of the canal at the embankment side.

(iii) As the pile restraint method, existing piles shall be re-driven into the ground.

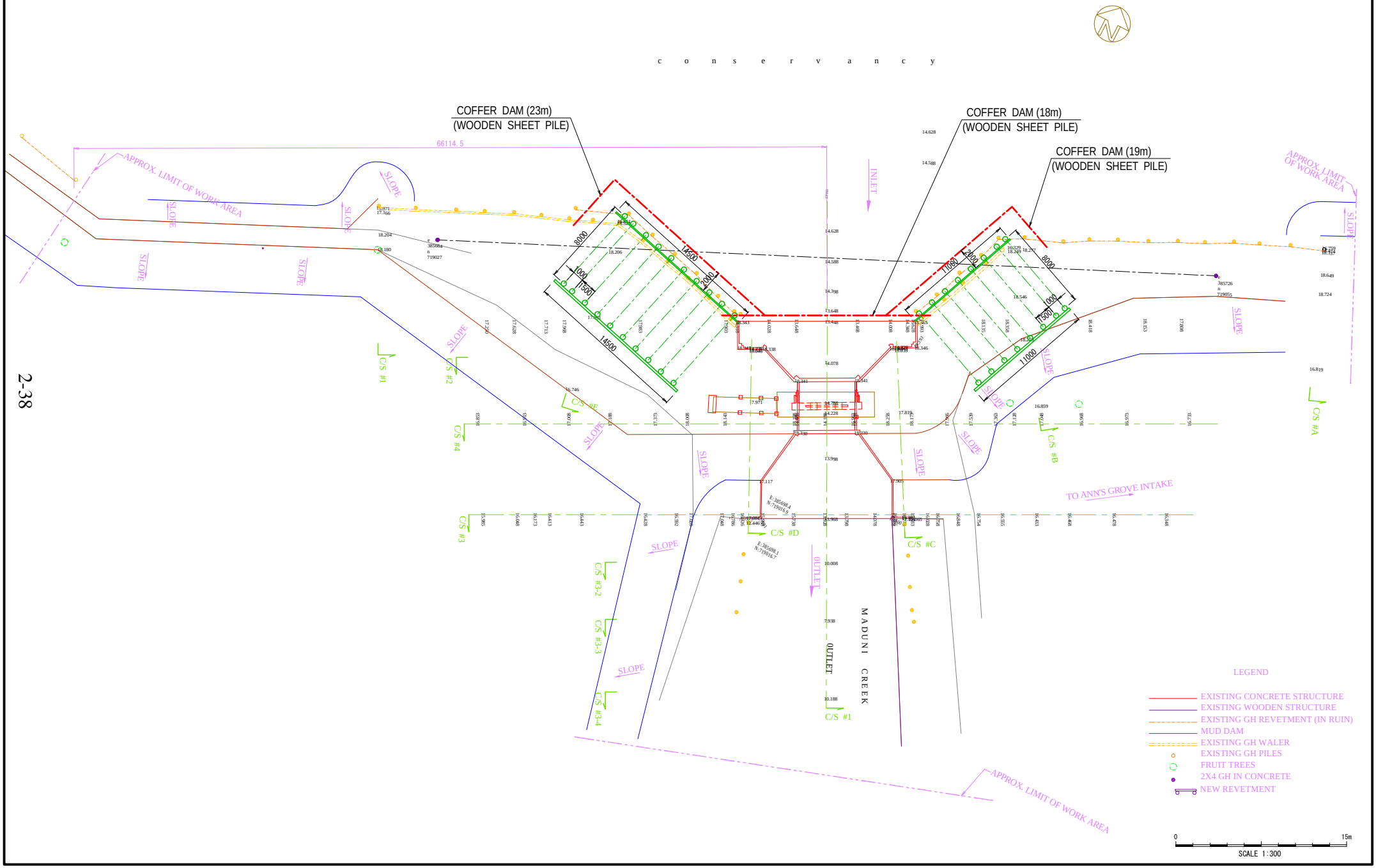


2-2-3 Outline Design Drawings

Outline design drawings for each rehabilitation of appurtenent facilities are shown in the following pages.

Title of Drawing
Maduni Sluice
Nancy Intake
Annandale Intake
Hope Intake
Shanks Intake
Ann's Grove
Sara Johanna Sluice
Typical plan of anchored Revetment

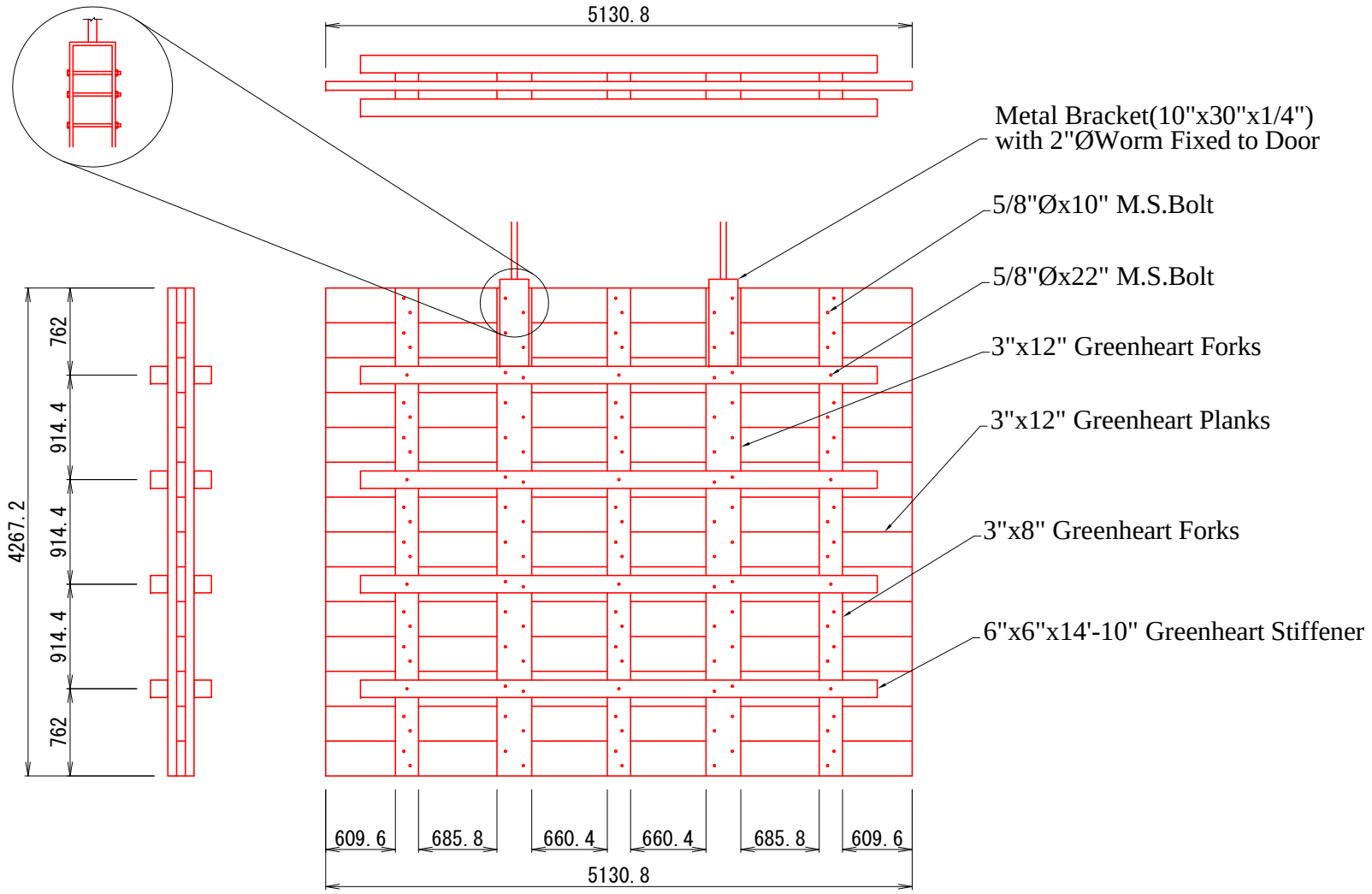
MADUNI


c o n s e r v a n c y
COFFER DAM (23m)
(WOODEN SHEET PILE)
COFFER DAM (18m)
(WOODEN SHEET PILE)
COFFER DAM (19m)
(WOODEN SHEET PILE)
66114.5
APPROX. LIMIT OF WORK AREA
APPROX. LIMIT OF WORK AREA
APPROX. LIMIT OF WORK AREA
SLOPE
INLET
OUTLET
OUTLET
MADUNI CREEK
C/S #1
C/S #2
C/S #3
C/S #3-2
C/S #3-3
C/S #3-4
C/S #4
C/S #A
C/S #B
C/S #C
C/S #D
C/S #E
TO ANN'S GROVE INTAKE
LEGEND
EXISTING CONCRETE STRUCTURE
EXISTING WOODEN STRUCTURE
EXISTING GH REVETMENT (IN RUIN)
MUD DAM
EXISTING GH WALER
EXISTING GH PILES
FRUIT TREES
2X4 GH IN CONCRETE
NEW REVETMENT
0
15m
SCALE 1:300

MADUNI

METAL BRACKET
Existing ones reused

MADUNI SLUICE DOOR FABRICATION

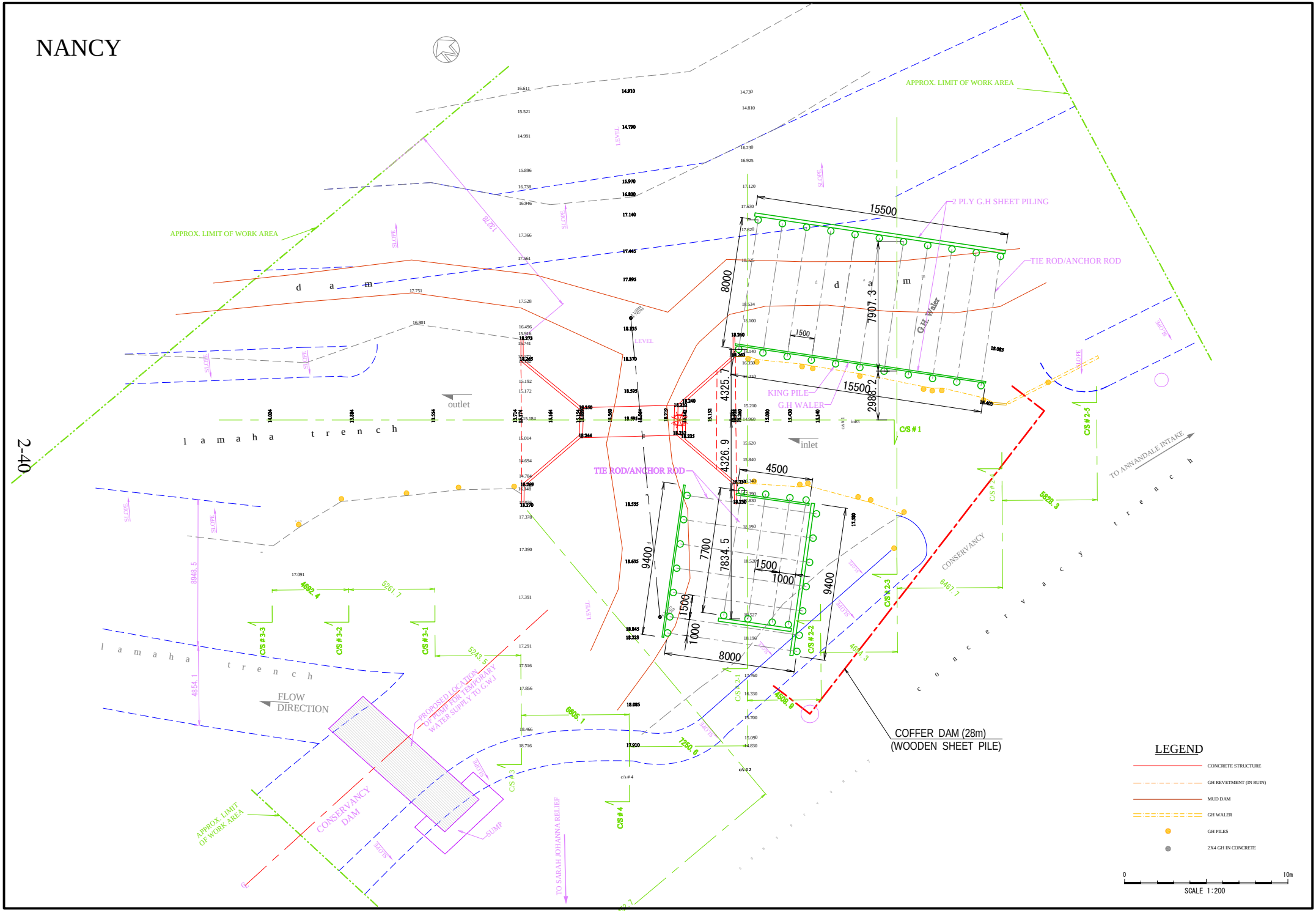


DOOR DETAILS
NOT DRAWN TO SCALE

Remarks:
The DOOR shall be fabricated upon measuring existing structure sizes among others door width/height and space between spindles.

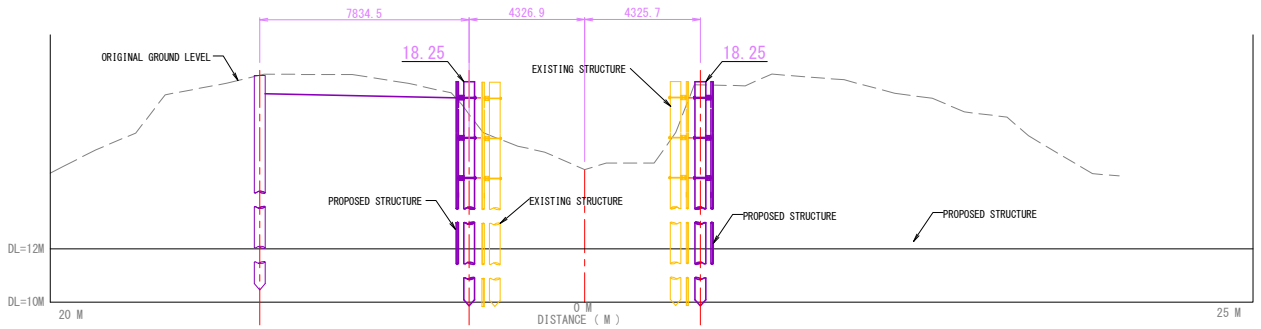
SCALE 1:40

NANCY

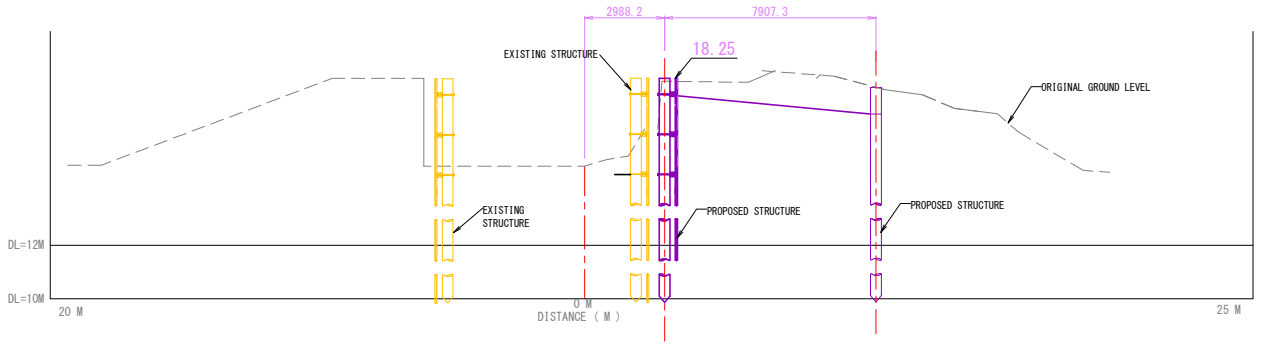

APPROX. LIMIT OF WORK AREA
APPROX. LIMIT OF WORK AREA
2 PLY G.H SHEET PILING
TIE ROD/ANCHOR ROD
KING PILE
G.H WALER
G.H. Waler
15500
8000
7907.3
1500
4325.7
2998.2
4326.9
4500
TIE ROD/ANCHOR ROD
9400
7700
7834.5
1500
1000
1000
8000
9400
d a m
l a m a h a t r e n c h
outlet
inlet
C/S # 1
C/S # 2-5
C/S # 2-4
C/S # 2-3
C/S # 2-2
C/S # 2-1
C/S # 3-3
C/S # 3-2
C/S # 3-1
C/S # 3
C/S # 4
TO ANNANDALE INTAKE
CONSERVANCY
CONSERVANCY DAM
PROPOSED LOCATION OF TEMP FOR TEMPORARY WATER SUPPLY TO G.W.I
FLOW DIRECTION
SUMP
TO SARAH JOHANNA RELIEF
COFFER DAM (28m)
(WOODEN SHEET PILE)
SLOPE
LEVEL
5828.3
6487.7
4092.4
5261.7
5243.5
6805.1
7250.6
4854.1
8948.5
4854.3
4508.9
LEGEND
CONCRETE STRUCTURE
GH REVETMENT (IN RUIN)
MUD DAM
GH WALER
GH PILES
2X4 GH IN CONCRETE
0
10m
SCALE 1:200

2-40

CROSS SECTION # 2-1

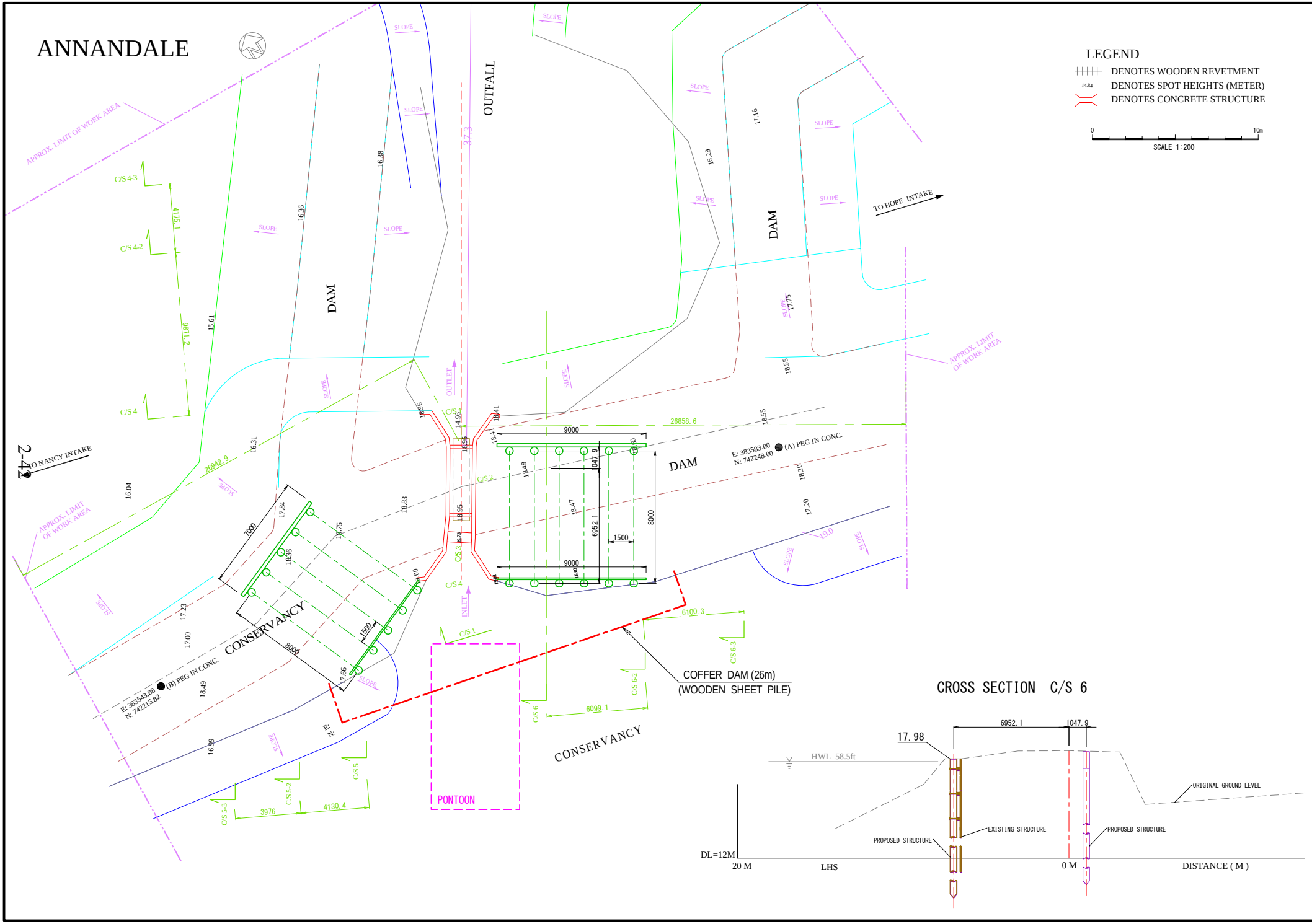


CROSS SECTION # 2-3

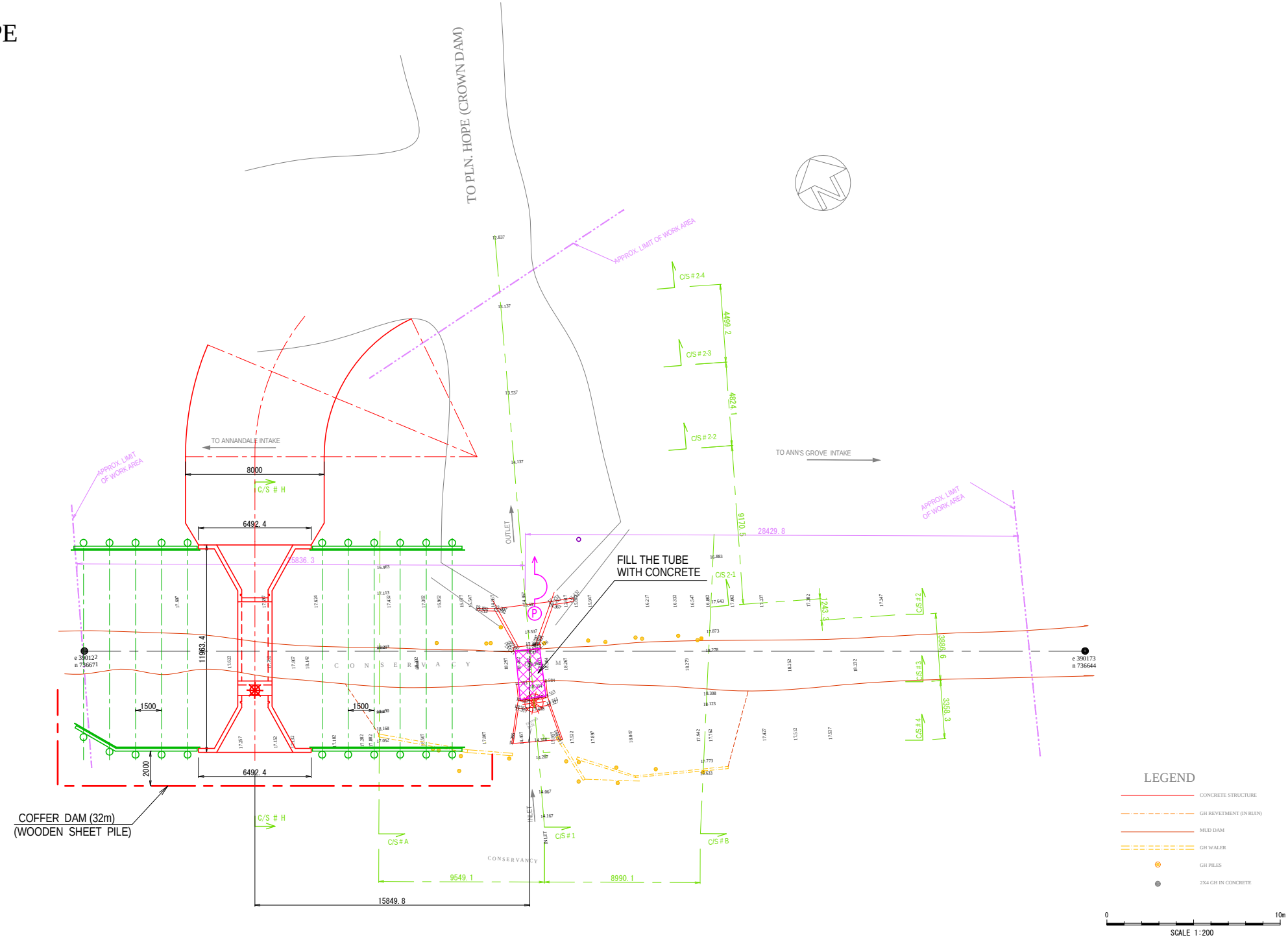


0 10m
SCALE 1:200

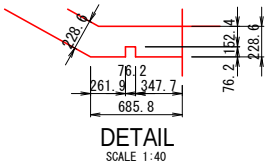
ANNANDALE

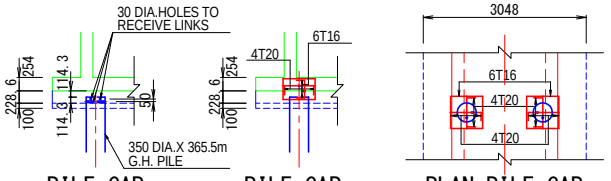

LEGEND
DENOTES WOODEN REVETMENT
DENOTES SPOT HEIGHTS (METER)
DENOTES CONCRETE STRUCTURE
0
10m
SCALE 1:200
OUTFALL
DAM
DAM
DAM
TO HOPE INTAKE
TO NANCY INTAKE
APPROX. LIMIT OF WORK AREA
APPROX. LIMIT OF WORK AREA
APPROX. LIMIT OF WORK AREA
SLOPE
OUTLET
INLET
C/S 4-3
C/S 4-2
C/S 4
C/S 3
C/S 2
C/S 1
C/S 5
C/S 5-2
C/S 5-3
C/S 6
C/S 6-2
C/S 6-3
4175.1
3971.2
26942.9
26858.6
6952.1
1047.9
6100.3
6099.1
4130.4
3976
9000
8000
7000
1500
CONSERVANCY
CONSERVANCY
PONTOON
COFFER DAM (26m)
(WOODEN SHEET PILE)
E: 383583.00
N: 742248.00
(A) PEG IN CONC.
E: 383543.88
N: 742215.82
(B) PEG IN CONC.
E:
N:
CROSS SECTION C/S 6
HWL 58.5ft
17.98
6952.1
1047.9
ORIGINAL GROUND LEVEL
EXISTING STRUCTURE
PROPOSED STRUCTURE
PROPOSED STRUCTURE
DL=12M
20 M
LHS
0 M
DISTANCE (M)

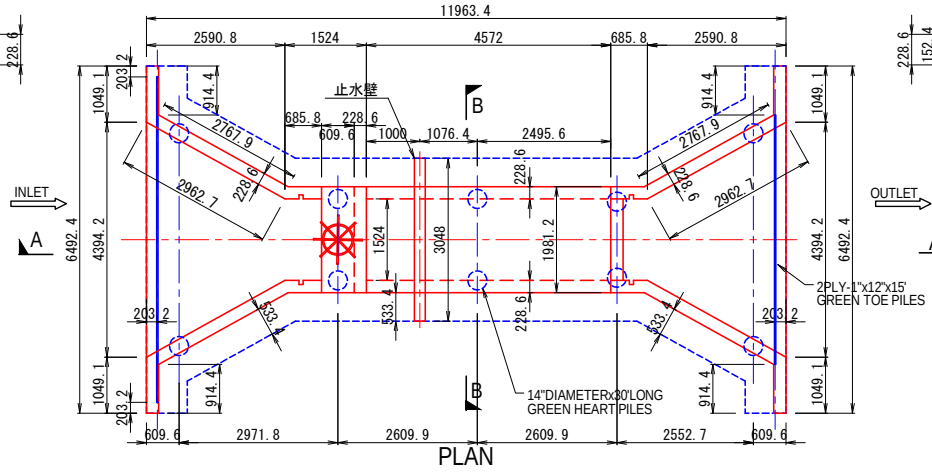
HOPE

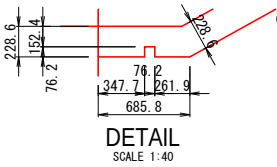

TO PLN. HOPE (CROWN DAM)
APPROX. LIMIT OF WORK AREA
TO ANNANDALE INTAKE
TO ANN'S GROVE INTAKE
APPROX. LIMIT OF WORK AREA
APPROX. LIMIT OF WORK AREA
OUTLET
FILL THE TUBE WITH CONCRETE
C/S # 2-4
C/S # 2-3
C/S # 2-2
C/S # 2-1
C/S # H
C/S # A
C/S # 1
C/S # B
C/S # 2
C/S # 3
C/S # 4
8000
6492.4
5836.3
11963.4
1500
1500
2000
6492.4
15849.8
9549.1
8990.1
4499.2
4824.1
9170.5
28429.8
1243.3
3988.6
3358.3
e 390122
n 736671
e 390173
n 736644
COFFER DAM (32m)
(WOODEN SHEET PILE)
CONSERVANCY
LEGEND
CONCRETE STRUCTURE
GH REVETMENT (IN RUIN)
MUD DAM
GH WALER
GH PILES
2X4 GH IN CONCRETE
0
10m
SCALE 1:200

HOPE

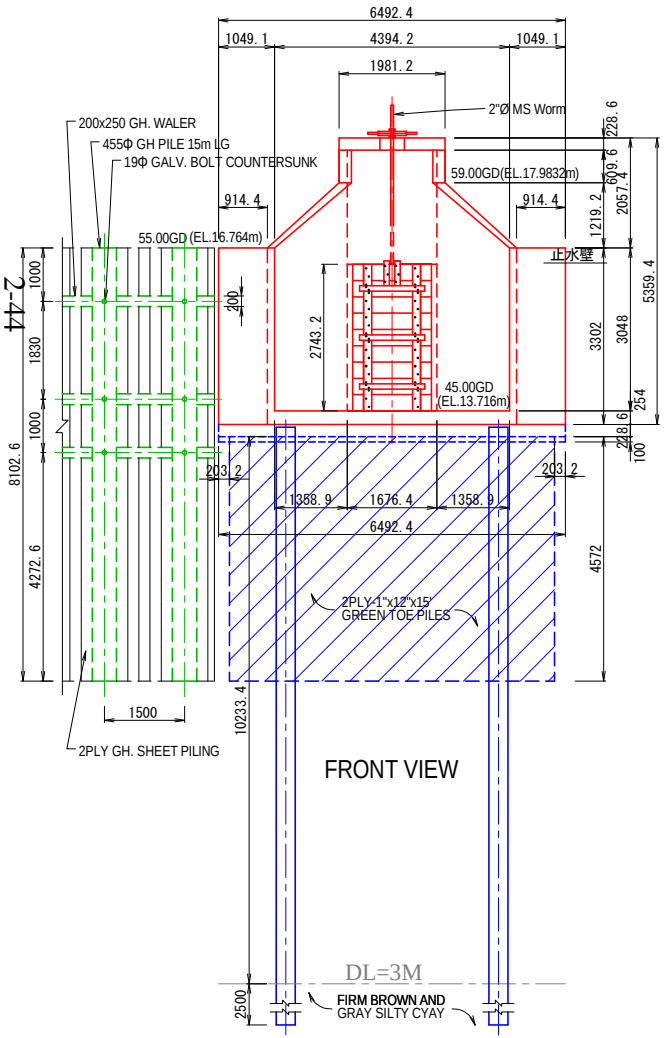

DETAIL
SCALE 1:40

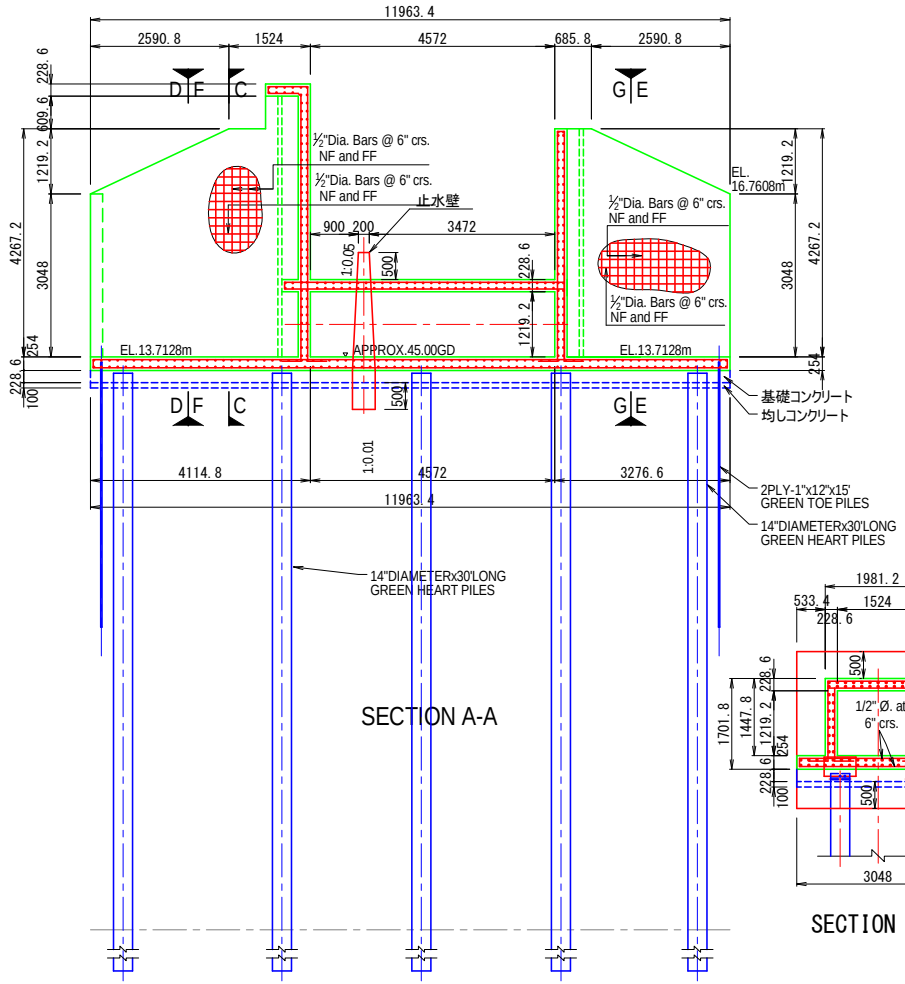

30 DIA.HOLES TO RECEIVE LINKS
350 DIA.X 365.5m G.H. PILE
4T20
6T16
3048
PILE CAP DETAIL
PILE CAP REINFORCEMENT DETAIL
PLAN PILE CAP


INLET
OUTLET
止水壁
2PLY-1"x12"x15' GREEN TOE PILES
14"DIAMETERx30'LONG GREEN HEART PILES
PLAN

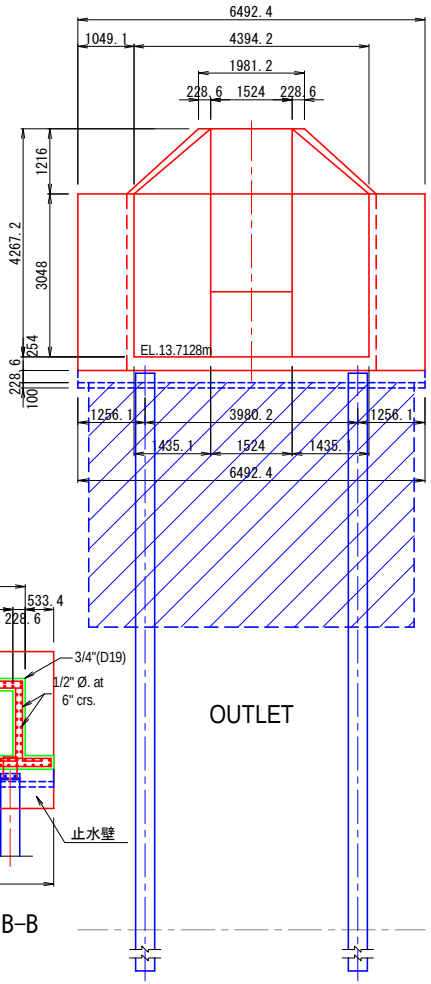

DETAIL
SCALE 1:40


SCALE 1:100


200x250 GH. WALER
455Φ GH PILE 15m LG
19Φ GALV. BOLT COUNTERSUNK
2"Ø MS Worm
59.00GD(EL.17.9832m)
55.00GD (EL.16.764m)
止水壁
45.00GD (EL.13.716m)
2PLY-1"x12"x15' GREEN TOE PILES
2PLY GH. SHEET PILING
DL=3M
FIRM BROWN AND GRAY SILTY CYAY
FRONT VIEW

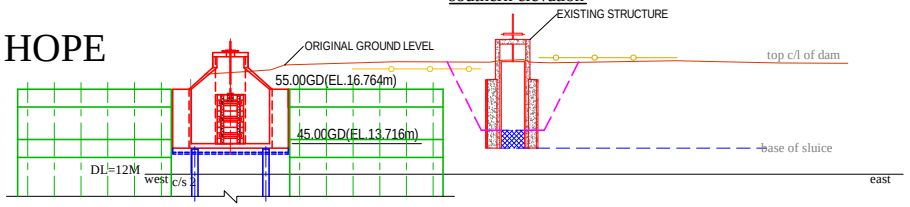

½"Dia. Bars @ 6" crs. NF and FF
止水壁
EL. 16.7608m
EL.13.7128m
APPROX.45.00GD
基礎コンクリート
均しコンクリート
2PLY-1"x12"x15' GREEN TOE PILES
14"DIAMETERx30'LONG GREEN HEART PILES
SECTION A-A

3/4"(D19)
1/2" Ø. at 6" crs.
止水壁
SECTION B-B

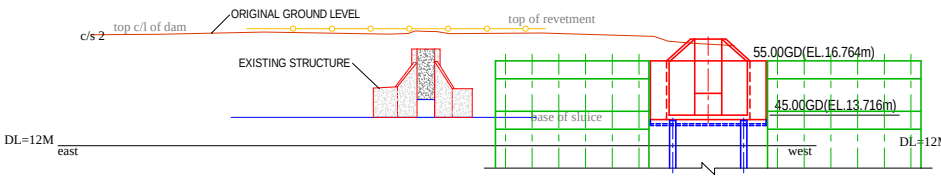

EL.13.7128m
OUTLET

HOPE

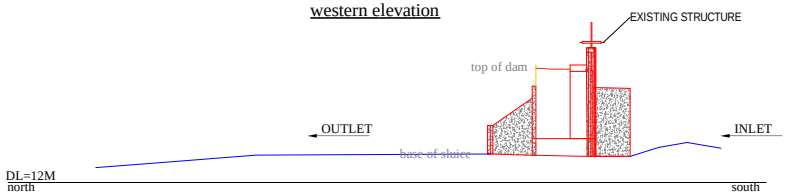
southern elevation



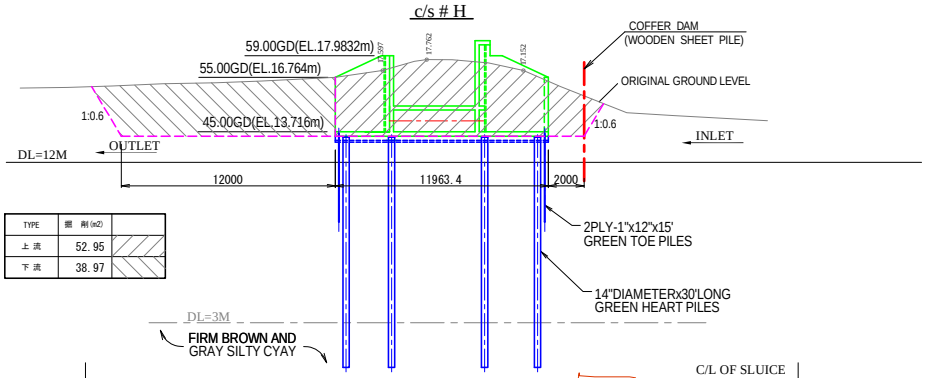
northern elevation



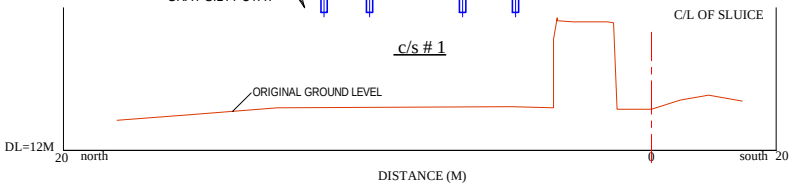
western elevation



c/s # H

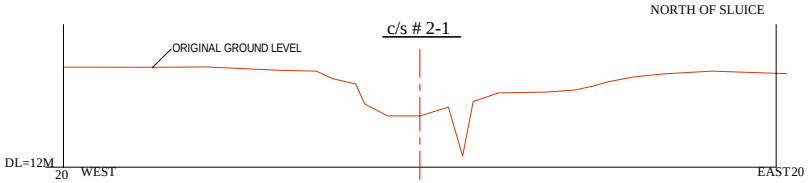


c/s # 1



DISTANCE (M)

c/s # 2-1



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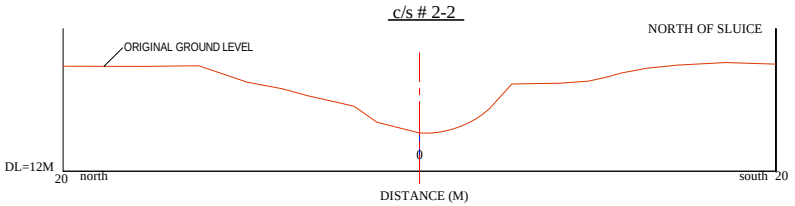
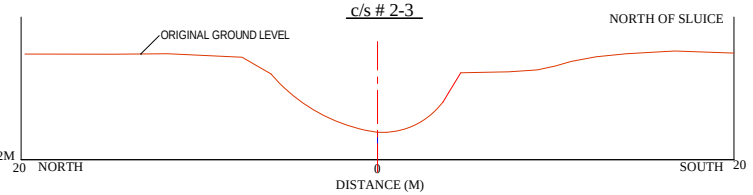


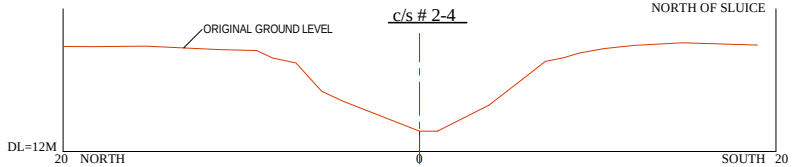
DISTANCE (M)

c/s # 2-3



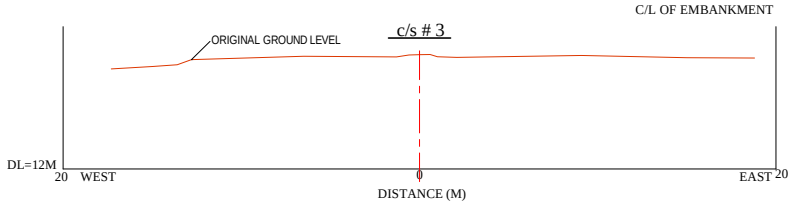
DISTANCE (M)

c/s # 2-4



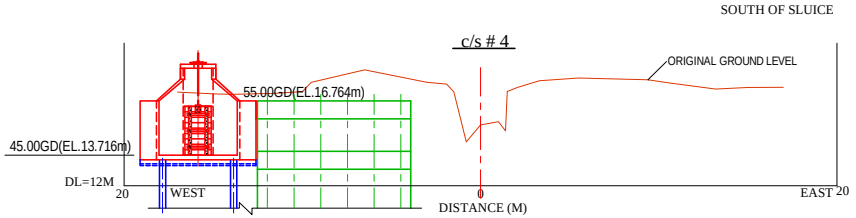
DISTANCE (M)

c/s # 3



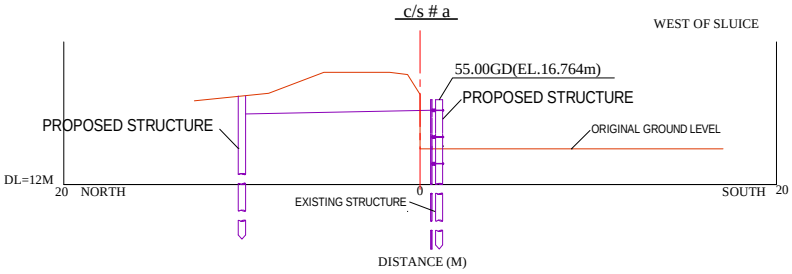
DISTANCE (M)

c/s # 4



DISTANCE (M)

c/s # a



DISTANCE (M)

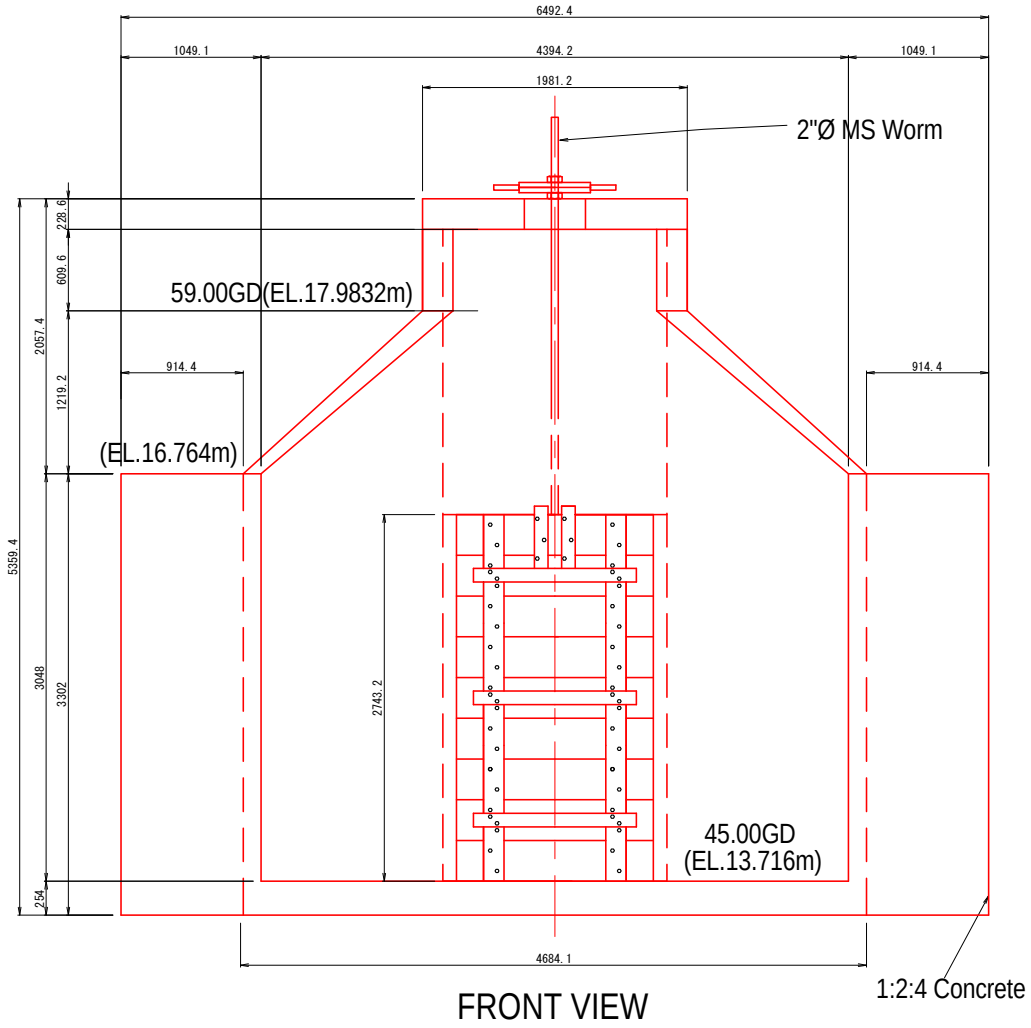
LEGEND

- NEW FILL ONLY
- EXCAVATE ONLY
- EXCAVATED AND BACKFILL

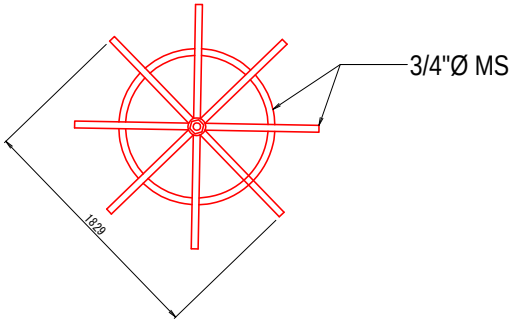
0 15m

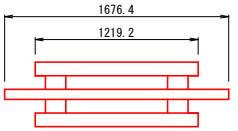
SCALE 1:300

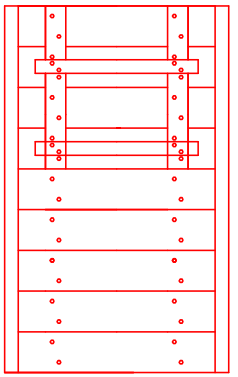
HOPE

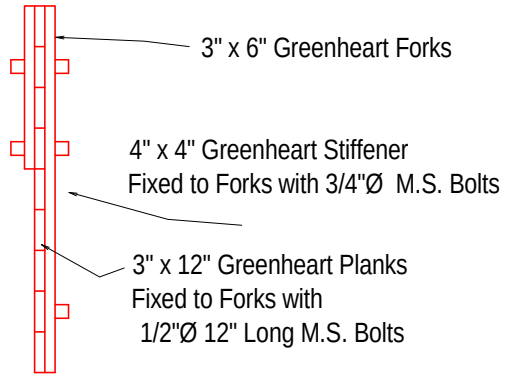


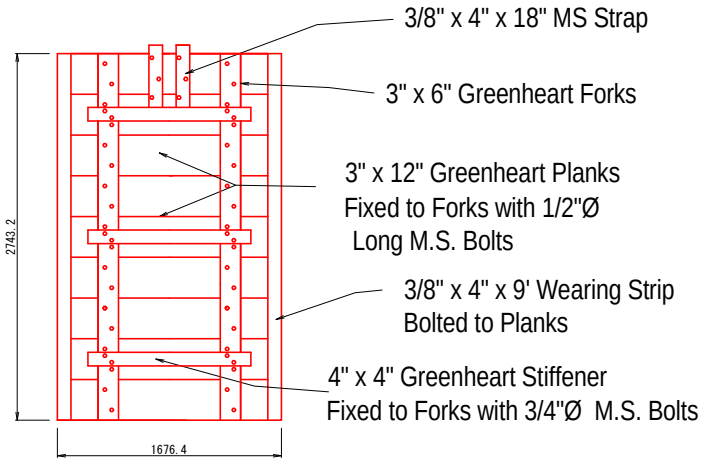
FRONT VIEW



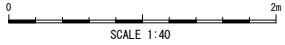




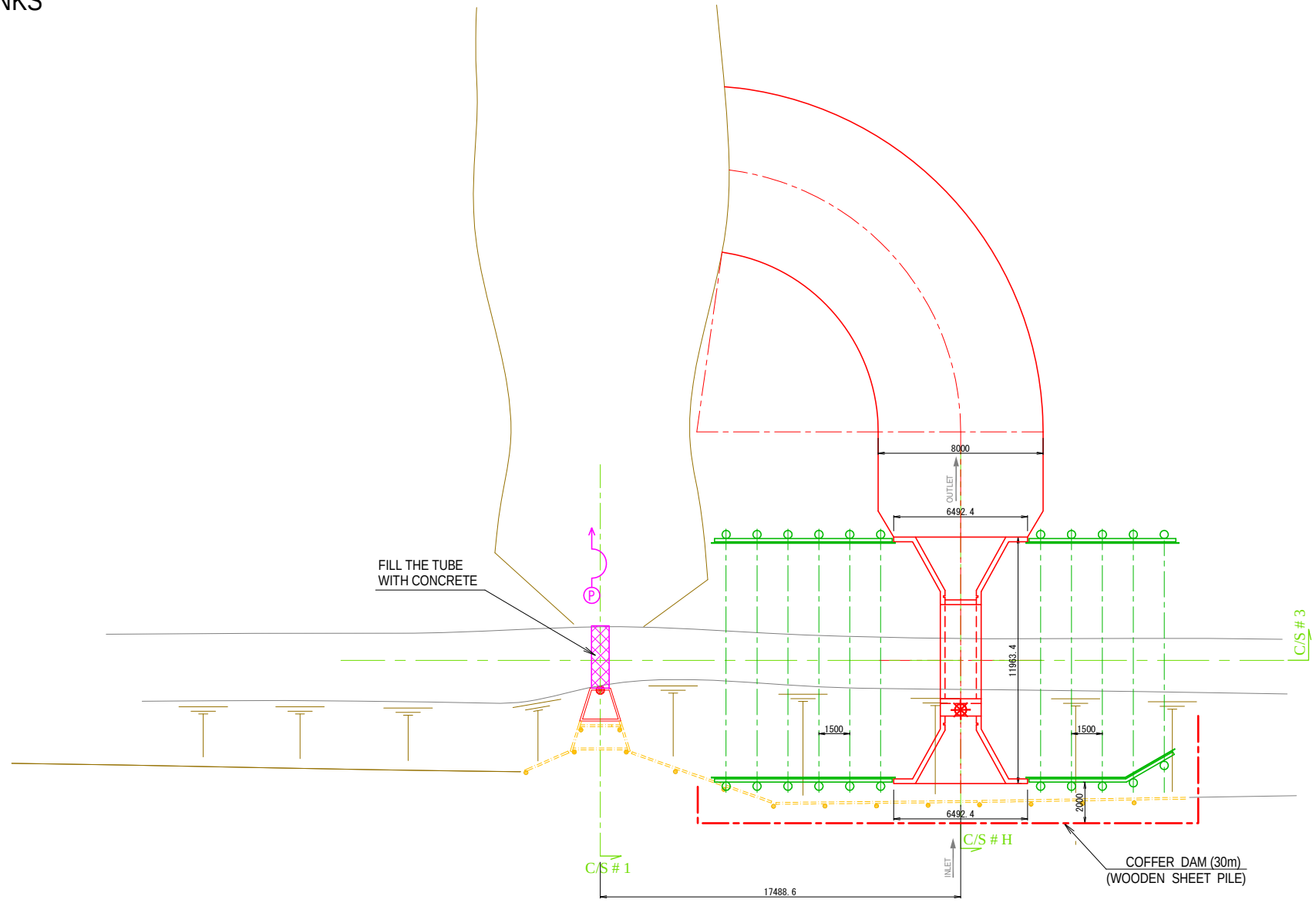




SLUICE DOOR

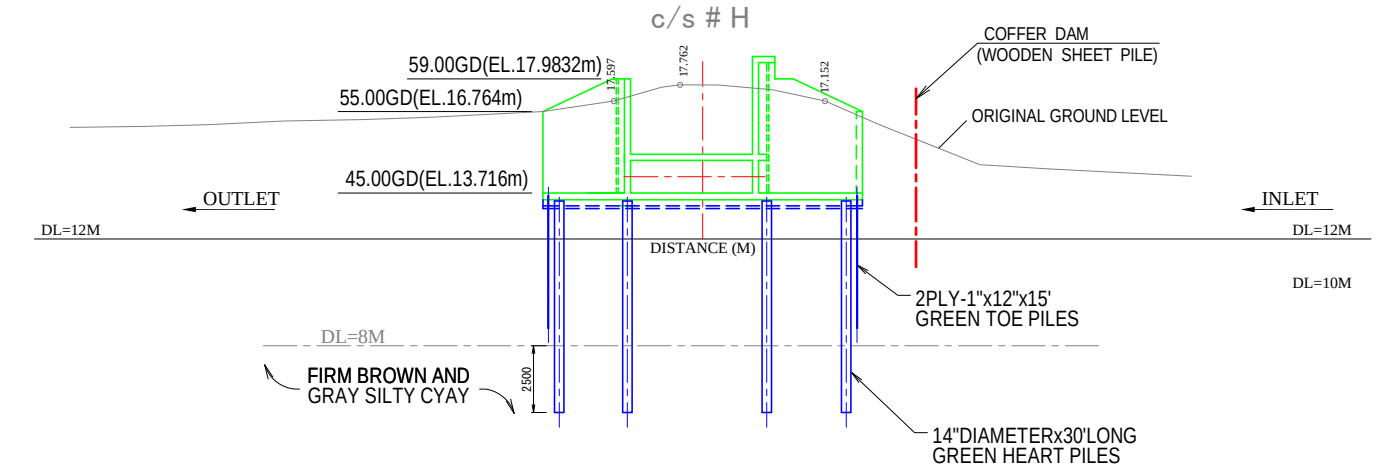


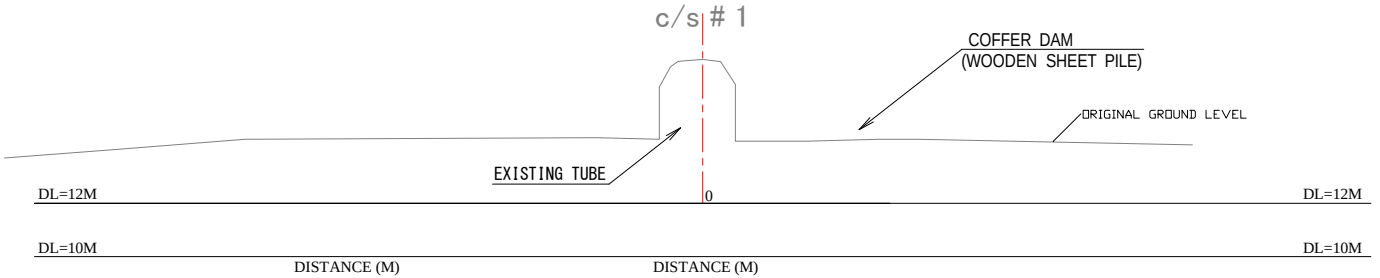
SHANKS

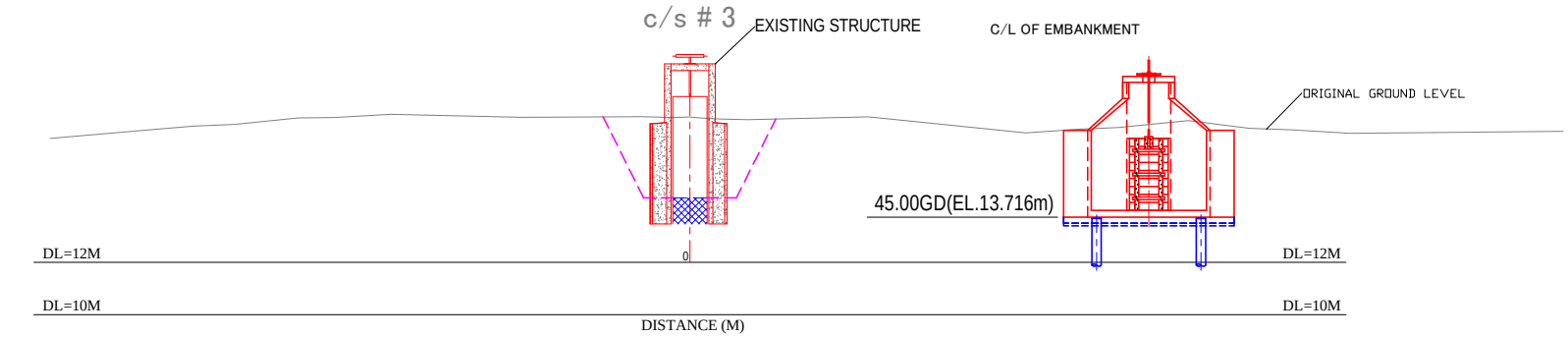


0 10m
SCALE 1:200

SHANKS

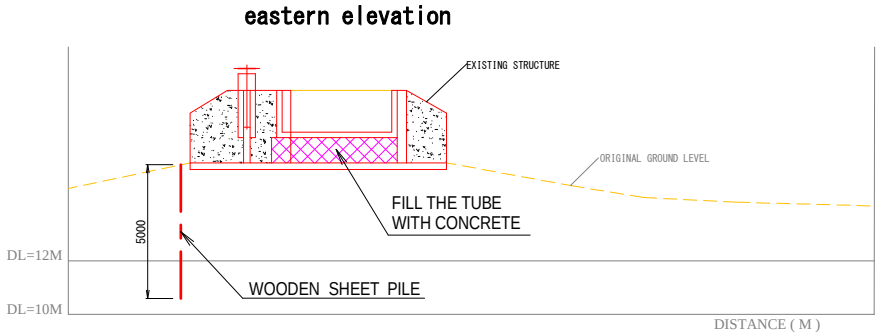






0 10m
SCALE 1:200

ANN'S GROVE



2-49

LEGEND

- DENOTES WOODEN REVETMENT
- DENOTES SPOT HEIGHTS (METER)
- DENOTES CONC. STRUCTURE
- NEW REVETMENT

0 10m

SCALE 1:200

NOTES:

ALL DIMENSION IN m EXCEPT AS OTHERWISE SHOWN

NO.	REVISIONS	DATE

end-user:
NATIONAL DRAINAGE & IRRIGATION AUTHORITY
MINISTRY OF AGRICULTURE
GOVERNMENT OF GUYANA
REGENT & VLISSENGEN ROADS
GEORGETOWN,GUYANA

employer:
The Crown Agents For Oversea And Administrations Ltd.
St Nicholas House, St Nicholas Road, Sutton, Surrey, SM11EL, United Kingdom.

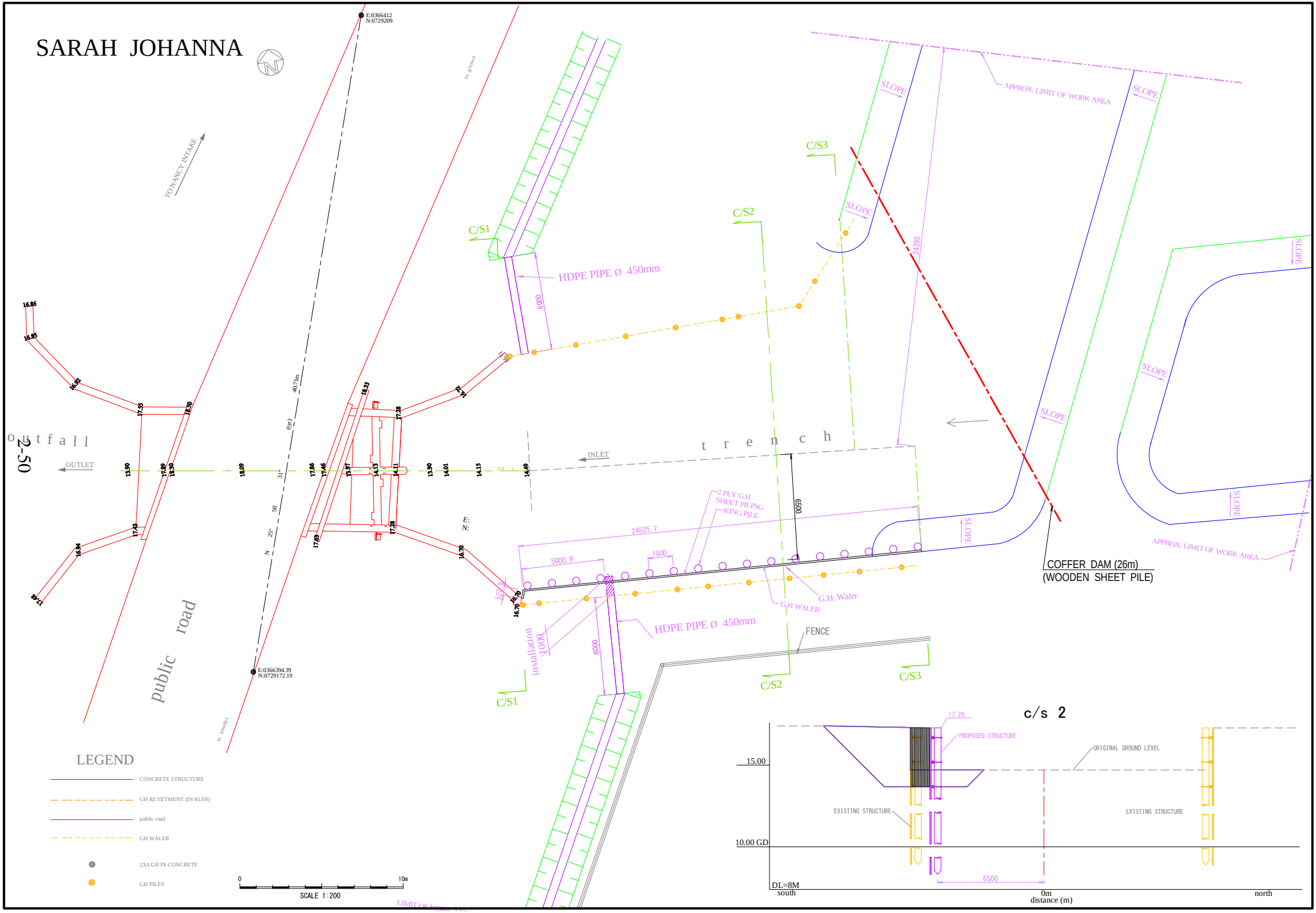
consultant:
Kensetsu Gijutsu Center ,Ltd.
4-7-10 Iidabashi, Chiyoda-Ku, Tokyo 102-0072 Japan.

project title:
EDWC INTAKE FACILITIES REHABILITATION SCHEME

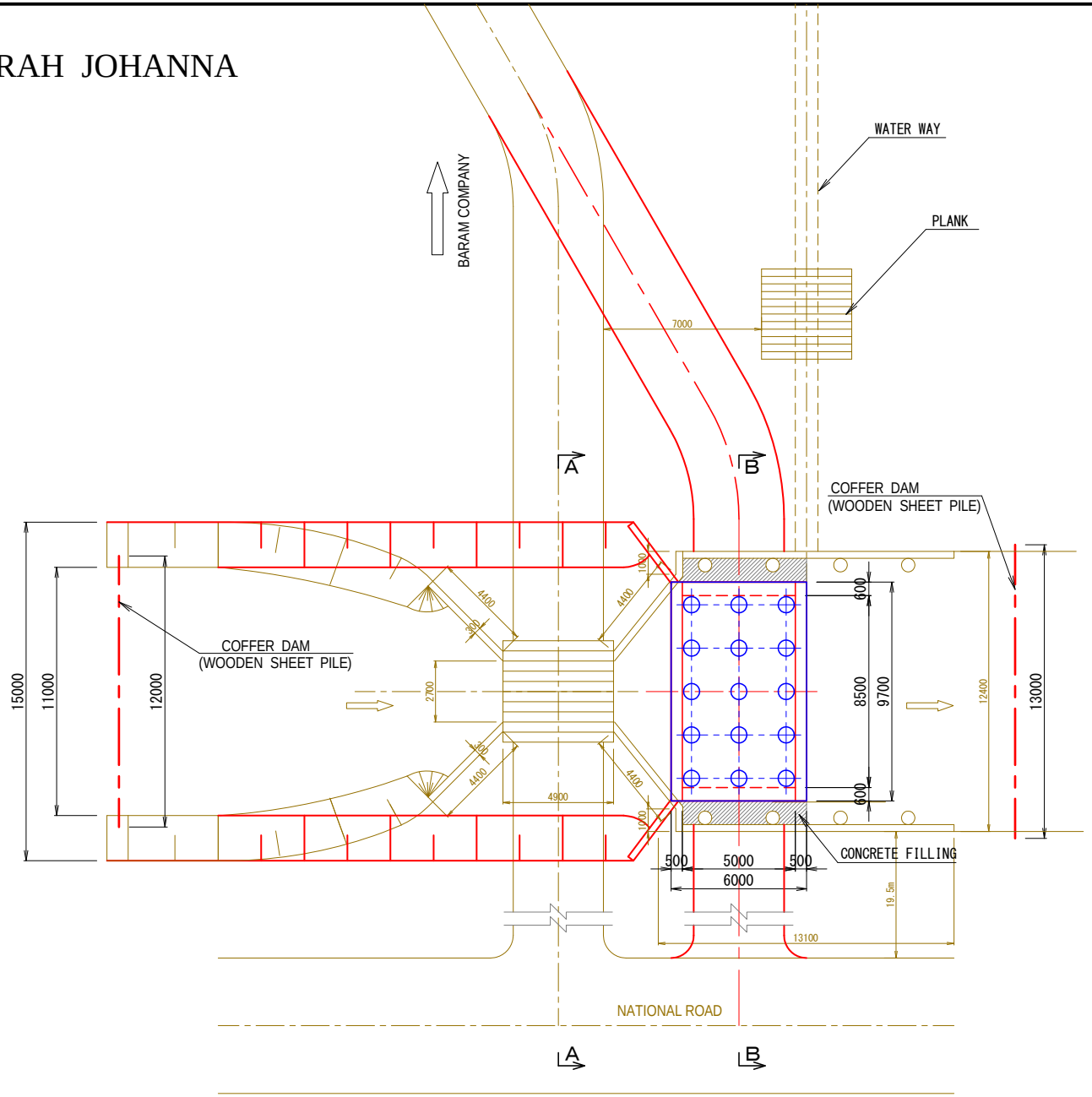
drawing title:
ANN'S GROVE EXISTING PLAN

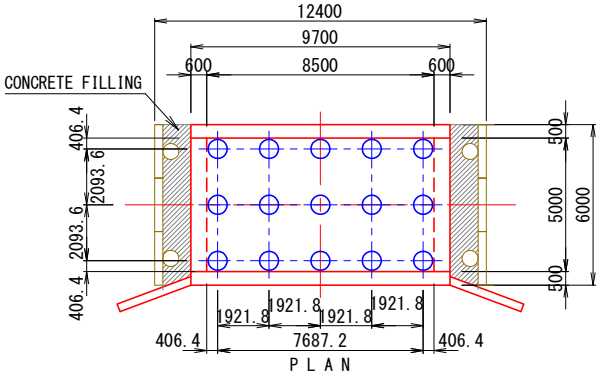
scale:	approved by:
AS SHOWN	
drawn: V.G	date: MARCH, 2012
project code:	drawing no. 1A/12

SARAH JOHANNA

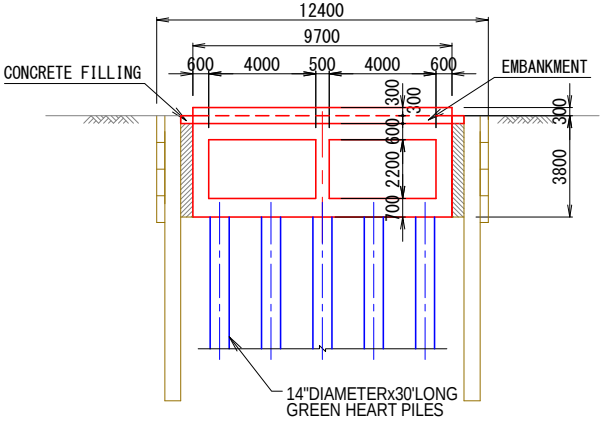


SARAH JOHANNA

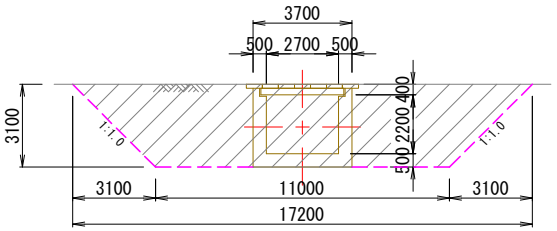




PLAN



SECTION B-B

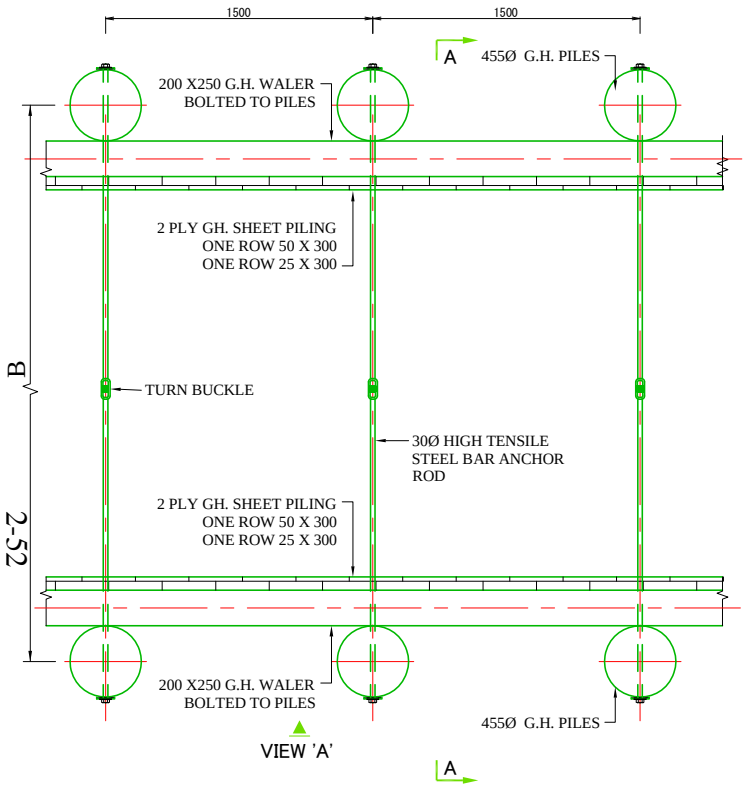


SECTION A-A

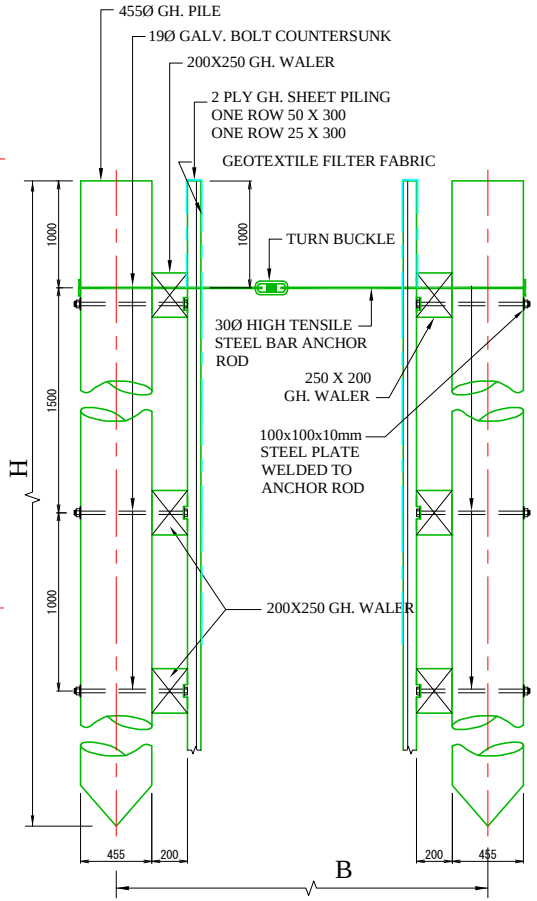
TYPE	AREA (m)	
EXCAVATION	43.71	
EMBANKMENT	-	

0 10m
SCALE 1:200

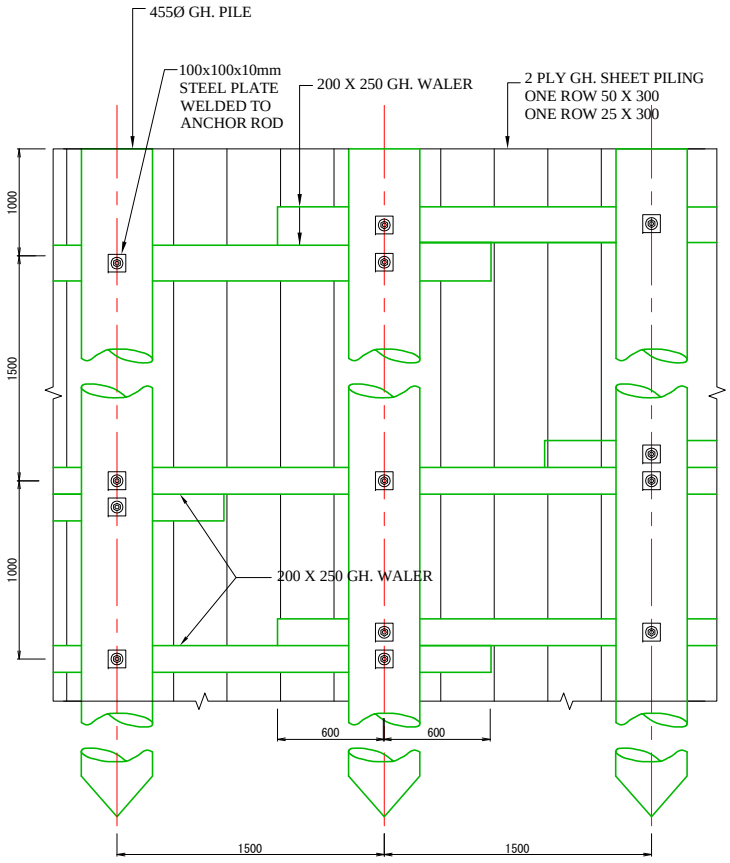
TYPICAL PLAN OF ANCHORED REVETMENT(1/2)



TYP. PLAN
SCALE. 1:25



SECTION A-A
SCALE. 1:25

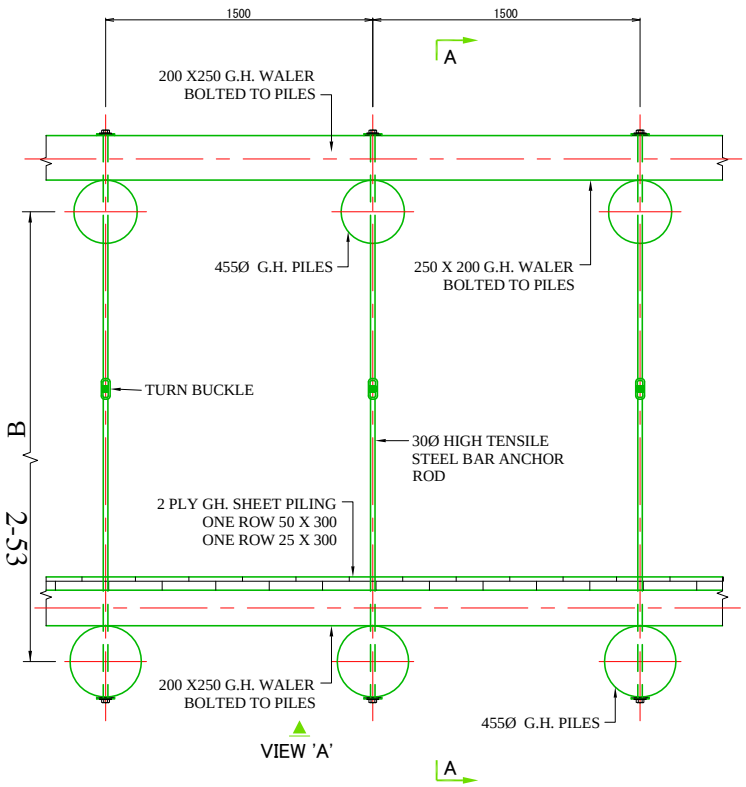


VIEW – 'A'
SCALE. 1:25

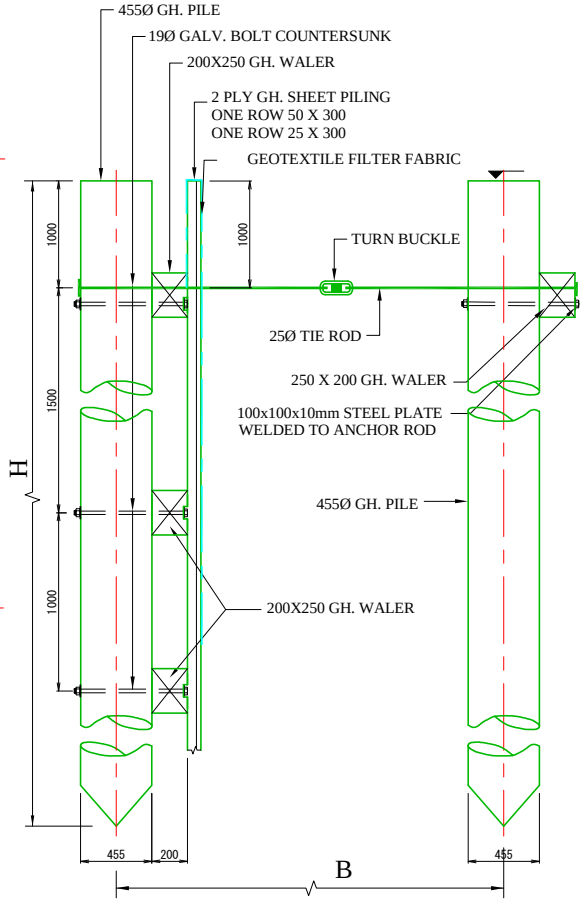
	B(m)	H(m)	
HOPE (LEFT)	12.5	15.0	
HOPE (RIGHT)	12.5	15.0	
SHANKS (RIGHT)	12.5	10.0	
SHANKS (LEFT)	12.5	10.0	

0 2m
SCALE 1:40

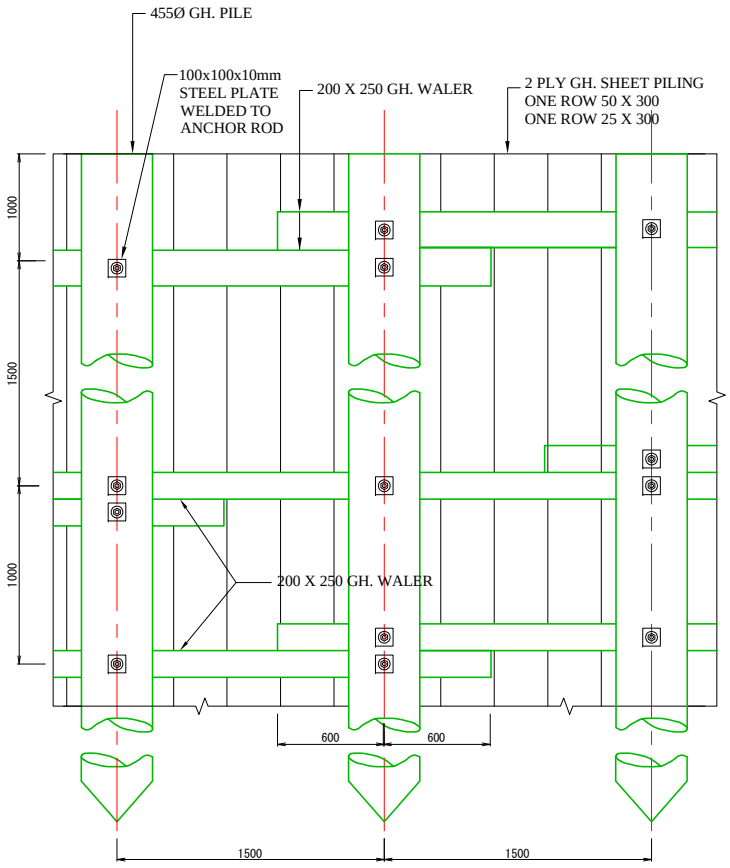
TYPICAL PLAN OF ANCHORED REVETMENT(2/2)



TYP. PLAN
SCALE. 1:25



SECTION A-A
SCALE. 1:25



VIEW – 'A'
SCALE. 1:25

	B(m)	H(m)	
MADUNI (LEFT)	8.0	6.0	
MADUNI (RIGHT)	8.0	6.0	
SARAH JOHANNA (LEFT)	0.0	10.0	
ANNANDALE (LEFT)	8.0	15.0	
ANNANDALE (RIGHT)	8.0	15.0	
NANCY (LEFT)	7.7	13.0	
NANCY (LEFT)	8.0	13.0	
NANCY (RIGHT)	8.0	13.0	

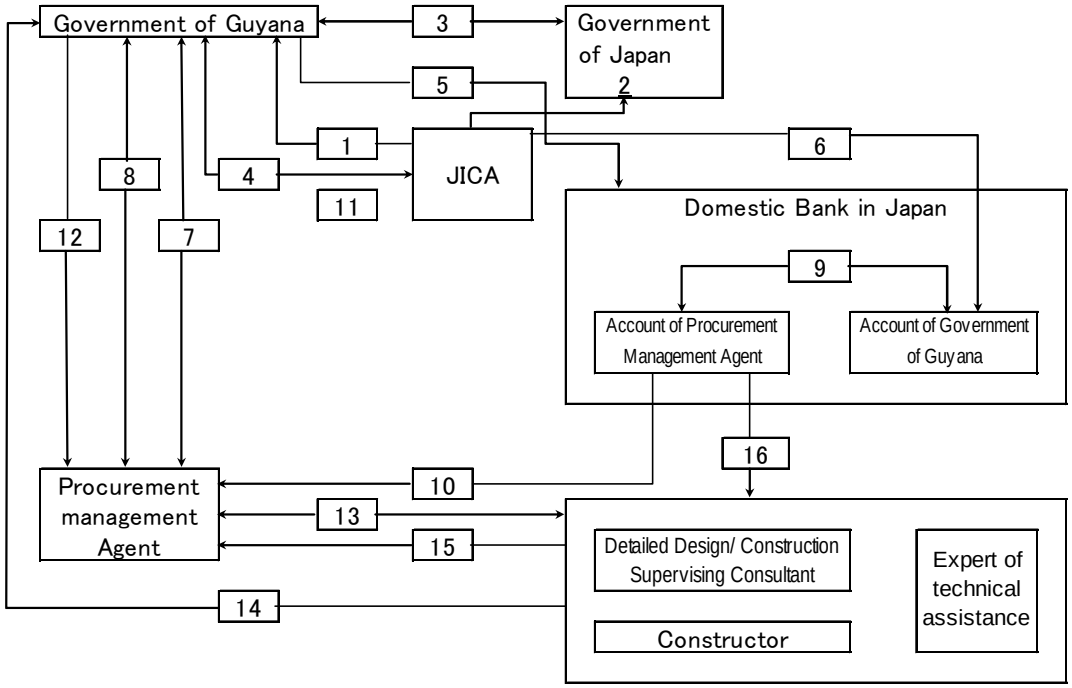
0 2m
SCALE 1:40

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

(1) Implementing system

Implementation flow of the project is shown in Fig. 2-2-1, and implementing system thereof is shown in Fig. 2-2-2.



1 Preparatory survey/ Provision of references on overall design
2 Decision making in ministerial council
3 Conclusion of E/N
4 Conclusion of G/A
5 Bank Agreement (B/A)
6 Payment of Assistance Fund
7 Conclusion of Procurement Management Contract (A/A)
8 Decision on the contents of procurement
9 Transfer of procurement fund (prepaid amount)
10 Payment of Agent Fee
11 Detailed Design/ Recommendation of Construction Supervising Consultant
(JICA→Government of Guyana)
12 Detailed Design/ Recommendation of Construction Supervising Consultant
(Government of Guyana→Procurement Management Agent)
13 Signing of Contract
14 Costruction of facilities, Procurement of materials/ Technical Assistance
15 Request of payment
16 Execurion of payment

Fig. 2-2-1 Flow of project implementation

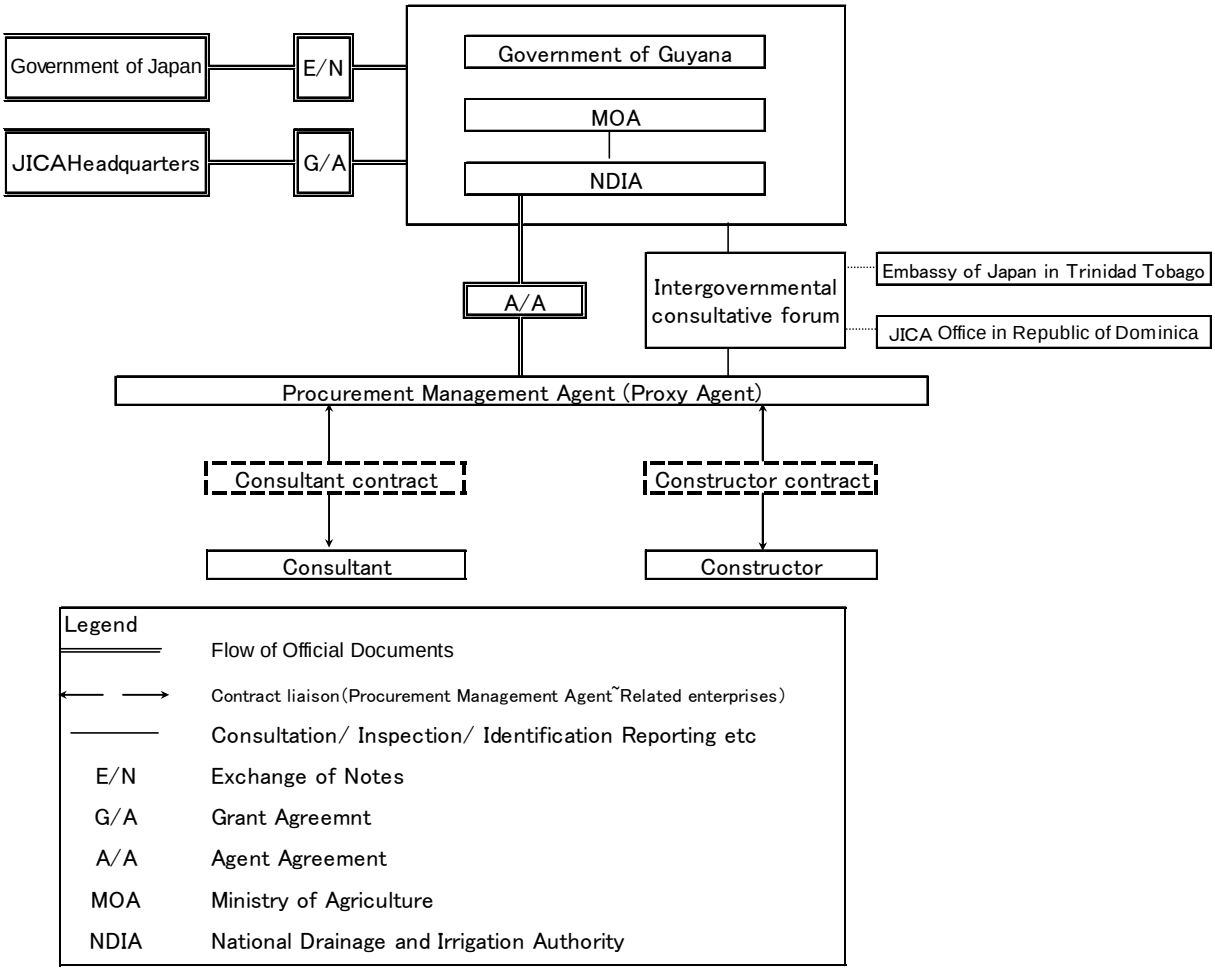


Fig. 2-2-2 Project implementing system

Contents of the obligation or role of the related organizations are as follows:

Organization	Contents of the obligation or role
NDIA	Implementation of the items to be bone by Guyana side
Procurement Management Agent	Contract with consultant, Provision of tender document, Procedure of contractor selection, Contract with contractor, Supervision of project implementation, Intermediate and completion inspection of the project, Fund management and payment service
Consultant	Collation of the tender document, Provision of reference materials to produce the tender document, Supervision of the rehabilitation works to appurtenant facilities, Technical support to the procurement agent on the implementation of soft components
Contractor	Execution of rehabilitation works to appurtenant facilities

(a) Project executing body

NDIA is responsible for the management, operation and maintenance of the related facilities as the executing organization of Guyana side on the implementation of this project. As regards the

process of grant aid program, after the Government of Guyana and the Government of Japan conclude the Exchange of Notes (E/N) on the implementation of the project and arrange international agreement between both sides, the Government of Guyana and JICA who is responsible for supervision of the project implementation conclude grant agreement (G/A) between both sides. For the subject grant aid project, however, E/N and G/A have been duly signed and procurement agent has been appointed with due agreement, therefore, the actions shall be commenced from recommendation of consultant for detailed design and construction supervision. After this, Consultative Committee is to be formed, consisting of government organizations representing both sides in order to perform various adjustments on the contents of assistance to be implemented under this framework and those of the implementing stage. Members of the Consultative Committee are composed of the following:

- NDIA
- Procurement agent
- JICA（Office of permanent representatives in Republic of Dominica）

(b) Procurement Management Agency

Procurement managing agent system is adopted in this project. In this system, "Procurement Management Agent" is to perform procurement of materials and services, and fund management on behalf of government of Guyana. The Procurement Management Agent concludes an agreement on agent procurement (A/A) with Government of Guyana and performs contract with consultant, provision of tender document, procedure of selecting constructor, contract with constructor, supervision of project implementation, intermediate and completion inspection of the project, fund management and payment service etc as an depute agent of Government of Guyana.

(c) Consultant

After concluding the agreement on agent procurement, the procurement management agent makes a contract with Japanese consultant on the implementation of this project. The Consultant provides the final design of this project, as well provides technical assistance to the Procurement Management Agent on the provision of tender document (draft), tender, supervision of the construction work etc, as well on supervision of quality/ implementation, inspection/ operation and maintenance in terms of soft component, which includes preparation of water level control plan for EDWC operation during flood period .

(d) Contractor

The procurement management agent concludes a contract on the rehabilitation work of appurtenant facilities with the contractor who has cleared the examination on the items required for implementing the construction and construction cost estimation and selected as the bid winner. The contractor performs delivery of the construction materials required by the Procurement Management Agent and implements the rehabilitation work of appurtenant facilities within the construction period indicated in the contract.

(2) Implementation Policy

(a) Concrete structures of intake facilities

After the excavating the dam body, the intake facilities are constructed by in-situ concrete. Because the foundation is too soft to install the concrete structures directly, they shall be supported their own loads by pile foundation. The construction works are executed in the following procedure.

(i) Cofferdam work, a portion of revetment work

(ii) Excavation work of intake

(iii) pile foundation work (piles pouring around revetment work are also carried out at the same time)

(iv) Base slab concrete work (with the pile head connection)

(v) conduit portion and retaining wall, concrete placement at wing wall

(vi) Gate installation

(vii) Backfilling work

The construction works is desirable to complete within one dry season. Since one dry season is only about three months, the cofferdam and revetment works, which can be constructed during the rainy season, shall be preceding.

As the water in the reservoir is a strong acid, it is required to secure a sufficient reinforcement covering depth in a corrosive environment. Therefore, the covering is required at minimum 50mm. During construction, this shall be strictly supervised.

(b) Slope protection work

Slope protection work is adopted for the revetment work with the wooden pile and sheet pile. The method was decided in consideration of the situation of Guyana and EDWC as shown the follows.

(i) The pH value of the existing soil at excavation shows the high acidity from 3 to 4.

(ii) Wooden material has a strength roughly equivalent to a hard steel and has excellent acid resistance. It has compressive strength of 220 kgf/cm^2, bending strength of 220 kgf/cm^2 , shear strength of 25 kgf/cm^2 and belongs to 70D of the hard wood type of material strength (see Table 2-2-5). In durable, the current acidic substances are the same component generated from the wood material. The material is strong from corrosion and erosion.

(iii) The weight of construction machine utilized is 1.2 ~2.0 tf/m^2 and the current bearing capacity of foundation around the dam body is Qa = 0.5 ~1.0 tf/m^2. In comparison of both ones, the bearing capacity is smaller than the machine weight. Therefore, to use of wood is suitable in consideration of transportation and workability.

(iv) Wooden pile, sheet pile and pillar etc. are available to procure and distribute in Guyana. The materials which are appropriate with the standard of BS and/or ASTM shall be used

actively.

(v) The wooden revetment work has many results in EDWC.

(c) Procurement of materials

Required materials include cement, sand, aggregates, reinforcement and timber for erection fixtures including log, steel, and all these are in principle sold in Georgetown. Procurement/ purchase of materials including procurement from third country is made by the contractor who submits information/ data related to their standard/quality to the Consultant and after it obtains approval thereof, then procures them on its own responsibility. Each of above-listed materials and their quality standard is summarized below.

In addition, for ensuring quality of concrete, water with mixing cement shall be utilized with good quality in civil works. Water from EDWC shall not be used because of a high acidity value of pH 4-5.

Table 2-2-4 List of procuring materials

Material	Standard	Quality certificate
Cement	Normal Portland cement	BS or ASTM
Sand	Natural sand	BS or ASTM
Coarse aggregates	Maximum particular diameter 20mm	BS or ASTM
Steel bar, bolt etc		BS or ASTM
Timber for wooden gate	Strength class ; A*	Guyana Forestry Department

(d) Wooden materials for revetment work

Wood belongs to the camphor tree family, scientific name is Ocota Rodiaei, shall be used for revetment work. The core portion and/or the raw wood shall be utilized. Processing wood is treated in the general goods as Green Heart, and is sold worldwide as structural wood as D70 hard wood. It is used in EU countries, in the United States as processing material.

Table 2-2-5 Property and Strength of Greenheart

Table 8 — Grade stresses and moduli of elasticity for various strength classes: for service classes 1 and 2

Strength class	Bending parallel to grain	Tension parallel to grain	Compression parallel to grain	Compression perpendicular to grain [a]		Shear parallel to grain	Modulus of elasticity		Characteristic density, ρ_k [b]	Average density, ρ_{mean} [b]
							Mean	Minimum		
	N/mm²	N/mm²	N/mm²	N/mm²		N/mm²	N/mm²	N/mm²	kg/m³	kg/m³
C14	4.1	2.5	5.2	2.1	1.6	0.60	6 800	4 600	290	350
C16	5.3	3.2	6.8	2.2	1.7	0.67	8 800	5 800	310	370
C18	5.8	3.5	7.1	2.2	1.7	0.67	9 100	6 000	320	380
C22	6.8	4.1	7.5	2.3	1.7	0.71	9 700	6 500	340	410
C24	7.5	4.5	7.9	2.4	1.9	0.71	10 800	7 200	350	420
C27	10.0	6.0	8.2	2.5	2.0	1.10	12 300	8 200	370	450
C30	11.0	6.6	8.6	2.7	2.2	1.20	12 300	8 200	380	460
C35	12.0	7.2	8.7	2.9	2.4	1.30	13 400	9 000	400	480
C40	13.0	7.8	8.7	3.0	2.6	1.40	14 500	10 000	420	500
D30	9.0	5.4	8.1	2.8	2.2	1.40	9 500	6 000	530	640
D35	11.0	6.6	8.6	3.4	2.6	1.70	10 000	6 500	560	670
D40	12.5	7.5	12.6	3.9	3.0	2.00	10 800	7 500	590	700
D50	16.0	9.6	15.2	4.5	3.5	2.20	15 000	12 600	650	780
D60	18.0	10.8	18.0	5.2	4.0	2.40	18 500	15 600	700	840
D70	23.0	13.8	23.0	6.0	4.6	2.60	21 000	18 000	900	1 080

NOTE Strength classes C14 to C40 are for softwoods and D30 to D70 are for hardwoods.

[a] When the specification specifically prohibits wane at bearing areas, the higher values of compression perpendicular to grain stress may be used, otherwise the lower values apply.

[b] The values of characteristic density given above are for use when designing joints. For the calculation of dead load, the average density should be used.

quote from BS5268-2:2002

Table 2-2-6 Standard of timber by Guyana Forest Department

BASIC PROPERTIES OF THIRTY SELECTED SPECIES

No.	Species	Strength Group	Durability Class	Air Dry Density Class lbs/cu. ft.
1	Aromata	B	1	65
2	Baromalli	C	2	35
3	Cedar, White	C	2A	35
4	Crabwood	C	1	35
5	Duka	D	2	30
6	Dukali	D	2	30
7	Fukadi	C	2A	45
8	Futui	D	2	30
9	Greenheart	A*	1A**	65 → 1.04tf / m³
10	Haiariballi	D	2	35
11	Hububalii	D	1A	40
12	Kabukalli	B	1	50
13	Kakaralli, Black	A	1A**	70
14	Kirikaua	D	2	35
15	Kurokai	D	2A	35
16	Locust	B	1	55
17	Manni	C	1	45
18	Manniballi	B	1	55
19	Maporokon	D	2	35
20	Mora	A	1A	65
21	Morabukea	A	1A	65
22	Purpleheart	A	1	60
23	Shibadan	B	1	40
24	Silverballi group	D	1	40
25	Simarupa	D	2	30
26	Suya	D	2	35
27	Tatabu	B	1	65
28	Tauroniro	B	1A	55
29	Wallaba	B	1A	60
30	Wamara	A	1A	75

* *See also special design stresses for greenheart*

** *Highly resistant to marine borer attack.*

Quoted from;
「The Guyana Grading Rules for Hardwood Timber」
Forest Department,
Georgetown, Guyana.
September 1974

2-2-4-2 Implementation Conditions

(1) Tax exemption

Materials to be procured for using appurtenant facilities rehabilitation work is procured by purchasing imported manufactured goods marketed in Guyana. Because no case of ordering materials to manufacturers abroad arises after the contract, no procedure needs tax exemption measures.

(2) Transport

Materials to be procured for using appurtenant facilities rehabilitation work is procured in Guyana. Accordingly, no cost of custom clearance etc occurs.

2-2-4-3 Scope of Works

(1) Measures taken by Japan and Guyana

Division in terms of responsibility for construction work under this project is as follows:

- Measures taken by Japanese side; Appurtenant facilities rehabilitation work, assistance for bidding and supervision of the construction work
- Measures taken by Guyana side; None

(2) Division of the work/allotment

Appurtenant facilities rehabilitation work by this project is composed of 7 sites/ case, in terms of sites and contents of the work, each of them can be completed in a comparatively short period. By this reason, if the work in all the sites can simultaneously be implemented, it is possible to complete the entire work in a short period / single year.

In this project, all the construction works shall be a bulk order in the following reasons.

The advantages are:

(i) Since construction machinery at each site can be in common use, it is possible to reduce the construction cost and it is easy to deal with situations such as the delay.

(ii) It is easy to keep the work quality with a constant level.

The demerits are:

(i) The amount of performance bond is large.

(ii) The small scale of companies is difficult to participate. But in the case of joint venture, it is possible to participate.

In this project, a bulk order has advantages that the construction is to be completed in the dry season limited together with good work quality.

2-2-4-4 Consultant Supervision

(1) Basic policy of supervision plan

Work supervision of this project is performed by Procurement Management Agent that is the partner of the contract with the government agency of Guyana and also by work supervising consultant that concluded the subcontract of work supervision with Procurement Management Agent.

In performing appurtenant facilities rehabilitation work, an implementing system where staffs with ample experiences on final design and work supervision are placed paying particular attention to the following items:

- To observe the contents of Exchange Notes (E/N) and Grant Agreement (G/A) concluded between the Government of Guyana and the Government of Japan/ JICA
- To be well acquainted with the system of grant aid project
- To understand the contents of project implementation study report, and in the implementation stage, to be able to instruct rapid work implementation based on design documents

(2) Contents of the services

(a) Services of detailed design

- Fund management
- Preparation of tender documents, delivery of design drawings
- Tender
- Tender evaluation
- Facilitation of signing of contract with contractors

(b) Services of construction supervision

- Inspection of shop drawings
- Prior quality inspection of materials
- Inspection in quality/ work supervision at the appurtenant facilities
- Inspection of the earned value and completion
- Identification of delivery
- Work schedule management / fund management

In this context, role of the procurement management agent and that of the consultant is defined as follows:

[Procurement Management Agent]

The procurement management agent concludes an agent-contract with NDIA, the executing agency based on G/A. The contents of the services are as in the following:

Table 2-2-7 Contents of the services of the procurement management agent

Item	Contents
Tender management service	General (prime) consultant contract Preparation of tender documents Execution of bid Tender evaluation Contract with a contractor
Work supervising service	Fund / management Design modification, Quality control, Inspection on the defects of work
Advocate selecting service	

[Work supervising consultant]

Work supervising consultant concludes an agent-contract on work supervising with the procurement management agent based on G/A. The contents of the work are shown in the following:

Table 2-2-8 Contents of the services of the work supervising consultant

Item	Contents
Tender assisting service	Assistance for tender by the procurement management agent Assistance fro preparing tender documents Aid of the evaluation after opening tender
Construction supervising service	Supervision over quality and progress of work and safety in construction work Progress control of the work and design alteration documents

(3) Supervisor Assignment plan

- The consultant dispatches technical (construction) managing staff to supervise appurtenant facilities rehabilitation work.
- The procurement management agent dispatches staff in charge of work supervision to the sites to supervise appurtenant facilities rehabilitation work. Also, it controls and supervises on fund operation and management, design alteration and the defects of the work. The agent/ organization responsible for guaranteeing defects is registered in contract documents. Also, it dispatches a superintending person to the sites in order to completion/ delivery and completion inspection of the work
- Superintending and vice-superintending persons perform services on controlling progress of the work and fund management. It dispatches vice-superintending person on the occasion of the completion of the work and that of appurtenant rehabilitation work. Also, it stations a clerk at the sites. The clerk aids the services of the procurement management agent on the appurtenant facilities rehabilitation work
- In selecting these supervising staffs, the related agent and consultant make it a premise to select those who have ample experiences on these services, adequate technical judgment and competence of adjustment/ coordination.

2-2-4-5 Quality Control Plan

Quality control in the appurtenant facilities rehabilitation work is planned as follows:

Table 2-2-9 Quality Control Plan of the Appurtenant Facilities Rehabilitation work

Item	Test/ check/ contents of the test	Testing period	Testing frequency
Concrete materials ・Cement ・Sand ・Coarse aggregates ・Kneading water ・Steel bar	 Identification of testing result table by the manufacturer Water absorbing rate, particle size, amount of clay clod Water absorbing rate, particle size, amount of clay clod Hydrogen ion concentration (pH) Identification of testing result table by the manufacturer, or result of actually performed test (identification of whether matching with BS, ASTM standard or not)	 Prior to the work Prior to the work Prior to the work Prior to the work Prior to the work Prior to the work	
Kneaded concrete ・State ・Strength	 Water-cement ratio, Slump Unconfined compression strength (7day/28day strength)	 During the work At the beginning	 Once/ work day
At the casting of concrete ・Steel bar ・Casting ・Curing	 Check on concrete cover and interval of reinforcement Check of the state of compaction Check of the state of curing application	 During the work During the work During the work	 Once/work day Twice / construction Twice / construction
After the finish of concrete work	State of finish/ inspection on the structural dimensions	After finishing	
Wood (material testing) raw wood (wood pile)	Confirmation of the Guyana Forestry Department standard pass certificate if necessary, Moisture test, bending test, modulus of elasticity, compression test, breaking strength test	At the beginning During the work	Prior to the work
Wood (daily management test) , raw wood	tension test, bending test, breaking strength test	End of each moth	Each place of production
Wood (material testing) Processed product (pillar-plate)	Confirmation of the Guyana Forestry Department standard pass certificate if necessary, Moisture test, bending test, modulus of elasticity, compression test, breaking strength test	At the beginning During the work	Prior to the work
Wood (daily management test) processed products	tension test, bending test, breaking strength test	End of each moth	Each place of production
Tightening test of tie rod bolts and nuts	Tightening test of tie rod bolts and nuts	Prior to the work	
Trial test of the wood pile	pile driving test	Prior to the work	Each site
Standard soil test	1lot of standard soil test	Prior to the work	Each job site
Standard soil test (Daily maintenance of embankment)	Compliant with standard method in Guyana	Work day	Each work day
Paints and preservative	Confirmation of the certificate of product	Prior to the work	Each item

Note) As to the quality control test to the concrete and the related matter, “Standard prescription of Concrete, Construction Part (2007)” was referred to.

For other materials, standard test items of each product are carried in advance, and are reported

to the supervisor of the consultant. Quality control tests listed above, it is an item which is conventional in Guyana, there is no problem in the practice through local technicians.

For daily management for the embankment, it is recommended that the same management approach has been carried out the rehabilitation works for EDWC.

2-2-4-6 Procurement Plan

(1) Expected supplier

(a) Materials

- To procure locally available product as far as possible.
- In the cases that imported goods are permanently marketed in the markets of Guyana, to procure these goods.
- As for materials for which local procurement is difficult, to procure them either from Japan or from the third countries.
- As regards anti-rust and anti-septic agents, to procure goods with past utilization results in Guyana are procured.
- To manufacture gates of outlet facilities/ those of intake facilities in factories, and to install them after carrying them into the sites.
- After installing the gates of outlet facilities/ those of intake facilities, to try testing operations 100 times consecutively in order to confirm no abnormality.
- As to the gates of outlet facilities/ those of intake facilities, to procure equipment/ materials for operation and maintenance simultaneously with gates.

Table 2-2-10 Material procurement plan

Name of material	Local	Japan	Remarks
Cement	○		Imported goods
Concrete aggregates	○		
Steel bar / steel material	○		Imported goods
Wood (for wooden pile, sheet pile, board)	○		
Paint	○		Imported goods
Drainage pipe	○		

(b) Construction machinery

There are a few constructors in Guyana with experiences of being engaged in the construction/ repair work of dams including East Demerara Water Conservancy by receiving order from NDIA. These constructors own such construction machines as excavators, bulldozers, cranes etc. Also, they are in a position to lease ultra-long arm excavators. As for ships and tug boats, large-scaled constructors own these vessels of their own. Information has been obtained from a hearing that there are two companies offering lease service of tug-boats.

Table 2-2-11 Interview summary on procurement of special construction equipment

Items	Situations
Low-bed trailer	Rental services by several companies are available. Large scale constructors have their own equipment. The wooden bridge at the entrance gate to the Flagstaff office can stand the load of the trailer with a heavy construction equipment such as the shovel dozer.
Tug-boat	2 Chinese companies operate rental service of tug-boat. Usual boats, not so small, can work as a tug-boat. Such boats consumes as much of gasoline costing 12,000 G$ for 4 ~ 5 hours operation. Traveling by the long-boom excavator's scratch on the canal bottom is the most efficient and economical way.
Pontoon	2 ~ 3 rental services are available. Large scale contractors possess pontoons of their own.
Pile Hammer Driver	Several companies are available for rental service. Large companies have their own. Fuel consumption is 10 galon/5 piles driving.
Long-boom excavator	Several companies are available for rental service. Large companies have their own. Rental cost: 12,000 G$/hour

Table 2-2-12 Inventory survey on the constructors owing machinery/ equipment

Company / Equipment	Khan's Construction & Transportation Sevice	K International Inc	D. Samaroo Investment Inc.
Excavator	4	15	5
Skid Steer	1	10	
Bull Dozer	1	7	4
Dump Truck	2	25	3
Back Hoe	5	7	
Crane		5	
Drag Line	1	6	2
Front End loader		6	
Motor Grader	1	3	
Asphalt Paver		3	
Pneumatic Roller	1	6	
Static Roller	1	6	
Mechanical Concrete Mixer	2		
Concrete Mixer Truck		7	
Concrete Batching Plant		1	
Water Truck	1	10	
Tractor		5	
Pontoon		13	
Tug Boat		10	
Ship		4	
Pile Driving Rig		1	

(2) Transportation route

As to carriage of materials and machinery to the sites, they are to be carried as far as Flagstaff by land then they are carried on the lake up to each of the construction sites loading them on ships. In the fore-running work of Hope/Dochfour outlet facility, this route has been used, implying that no problem arises from overloading or insufficient width for passing along land routes. In this regard, as far as Sara Johanna is concerned, it is possible to carry them only by land.

2-2-4-7 Soft component plan

(1) Background and justification for soft component plan

Since the damages caused by large flood in 2005, rehabilitation/ consolidation work of East Demerara Water Conservancy has been implemented in compliance with the action plans suggested in UNDAC report issued in February 2005. As of now, four projects have been implemented, namely, construction work of Hope/Dochfour outlet discharge channel that is under way and scheduled to be completed soon, embankment rehabilitation work by NDIA as supported by the grant aid (procurement of equipment) from Japan, this subject project (the second phase East Demerara Water Conservancy rehabilitation plan) and Cuhnia outlet discharge channel rehabilitation work which is going to start from now on. According to the UNDAC report, even after completing Hope/Dochfour outlet discharge canal, once heavy rain with the probability of about 1,000 year would happen, the reservoir water possibly will spill over the dam embankment, and drainage projects have been pushed straightly forward including rehabilitation of Cuhnia sluice facility.

On the other hand, from the standpoint of the operation, the operation rule of Hope/Dochfour outlet discharge facilities still now has yet to be elaborated, in addition, operating regulations of the existing outlet facilities has not been determined based on their actual outlet capacity. It is considered essential to establish operation rule covering the entire outlet facilities. In view of the above, it can be said that there is a need for exerting more efforts in improving the technical level of safety securing in view of the soft aspect of reservoir operation.

(2) Overall goal of soft component

Overall goal of soft component is to be understood the technical knowhow on the setting method of limiting water level during flood period, the provision of basic knowledge and effects of reservoir operation by the staff of concerning agencies for EDWC. The outcomes (storage of information) are expected to make safety operation of limiting water level during flood period.

For this reason, the implementation of the soft component will contribute not only the safety of the reservoir in the future, but also the persistent effect of facilities rehabilitated in this project.

(3) Outcome of soft component and its identification method

Outcomes expected from the above-mentioned soft component and their identification methods are summarized in the following table.

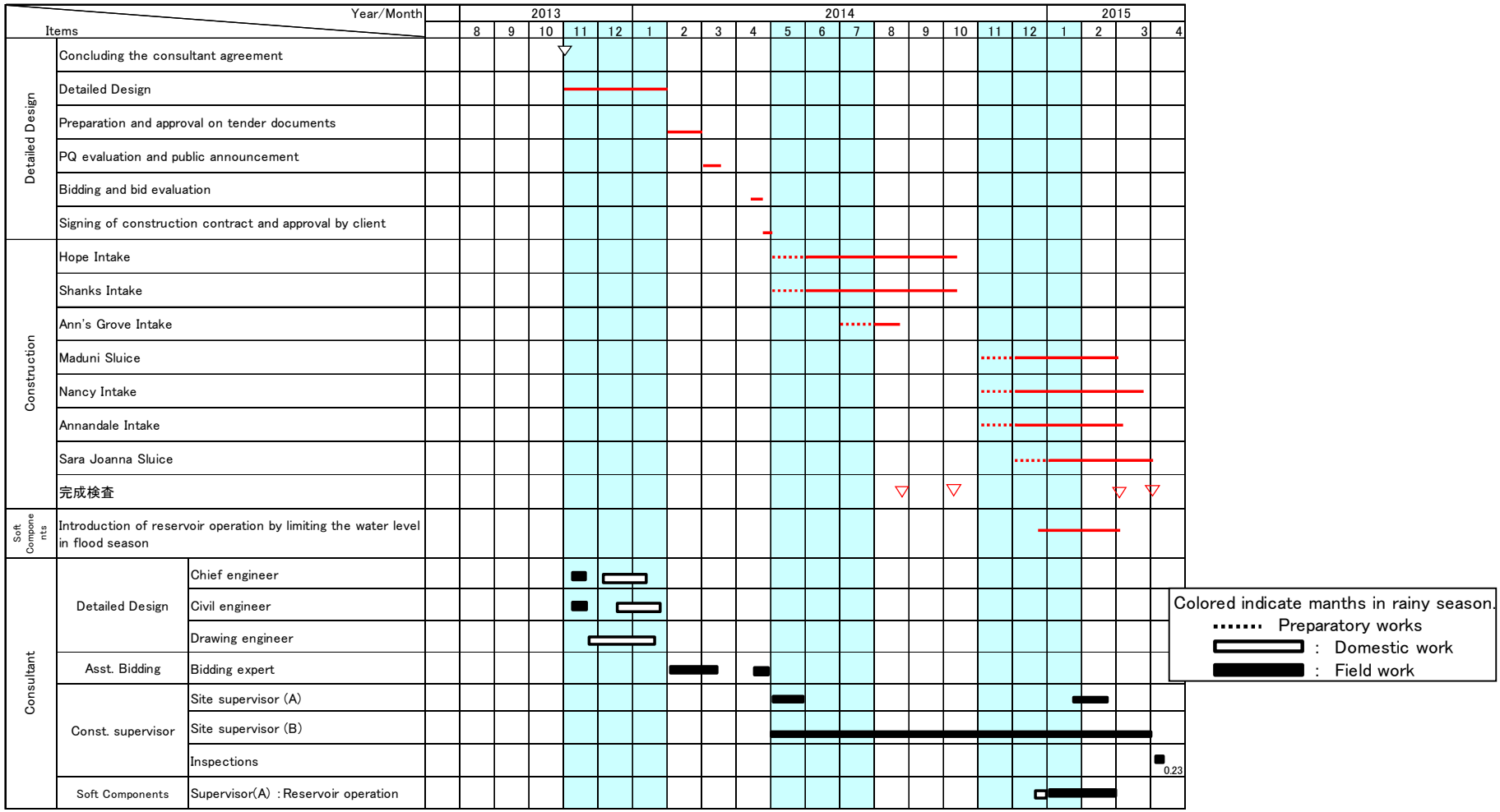
Table 2-2-13 Expected outcomes of soft component and its identification method

Outcomes	Contents	Identification method and the degree of attainment
Importance of setting limiting water level during flood period is understood from disaster prevention point of view, and basic data/info. will be collected for establishing the limiting water level.	Technical knowhow on the setting method of limiting water level during flood period and effects of reservoir operation is understood. Basic data/info. for analysis below toward setting of limiting water level shall be collected. -Hydrological analysis -Inflow/outflow analysis -Capacities of sluice facilities -Tidal analysis	To identify the degree of related engineers of Guyana side on the technical knowhow on safety operation of the reservoir through setting limiting water level during flood period. This shall be done in the group discussion organized for issues designed for particular purpose.

2-2-4-8 Implementation Schedule

Implementation schedule of the work under this project is shown in the table below.

Table 2-2-14 Implementation schedule of the work of the project



2-3 Outline of the work to be borne by Guyana side

The items to be borne by Guyana side are as follows.

1. General items	-Taking banking procedures including Banking Arrangement（B/A）etc -Bearing bank commission charge including commission for opening the account of B/A -Providing conveniences on disembarkation/ embarkation, sojourn etc of the procurement management agent and the consultant who are engaged in the project implementation -Assuring security measures for the activities related to the project implementation
2. Preparation for material/equipment procurement	-Securing and consolidating storage yard and unloading space (site of Flagstaff) for construction materials, construction machinery and transporting machines
3. Preparation for carrying out soft component	-Procuring required staff/personnel and training facility -Budget allocation for personnel costs and cost of preparing training facility

2-4 Project Operation Plan

Management of EDWC and O & M activities for EDWC discharge facilities are undertaken under the authority/responsibility assigned for the EDWC Committee and in practice as many as 24 staffers under the Committee are undertaking required activities being assigned for various stations as Lama, Maduni, Land of Canaan and Kofi. As to the daily patrolling and operation/management of intake facilities are consigned to private sectors by NDIA and the staff from private sector as assigned at the Flagstaff O & M office (18 persons in dry season and 32 persons in rainy season) are working for the assigned jobs. These mentioned conditions are shown in Fig. 2-4-2.

Though details are yet to be fixed, in future, the following 2 facilities will be added and the O & M works for EDWC will be carried out in accordance with the organization chart as indicated in the Fig. 2-4-1.

-Hope/Dochfour discharge canal-----To be completed soon

-Cuhnia sluice facility----------Construction work to commence soon.

The Figure shows the relationship between the EDWC and the higher authorities, but it is interpreted that the EDWC is in fact under the authority of Civil Defense Committee in terms of the chain of command, as EDWC committee is prohibited to undertake operation of both Lama and Maduni sluice facilities during flood disaster period without having command order by the President's Office or the Civil Defense Committee. The CEO of NDIA participates in the EDWC management

committee as a member of the committee Board.

Budget amount allocated for the EDWC committee in the past is as shown in the Table 2-4-1. The budget is secured independently from the NDIA and the amount is expected to be increased due to the increasing number of facilities to be responsible for the O & M activities. Sara Johanna sluice facility, one of the target facilities to be implemented under the subject grant aid project falls under the control of Cuhnia station.

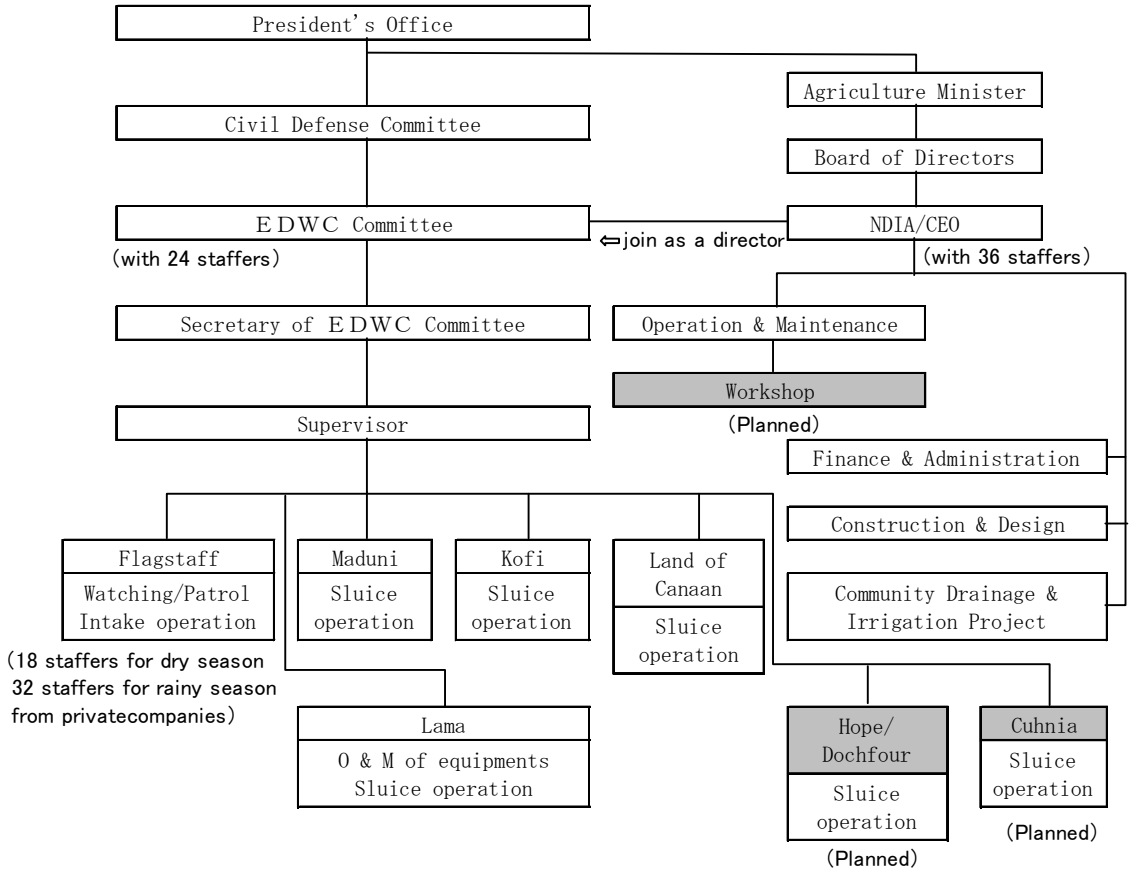


Fig.2-4-1 Organization chart of O & M works for EDWC

Table 2-4-1 Budget of NDIA and EDWC (Unit; million G$)

	2008	2009	2010	2011	2012	2013
NDIA	1,993	4,947	4,284	5,363	6,625	—
EDWC	53	53	53	53	53	53

Note: * The budget amounts of NDIA indicate the actually executed ones.

* In case of EDWC, initially allocated amounts and the executed ones are always equal. Also, the amount is not included in the budget amount of NDIA.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

[Project Cost to be born by Guyana side]

(Commission charges)

-Notification on Authorization to Pay (A/P) and commission charge for Bank	690 US$
-Bank charges	2,240 US$
-Others including issuance of certificates	1,270 US$
Sub-total	4,200 US$

(Soft component undertaking)

-Personnel cost and preparation for seminar	400 US$

Total 4,600 US$ (About 435,000 Yen)

*Estimation conditions

Time of estimation: March 2013

Exchange rate: 1.0 US$=99.38 Yen

Procurement period: As shown in the project implementation schedule

Others: Cost estimate is made based on the system/guideline as applied under the grant aid project by the Government of Japan.

2-5-2 Operation and Maintenance Cost

National Drainage and Irrigation Agency (NDIA) in charge of drainage and irrigation in the country plays an important role in the overall nation's management for Guyana where 90% of national population concentrates in lowland area located along the Atlantic coast, and the fact that its importance has recently been raised as manifested in the growth of its executed budget amount in an increasing trend as 1,993 million GD as of 2008 ~ 6,625 million GD as of 2012.

In particular, special consideration is given to East Demerara Water Conservancy (EDWC) that is located at immediate upstream of the Capital Georgetown, with high importance in terms of disaster prevention of the Capital, domestic water supply, irrigation water supply to nearby farmland, for which fixed amount of operation and maintenance budget, 53 million GD has annually been allocated under the control of EDWC committee. Though personnel placement plan in concrete manner is being under preparation for the operation of Hope/ Dochfour outlet sluice facilities, it will be determined soon and budget will be allotted for O & M activities for these facilities as per the confirmation made by Guyana side. It is noted that the works for Hope/Dochfour is scheduled to be completed at the end of 2013 and Cuhnia outlet sluice facilities will be completed soon after the former.

As mentioned above, EDWC has been continuing stable developing performances in its activities with the reliable operation and maintenance organization and the well-established budgetary system. From these facts, appurtenant facilities to be rehabilitated under this project are to be put under this management system and sufficient operation and maintenance are expected to be provided.

Under the implementation of the subject grant aid project, drastic measures will be taken for rehabilitation of Hope and Shanks (Ann's Grove) Intakes. The outcome implies that those intake facilities repeatedly rehabilitated in the past will break the spell, and in a long term perspective, the required O & M cost will be saved considerably. Also, the saving/reducing of O & M cost on a long term basis can be expected for the slope protection works for Maduni sluice facility and Nance Intake facility too, as the said facilities be rehabilitated to avail slope protection works with higher durability.

In view of the above, it can be noted that the necessary O & M activities will never be neglected or ignored due to the budget limitation classified as costs for project management and O & M activities.

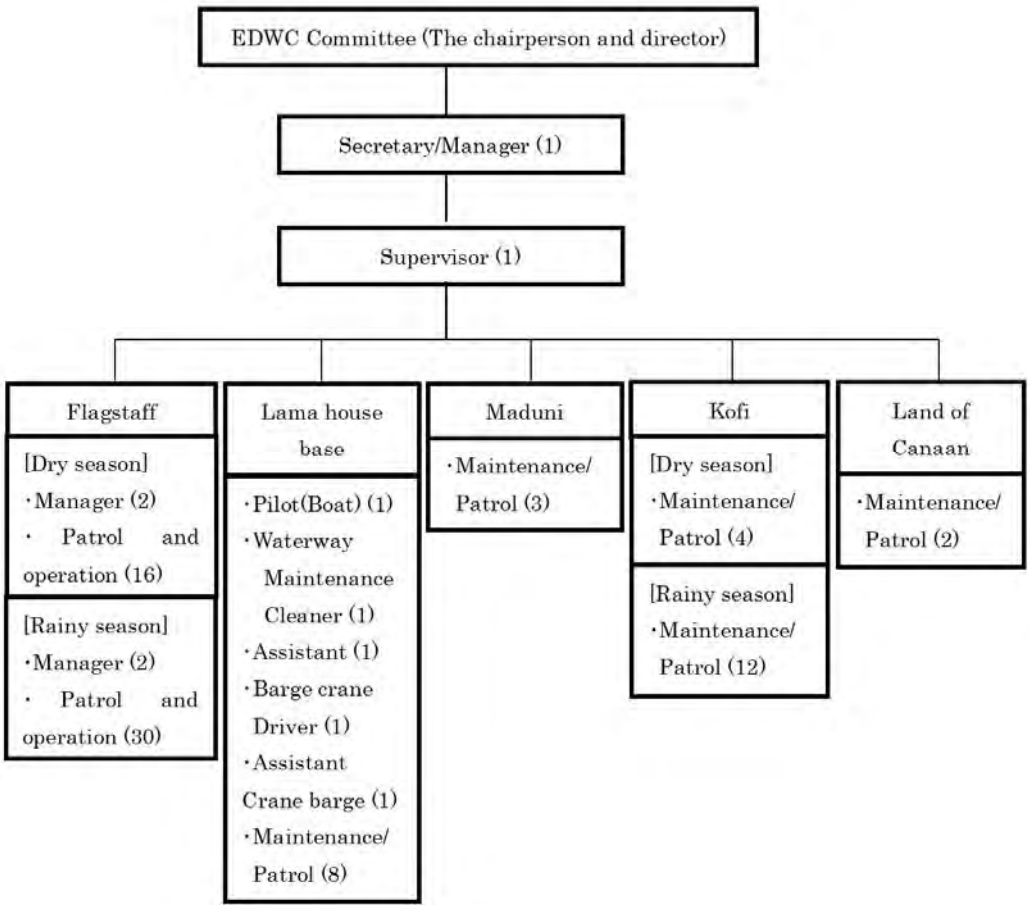


Fig. 2-5-1 Operation & Maintenance Organigram for EDWC

Chapter 3 Project Evaluation

Chapter 3 Project Evaluation

3-1 Preconditions

(1) Land

Rehabilitation work for Sara Johanna outlet sluice facility consists of widening the existing narrow flume section and slope protection work by revetment. Flank wall of the existing work functions also as the deck/ pier of a wooden bridge being a branch route off the national road into the entrance to the lot owned by Barama Company Limited. Consequently, in implementing the rehabilitation work for width expansion, it is necessary to secure due consent by this company on the alteration of the entrance location.

Since the revetment work is to be carried out from scaffold assembled inside the canal, occupying of a part of national road will not happen. However, it is necessary to obtain consent by related stakeholders for utilizing the neighboring vacant lots as material stock yard. Also it is necessary to obtain consent by the national road managing authority on temporary use and occupying it in a closed condition for unloading materials onto the yard.

For the other cases than Sara Johanna outlet sluice facility, those works are to be carried out within the land lot managed by EDWC, and no problem on land will take place.

(2) Environment and Social Consideration

Concerning the permission on environmental affairs related to the implementation of this Project, NDIA acquired it from the Environment Conservation Authority (EPA) in February 2011, in which none of the evaluation items under the Detailed Environmental Impact Assessment (DEIA) is included. In this context, however, monitoring during the construction work on the following items classified as “B” of environmental scoping is required. Also, it is necessary to expedite prompting consultation/ adjustment among the related parties concerned prior to the completion of the facilities construction.

- Adjustment of intake water volume: Ann’s Grove Intake facility will be installed side by side with Shanks Intake facility. Irrigation water taken through both intake facilities is firstly released into Shanks canal and diverted at the diversion work located at the downstream. Concerning operation of this diversion work and that of intake facilities, the stakeholders are advised to have due consultation / coordination among beneficiaries of both intake facilities.

- Water quality at the inlet of Nancy Intake facility: Water taken into this facility is utilized as a raw water source of potable water for the citizens of Georgetown. Therefore, the effect of construction onto the water quality (pH and turbidity) is to be regularly measured with Litmus testing paper as well by turbidity-meter and to report these results to water works. At the same time, the manager of the construction work is to obtain feedback information from the water works on the extent of influence of the work on potable water quality.

(3) Custom Clearance of Equipment and Materials

In the cases where custom clearance is required for materials/equipment related to construction work, construction supervision and the implementation of soft component etc, Guyana side is to take necessary measures for tax exemption related with the procurement.

(4) Securing of space for stock yard for temporarily storing materials for construction work and mooring facility

Carriage of materials for construction work to the construction site under currently on-going construction work of Hope/Dochfour outlet sluice is carried out by using tug-boats/ships from Flagstaff point. In this Project, as each of the construction sites is located near Flagstaff, materials are to be carried from this point by similar transportation means to each of the construction sites. In this regard, securing of space for stock yard for temporary materials storing for construction work and related mooring facility is to be fulfilled by Guyana side.

3-2 Necessary Inputs by Recipient Country

Management system and organizations have already been established for East Demerara Water Conservancy in the light of its importance on its flood control function for the capital, Georgetown as well as that on the source of portable water, that of irrigation water covering about 18 thousand ha of farmland. However, the required management system for newly to be constructed Hope/Dochfour outlet sluice facility and Cuhnia outlet sluice is yet to be determined. Guyana side is requested in this concern to urgently review the entire management system including all the facilities related with the EDWC.

As to the existing outlet sluice facilities, the operational regulations have already been established, but it is also requested to the Guyana side to finalize operational regulations covering the entire outlet system including these two new outlet facilities.

No concept of limiting water level during flood period is yet to be applied for the existing operational rule, but hereafter it is requested to elaborate the formulation and application of the operational rule based on this concept from the viewpoint to grade up the level of safety against floods.

3-3 Important Assumptions

Rehabilitation project for East Demerara Water Conservancy aims to strengthen the dam safety measure consisting of three elements, namely: ① Strengthening embankment by rehabilitation, ② Improving outlet sluice capacity and ③ Rehabilitation/consolidation of appurtenant facilities. As regards ①, material supply under Japanese grant-aid project “East Demerara Water Conservancy Rehabilitation Plan” contributes partly for the rehabilitation work being undertaken at present. As to ②, it has been/ is going to be carried out with the assistance by World Bank or as self-sponsored

project by Guyana, including such as Hope/Dochfour as well as Cuhnia outlet discharge canal construction projects. The subject grant aid Project covers ③, in which strengthening of outlet sluice capacity by rehabilitating Maduni, Sara Johanna outlet facilities, solution for the part of structural weakness/strengthening embankment and enhancing convenience of water utilization by rehabilitating Hope Intake facility etc are expected. This Project holds an important position in a sense that with having the completion of all these projects, safety for East Demerara Water Conservancy can be fully attained.

3-4 Project Evaluation

3-4-1 Relevance

In Guyana, decreasing of mean rainfall amount and increase in rainfall intensity are forecasted as affected by the global basis climate changes. This requires rehabilitation of EDWC related facilities at the earliest so that the EDWC as a whole can stand with possible intensified/concentrated rains in the area through proper discharging of flood water. The subject grant aid project is to contribute to the safety operation of EDWC with having improved drain/discharge capacity of EDWC acquired through dissolving the weak points by means of rehabilitation of deteriorated outlet sluice and intake facilities, embankment as well as the appurtenant facilities.

As per the sea water level records in Guyana, the raise of surface water during the period of 1951-1979 is 10 mm/year as an average, indicating a fear for negative effects of sea water surface raising as caused by the global warming. For EDWC, the western discharge facility functions draining the water to the sea through Demerara river, but the river water level directly link with the sea water, having almost same level, and therefore, the raise-up of sea water level may cause hindrances for lowering the EDWC reservoir water level during flood period and also causing the need for expansion of discharge capacities of outlet sluice facilities. For this particular aspect, the subject project is to respond to this need by increasing the discharge capacity through rehabilitating the Sara Johanna outlet facility.

Further, the subject grant aid project conforms to the overall rehabilitation plan for EDWC being progressed by Guyana side, and judged to effect in various project benefits as the key facility for multi-purpose water uses in the capital area including flood prevention through regulating the flood discharge to capital area, securing of irrigation water source for the neighboring farm lands and stable supply of raw water for city water work (For about 40 % of 360,000 beneficiary people). Supply of irrigation water for as large as 17,900 ha located on the northern stretch of EDWC reservoir and the area along the Atlantic Ocean is conveyed from this reservoir, and therefore, improvement/consolidation of Shanks Intake located on the northern embankment of EDWC will largely contribute to the agriculture sector. Further to mention, it is the Nancy intake, one of the targets for rehabilitation under the project that divert the raw water for the city water work of Georgetown, the capital city. For Nancy Intake, the project will seek stabilized safety of the facility through implementing the surrounding embankment stability by slope protection works.

The EDWC reservoir is as featured as noted above, however, the storage capacity is not capable for the radical intensification of rainfall pattern as affected by the climatic change being developed on global basis, and as the mater of facts, flood damages have occurred frequently as those happened in the years 2005, 2006 and 2009. Especially, it was the flood damage occurred in the year 2005 that as many as about 40 % of capital population suffered seriously and as large as 60 % of GDP was lost. Today, Guyana has recovered from the huge flood damage as said and has been attaining steady economic growth in recent year, however the people will suffer seriously from the flood damages if similar scale of flood disaster may happen again. To this end, it can be said that the vulnerability against possible flooding by EDWC reservoir will surely be reduced after rehabilitation of outlet sluice ad intake facilities under the subject project implementation.

Those benefits as mentioned above will contribute largely to the people residing at the downstream area of EDWC in the form of stabilization of livelihood and improved living condition, and the project is considered suited to the grant aid program by the Government of Japan.

It is necessary to strengthen the safety EDWC operation from the soft component viewpoint, taking into consideration the tendencies of seawater surface rising and higher rainfall intensity as affected by the global warming, though rehabilitation and new construction of outlet sluice facilities have been continued to date. In this concern, the project introduced “Safety management of EDWC by applying limiting water level during the flood period” as a part of the soft component.

In view of all the points as noted above, it is judged reasonable to implement the subject project under the grant aid program by the Government of Japan.

3-4-2 Effectiveness

Through successful implementation of the subject Project, rehabilitation of deteriorated appurtenant facilities attached to the dam/embankment of East Demerara Water Conservancy can be revived/improved totally, thereby not only dissolution of weak point in the embankment/ fortification of dam safety are pursued, but also improvement of outlet sluice capacity, stable supply of irrigation water, stabilization of embankment slope around the appurtenant facilities and betterment of overall scenery can be brought about.

Further, under this project implementation review study, through re-examining the PDM of the preparatory survey and considering the qualitative and quantitative effect on this project, the project purpose is determined "Stability of the EDWC embankment can be remarkably improved". Therefore, it has changed the part of "Summarized Project Outline"(refer to Table 2-1-1). The quantitative and qualitative effect of this project is tabulated in the table below.

(1) Quantitative effect

	Project of cooperation target	
Target item	Vulnerability elimination and safety strengthening of embankment by rehabilitating appurtenant facilities	Improvement of discharge capacity of sluice facilities
Quantitative effect	Declining of frequency for repair or problem occurrence in intake facilities and surrounding embankment	Improvement of discharge capacity of Sara Johanna outlet facilities
Baseline value	3 or 4 times of repair for 3 years duration before rehabilitation	5.2 m^3/sec (measured in 2009 at the water level WL=54.0 feet GD)*
Target value**	No occurrence of repair works	Approximately 10.0 m^3/sec

Note; * Quoted from “Presentation on the Hope Canal (Region 4) by Mr. Maurice Veecock”

** In 3 years after the completion of rehabilitation

(2) Qualitative effect

The qualitative effects discussed below are caused not only by the subject grant aid project but also by the equipment supply project implemented before.

Expected effects	Qualitative effects
Effect-1 Mitigation of flood damages	Through the rehabilitation of discharge facilities, the structural stability be improved and cause mitigation of flood damages on the downstream watershed area of EDWC (About 350 km^2 and 300,000 people).
Effect-2 Stable supply of irrigation water	By rehabilitating the main bodies of intake facilities (Shanks, Hope, and Ann's Grove), intake capacities can be recovered and stabilize the needed irrigation water supply for the farm land (About 18,000 ha) situated at downstream of EDWC in dry season.
Effect-3 Stable supply of potable water	By rehabilitation of Nancy Intake, the intake for city water supply, the capacity be recovered and the supply for capital area (40% of 360,000 beneficiaries) can be stabilized.
Effect-4 Slope and crest of the embankment around intakes	Through the rehabilitation of intake facilities, slopes and crests of embankment around the facilities can be stabilized and the landscape be improved there.
Effect-5 Technical transfer	Through the implementation of soft component, technical understanding by the staff of NDIA could be leveled up and chances for applying the concept of limiting water level during the flood period for safe operation management of EDWC will be created for future O & M activities for EDWC.

(3) Summarized conclusion of effectiveness

In view of the above, the subject project is evaluated as a project with high effectiveness, provided however, the management system with the concept of limiting water level during flood period is considered positively effective in enhancing further the safety of EDWC and a follow-up examination towards the said management system is suggested.

[Appendices]

Appendix-1. Member List of the Study Team

Name	Position	Organization/ Status	Period
Kohei Sato	Team Leader	Chief, Third Executing Supervision Division, Fund Cooperation Assistance Division JICA	4th ~ 8th March, 2013
Hayakazu Yoshida	Cooperation Planning	Third Executing Supervision Division, Fund Cooperation Assistance Division JICA	4th ~ 7th March, 2013
Haruo Hiki	Chief Engineer/ Facility Design	Sanyu Consultants Inc.	5th ~ 27th March, 2013
Sinta Ishida	Construction Planning/Cost Estimation	Sanyu Consultants Inc.	5th ~ 27th March, 2013

Appendix-2. Study Schedule

Month	Date	Day	Staff of JICA		Proxy Investigators of Consultant
			Kohei Sato, Leader	Hayakazu Yoshida, Cooperation Planning	Haruo Hiki, Sinta Ishida
March	1	Fri.			
	2	Sat.			
	3	Sun.	Departure from Narita	Departure from Narita	
	4	Mon.	Visit Japanese Embassy in Trinidad Tobago for courtesy call / explanation		Departure from Chubu International Airport, Japan
	5	Tue.	Visit Ministry of Foreign Affairs, Guyana & State Drainage and Irrigation Department (NDIA) of Ministry of Agriculture, Guyana, Reconnaissance Study at the dam		
	6	Wed.	Site study at the dam, Meeting/ consultation with State Drainage and Irrigation Department (NDIA)		
	7	Thu.	Sign the Minutes, & site study	Sign the Minutes, & leave Guyana	Witness of the signature on the Minutes, site study
	8	Fri.	Leave Guyana		Site study (Hope, Dochfour)
	9	Sat.			Site study (Maduni Sluice)
	10	Sun.			Intermediate compilation of site-study result
	11	Mon.			Interview survey to staff of NDIA, related constructor
	12	Tue.			Interview survey to staff of NDIA, related constructor, Site survey for confirmation
	13	Wed.			Interview survey to related constructor & concrete dealer, Visit Statistic Office, Site study (Sara Johanna)
	14	Thu.			Preparation of a letter to the Statistic Office, Interview survey to staff of Flagstaff Office
	15	Fri.			Visit Statistic Office, Interview survey to related constructor, Reporting work
	16	Sat.			Visit dealers of cement & construction materials
	17	Sun.			Preparation of requesting-list for data/references to NDIA, preparation of the study on Hope Waste-way
	18	Mon.			Request data/ references to NDIA, Visit & interview related constructors etc,
	19	Tue.			Meet staff of NDIA (Mr. Surendra, Mr. Avinash, Mr. Chandon Samuel)
	20	Wed.			Survey on access road from downstream side to Nancy Intake Facility
	21	Thu.			Meet staff of NDIA discussing on Cuhnia waste-way (Mr. Surendra, Mr. Samuel)
	22	Fri.			Meet staff of NDIA discussing on Hope waste-way (Mr. Surendra)
	23	Sat.			Survey on access road from downstream side to Nancy Intake Facility
	24	Sun.			Survey on access road from downstream side to Shanks Intake Facility
	25	Mon.			Reporting on draft report & technical note
	26	Tue.			Explanation on the study result and technical note to Ministry of Foreign Affairs and NDIA
	27	Wed.			Leave Guyana, Explanation of study result to Japanese Embassy in Trinidad Tobago
	28	Thu.			Departure from New York
	29	Fri.			Arrive at Chubu International Airport, Japan
	30	Sat.			
	31	Sun.			

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

Date	Place	Attendance/Interviewee	Position
Mar. 5th	Ministry of Foreign Affairs	Ms. Vanessa Dickenson	Director, Department of International Cooperation
Mar. 5th	National Drainage & Irrigation Authority (NDIA)	Mr. Lionel Wordsworth Mr. Surendra Shingh	Chief Executive Officer Engineering Coordinator
Mar. 6th	NDIA	Mr. Surendra Shingh	Engneering Coordinator
Mar. 7th	NDIA	Mr. Lionel Wordsworth Mr. Surendra Shingh	Chief Executive Officer Engineering Coordinator
Mar. 8th	Hope/Dochfoure Project Office	Mr. Paul Sarran	Project Engineer of NDIA
Mar. 9th	EDWC	Mr. Naresh Toonoo	Flagstaff office staffer
Mar.11th	NDIA	Mr. Surendra Shingh	Engneering Coordinator
Mar. 11th	NDIA	Mr. Fyuse Hoosain	Fyuse Hoosain Con. Inc.
Mar. 12th	NDIA	Mr. Timothy Inniss Mr. Samuel La Fluer	Irrigation Engineer of NDIA Secretary of EDWC Committee
Mar. 12th	B.K. International Inc.	Mr. Brian Tiwarie Ms. Agnes Dolymple	Maging Director Engineer
Mar. 13th	NDIA	Mr. Samaroo Doodnauth	Samaroo Investment
Mar. 13th	CR International Inc.		Secretary
Mar. 13th	Bureau of Statistics	Ms. Torrington	Statistician
Mar. 14th	EDWC	Mr. Brodo	Flagstaff office staffer
Mar. 14th	NDIA Workshop		Security gard
Mar. 14th	NDIA	Mr. Samuel La Fluer	Secretary of EDWC Committee
Mar. 15th	Bureau of Statistics	Ms. Maxine Bentt	Head of Depart., trade & price
Mar. 16th	Anral Investment	tel 225 5522	Cement Dealer
Mar. 16th	Caricom Cement Company Inc.	tel 225 1853	Cement Dealer
Mar. 16th	Gafsons Industries Limited	tel 223 8601	Construction Material Dealer
Mar. 16th	Ultrawoods Enterprise	Ms. Robina Ragnauth	Timber Dealer
Mar. 18th	Flagstaff office	Mr. Shafiek Nazeerbakh	office staffer of EDWC
Mar. 18th	B.K. International Inc.	Mr. Dellon	Supervisor of B.K. Inter.
Mar. 18th	DIPCON (tel 270 4546)	Mr. Mungal	Manager
Mar. 19th	NDIA	Mr. Suendra Shingh Mr. Samuel La Fluer Mr. Avinash Mr. Chandon	Engineering Coordinator Secretary of EDWC Committee NDIA mechanical engineer NDIA engineer (Cons./design)
Mar. 21st	NDIA	Mr. Suendra Shingh Mr. Samuel La Fluer	Engineering Coordinator Secretary of EDWC Committee
Mar. 22nd	NDIA	Mr. Suendra Shingh	Engineering Coordinator
Mar. 26th	Ministry of Foreign Affairs	Ms. Vanessa Dickenson	Director, Department of International Cooperation
Mar. 26th	NDIA	Mr. Surendra Shingh	Engineering Coordinator
Mar. 27th	Torinidad and Tobago, Japan Embassy	Mr. Yoshimasa Tezuka Mr. Koji Fujimura Mr. Tsuyoshi Koga	Embassador Second secretary Second secretary

Appendix -4. Minutes of the Discussions（M/D）

MINUTES OF DISCUSSIONS
ON THE IMPLEMENTATION REVIEW STUDY
ON
THE PROJECT THE REHABILITATION OF THE EAST DEMERARA WATER CONSERVANCY(II)
IN THE REPUBLIC OF GUYANA

The Japan International Cooperation Agency (hereinafter referred to as 'JICA') decided to conduct an Implementation Review Study for the Project for the Rehabilitation of the East Demerara Water Conservancy (II) (hereinafter referred to as "the Project").

JICA sent an Implementation Review Study Team (hereinafter referred to as "the Team")to the Republic of Guyana(hereinafter referred to as "Guyana") which is headed by Mr.Kohei SATO, Director of the Grant Aid Project Management Division 3, Financing Facilitation and Procurement Supervision Department, JICA. The duration of the Team's work in Guyana is from 4th March to 26th March.

The Team held a series of discussions with officials of National Drainage and Irrigation Authority (hereinafter referred to as "NDIA") representing the Government of Guyana (hereinafter referred to as "GOG") and conducted a field survey at the study area.

In the course of the discussions and field survey, both parties confirmed the main items described on the attached sheets.

Georgetown, March 7th, 2013

Mr. Kohei SATO
Leader
Implementation Review Study Team
Japan International Cooperation Agency

Mr. Lionel Wordsworth
Chief Executive Officer
National Drainage and Irrigation Authority
Ministry of Agriculture
The Republic of Guyana

In witness of

Mr. Safraaz Shadood
Foreign Trade Officer
Ministry of Foreign Affairs
The Republic of Guyana

ATTACHMENT

1. Outline of the Implementation Review Study

The objective of the Implementation Review Study (hereinafter referred to as the 'Study') is, through the field study and the meetings with the officials concerned, to review the current situation of the Project site. Based on that, the Team reviews the appropriate contents and re-estimates the cost of the contents of the Project.

2. Contents of the Project

The Guyana side agreed that the contents of the Project will be determined after further study conducted by the Team. In principal, the contents will be the same as in the report of preparatory survey. However, both sides confirmed contents will be changed depending on the necessity and functionality of the contents.

3. Schedule of the Study

The Team explained that the Study report will be finalized and submitted to the NDIA in June 2013.

4. Other Relevant Issues

(1) Both sides agreed that GOG will proceed with the termination of the previous consultant's contract for the Project.

(2) Both sides reconfirmed that GOG shall take necessary measures, in conformity with each the Exchange of Notes signed on September 6th, 2011 between GOG and Government of Japan and Grant Agreement signed on September 6th, 2011 between GOG and JICA. GOG understands total project cost is, same as Exchange of Notes referred above, up to three hundred and twenty million Japanese Yen (JPY320,000,000).

(3) Both sides confirmed that GOG shall be responsible for taking any necessary measures including allocation of required budget and personnel in order to operate and maintain the facilities rehabilitated by the Project.

(4) The Team explained the role of the agent in the Project and GOG understand it.

(5) GOG agreed that GOG will make the necessary arrangements, especially to provide necessary information about Hope/Dochfour drainage channel and a boat for the Team to access the locations.

END

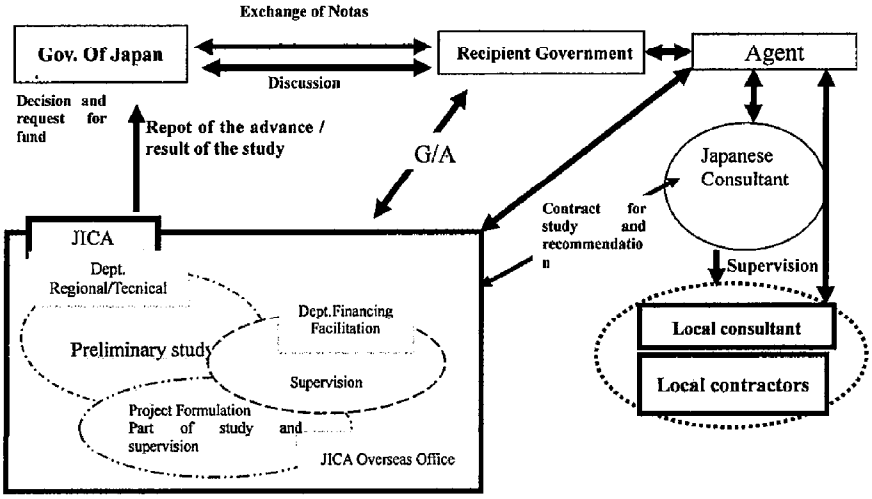
Annex-1.Tentative Schedule
Annex-2 Flowchart of Japan's Grant Aid through Agent

Annex-1 Tentative Schedule

Item/Month	2013/2	3	4	5	6	7	8
Preparation	□						
Field Survey		■					
Analysis			▭				
Draft Report				△			
Final Report					△		

□ : In Japan
■ : In Guyana
△ : Deadline for submission in Japan and Guyana

Annex-2 Flowchart of Japan's Grant Aid through Agent



*Note:The difference between the Agent and JICA

The Agent is in a situation different from JICA, Agent has authority to sign the contract as the deputy executive agency of the recipient country. The agent administers the tender directly, which is similar to the work of a consultant. At the same time the task of administering the fund has similarities with the task of JICA. Support system by Agent aims to loosen the restrictions that the Grant Aid for General Projects has in some ways and also enable more agile projects.

Appendix -5. Technical Note

Technical Note on the Implementation Review Study

NDIA and the senior surveyor confirmed to share a common understanding regarding the conformance between the current conditions and the ex-implementation plan for the Component-2 that is shown as Chapter 3-1-5 in the draft report and attached here as the Appendix-1.

NDIA agreed with the contents of the rehabilitation works being decided according to the priority ranking, which is shown as Chapter 3-2-1 in the draft report and attached here as the Appendix-2, and the design policy shown as Chapter 3-2-2 in the draft report and attached here as Appendix-3.

Georgetown, August 30, 2013

Shinta Ishida

for Mr. Haruo Hiki
Senior Surveyor
Implementation Review Study Team
Sanyu Consultant Inc.

Mr. Lionel Wordsworth
Chief Executive Officer
National Drainage and Irrigation Authority
Ministry of Agriculture
The Republic of Guyana

Appendix-1
3-1-5. Confirmation of conformance between the current conditions and the plan
(1) Confirmation of conformance between the current conditions and the plan

Rehabilitation plan	Current conditions	Conformance	Recommendation
Ann's Grove Intake Improvement of revetments at the inlet and outlet mouth, and the embankment	Ann's Grove Intake can not work as usual because of the Hope/Dochfour Canal cutting the Ann's Grove Canal at its throat.	The current conditions and the plan do not match up.	Ann's Grove Intake must be moved to the right bank side of the Hope/Dochfour canal line and construct another gate in parallel with the Shanks Intake.
Shanks Intake During the preparatory study, the facility was in a condition immediately after the rehabilitation works.	Shanks Intake The embankment around the intake structure has been repeating the leakage failure due to piping. The narrow embankment crest seems to be flushed off and request the thorough rehabilitation.	Shanks Intake was not on the list of rehabilitation.	It is adequate to rehabilitate Shanks Intake thoroughly in parallel with Ann's Grove Intake.
Hope Intake Door guide Revetments, inlet and outlet Extension of the conduit Embankment quality Anti-piping works	The Hope Intake looks stable at this moment. But it has the history of repeated leakage failures due to the piping phenomena in the past.	The current conditions and the plan match up.	Rehabilitate as per plan.
Annandale Intake Door, partially Revetments, inlet and outlet Additional embankment	All the structures/facilities and embankment are stable. Since the thorough rehabilitation in 2003, no problems have occurred except the spindle bending once.	Does not match up. There are no facilities that request the rehabilitation in the site. All the facilities are stable.	Give the last priority of rehabilitation to Annandale Intake. Identified works are needs.
Nancy Intake Revetment installation Additional embankment	The revetment was installed in 1996 and has already decayed completely. But the slopes behind are stable.	Match up.	Provide the revetment to keep the slope stable. Slope protection is also required.
Maduni Sluice Door, renewed Revetments, inlet and outlet Rehabilitation of embankment Additional embankment	The revetment works have already been decayed. But the steep slopes behind the revetment remain stable. And the embankment is composed of clayey soils and sound. On the sluice door, there are leakages.	Match up partially.	Provide the revetment to keep the slope stable. Slope protection is also required. The sluice door needs to be changed.
Sara Johanna Sluice Revetments, inlet and outlet Drainage pipe	The existing revetment covers the partial area only. In other area, the slopes are self-sustained and stable. There is a narrow concrete flume in the connection waterway.	Match up partially. The plan does not improve the capacity of the canal directly.	The plan shall be reviewed and to include as per rehabilitation plan so as to give the priority restoring the original canal capacity directly.

(2) Necessity of the rehabilitation after the completion of the Hope/Dochfour Drainage Channel

The Hope/Dochfour Drainage Channel is the drainage facility so that the discussion shall be done on the necessity of the rehabilitation of existing drainage facilities, i.e. relief sluices of Maduni and Sara Johanna. The necessity of the rehabilitation of intake facilities is not the target of discussion as the Hope/Dochfour Drainage Channel does not have the function of intakes.

(a) Maduni Sluice

The Maduni Sluice has two functions; one is the emergency spillway and the other is the regulation function between the Maduni River and the conservancy, that is to say the water is led through the sluice from the Maduni River into the conservancy at the time of the conservancy water level descending down due to the drought.

Regarding the former function "emergency", as the report "The Design of the East Demerara Water Conservancy (EDWC) Northern Relief: Hope/Dochfour, December 2009" pointed out the possibility of flood occurrence, over topping of the conservancy dam, under the condition of heavy rain with more than 1,000 year probability attacking the conservancy, it is considered for the Maduni Sluice to be used as the emergency spillway that is opened only at the time of "national scale catastrophe".

Based on these two points of view, the rehabilitation of the Maduni Sluice is considered to be necessary.

(b) Sara Johanna Sluice

The relationship between the rehabilitation of the Sara Johanna Sluice and the rehabilitation of the Cuhnia Canal is considered as follows.

It is assumed that the water surface level at the branch point would descend as the two waterways can provide with a larger flowing down capacity; thus descended water surface at the branch point makes the hydraulic gradient between the Cuhnia Sluice and the branch point larger and then the flowing down capacity increases upstream of the branch point even though the sectional area of the sluice is constant. Therefore, it is significant to rehabilitate the Sara Johanna waterway and revetments, inlet, outlet and pipes and improve its flowing down capacity even if the Cuhnia Canal is constructed.

It is assumed that the rehabilitation of the Cuhnia Canal and the Sara Johanna Sluice is considered to be necessary based on the description in the design report of Hope/Dochfour as shown above. Such a recognition would be understandable considering the situation that the additional height of the conservancy dam, the height between the design flood water level (58.5 feet DG) and the dam crest (59.0 feet DG), is only 0.5 feet, i.e. 15 cm where a small pond for the irrigation use must be provided with not less than 1.0 m of additional height in Japan.

(3) Crown Dam and Hope/Dochfour Drainage Channel

The field reconnaissance was carried out with an expectation that the rehabilitations of intakes on the northern conservancy dam might become unnecessary if the Crown Dam can function as the conservancy dam in place of the existing one as the line of extension from the Crown Dam to the Hope/Dochfour Drainage Channel looks to be alternative to the existing

Conservancy dam in front of them in the map (refer to Fig.3-1-5-1).

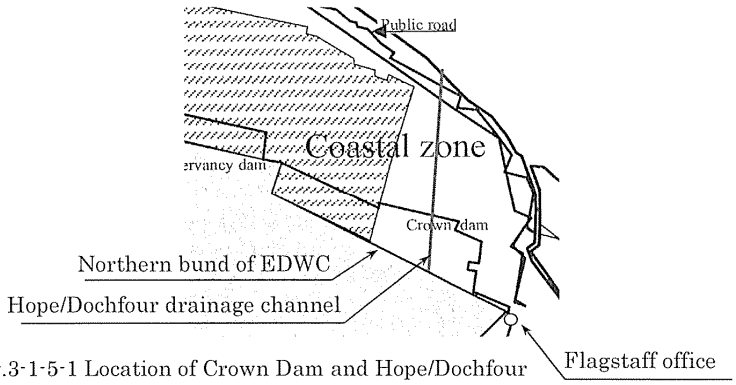
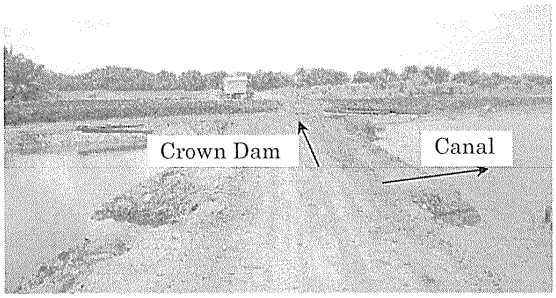


Fig.3-1-5-1 Location of Crown Dam and Hope/Dochfour

Here in Guyana, all the old roads in rural area are not called "road" but called "dam" or "trail". The Crown Dam is the road and its surface elevation is lower than the crest elevation of the conservancy dam and the Hope/Dochfour Drainage Channel. The conclusion is that the Crown Dam can not function as the conservancy dam in place of the existing one.



PH 3-1-5-1 Crossing point of Crown Dam and Hope/Dochfour

Appendix-2
3-2. Analysis and Grand design of the EDWC Rehabilitation Project, Component-2
3-2-1. Review of the contents of the rehabilitation works

Based on the study result shown in the chapter 3-1-5, the contents of the rehabilitation works are prioritized as follows and are adopted for implementation according to their priority rankings that reflect the degree of requirement for rehabilitation.

Facility	Object of rehabilitation	Ranking of priority
Shanks Intake (Ann's Grove)	Whole intake facilities (Treatment of the existing facilities)	1
	Treatment of Ann's Grove intake facilities	
Hope Intake	Whole intake facilities (Treatment of the exiting facilities)	2
Sara Johanna Sluice	Reconstruction of the flume channel	3
	Rehabilitation of the revetment	5
Maduni Sluice	Change of the door	4
	Rehabilitation of the revetment	6
Nancy Intake	Rehabilitation of the revetment	7
Annandale Intake	Rehabilitation of the revetment	8

Appendix-3
3-2-2. Design Policy
(1) Intake structure
(a) Foundation treatment

The foundation works shall comprise of the following:

i) Excavation of the pit to a stiff stratum below the invert of the structure.
ii) Driving of bearing piles as needed.
iii) Placing and compaction of white sand fill to 95% if the maximum density as determined by AASHTO T180.
iv) Driving of toe/tanking piles to provide the necessary cut-off to prevent seepage below the structure.
v) Following this, a blinding layer would be placed to allow for the construction of the reinforced concrete structure.

(b) Extension of the conduit and concrete retaining walls

In case of the existing intake structures, the length of the conduit is short; this brings the irregular slope shape of the embankment and makes it necessary to apply the revetment works. The shortness of the conduit, i.e. the short seepage length along the conduit, and the incompleteness and the vulnerability of the revetment works make the condition around the intake structure unstable. By giving a long enough length to the conduit and providing with long wing retaining walls not to make the embankment slope irregular as much as possible, the intake structure would be designed and constructed as a sustainable and long life-span structure. Here, the revetment works shall not be applied.

(2) Revetment

The revetment works have two functions; one is supporting and stabilizing function against the soil mass or embankment tending to slide, the other is the function of slope protection. In case of the embankment/ground slope being stable, it requires the slope protection only so that the slope protection method shall be decided from the view point of economy and sustainability among some alternatives including the revetment method.

Appendix -6. Soft Component (Technical Assistance) Plan

1. Background and justification for soft component plan

Since the damages caused by large flood in 2005, rehabilitation/ consolidation work of East Demerara Water Conservancy has been implemented in compliance with the action plans suggested in UNDAC report issued in February 2005. As of now, four projects have been implemented, namely, construction work of Hope/Dochfour outlet discharge channel that is under way and scheduled to be completed soon, embankment rehabilitation work by NDIA as supported by the grant aid (procurement of equipment) from Japan, this subject project (the second phase East Demerara Water Conservancy rehabilitation plan) and Cuhnia outlet discharge channel rehabilitation work which is going to start from now on. According to the UNDAC report, even after completing Hope/Dochfour outlet discharge canal, once heavy rain with the probability of about 1,000 year would happen, the reservoir water possibly will spill over the dam embankment, and drainage projects have been pushed straightly forward including rehabilitation of Cuhnia sluice facility.

On the other hand, from the standpoint of the operation, the operation rule of Hope/Dochfour outlet discharge facilities still now has yet to be elaborated, in addition, operating regulations of the existing outlet facilities has not been determined based on their actual outlet capacity. It is considered essential to establish operation rule covering the entire outlet facilities. In view of the above, it can be said that there is a need for exerting more efforts in improving the technical level of safety securing in view of the soft aspect of reservoir operation.

2. Overall goal of soft component

Overall goal of soft component is to be understood the technical knowhow on the setting method of limiting water level during flood period, the provision of basic knowledge and effects of reservoir operation by the staff of concerning agencies for EDWC. The outcomes (storage of information) are expected to make safety operation of limiting water level during flood period.

For this reason, the implementation of the soft component will contribute not only the safety of the reservoir in the future, but also the persistent effect of facilities rehabilitated in this project.

3. Outcome of soft component and its identification method

Outcomes expected from the above-mentioned soft component and their identification methods are summarized in the Table 6-1.

· Preparation for the determination of limit water level during flooding season to be applied to the management of East Demerara Water Conservancy

As means of enhancing safety level on the management of the dam from soft component point of view, it is considered effective to introduce the method for the control of stored water level by

establishing the limit water level during flooding season in multi-purpose dams or disaster prevention dams in Japan. In this soft component activity, technical introduction on how to establish the water level in this method is scheduled, and collection of basic information for establishing it in future is to be practiced.

Table 6-1 Expected outcomes of soft component and its identification method

Outcomes	Contents	Identification method and the degree of attainment
Importance of setting limiting water level during flood period is understood from disaster prevention point of view, and basic data/info. will be collected for establishing the limiting water level.	Technical knowhow on the setting method of limiting water level during flood period and effects of reservoir operation is understood. Basic data/info. for analysis below toward setting of limiting water level shall be collected. -Hydrological analysis -Inflow/outflow analysis -Capacities of sluice facilities -Tidal analysis	To identify the degree of related engineers of Guyana side on the technical knowhow on safety operation of the reservoir through setting limiting water level during flood period. This shall be done in the group discussion organized for issues designed for particular purpose.

4. Activities of soft component (input plan)

The soft component consists of technical transfer on the method of establishing limiting water level during flooding season at disaster prevention dams and basic information collection for elaborating the water level. Each of these activities will be performed through the direct assistance of a staff of Japanese consultant per each subject.

Table 6-2 Plan of soft component activities

Achievement	Target group	Method	Resource	Product
Importance and establishing method of determining the limiting water level during flooding season are understood from disaster prevention point of view, basic information for elaborating the determination of this level.	Technical staff of NDIA	A brochure is provided in which the determining method and the significance of the limiting water level to be applied to disaster prevention dams, and introduce it to NDIA staff in workshops to facilitate their understanding. Basic information is collected through referring to the related reports published by the divisions/ department of NDIA in charge of related information, by those of other related ministries/agencies, or by the dam adaptation project (World Bank) supported by the counterpart staff of NDIA.	Consultant responsible for construction supervision (directly assisting type) 2.3 M/M	Brochure in which the determining method and the significance of the limiting water level to be applied to disaster prevention dams, basic information for making effort to establish the water level.

The followings show the contents of each activity and working days.

Support program	Activity	Target group	person in charge	Contents of activity	Working day	
					Japanese	C/P
Introduction of establishing method of determining the limiting water level during flooding	Preparation in Japan		Japanese expert	Review of soft component plan, Make activity plan	3.0	
				References/collection of data	7.0	
	Total (Japan)				10.0	
	Preparation in Guyana		Japanese expert	Discussion for contents of activity Coordination of the schedule	3.0	
	Provide brochure		Japanese expert	Making brochure including operation system and method for the limiting water level during flooding season	37.0	
	workshop	Technical staff of NDIA	Japanese expert, Counterpart (C/P)	Making data for workshop, Hold workshop (Introduction for safety dam operation and management system with the limited water level)	5.0	5.0
	Data collection	NDIA, concerning agencies of government	Japanese expert, C/P		15.0	15.0
	Total (Guyana)				60.0	20.0

5. Method of procuring resources for implementing the soft component

Direct assistance by Japanese consultant who is engaged in the construction supervision of this Project is proposed as the resources for providing soft component. The reasons why this is proposed are as follows:

・East Demerara Water Conservancy has a high ratio of water storage surface to its catchment area, and it has a specific condition, i.e., most area inside the dam is occupied by floating

islands which absorb and release rainwater like a sponge. It follows that it is appropriate for a Japanese consultant who is engaged in the construction supervision with an ample recognition on this specificity to be in charge of the soft component for transferring techniques.

・In order to ensure the safety of the dam and downstream in Japan, operation and management system is applied to control by the limited water level during a large-scale flooding. Accordingly, a Japanese consultant is considered suitable for introducing this Japan's dam operation and management system to Guyana.

6. Implementation schedule of soft component

The preparation for revising managing regulations of outlet facilities is scheduled during rainy season. The implementation schedule of soft component is summarized in the following table. Number of months required to cover the soft component is totaled at 2.3 months for the preparation for revising managing regulations of outlet facilities.

Contents of Soft Component	person in charge	2014									2015		
		Oct			Nov			Dec			Jan		
		10	20	30	10	20	30	10	20	30	10	20	30
[Introduction of operation and management method by the limiting water level during flooding]	Japanese expert												
Preparation in Japan													
Making brochure concerning operation system													
Operation and Management Concept													
Method of setting of the limiting water level													
Actual operation example													
Operation system/necessary equipment													
Accidents/ the enhancement of safety of dam													
Workshop (one time)													
Basic data/collection of information													

note: color portions from November to January are in rainy season

7. Products of soft component

Products of this soft component are shown below.

Classification	Name of references/ title of activities	Contents	No. of pages
Brochure / Guideline (in English)	[Introduction of the dam management through the establishment of the limiting water level during flooding season] Introduction of method/ significance of establishing limiting water level for disaster prevention dams Collection of basic information	・Provision of a brochure for the introduction of the method of determining the water level and its significance ・Compilation of basic data/ information	20
Report	Report of completion (in English, in Japanese)	・Activity plan and actual performances Brochure introducing method/ significance of establishing limiting water level of disaster prevention dams, ・Degree of achieving activities/ targeted fruit ・Factors influencing the degree of achievement ・Tasks to hereafter achieve / proposals	30
References of presentation	References distributed to the participants of workshops	・References explaining the method of determining the limiting water level for disaster prevention dams	20

8. Cost of soft component

To be borne by the Guyana side:

・Personnel cost and the cost required for preparing training facility : 400

Total：400 US$ (about 400 thousand Yen)

＊Conditions of the cost estimation

Period of the estimation; March 2013

Currency exchange rate; 1.0 US$=99.38 ¥

9. Responsibility of the executing agencies of the counterpart country

Responsibility of Guyana in terms of the implementation of the soft component is as follows:

- To procure personnel and training facility necessary for implementing the soft component,
- To bear personnel cost and the cost for procuring training facility required for the soft component activities,
- In collecting basic information for establishing limiting water level during flooding season, to cooperate with the collection as the part of Guyana,
- Provided that further requirement of consolidation of measurement system arises from a result of collecting basic information for establishing limiting water level during flooding season, to provide necessary preparation for the consolidation and thereafter measurement practice.

Appendix -7. Notes of Interviews

1. Courtesy call and meeting to/with NDIA

(1) General

Date; March 5th, 2013

Place; NDIA office

Attendance; Mr. Lionel Wordsworth (Chief Executive Officer, NDIA)
Mr. Surendra Shingh (Engineering Coordinator, NDIA)
Mr. Kohei Sato (Team Leader of the JICA mission)
Mr. Hayakazu Yoshida (JICA agent)
Mr. Haruo Hiki (Survey team member, Sanyu Consultant Inc.)
Mr. Shinta Ishida (Survey team member, Sanyu Consultant Inc.)

(2) Contents of the meeting

・Mr. Sato explained the purpose of the implementation review survey and the condition of the review works being done within the amount of the budget already agreed and fixed between Japan and Guyana; and the explanation was accepted by NDIA.

・Mr. Hiki explained the three subjects of the survey; the first one is to grasp the change of site conditions brought from the Hop/Dochfour Drainage Channel construction project, the second one is to grasp the influence of the price rise during these two years' delay of the start of construction, and the last one is to review the contents/targets of the rehabilitation where maximum efforts shall be made not to decrease the contents/target of the rehabilitation through reviewing the design or construction methods. His expression was accepted by NDIA.

2. Meeting with Mr. Surendra Shingh

(1) General

Date; March 11th, 2013

Place; NDIA office

Attendance; Mr. Surendra Shingh (Engineering Coordinator, NDIA)
Mr. Haruo Hiki (Survey team member, Sanyu Consultant Inc.)
Mr. Shinta Ishida (Survey team member, Sanyu Consultant Inc.)

(2) Contents of the meeting

・Explanation on the survey achievement in the previous week

1) It seems necessary for the Ann's Grove Intake to be newly constructed on the right bank side of the Hope/Dochfour drainage channel as the existing main canal line is cut by the drainage channel just after its outlet mouth before reaching its command area.

2) Considering the rehabilitation purpose of the Sarah Johanna to increase the drainage capacity, the narrow concrete flume which functions as the pasture of the wooden bridge in front of the entrance of

Barama Company has the first priority of rehabilitation here.

3) There are two functions in the revetment work. One is to support the embankment that tends to slide, and the other is to protect the embankment slope against erosion. In Maduni Sluice, the revetment work has already decayed and the embankment slope surfaces are exposed; but these steep slopes have no collapse so that how to protect the slope against erosion is only to be considered. One idea is to make the steep slope gentle and provide a protection work on it.

4) In case of the embankment/bank slope being stable such as the Maduni Sluice, the only matter to be considered is the slope protection; even if the revetment is applied, a large and firm revetment structure is not necessary, and also other kinds of protection works are applicable.

・Mr. Surrender's request

1) Summarize the survey result on a table together with the consultant's recommendation.

2) The rehabilitation idea of providing the slope protection work in the Maduni Sluice should be shown together with an illustration.

3. Meeting with Mr. Samuel La Fluer

(1) General

Date; March 14th, 2013

Place; NDIA office

Attendance; Mr. Samuel La Fluer (Secretary of EDWC)

Mr. Haruo Hiki (Survey team member, Sanyu Consultant Inc.)

(2) Contents of the meeting

・Mr. Hiki's opinion at this moment

1) The Shanks Intake seems to have the problem of the leakage caused by piping phenomena soon. The line of step caused by depression or sliding makes the embankment look unstable at the right side of the intake. It would be necessary for the intake to be rehabilitated thoroughly including the surrounding embankment.

2) To rehabilitate the existing Ann's Grove Intake has lost the significance. But the problems of leakage around the intake structure and the unstable embankment exist, that would be harmful for the stability of the bund here so that the existing intake structure should be taken off, the complete bund should be constructed there, and the unstable embankment at the left side of the intake should be rehabilitated.

3) The Hope Intake looks stable at this moment but should be rehabilitated or improved regarding the short conduit length that caused leakage problems several times in the past.

4) The Annandale Intake has the longer length of the conduit (dam crest) than other intakes and any tendency of leakage is not found around the structure. The conservancy side slopes look stable and the revetment works look old but no deteriorated condition is found. At the downstream (outlet mouth) side, wider and taller concrete walls than other intakes are provided to the intake structure, and the

bank/embankment slopes behind the decayed revetment are stable covered by trees and grasses. Therefore, it is difficult to find any portion that requires the rehabilitation, i.e. the priority of conducting rehabilitation works to the Annandale Intake is low.

・Mr. Samuel's opinion to Mr. Hiki's opinion

1) The Shanks canal network is the biggest and the most important one in the Mahaica region and because the Shanks Intake has had repeated troubles of the leakage and the unstable embankment conditions caused by piping phenomena, it is significant to rehabilitate the intake structure thoroughly.

2) The idea of taking off the existing intake structure and replacing it by the stable embankment is appropriate.

3) The judgment to the Hope Intake that the rehabilitation is required is appropriate.

4) The opinion of not recognizing the necessity of rehabilitation to the Annandale Intake is agreeable.

4. Interview to Mr. Brodo

(1) General

Date; March 14th, 2013

Place; Flagstaff office, EDWC

Interviewee; Mr. Brodo (Flagstaff office staffer)

Interviewer; Mr. Haruo Hiki (Survey team member, Sanyu Consultant Inc.)

(2) Information from Mr. Brodo

・Almost all the piles in the conservancy were driven into the ground by the bucket of the excavator sitting on the pontoon.

・Piles were kept vertical by another excavator sitting on the pontoon and catching the top of the pile.

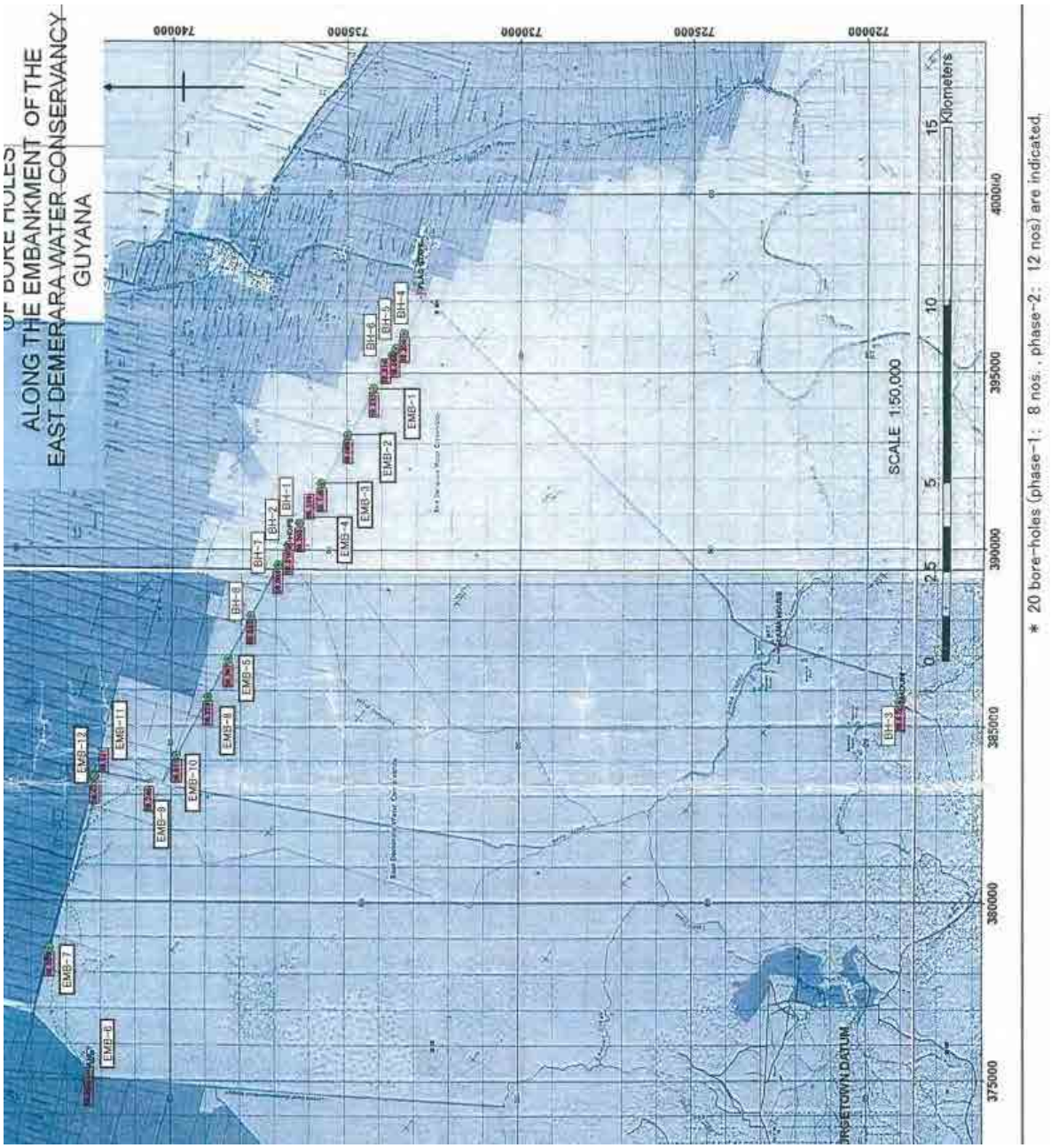
・The positions of the two excavators were fixed by anchors.

Appendix -8. Examination of revetment work

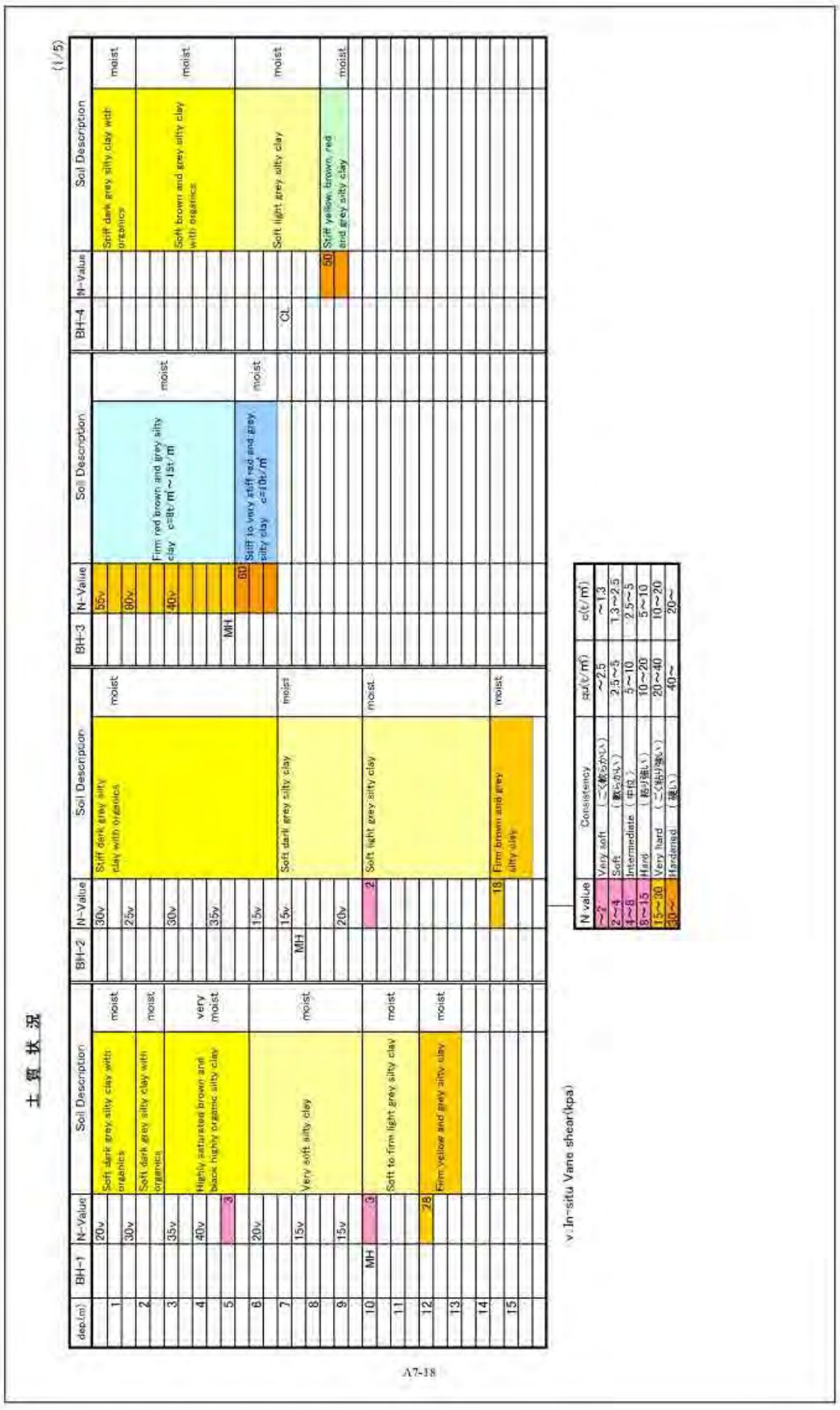
8-1 Results of Survey

From the drilling investigation in the past, the results of each survey site are shown below. Quoted from "Preparatory Survey (I) on the Rehabilitation of East Demerara Water Conservancy in 2009".

(1) Location Map of Drilling Investigation



(2) Results of Drilling Investigation



dep.(m)	BH-5	N-Values	Soil Description		BH-6	N-Value	Soil Description		BH-7	N-Value	Soil Description		BH-8	N-Value	Soil Description	
		30v	Soft dark grey silty clay with organics c=4t/㎡～13t/㎡	moist			Soft grey silty clay with organics	moist		30v	Soft dark grey silty clay with organics	moist		30v	Soft dark grey silty clay with organics c=3.3t/㎡～5t/㎡	moist
1										15v				15v		
2		35v														
3		30v								25v				29v		
4																
5		25v								15v				15v		
6		30v								15v				15v		
7													CL			
8		50v			MH		Firm light grey silty clay	moist		15v				15v		
9		90v								20v				20v		
10	MH	90	Stiff yellow red brown grey silty clay	moist		20	Very stiff red yellow and grey silty clay	moist		20	Very stiff red brown and grey silty clay	moist				
11																
12																
13																
14														5	Soft light grey silty clay	moist
15														15	Stiff yellow brown and grey silty clay	moist

N value	Consistency	qu(t/㎡)	c(t/㎡)
～2	Very soft	～2.5	～1.3
2～4	Soft	2.5～5	1.3～2.5
4～8	Intermediate	5～10	2.5～5
8～15	Hard	10～20	5～10
15～30	Very hard	20～40	10～20
30～	Hardened	40～	20～

dep.(m)	EMB-1	N-Value	Soft Description		EMB-2	N-Value	Soft Description		EMB-3	N-Value	Soft Description		EMB-4	N-Value	Soft Description	
						60v								0v		
1						50v								40v		
2												moist				
3						55v								35v		
4			Soft dark greenish black highly organic silty clay and fibrous matter	moist			Soft dark greenish black highly organic silty clay and fibrous matter: c=5t/㎡～10t/㎡	moist		2	Soft dark brown highly organic silty clay and fibrous matter			20v	Soft dark greenish black highly organic silty clay and fibrous matter c=4t/㎡～8.4/㎡	moist
5																
6						40v								20v		
7																
8						30v				35		moist		15v		
9							15 Firm brownish greenish dark grey silty clay	moist		43	Firm reddish brown silty clay			50v		
10		15	Very stiff dark brown silty clay	moist												
11															Firm reddish dark brown silty clay	moist
12																
13																
14																
15														22	Dark brown silty clay	

N value	Consistency	qu(t/㎡)	c(t/㎡)
～2	Very soft	～2.5	～1.3
2～4	Soft	2.5～5	1.3～2.5
4～8	Intermediate	5～10	2.5～5
8～15	Hard	10～20	5～10
15～30	Very hard	20～40	10～20
30～	Hardened	40～	20～

dep.(m)	EMB-5	N-Value	Soil Description		EMB-6	N-Value	Soil Description		EMB-7	N-Value	Soil Description		EMB-8	N-Value	Soil Description	
1		30v	Soft dark greenish black highly organic silty clay and fibrous matter,damp c=4t/㎡~10/㎡	moist			Soft dark brown highly organic silty clay and fibrous matter	moist			Soft dark greenish black highly organic silty clay and fibrous matter	moist			Soft dark brown highly organic silty clay and fibrous matter	moist
2		30v														
3		30v											CH			
4																
5		25v														
6		30v											CH		Firm greyish greenish light brown silty clay	moist
7							Firm brownish grey silty clay	moist								
8		60v														
9		32								30				22	Firm greyish greenish light brown silty clay	moist
10			Firm reddish grey silty clay	moist	CH						Firm greenish brownish light grey silty clay	moist				
11																
12						30										
13							Firm greenish brownish grey silty clay	moist								
14																
15																

N value	Consistency	qu(t/㎡)	c(t/㎡)
~2	Very soft	~2.5	~1.3
2~4	Soft	2.5~5	1.3~2.5
4~8	Intermediate	5~10	2.5~5
8~15	Hard	10~20	5~10
15~30	Very hard	20~40	10~20
30~	Hardened	40~	20~

A7-21

(5/5)

dep.(m)	EMB-9	N-Value	Soil Description		EMB-10	N-Value	Soil Description		EMB-11	N-Value	Soil Description		EMB-12	N-Value	Soil Description	
		50v	Soft dark greenish black highly organic silty clay and fibrous matter,damp c=5t/㎡~8.5t/㎡	moist			Soft grey silty clay	moist		40v	Soft dark greenish black highly organic silty clay and fibrous matter c=5t/㎡~9.0t/㎡	moist		45v	Soft dark grey silty clay	moist
1		30v								55v				65v		
2																
3		30v								45v				70v		
4																
		30v			CH					30v			CH	30v		
5							Soft brown silty clay	moist								
6		30v								30v				20v		
7																
		45v														
8										30v				20v		
9		32				17	Firm greyish brown silty clay	moist		23			CH			
			Firm dark grey silty clay								Firm dark greyish green silty clay					
10															Soft dark grey silty clay	moist
11																
12															Firm dark grey silty clay	
13																
14																
15														23		

N value	Consistency	qu(t/㎡)	c(t/㎡)
~2	Very soft	~2.5	~1.3
2~4	Soft	2.5~5	1.3~2.5
4~8	Intermediate	5~10	2.5~5
8~15	Hard	10~20	5~10
15~30	Very hard	20~40	10~20
30~	Hardened	40~	20~

8-2 Design Prameter

8-2-1 [Preparatory Survey Report (I) on the Rehabilitation of East Demerara Water Conservancy in the Republic of Guyana in 2009]

The design paremeters of soil material are quoted from the above report.

(1) Outline

Based on the field survey results, which conducted by **"**Preparatory Survey Report (I) on the Rehabilitation of East Demerara Water Conservancy in the Republic of Guyana in 2009", the design soil parameters to be employed are determined in consideration of general ones. Unit weight of soil (γ) by reference to the "Standards of the Port and Harbor" and "Specification of the Highway Bridge" in Japan, and the relationship between the N-value and cohesion (C) are calculated by Mohr's formula(C = qu / 2). Unconfined compression strength shows as qu. The relation of N-Value and C is also confirmed by the "Design and Use of Sheet pile Wall in Stream Restoration and Stabilization Projects" and "Guidance for the Temporary works" in Japan.

(2) List of soil investigations and soil parameters designed

(i) Ann's Grove ～Hope

Ann's Grove Just Point	P1	BH1				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	8		24.15	2		24.15	12.2		9.8		24.15
Firm silty CLAY	13	14		28			170.7		13		170.7

	P2	EMB1				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	9	17	0	0					9	17	0
Firm silty CLAY	10	21		15	183		91.46	183	10	21	183

	P2	EMB2				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	0								0		
Firm silty CLAY	10		46.04	15		46.04	91.46		10		46.04

	P2	EMB3				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	7.3			3			18.29		0		18.29
Firm silty CLAY	10			38.5			234.8				234.8

	P2	EMB4				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY									0		
Firm silty CLAY	8		21.3			21.3			8		21.3
silty CLAY	15.8			21			128				128

Hope Just Point	P1	BH2				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	8	13	24.15			24.15			13	13	24
Firm silty CLAY	14.3			18			109.8		14	18	105

Ann's Grove						Calculation			Design adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	DEEP is adopted the Just point numbers, γ and C is adopted the								8	15	24
Firm silty CLAY	average or general numbers.								13	17	125

Hope						Calculation			Design adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	DEEP is adopted the Just point numbers, γ and C is adopted the average or general numbers.								11	15	24
Firm silty CLAY									14	17	125
Soft silty CLAY											

(ii) Annadale ～Nancy

	P2	EMB8				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	6	20	0	0					6	20	
Firm silty CLAY	10	19	0	22	53.42		134.1	53.42	10	19	53.42
Soft silty CLAY											

	P2	EMB9				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	8	20	36.42	0		36.42			8		36.42
Firm silty CLAY	10	19		34			207.3		9		207.3
Soft silty CLAY											

	P2	EMB10				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	8	16.5	0	0					8	16.5	
Firm silty CLAY	10		0	19			115.9		10		115.9
Soft silty CLAY											

	P2	EMB11				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	11	19	41.91	0					11	19	41.91
Firm silty CLAY	16		0	24			146.3		16		146.3
Soft silty CLAY											

Annadale, Nancy						Calculation			Design adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	DEEP is adopted the Just point numbers, γ and C is adopted the average or general numbers.								11	17	40
Firm silty CLAY									16	18	130
Soft silty CLAY											

(iii)3 Maduni

Maduni Just Point	P1	BH3				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	5.2	17	59.1						5.2	17	59.1
Firm silty CLAY	7			60	25.77		365.9	25.77	7		300
silty CLAY											

	P2	#10				Calculation			Adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	9	16.5	59.1						9	16.5	
Firm silty CLAY				18			150				150
silty CLAY											

Maduni						Calculation			Design adoption		
	DEEP	γ	C	N	S	C	N	S	DEEP	γ	C
Soft silty CLAY	DEEP is adopted the Just point numbers, γ and C is adopted the average or general numbers.								5.2	17	60
Firm silty CLAY									7	18	150
silty CLAY											

8-2 Review of soil parameter designed

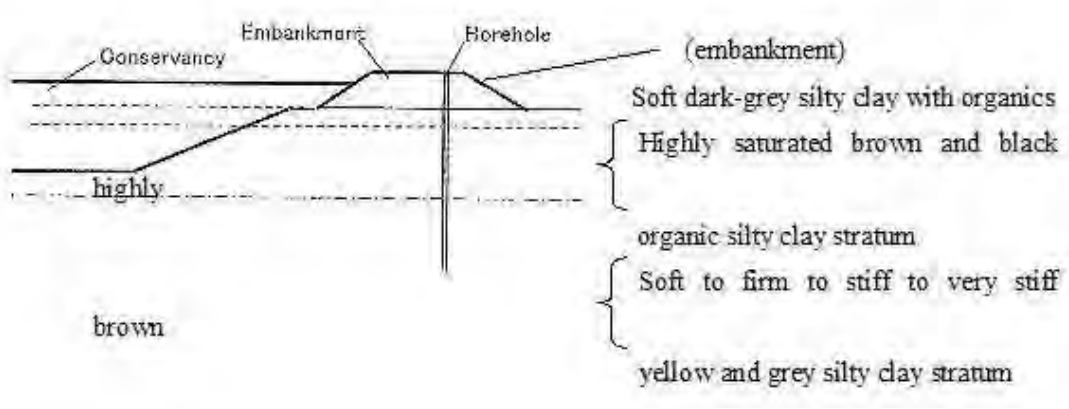
Soil parameters designed for the wooden pile revetment is reviewed as follows.

- The embankment for wooden pile revetment will be difficult to make enough compaction by the heavy construction machine, due to the narrow width of available area for the construction and, conceivably, the soft and weak soil for the embankment, which is taken the bottom of reservoir out. Therefore the possibility of less strength of soil on the fresh embankment shall be considered.
- To use the N-value which is taken from the inside of reservoir, is conceivable to underestimate the cohesion because of the less sample numbers and the wide discrepancy in soil condition between the disturbed and non-disturbed soil.
- Therefore the minimum cohesion in the surveyed area, which is assumed around the Hope intake, shall be applied the design cohesion to all of structures so as to secure the safe factor.
- Although the obtained unit weight of soil from the survey make more or less difference each other, the maximum value in the surveyed area shall be applied to the design so that the earth pressure value is large.
- Cohesive soil shall be defined the internal friction angle as zero "0" degree.

According to the above mention, the following design parameters shall be applied.

	Upper layer (Soft silty clay)	Bottom layer (Firm silty clay)
wet unit weight of soil γt (kN/m^3)	17	18
Cohesion c (N/m^2)	24	125

Quoted from “Preparatory Survey (I) on the Rehabilitation of East Demerara Water Conservancy in 2009”.



8-3. Revetment work

(1) Outline

Considering the secureness of the safety for reservoir, the wooden pile revetment with supported pile shall be applied, except for Sara Joanna. Sara Joanna shall be the stand-alone type of the wooden pile revetment.

The material of wooden pile and sheet pile shall use the Green Heart which is procured popularly in Guyana

(2) Applied code and specification

a) BS 8002 : Code of Practice for Earth Retaining Structures

b) THE GUYANA GRADING RULES FOR HARDWOOD TIMBER

Forest Department, Georgetown, Guyana, September 1977

c) Guidance for the temporary works in March, 1999

d) Refer to the " Design concept ", if any addition

(3) Material

a) Wooden pile and sheet pile

Strength Class：Greenheart D70 HS

Bending paralleled to grain ：23 N/mm2

Shear parallel to grain：2.6 N/mm2

Modulus of elasticity：21000 N/mm2

Safety factor：0.8

Table 1 Strength graded hardwoods assigned to BS EN 338 strength classes

Species	Strength class				
	D30	D40	D50	D60	D70
Balau					HS
Ekki				HS	
Greenheart					HS
Iroko		HS			
Jarrah		HS			
Kapur				HS	
Karri			HS		
Kempas				HS	
Keruing			HS		
Merbau			HS		
Oak *	TH1 THB	THA			
Opepe			HS		
Teak		HS			

* Note that the TH2 grade of oak does not meet the requirements for the D30 strength class. Designs using TH2 grade oak should be based on the grade stresses given in BS 5268-2 for the individual species and grade.

Table 2 Characteristic values for hardwood strength classes (BS EN 338)

Strength properties N/mm²	**D30**	**D40**	**D50**	**D60**	**D70**
Bending	30	40	50	60	70
Tension parallel to grain	18	24	30	36	42
Tension perpendicular to grain	0.6	0.6	0.6	0.7	0.9
Compression parallel to grain	23	26	29	32	34
Compression perpendicular to grain	8.0	8.8	9.7	10.5	13.5
Shear	3.0	3.8	4.6	5.3	6.0
Stiffness properties kN/mm²					
Mean MOE parallel to grain	10	11	14	17	20
5th percentile MOE parallel to grain	8.0	9.4	11.8	14.3	16.8
Mean MOE perpendicular to grain	0.64	0.75	0.93	1.13	1.33
Mean shear modulus	0.60	0.70	0.88	1.06	1.25
Characteristic density kg/m³	530	590	650	700	900

Table 3 Grade stresses and moduli of elasticity for hardwood strength classes for Service Classes 1 and 2 (BS 5268-2).

N/mm²	D30	D40	D50	D60	D70
Bending parallel to grain	9.0	12.5	16.0	18.0	23.0
Tension parallel to grain	5.4	7.5	9.6	10.8	13.8
Compression parallel to grain	8.1	12.6	15.2	18.0	23.0
Compression perpendicular to grain*	2.8 / 2.2	3.9 / 3.0	4.5 / 3.5	5.2 / 4.0	6.0 / 4.6
Shear parallel to grain	1.4	2.0	2.2	2.4	2.6
Modulus of elasticity Mean Minimum	 9500 6000	 10800 7500	 15000 12600	 18500 15600	 21000 18000
Average density kg/m³ at 20°C/65% RH	640	700	780	840	1080
* When specification excludes wane at bearing areas, the higher value of compression perpendicular to grain stress may be used, otherwise the lower values apply					

b) Steel

b-1. Anchor (tie-rod)

Tensile strength of Steel　F y ＝460N/mm^2

Allowable bending stress　f a = 0.9・F y = 0.9・460N/mm^2 = 414N/mm^2

b-2. Bolt-Nut(3.6）

Tensile strength of Steel　F y ＝180N/mm^2

Allowable bending stress　f a = 0.9・F y　= 0.9・180N/mm^2 = 160N/mm^2

(4) Design Method

1) External force

a. Overburden pressure :　W=3kN/m^2（crowd load ）

b. unit weight of water : γw=9.8kN/m^3

c. unit weight of water :r, cohesion :C, internal friction angle :φ

d. earth and water pressure, Overburden pressure

Pa = Ka (Σγh＋ q) - 2c√ka

Pp = Kp (Σγh’ ＋ q) + 2c√kp

Where,

Pa : Active earth pressure (kN/m^2)

Pp : Passive earth pressure (kN/m^2)

Ka : Coefficient of active earth pressure at the targeted point

Ka=tan^2（45°- φ/2）

Kp: Coefficient of passive earth pressure at the targeted point

Kp=tan2（45°+ φ/2）

ϕ : Shearing resistance angle of soil at the targeted point

Σ rh : Effective depth at the targeted point for active earth pressure (kN//m^2)

Σ rh' : Effective depth at the targeted point for passive earth pressure (kN//m^2)

γ : wet or unsaturated unit weight of soil at the targeted point (kN/m^3)

Unsaturated unit weight of soil shall be used, if the targeted soil is under the water

H : Each thickness of layer up to the targeted point for the active earth pressure (m)

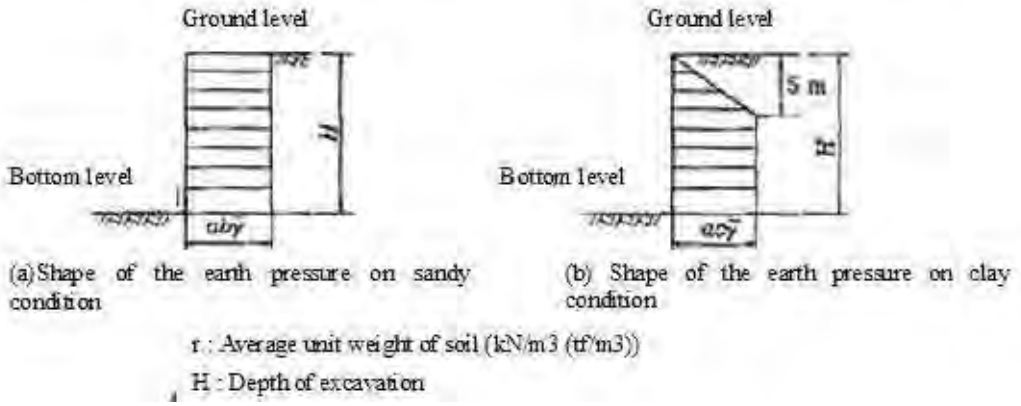
h' : Each thickness of layer up to the targeted point for the passive earth pressure (m)

q : Overburden at surface

c : Cohesion at the targeted point (kN/m^2)

e. Earth pressure for the calculation

Calculation for the retaining wall and anchor shall use as following formulation.



(a) Shape of the earth pressure on sandy condition

(b) Shape of the earth pressure on clay condition

r : Average unit weight of soil (kN/m3 (tf/m3))

H : Depth of excavation

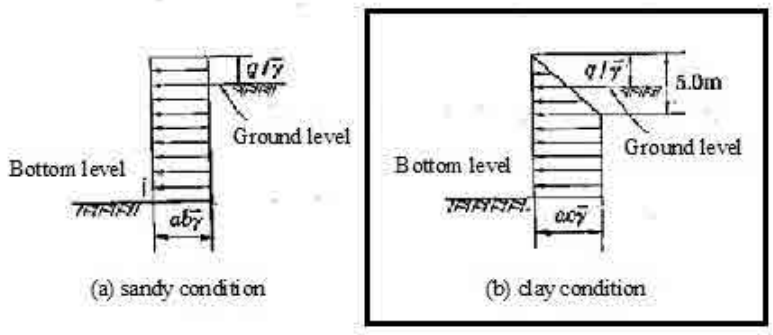
Coefficient for the excavation depth

$5.0m \leqq H$	$a=1$
$5.0m > H > 3.0m$	$a=\frac{1}{4}(H-1)$

Coefficient for the geological feature

b	c	
Sandy soil	Cohesive soil	
2	N>5	4
	N≦5	6

The loading weight on the ground and soil weight which is higher than top of the retaining wall shall be considered as following the converted soil depth, if the embankment is higher than the retaining wall.

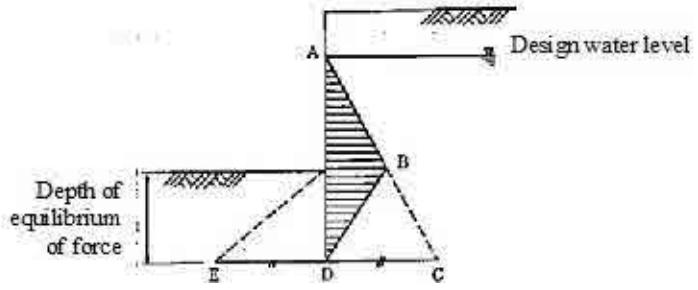


(a) sandy condition

(b) clay condition

f. Water pressure

The water pressure for the calculation shall be the hydrostatic pressure which is showed as following the triangular shape



2) Design Calculation

a. Minimum embedded depth for the main pile

The design for the embedded depth for the main pile shall consider of preventing from the settlement of the structure and embankment

Therefore the embedded depth shall be reached at the hard sandy stratum, even if the necessary embedded depth by the calculation is upper than the hard sandy stratum. In addition, the supported pile as well.

b. Stability of the embedded part against the earth and water pressure

b-1. Anchor type

The embedded depth shall be by the limit equilibrium method in which the depth of equilibrium of force is calculated the balance between the moment by active earth pressure and the resistance moment by reservoir As the condition of the minimum depth, the embedded depth shall secure the more than 1.5 meter against the bottom level of reservoir.

b-2. Stand alone type

The embedded depth shall be by the Chang method. However according to available range of this method, the embedded depth shall need more than the semi-infinite length, which length is defined same as $3/\beta$. But difference of displacement of pile head and bending moment between the case that embedded length of pile is $2.5/\beta$ and the case that embedded length is semi infinite, is a few percent. Therefore, embedded length (Lo) is calculated as $2.5/\beta$.

c. Cross section Calculation

c-1. Calculations of anchor and others

・Calculation of anchor

It is assumed that a sum of horizontal active horizontal load from sheet pile head to the balanced position, ΣH works on the wall surface supposed as a simple beam, then, anchor supports a half of this horizontal load as reaction force. Hence, relation between tensile force of anchor and the horizontal load is the following.

$$T = \Sigma H/2$$

$$f = T/As \leqq fa$$

Where,

Allowable tensile stress :	$fa = 0.9 \times Fy = 0.9 \times 460 N/mm^2 = 414 N/mm^2$
Tension strength of steel :	$Fy = 460 N/mm^2$
Tensile force of anchor :	T
Cross sectional area of anchor :	As

・ Calculation of Wooden pile

Soldier pile is assumed as a simple beam. ΣH is a sum of active horizontal load from sheet pile head to river bed. “w“ is a uniformly distributed load between anchor to river bed. Maximum bending moment is calculated with “w”.

$$W = \Sigma H/S, \quad Mmax = w \times S^{(2/8)}, \quad \sigma b = Mmax/z \leqq \sigma ba$$

Where,

A sum of active horizontal load:	ΣH
Distance between supports :	S
Uniformly distributed load :	w
Maximum bending moment :	Mmax
Bending strength of Greenheart Timber :	σb
Allowable bending stress :	$\sigma ba = 0.8 \times \sigma b$

・ Calculation of Waling

Load on waling is calculated with earth pressure for the decision of cross sectional area. Also, water pressure and topping load are considered. Load on the first waling is assumed to be shared by both upper and lower directions. Load on the second waling is assumed to be shared by the lower direction. Distance between supports, S is an interval of piles. Waling is considered as continuous beam. Maximum bending moment is calculated as the following.

$$Mmax = w \times s\text{^}(2/10)$$

・ Calculation of Earth retaining board

Load on board is calculated with earth pressure for the decision of cross sectional area. Also, water pressure and topping load are considered. Design distance between supports of earth retaining board, “s” is an interval of waling members. Maximum bending moment is calculated as the following.

$$Mmax = w \times s\text{^}(2/10)$$

・ Calculation of Stay pile

1. Embedded length, Calculation of cross sectional area, Displacement

Length of stay pile is calculated as the following form with the assumption of a pile of semi infinite length on the elastic bed. Required embedded length is to be ensured under the virtual ground level.

$$L = 2.5/\beta$$

in which

L : Required embedded length (m)

2.5 = Safety factor

β = Characteristic value (m^{-1})

$$Mm = 0.3224 \times H/\beta$$

Where,

L : Required embedded length (m)

Mm : Maximum bending moment (kN・m)

H : Horizontal force working on the stay pile (Tensile force of tie rod) (kN)

β : Characteristic value (m^{-1})

Displacement of stay pile at the attachment position of tie rod is calculated as the following.

$$\sigma = H/2EI\beta^3$$

Where,

σ : Displacement of stay pile at the attachment position of tie rod

H : Horizontal force working on the stay pile (Tensile force of tie rod) (kN)

E : Young modulus of stay pile (kN/m^2)

I : Second moment of area of stay pile (m^4)

β : Characteristic value (m^{-1})

2. Set position of Stay pile

Set position of stay pile follows a principle condition as shown the figure below. Hence, two sliding surfaces do not intersect under the level of tie rod. One is an active sliding surface beginning from the virtual bearing point on the earth retaining wall and extending upward of tie rod side of the wall. The other is a passive sliding surface beginning at the point that is located under the attaching point of tie rod on the stay pile. Depth of the beginning point is $1/\beta$ from the attaching point of tie rod. This sliding surface extends upward of tie rod side of the stay pile.

c-2. Self support type

・ Calculation of cross sectional area of pile

Bending moment used for calculation of cross sectional area of earth retaining wall acts the load on the back side of the wall. This load is calculated as below.

$$M = P/2\beta \times \sqrt{\{(1+2\beta h_0)^2+1\}} \exp[(-\tan^{-1}\{1/(1+2\beta h_0)\})]$$

in which

M : Maximum bending moment on the earth retaining wall (kN・m)

P : total force of lateral pressures (kN) This value is per unit width.

H_0 : Height from river bed to the working point of the total force (m)

β : Characteristic value (m^{-1})

(Unit of inverse trigonometric function in the above is radian.)

d. Calculation of Displacement

d-1. Anchor type

In anchor type calculation, displacement of stay pile is examined with a referential value. The allowable displacement is 3% of the height from river bed to pile head. Formula of Chang is applied to this calculation of the displacement.

d-2. Self support type

Displacement is calculated as following.

Allowable value of displacement is as below depending on the surrounding situations.

・ in the case there is facilities such as residential road.

→ Allowable displacement is 3% of height of earth retaining, H.

(σa = 0.03×H : Sarah Johanna)

Calculation of displacement of head point on earth retaining wall of self support type is shown as below.

$\sigma = \sigma1+\sigma2+\sigma3$

Where,

σ : Displacement of head point on earth retaining wall (m)

σ1 : Displacement on the river bed (m)

σ2 : Displacement with deflection angle on the river bed (m)

σ3 : Deflection of cantilever at the upper part than the river bed (m)

$\sigma1 = (1+\beta h0)\times P/(2EI\beta^3)$

$\sigma2 = (1+2\beta h0)\times P\times H/(2EI\beta^3)$

β : Characteristic value (m^{-1})

h0 : Height from river bed to the working point of the total force (m)

P : total force of lateral pressures (kN)

E : Young modulus of earth retaining wall (kN/m^2)

I : Second moment of area of earth retaining wall (m^4)

H : Depth of river bed (m)

$\sigma 3 = p_2' \times H^4/30EI$

p_2' : Load intensity on the river bed under the triangle distributed load converted as the moment is equivalent to the original loads (kN/m^2)

$p_2' := 6\Sigma M/H^2$

ΣM : Moment of rotation about axis on the river bed caused by lateral pressure (kN･m)

3) Examination against Heaving risk (Examination of earth retaining board)

Risk of heaving increases on the ground of thickly sediment with high water content cohesive soil such as Dilvial cohesive soil ground.

Ordinary, stability value Nb is applied to the determination of stability. In the case that Nb is under 3.14, examination against heaving risk can be omissible. When Nb exceeds 3.14, plastic region begins to develop from the corner on the river bed. If Nb is 5.14, destruction of river bed is supposed to arise.

$Nb = (\gamma \times H)/c < 3.14$

Length of earth retaining board is decided with the embedded length that done not have a heaving risk.

Appendix-9. Examination of Pile Foundation

9-1 Allowable axial bearing capacity per pile

Allowable axial bearing capacity per pile against ultimate bearing capacity, which is determined in consideration of ground conditions, construction methods etc., is calculated by the following formula to take into account the safety factor.

The following examinations pursuant to “Specifications for highway bridges (March 14, 2010) (Japan Road Association)” (hereinafter referred to as “the Specifications”).

$$Ra=\frac{\gamma}{n}Ru$$

Where, Ra: Allowable axial pushing bearing capacity at pile head (kN)

n: safety factor, bearing pile (ordinary; 3.0, at earthquake;2.0)

γ: coefficient of safety factor due to differences in ultimate bearing capacity estimation method,

Case of the bearing capacity estimation formula, γ = 1.0

Ru: ultimate bearing capacity of a pile determined from ground condition (kN)

Further, when the ultimate bearing capacity is calculated by the estimation formula, Ru can be calculated by the following formula.

$$Ru = q_d \cdot A + U \Sigma Li \cdot fi$$

Where, qd: ultimate bearing capacity per unit area at pile head (kN/m^2)

A: area of the pile edge (m^2)

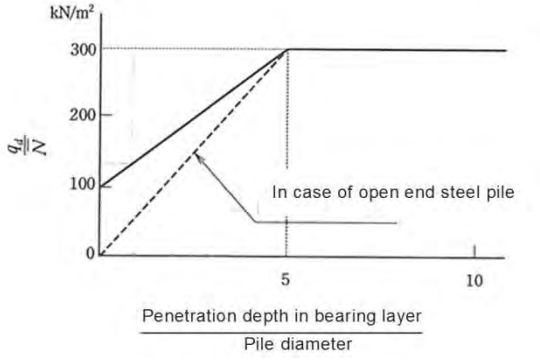
U: perimeter of the pile (m)

Li: thickness of the layer to be considered the skin friction (m)

fi: ultimate skin friction of the layer to be considered the skin friction (kN/m^2)

In case of driven pile, the ultimate bearing capacity at pile edge (qd) is estimated as follow.

When the penetration depth to the bearing layer is more than 5 times of pile diameter, the ultimate bearing capacity shall be expected at 300 kN/m^2.



The skin friction is only considered to the penetration depth into hard clay layer.

N-value inside of hard soil=18 (boring BH-2)

Penetration depth L=1.5m

The cohesion of the clay layer is calculated from the following formulas.

The equation of N-value and the cohesion;

Terzaghi qu = $qu=\frac{N}{0.082}$ and

The equation of unconfined compression strength and the cohesion;

since $qu=\frac{N}{0.082}$, $2c=\frac{N}{0.082}$

$c = N/(2\cdot 0.082)$

$= 18/(2\cdot 0.082)$

$= 109.7 kN/m^2$

The cohesion is to be adopted because of within 150kN/m^2 (driven pile method) of ultimate skin friction shown in the following table.

Ultimate skin friction (kN/m^2)

Method of execution	Chhensionless soil	Cohensive soil
Driven pile	2N (≦100)	c or 10N (≦150)
Bored pile	5N (≦200)	c or 10N(≦150)

The allowable axial bearing capacity per wooden pile is calculated as follows.

Item / pile	Lengh L (m)	Pene Depth (m)	Pene. Depth / Dia. Meter	qd N (kN/m2)	N-value N (times)	qd (kN/m2)	Area A (m2)	peri meter U (m)	fi (kN/m2)	ΣLi・fi (kN/m)	*2 U・ΣLi・fi (kN/p)	S.factor n	B.Capacity Ra=Ru/n (kN/p)
Hope Intake (BH-1, 2, 7)													
wood pile												3	311
φ355	13.00	2.5	7.04	300.00	20	6000	0.099	1.115	122	305.0	340	2	467
Shanks Intake (EMB-1, EMB-2, EMB-3)													
wood pile												3	311
φ355	9.00	2.5	7.04	300.00	20	6000	0.099	1.115	122	305.0	340	2	467

9-2 Arrangement of the pile

The loads of structure effect to both foundation and piles. When the subsidence of the foundation occurs, all the structure load is loading to the pile foundation. Therefore, when determining the necessary number of piles, it is considered the following load.

(i) structure load (weight of concrete and wooden piles)
(ii) weight of soil (Range to be loading to the structure)
(iii) weight of water (assume the water level in the canal, without considering the buoyancy acting on the structures)

(i) structure load

Concrete W = $65m^3 \times 24.5kN/m^3 = 1,593$ kN

(ii) weight of soil

Upper part of diversion canal Ws = $1.981 \times 4.572 \times 2.819 \times 17kN/m^3 = 434kN$

Upper part of base slab Ws = $(11.963 \times 4.267\text{-}2.59 \times 1.219 \times 2) \times 0.533 \times 2 \times 17kN/m3$
= 810kN

(iii) weight of water (assume that the water depth in diversion canal is full, water level; 1.219m)

Area of base slab at reservoir side A = $1/2 \times (4.394 +1.524) +1.524 \times 1.524 = 5.28m^2$

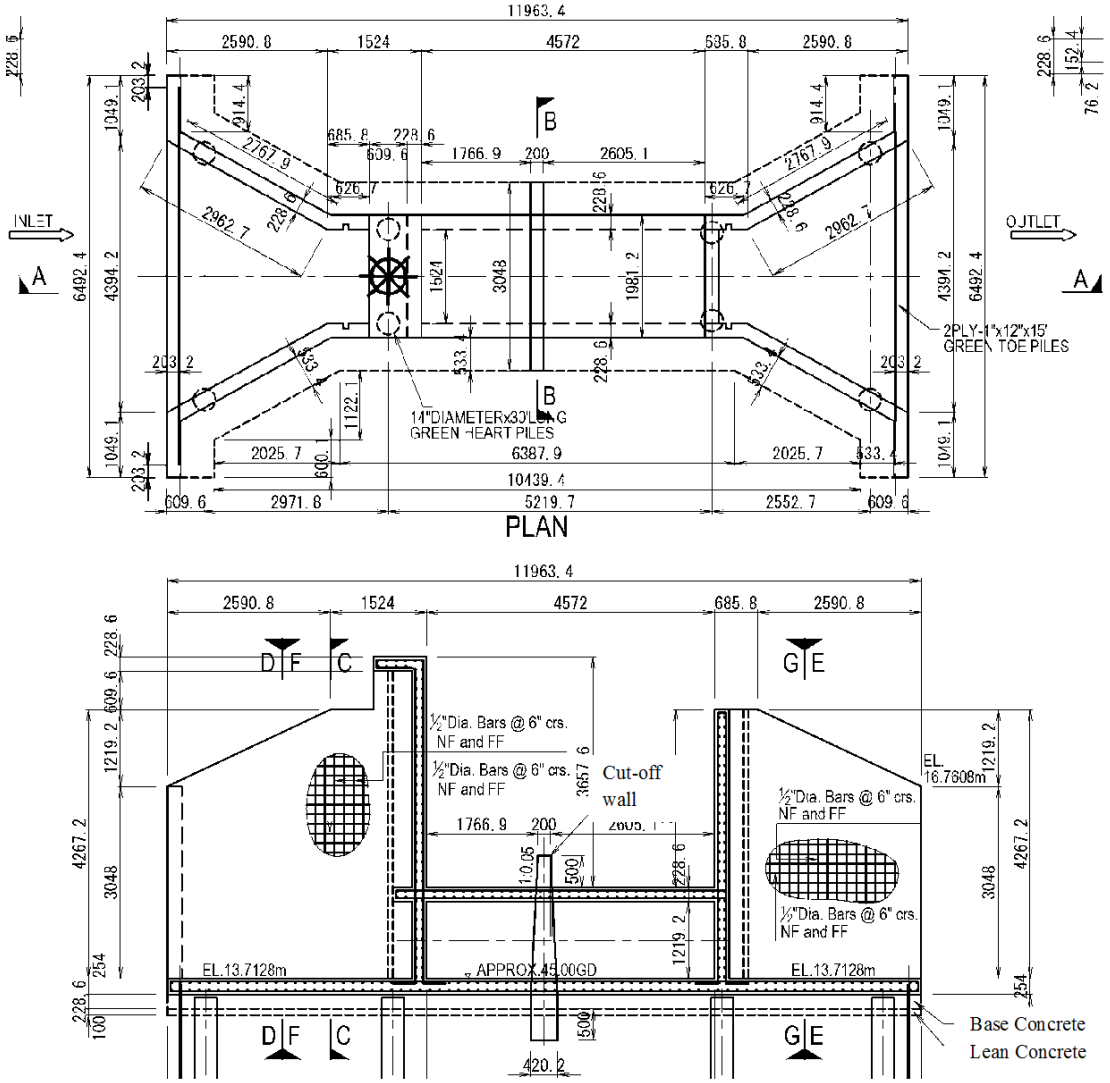
Area of base slab at downstream side A = $1/2 \times (4.394 +1.524) +0.685 \times 1.524 = 4.00m^2$

Reservoir, downstream side water weight W = $(5.28 +4.00) \times 1.219 \times 10.0kN/m3$

= 113kN

Water weight of inside of diversion canal W = $1.524 \times 1.219 \times 4.572 \times 10kN/m3 = 85kN$

Total weight of (i) +(ii)+(iii) = 1,593 +434 +810 +113 +85 = 3,035 kN



In case of the wooden pile of penetration depth at 2.5m in hard clay layer, as the allowable axial bearing capacity per pile is Ra = 311kN/pile, required number of piles is calculated the follows.

Required number of piles; n = 3035/311 = 9.8 ≒ 10 piles

Therefore, 10 wooden piles are placed in the foundation. Standard drawing for the intake facility in Guyana shows generally the eight (8) wooden piles with 15m each in the foundation, however, in consideration of workability and stopping at a high position of pile, it is cautioned to install the piles not too large penetration depth during construction.

As a result, the length of wooden pile shall be as follows.

Hope Intake: EL.13.728-0.254-EL.3.0 +2.5 m = 12.984 ≒ 13.0m/pile

Shanks Intake: EL.13.728-0.254-EL.8.0 +2.5 m = 7.974 ≒ 8.0m/pile

Appendix-10. Examination of Soil improvement and soil cement method

10-1 Soil improvement method

(1) Foundation treatment

The soil improvement method* shall be applied as the foundation treatment instead of the supporting pile method. In case of the structure requiring the water-tightness around it, the pile supporting system has a problem. The problem is that something like a void space appears when the soft ground settles down by the load of the embankment while the structure keeps its elevation due to the support of the pile (refer to the Fig.10-1 bellow). This void space becomes easily to be a large seepage path and invites the rise of piping phenomenon.

[Soil improvement method]

Soft grounds can be hardened by mixing the cement powder with soil that composes the soft ground. The process of the works by this method is as follows.

- Adjust the ground surface for the improvement work to be flat.
- Scatter the cement powder evenly on the ground surface (usually 50kg/m^3~100kg/m^3).
- Mix the cement powder into soil evenly to the depth of about 2m or 3m by the excavator.
- It takes about 3 days for the ground to become hardened.

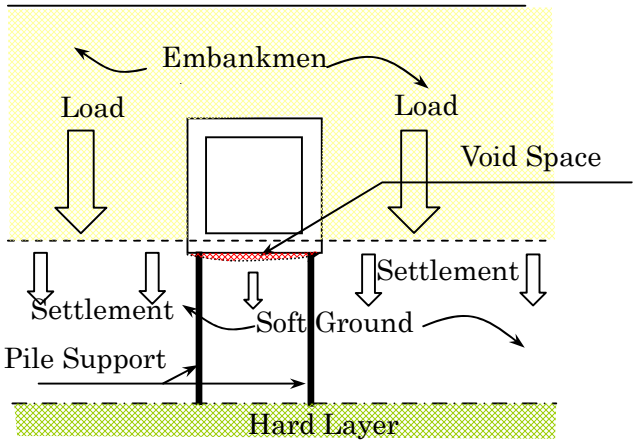


Fig. 10-1 Defect arising model in pile support

[Standard criteria for the approval of installing sluice gates/pipes on the bund]

In Japan, Ministry of Land and Transport prohibits to provide the sluice gates/pipes constructed on/in the bund with the pile support foundation treatment as described in “standard of permission for installing structures”. The following is the quotation of the related part of this standard:

Standard of installation to the site where measures are necessary;

① If it is installed at the site near the existing gates etc, such necessary measures shall be adopted for integrating the attached revetment with the existing ones etc.

② If it is installed at the site with poor subsoil or with past leakage records in embankment or foundation ground, sufficient leakage-preventive (staunching) measures are to be taken.

[Note on ②]

If it is installed at the site with poor subsoil, flexibility on deflection, standing capacity, safety on the occasion of earthquakes, durability of the caisson must thoroughly be examined to provide structures in which no cavity space appears between the water gate etc and the embankment

attributable to land subsidence, at the same time such defects as breakage of the caisson must be avoided. Similarly, If it is installed at the site of past leakage records in the embankment or the foundation ground, such water leakage avoiding means as mechanical astounding measures must be taken as well to do elaborated examination cavity formation around the caisson and identify prior to the work such trouble does not occur.

In this case, if such cavity formation is a concern at sluice gate (including sluice pipes) flexible structure/ structure with flexible sustention must be adopted, in addition, grout holes are to be installed so that treatment of cavity portion from inside the caisson can be made. In this occasion, sinkage must be regulated within the permissible range that does not affect the embankment and the body of caisson, by taking account of the length of caisson, the scale of section thereof, shape of sinkage distribution, deformation capacity of joint part, settling behavior of the foundation etc so that the discharge capacity is not affected by sedimentation inside the caisson, causing hindrance on O/M work, even though the caisson can flexibly adapt itself to the deformation of the foundation after the construction. In this connection, attention should be paid to that new construction and rehabilitation of sluice gates with pile (toe-supporting pile as well as friction supporting pile) foundation is prohibited. Also, in the case to couple with the existing sluice gates accompanying pile foundation structure, it is important to couple additional structure by means of coupling method other than pile structure taking this opportunity by surveying and taking measures against cavity formation.

(2) Scale of the soil improvement works

[Constructing condition and the analysis model]

Constructing conditions and foundation conditions are assumed as follows:

・Load condition

The newly constructed structure is placed on the foundation, open space, that is brought from the removal of the existing embankment. The structure is composed of a flume and a conduit of which surrounding portion is backfilled by soil cement. The load condition is assumed not to be changed because of the cancel effect between the minus factor of the embankment being replaced to an open channel or a conduit and the plus factor of the embankment being replaced to soil cement.

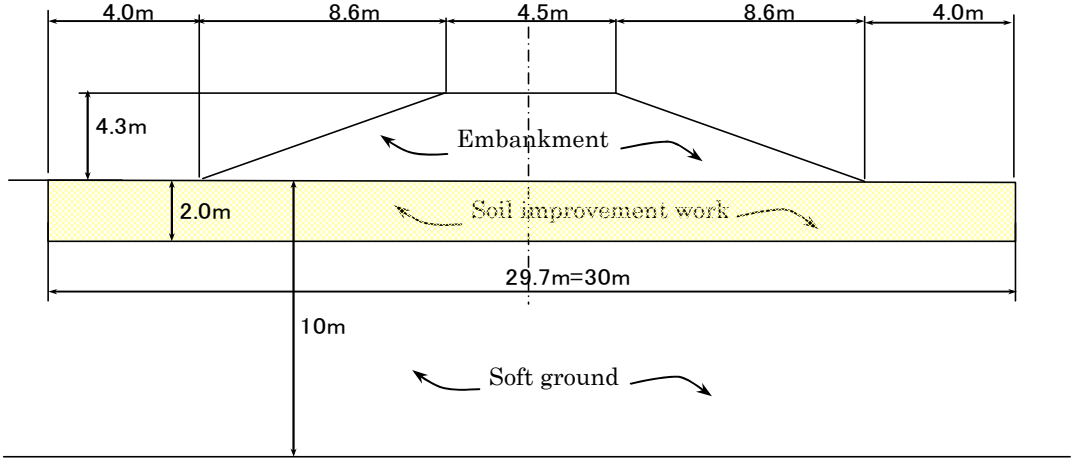


Fig. 10-2 Soil improvement work model

・Range of the soil improvement work

Based on the following study result and considering the difficulty level, the range of the soil improvement work is assumed to be 30m in the cross section length, 6m in width and 2.0m in thickness.

・Thickness and the physical properties of the soft ground

According to the Preparatory Survey Report (September 2011), five bore holes were drilled on the northern embankment near the Shanks Intake and the Hope Intake. Based on these results (see Table 10-1), thickness of the soft ground is evaluated to be 10m. The N value (the blow number of Standard Penetration Test) of this layer is also evaluated to be N = 1~2 from the following process.

; from Fig.10-4, $\tau_v=q_u/2$

; from Fig.10-5, at N=1: $q_u=80$, at N=2: $q_u=90 \rightarrow q_u=45\sim80N$, then $N=(1/45\sim1/80)\ q_u$

$\tau_v=q_u/2 \rightarrow q_u = 2\tau_v \rightarrow N=(1/45\sim1/80)\ 2\tau_v \rightarrow N=(1/22.5\sim1/40)\tau_v \rightarrow$from Table 10-1, N = 1~2

Based on the relationship between the deformation coefficient in the lateral loading test in bore holes and the N value (refer to Fig. 10-5), the deformation coefficient of the layer corresponding to the N value of 1~2 is estimated to be E=1000 KN/m^2. Then, based on the relationship between the deformation coefficient in the lateral loading test in bore holes and the deformation coefficient E_{df} of the plate loading test (refer to Fig. 10-6), E_{df} of the layer is estimated to be E_{df} =4000 KN/m^2.

In addition, the unit weight of the dam embankment is estimated to be 1.7t/m^3 (=1.7×9.8KN/m^3=1.7×10KN/m^3) as the general unit weight of organic soil.

Table 10-1 Survey results by bore holes

Depth	BH−1		BH−2		BH−7		EMB−3		EMB−4	
(m)	V	N	V	N	V	N	V	N	V	N
1			30		30					
2	30		25		15				40	
3	35		30		25					
4	40								35	
5		3	35		15			2	20	
6	20		15		15				20	
7			15							
8	15				15			35	15	
9	15		20		20			43	50	
10		3		2		20				
11										
12		28								

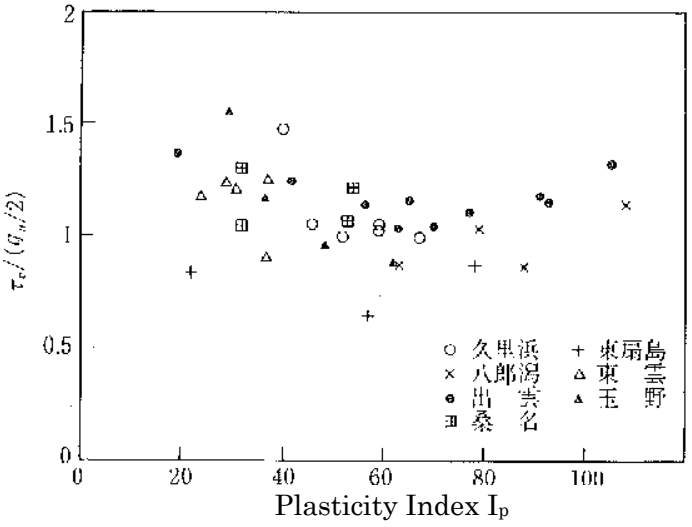


Fig. 10-3 Relationship between Vane shear strength and $q_u/2$

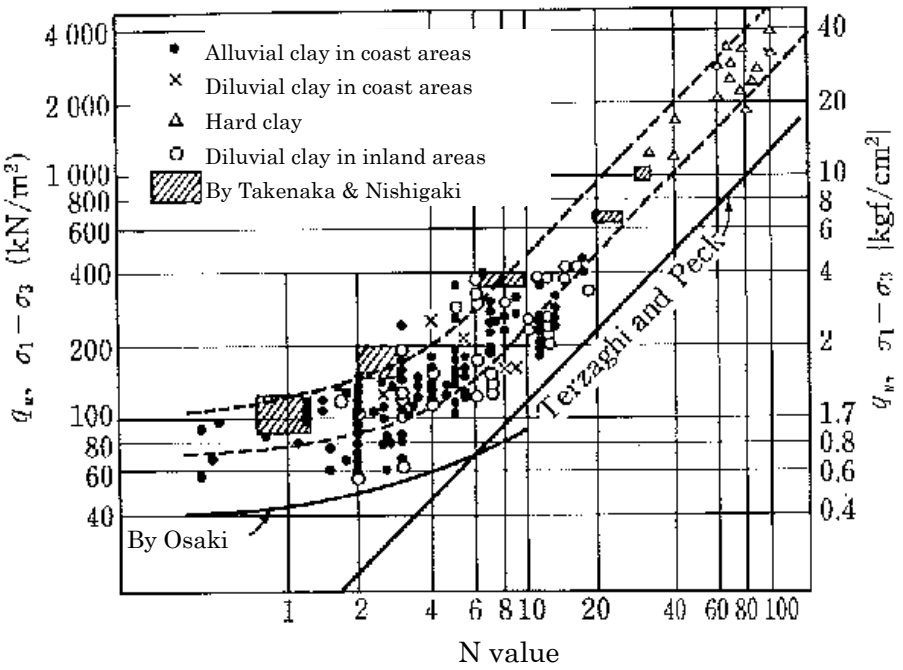


Fig. 10-4 Relationship between q_u and N-value

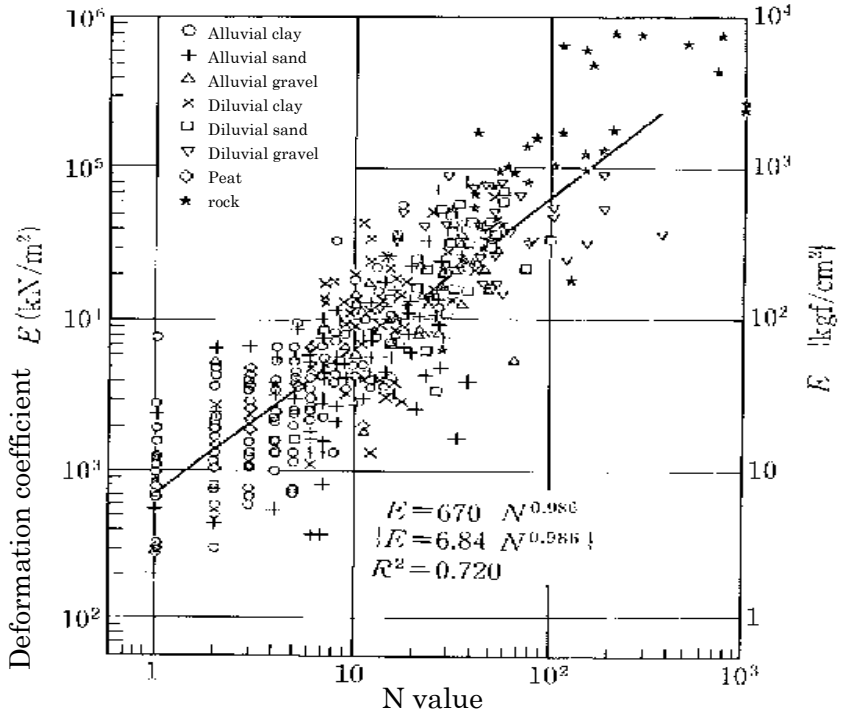


Fig. 10-5 Deformation coefficient by lateral loading test in borehole and N-value

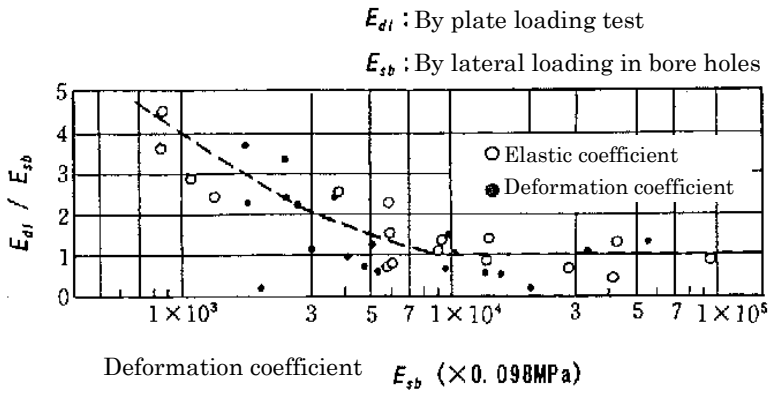


Fig. 10-6 E of the lateral loading test and E of the plate loading test

(Note: Fig. 10-3 - Fig. 10-6 are quoted from the Ground Survey Method (by Society of Foundation Engineering))

[Evaluation of behavior]

New intake facilities are installed on the foundation provided by excavating the existing embankment. The ground is rebounded and somewhat swollen by the liberation of stress produced by this excavation. The rebounded surface shall be settled down under the load of backfill brought around the structure after its installation. The deformation caused by this process shall be smaller due to the soil's elastic-cum-plastic property. Here, from the view point of safety side, the immediate settlement, i.e. the elastic deformation by the load, shall be estimated under the assumption of the ground being virgin to the load.

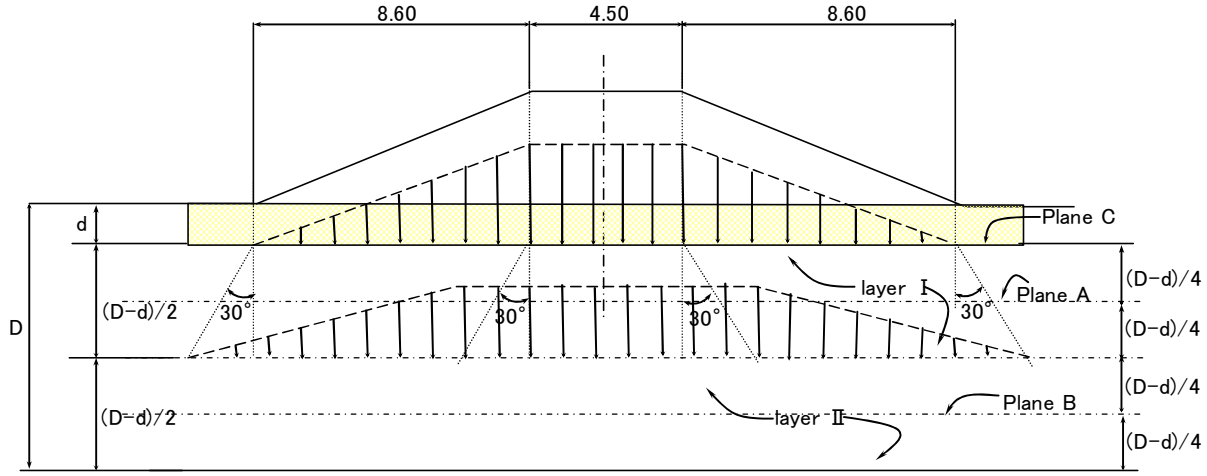


Fig.10-7 Illustration of the load dispersion and the settlement evaluation

・Load dispersion in terms of the cross-sectional direction of the embankment

Provided that the total reaction force after the range of the soil improvement work being extended by L meters is same as the one before its extension, this relation is expressed as follows:

$$(8.6/2+4.5+8.6/2)\times 4.3=\{(L+8.6)/2+4.5+(L+8.6)/2\}\times(4.3-H)$$

Here, after the replacement of $A=(8.6/2+4.5+8.6/2)\times 4.3$, $B=(L+8.6)/2+4.5+(L+8.6)/2$, the equation "$H=4.3-A/B$" is derived.

・Settlement on the axis of the embankment

Settlement is calculated at various L values of 2m, 3m and 4m, and d values of 1.0m, 1.5m, 2.0m, 2.5m and 3.0m. Calculation results shown in Table 10-2 suggest that the longitudinal extension of the improvement range and the consequent dispersion of load are effective to reduce the settlement. Also considering the settlement degree of 5 cm shown as the allowable value in the design guideline of the

flexible sluiceway (by National Land Technical Research Center, Japan), 4 meter shall be applied to the extension length of the improvement range to both upstream and downstream directions, and 2 meter shall be applied to the depth of the improvement range.

Table 10-2 Calculation result of the foundation settlement

layer Ⅰ Maximum settlement (L=2.0m)

D (m)	d (m)	① (D−d)/2 (m)	② (D−d)/4 (m)	A (m)	B (m)	H (m)	③ Load on Plane C(KN/m) 17×4.5×(4.3−H)	④ Dispersed load on Plane A(KN/m^2) ③/(4.5+②×2/1.732)	⑤ Deformation. Coefficient E (KN/m^2)	Max. settlement (m) ①×④/⑤
10.0	1.0	4.5	2.25	56.3	15.1	0.57	285.345	40.20	4000.00	0.045
10.0	1.5	4.25	2.125	56.3	15.1	0.57	285.345	41.03	4000.00	0.044
10.0	2.0	4	2	56.3	15.1	0.57	285.345	41.90	4000.00	0.042
10.0	2.5	3.75	1.875	56.3	15.1	0.57	285.345	42.81	4000.00	0.040
10.0	3.0	3.5	1.75	56.3	15.1	0.57	285.345	43.76	4000.00	0.038

layer Ⅱ Maximum settlement (L=2.0m)

D (m)	d (m)	① (D−d)/2 (m)	② (D−d)/4 (m)	A (m)	B (m)	H (m)	③ Load on Plane C(KN/m) 17×4.5×(4.3−H)	④ Dispersed load on Plane B(KN/m^2) ③/(4.5+②×6/1.732)	⑤ Deformation. Coefficient E (KN/m^2)	Max. settlement (m) ①×④/⑤
10.0	1.0	4.5	2.25	56.3	15.1	0.57	285.345	23.21	4000.00	0.026
10.0	1.5	4.25	2.125	56.3	15.1	0.57	285.345	24.06	4000.00	0.026
10.0	2.0	4	2	56.3	15.1	0.57	285.345	24.97	4000.00	0.025
10.0	2.5	3.75	1.875	56.3	15.1	0.57	285.345	25.95	4000.00	0.024
10.0	3.0	3.5	1.75	56.3	15.1	0.57	285.345	27.02	4000.00	0.024

layer Ⅰ Maximum settlement (L=3.0m)

D (m)	d (m)	① (D−d)/2 (m)	② (D−d)/4 (m)	A (m)	B (m)	H (m)	③ Load on Plane C(KN/m) 17×4.5×(4.3−H)	④ Dispersed load on Plane A(KN/m^2) ③/(4.5+②×2/1.732)	⑤ Deformation. Coefficient E (KN/m^2)	Max. settlement (m) ①×④/⑤
10.0	1.0	4.5	2.25	56.3	16.1	0.8	267.75	37.72	4000.00	0.042
10.0	1.5	4.25	2.125	56.3	16.1	0.8	267.75	38.50	4000.00	0.041
10.0	2.0	4	2	56.3	16.1	0.8	267.75	39.32	4000.00	0.039
10.0	2.5	3.75	1.875	56.3	16.1	0.8	267.75	40.17	4000.00	0.038
10.0	3.0	3.5	1.75	56.3	16.1	0.8	267.75	41.06	4000.00	0.036

layer Ⅱ Maximum settlement (L=3.0m)

D (m)	d (m)	① (D−d)/2 (m)	② (D−d)/4 (m)	A (m)	B (m)	H (m)	③ Load on Plane C(KN/m) 17×4.5×(4.3−H)	④ Dispersed load on Plane B(KN/m^2) ③/(4.5+②×6/1.732)	⑤ Deformation. Coefficient E (KN/m^2)	Max. settlement (m) ①×④/⑤
10.0	1.0	4.5	2.25	56.3	16.1	0.8	267.75	21.78	4000.00	0.025
10.0	1.5	4.25	2.125	56.3	16.1	0.8	267.75	22.57	4000.00	0.024
10.0	2.0	4	2	56.3	16.1	0.8	267.75	23.43	4000.00	0.023
10.0	2.5	3.75	1.875	56.3	16.1	0.8	267.75	24.35	4000.00	0.023
10.0	3.0	3.5	1.75	56.3	16.1	0.8	267.75	25.35	4000.00	0.022

layer Ⅰ Maximum settlement (L=4.0m)

D (m)	d (m)	① (D−d)/2 (m)	② (D−d)/4 (m)	A (m)	B (m)	H (m)	③ Load on Plane C(KN/m) 17×4.5×(4.3−H)	④ Dispersed load on Plane A(KN/m^2) ③/(4.5+②×2/1.732)	⑤ Deformation. Coefficient E (KN/m^2)	Max. settlement (m) ①×④/⑤
10.0	1.0	4.5	2.25	56.3	17.1	1.0	252.45	35.57	4000.00	0.040
10.0	1.5	4.25	2.125	56.3	17.1	1.0	252.45	36.30	4000.00	0.039
10.0	2.0	4	2	56.3	17.1	1.0	252.45	37.07	4000.00	0.037
10.0	2.5	3.75	1.875	56.3	17.1	1.0	252.45	37.88	4000.00	0.036
10.0	3.0	3.5	1.75	56.3	17.1	1.0	252.45	38.71	4000.00	0.034

layer Ⅱ Maximum settlement (L=4.0m)

D (m)	d (m)	① (D−d)/2 (m)	② (D−d)/4 (m)	A (m)	B (m)	H (m)	③ Load on Plane C(KN/m) 17×4.5×(4.3−H)	④ Dispersed load on Plane B(KN/m^2) ③/(4.5+②×6/1.732)	⑤ Deformation. Coefficient E (KN/m^2)	Max. settlement (m) ①×④/⑤
10.0	1.0	4.5	2.25	56.3	17.1	1.0	252.45	20.53	4000.00	0.023
10.0	1.5	4.25	2.125	56.3	17.1	1.0	252.45	21.28	4000.00	0.023
10.0	2.0	4	2	56.3	17.1	1.0	252.45	22.09	4000.00	0.022
10.0	2.5	3.75	1.875	56.3	17.1	1.0	252.45	22.96	4000.00	0.022
10.0	3.0	3.5	1.75	56.3	17.1	1.0	252.45	23.90	4000.00	0.021

・Check on the bearing capacity of the untreated foundation surface

According to the design guideline of the flexible sluiceway (by National Land Technical Research Center, Japan), the allowable vertical bearing strength of the foundation is given by the following equation:

$$q_a=(q_d-W_s/A)/F_s+W_s/A$$

Here q_a : allowable vertical bearing strength of the foundation surface (KN/m^2)

F_s : safety factor $F_s=3$; ordinary occasion

q_d : critical bearing strength of the foundation surface (KN/m^2)

; Estimation of the critical bearing strength q_d of the foundation :

Estimated N value of the untreated foundation surface : N=1

Then, Fig.10-4→q_u=80 kN/m^2=8 tf/m^2, Table 10-3→$q_d=3q_u=3\times8$tf/m$^2=3\times8\times9.8$ kN/m^2

$=235$ kN/m^2

Table 10-3 Standard value of marginal bearing capacity

Foundation type	Critical bearing strength q_d (tf/m^2), (kN/m^2)
Sand & gravel ～Sand (N≧30)	300 (3,000)
Sand & gravel ～Sand (10≦N＜30)	150 (1500)
Clay layer	$3q_u$ ($30q_u$)

A : Bottom area of the soil improvement work $A=6\text{m}\times30\text{m}=180$ m^2

W_s : Effective weight of soil corresponding to the soil improvement work

$W_s=(1.7-1.0)\times9.8\times180\times2=2470$ kN

From the above, $q_a=(q_d-W_s/A)/F_s+W_s/A=(235-2470/180)/3+2470/180=87.5$ kN/m^2

87.5 kN/m^2＞$1.7\times9.8\times(4.3-1.0^*)=55.0$ kN/m^2 (*Fig 10-3, Table 10-7; N=1.0)

Here, it is confirmed that the untreated foundation has the enough bearing capacity against the overburden load.

2) Specification of the soil improvement work

Based on the result of the in-situ cement mixing test carried out in “the Preparatory Study for the Improvement of Environment/Disaster Risk Management Program (August 2009)”, the mixing ratio of cement is determined. At that time, cement powder was mixed with clay excavated from the canal bottom. The test cases and the test results are shown in Fig. 10-8.

According to “the Ground Survey Method” published by Japanese Geotechnical Society, the relationship between cone index q_c and un-confined compression strength q_u is as shown in Fig. 10-9, where the equation “$q_c=4.19q_u+53.0$” is shown and the equation “$q_u=(q_c-53.0)/4.19$” is derived.

Based on the above, and also taking into account the in-situ test results and the following aspects, “cement mixing rate; 3 bags per 1.0m^3” is to be adopted.

・The mixing work was conducted in the storage bin on the pontoon or on the embankment surface in the last in-situ test. Therefore, the mixed materials were not influenced by the ground water. On the contrary, the mixing work of this time shall be conducted directly in the ground where groundwater level is high, so that the water-cement ratio would become higher than the ones in the last case and the strength of the produced materials would become in a lower level. It is necessary to consider a margin to the test results.

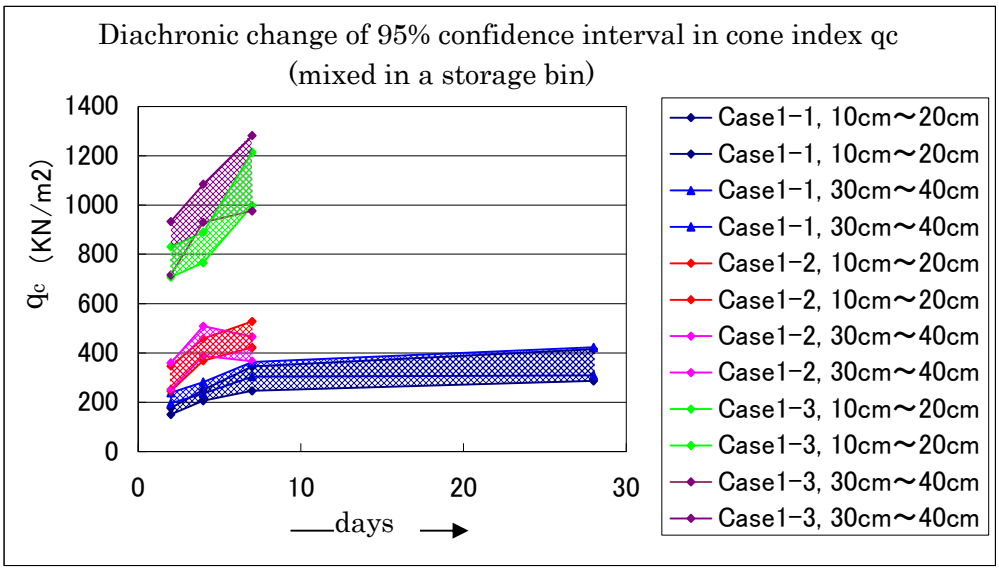
・In the above-mentioned mixing test, clay excavated from the canal bottom was used. This time, the

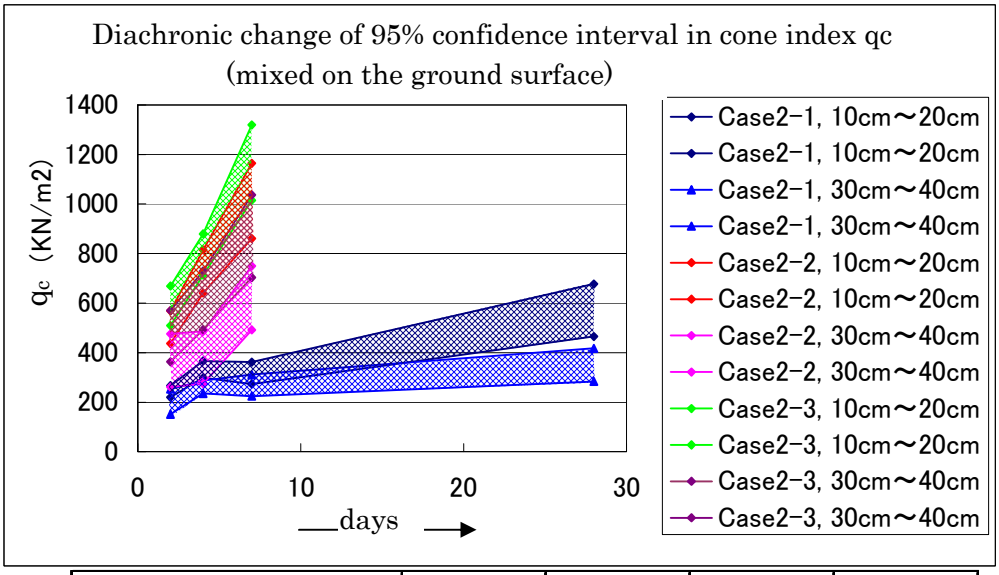
mixing shall be done directly in the ground where soils consist of organic materials, which lead the strength of the produced materials to a low level. It is necessary to consider a margin to the test results.

・Referring to Fig. 10-8, in case of the mixing ratio of 3 bags /m^3 of cement per 1.0m^3 of soil, cone index q_c=1000kN/m^2 can be expected. From the equation "$q_u=(q_c-53.0)/4.19$" shown above, the un-confined compression strength $q_u=(1000-53.0)/4.19=226$KN/m^2 can be expected. Then, the load level at Plane C in Fig.10-9 is estimated to be 43.2kN/m^2 as follows.

$$1.7\times9.8\times3.3+(1.7-1.0)\times9.8\times2.0=43.2\text{KN/m}^2$$

Here, the safety factor more than 3.0 is confirmed.





Cement quantity / Mixing method	zero	1 sack/m^3	2 sack/m^3	3 sack/m^3
mixing in a storage bin	case-0	case1-1	case1-2	case1-3
mixig on the ground		case2-1	case2-2	case2-3

Fig.10-8 in-situ mixing test of soil cement

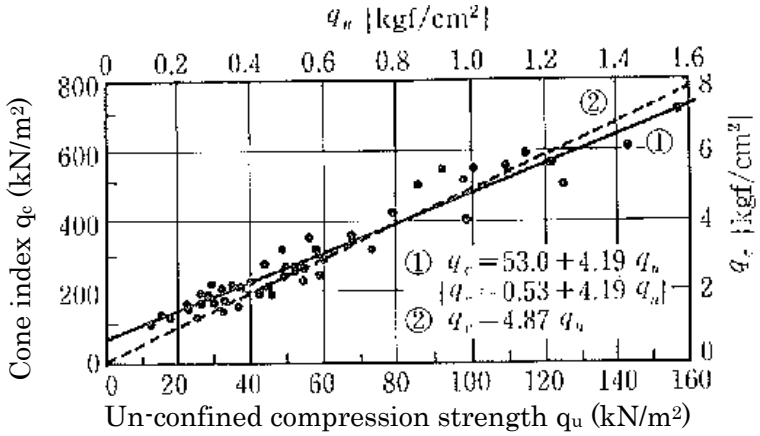


Fig. 10-9 Cone index q_c & un-confined compression strength q_u

10-2 Soil cement method

(1) Adoption of soil cement as the embankment/backfill material around the intake facilities

The embankment/backfill material around the intake facilities is required to equip with the following properties:

- To achieve high water-tightness between concrete surfaces of the conduit pipe and the retaining walls
- To be impermeable itself
- Not to need compaction（In the conservancy, it is difficult to obtain materials with satisfactory quality and suitable moisture content condition, moreover the ground is soft everywhere, and it is impossible to compact soils on the soft ground.）
- To have almost the same unit weight / volume as that of surrounding embankment (If the weight increases, additional settlement shall newly arise.)

Soil cement obtained by mixing the cement powder with soils can satisfy all these requirements listed above.

(2) Specification of the soil cement

Specifications of the soil cement is the same as soil improvement.

(3) Procurement of earth for soil cement at the sites

As regards soil cement, kneading test has been performed at the sites in "Preparatory Study on East Demerara Water Conservancy Rehabilitation (November 2009)" in which it has been identified that soil cement rich in viscosity can be manufactured by mixing cement powder with earth excavated from the canal bed inside the dam. Taking this into consideration, soil material mixed with cement powder is to be supplied from excavated earth obtained in each construction site or that from nearby canal bed. Also, mixing of cement powder with earth is as a rule to be performed by means of a backhoe or an ultra-long arm excavator within a mixing trough installed on a ship.

Ph.10-1 In-situ mixing test of Soil cement at the Preparatory study

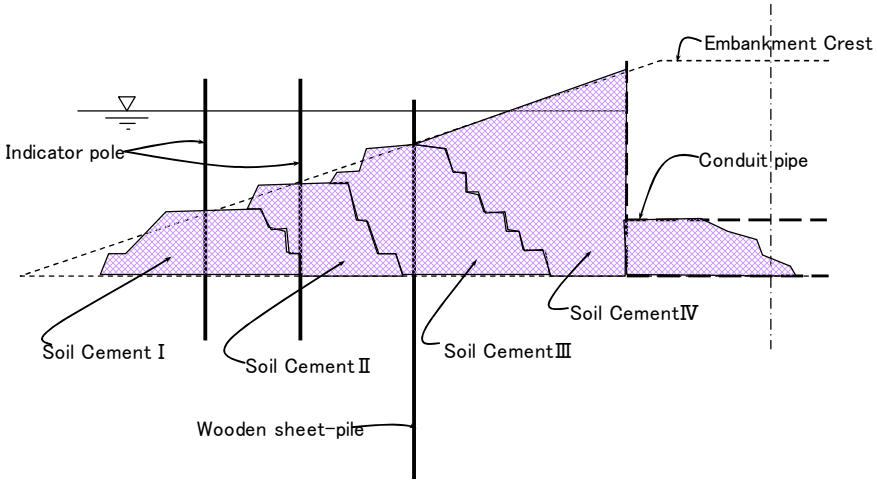
10-3 Disposal of the existing facilities

(1) Treatment of the Shanks, Ann's Grove, and Hope intake facilities

These existing intake facilities have the past experiences of repeated leakage due to the occurrence of piping and subsequent repeated repairs, so that the treatment to these facilities shall be adequately conducted to eliminate the occurrence of these events. It is the most complete way to remove these facilities and replace them with the embankment. However, for this it is necessary to enclose the work area by installing temporary sheet piles, which invites the high cost of construction. Consequently, the treatment shall be done as follows by the bury-and-chock method that utilizes the characteristics of soil cement, i.e. the water tightness and the solidification in water.

① To finish the backfill of soil cement with the mean slope inclination of 1 to 3.0 in the upstream side

- To drive wooden poles at the interval of 3m as the target of measuring, 8.1m forward from the upstream edge of the dam crest
- To mound soil cement (blending 1.5 bags of cement per $1m^3$ of soil) around the target poles till its top elevation reaching the level lower by 2.7m to the dam crest (Soil cement Ⅰ)
- To drive wooden poles at the interval of 3m as the target of measuring, 6.6m forward from the upstream edge of the dam crest
- To mound soil cement (blending 1.5 bags of cement per $1m^3$ of soil) around the target poles till its top elevation reaching the level lower by 2.2m to the dam crest (Soil cement Ⅱ)
- To install wooden sheet piles, with the top elevation higher than the water level and the length of 5m driven into the foundation, 4.6m forward from the upstream edge of the dam crest
- To mound soil cement (blending 1.5 bags of cement per $1m^3$ of soil) around the target poles till its top elevation reaching the level lower by 1.53m to the dam crest (Soil cement Ⅲ)
- To drain water between the sheet piles and the dam
- To fill soil cement (blending 3 bags of cement per $1m^3$ of soil) in the space between the sheet piles and the dam (Soil cement Ⅳ) and to finish the slope inclination to be 1 to 3.0



＊ The purpose of driving sheet piles 5m deep into the ground is to shut the seepage path that once might cause leakage problems.

＊ The vibration work by using the stick-type vibrator shall be conducted to the dam-side portion of soil cement Ⅲ and soil cement Ⅳ to make them dense and watertight.

② Conduit

As for the existing conduit, particular treatments shall not be applied except chocking it and letting it being covered and buried with fluid soil cement and leaving it lying in the site because such abnormal events as a depressive subsidence on the embankment crest attributed to leakage around it has never occurred.

③ To finish the downstream slope at the gradient of 1 to 2.5.

Soil cement shall be put from a storage bin on the pontoon onto the downstream space by the long-boom excavator and shall be shaped by the excavator positioned on the embankment.