DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
MAHAWELI AUTHORITY OF SRI LANKA (MASL)

PREPARATORY SURVEY
ON
MORAGAHAKANDA DEVELOPMENT PROJECT

FINAL REPORT

VOLUME I
MAIN REPORT

JULY 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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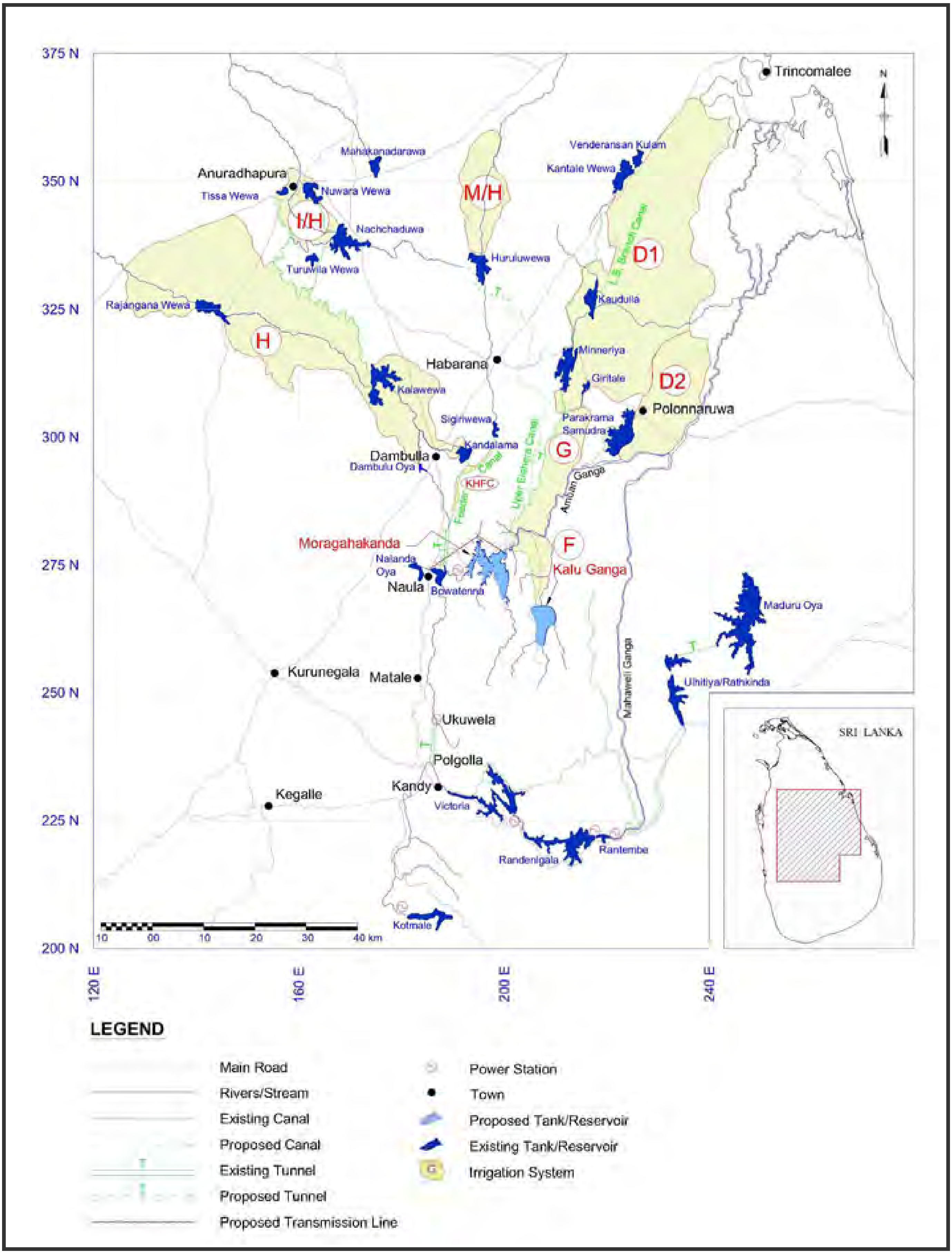
LIST OF VOLUMES



Preparatory Survey on Moragahakanda Development Project
Project Location Map

Photograph Documentation (1 / 4)

Date : Jan. 13, 2010
Place: MASL
Title: Inception Report Presentation

Date : Jan. 13, 2010
Place: MASL
Title: Inception Report Presentation

Date : Feb. 2, 2010
Place: Moragahakanda Dam Site
Title: Moragahakanda Project Office

Date : Feb. 2, 2010
Place: Moragahakanda Dam Site
Title: Amban Ganga Bridge

Date : Feb. 2, 2010
Place: Moragahakanda Dam Site
Title: Saddle Dam No.2

Date : Jan. 19, 2010
Place: Moragahakanda Dam Site
Title: Site reconnaissance by experts

Photograph Documentation (2 / 4)

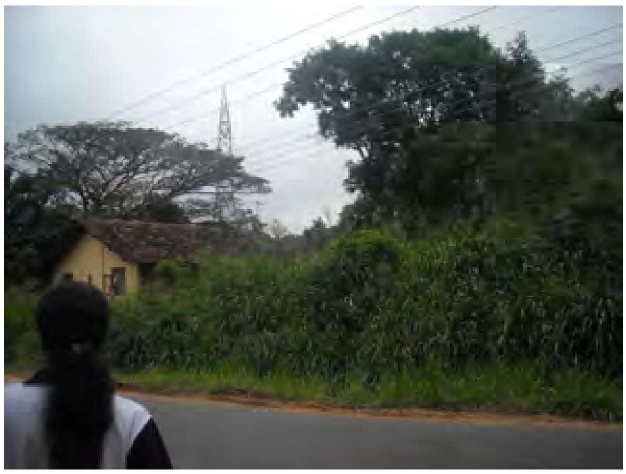
Date : Feb. 2, 2010
Place: Moragahakanda Dam Site
Title: Perspective of Dam Site

Date : Feb. 2, 2010
Place: Moragahakanda Dam Site
Title: Dam Axis of Main Dam, view from left bank

Date : Feb. 3, 2010
Place: Kaudulla Left Bank
Title: Improvement Work of Kaudulla Left Bank Main Canal
(Existing: 6m – New: 9m)

Date : Feb. 3, 2010
Place: Kaudulla Branch Canal
Title: Beginning point of Kaudulla Branch Canal

Date : Feb. 16, 2010
Place: Moragahakanda Dam Site
Title: Diversion road with 33kV power transmission line



Date : Feb. 16, 2010
Place: Naula
Title: Proposed CEB Naula grid power station site
(132kV transmission line)

Photograph Documentation (3 / 4)

Date : Feb. 2, 2010
Place: Moragahakanda Dam Site
Title: Proposed Elephant Corridor

Date : Feb. 3, 2010
Place: SystemD1
Title: Proposed Resettlement Site

Date : Feb. 2, 2010
Place: System F
Title: Proposed Resettlement Site

Date : Jan. 20, 2010
Place: Wallewala
Title: Service Center

Date : Mar. 4, 2010
Place: MASL
Title: Presentation for the result of 1st field survey

Date : Mar. 4, 2010
Place: MASL
Title: Presentation for the result of 1st field survey

Photograph Documentation (4 / 4)

Date: Mar. 24, 2010
Place: MASL
Title: Interim Report Presentation

Date: Mar. 24, 2010
Place: MASL
Title: Interim Report Presentation

Date: Apr. 24, 2010
Place: Borrow Area
Title: Environmental and Social Field Investigation

Date: Apr. 24, 2010
Place: Borrow Area
Title: Environmental and Social Field Investigation

Date: June. 11, 2010
Place: MASL
Title: Draft Final Report Wrap-up Meeting

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Place: MASL
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SUMMARY

01 Authority

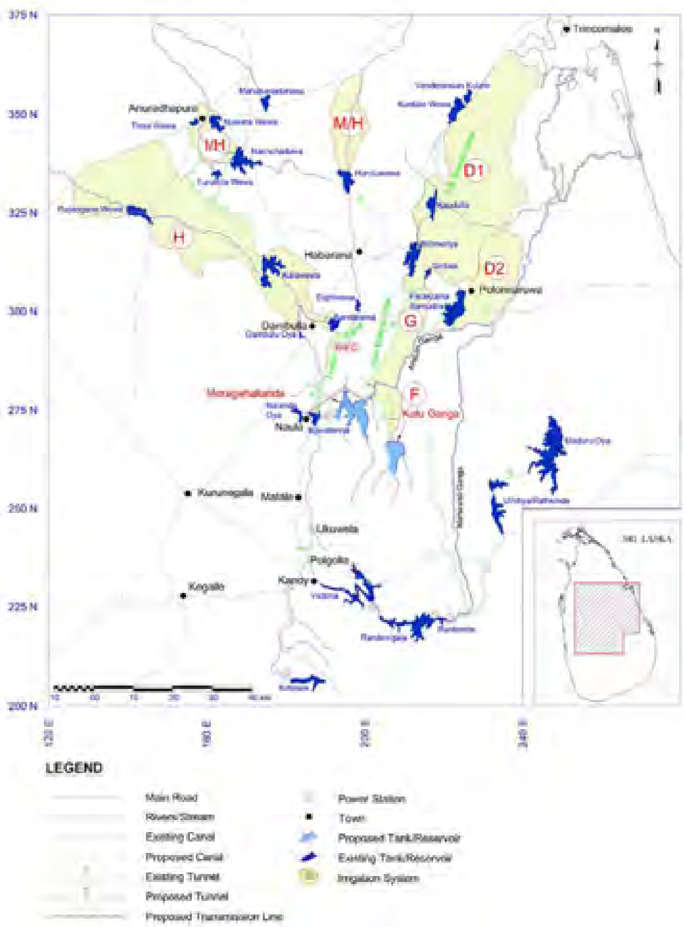
The Preparatory Survey for the Moragahakanda Development Project (the Project) was carried out for eight months from December 2009 to July 2010 in accordance with the Terms of Reference contained in the Implementation Program for the Moragahakanda Development Project agreed between the Mahaweli Authority of Sri Lanka (MASL) and the Japan International Cooperation Agency (JICA) in October 2009.

02 Present Status of Relevant Sectors in the Project Area

1) Agriculture

Agriculture is the dominant and most important economic activity in Sri Lanka. The share of agriculture sector accounted for 12.1% of the total gross domestic product (GDP) of LKR 2,365,500 million in 2008. Although the contribution from the agriculture sector to GDP, which used to be 28% of the total GDP in early 1980s, has been declining, the agriculture sector still plays a vital role in Sri Lanka's economy.

The ten-year development framework (2006-2016) for the agriculture sector in "Mahinda Chintana (Vision for a New Sri Lanka)", which was published by the Department of National Planning, the Ministry of Finance and Planning in 2005, has set the development targets in the agriculture sector. During the planned period (2006-2016), the agriculture sector as a whole is planned to grow at an average rate of over 5%. The growth will result from a combination of increase in the extent area for agricultural production and improvement of its productivity. Growth rates of the extent area and the productivity of non-plantation sector that are required to achieve the overall



Source of data: MASL and FS2001

Fig. S-1 Irrigation Systems in the Project Area growth rate of 5% are shown in Table S-1 according to the ten year development framework of "Mahinda Cintana".

Table S-1 Target Growth Rates of Extent and Productivity

Description	Rate of Increase for the ten-year period (2006-2016)	
	Extent Area Increase	Productivity Increase
Non Plantation Sector		
- Paddy	0.1%	10.0%
- Field Crops, Vegetables, Fruits etc.	0.8%	25.0%

Source of data: Mahinda Chintana: Vision for a New Sri Lanka A Ten Years Horizon Development Framework 2006 - 2016 Discussion Paper

The benefited areas of the Project consist of seven operational systems of the MASL, namely System H, I/H, M/H, Kandalama Huruluwewa Feeder Canal (KHFC), G, D1 and D2 (see Fig. S-1). The estimated total irrigable area in the Project area in 2010 is approximately 86,000 ha.

The major crop cultivated in the Project area is paddy during both Maha and Yala seasons. Other field crops (OFC) such as chili, big onion, maize, cowpea, vegetables, and banana are cultivated mainly during Yala seasons. Meanwhile very little OFC are grown during Maha season. The cultivated area and cropping intensity in the project area is summarized in Table S-2.

Table S-2 Cultivated Area and Cropping Intensity in the Project Area

Description	Maha Season			Yala Season			Annual Total
	Paddy	OFC	Total	Paddy	OFC	Total	
Cultivated area (ha)	81,218	2,055	83,273	54,423	12,193	66,616	149,889
Cropping Intensity	95%	3%	98%	64%	14%	78%	176%

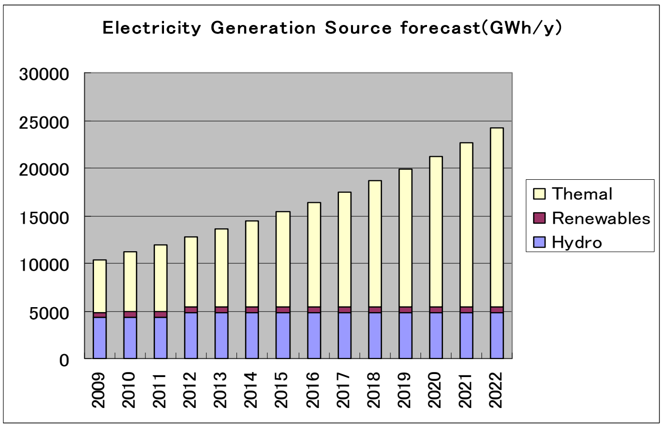
Source of data: MASL and Irrigation Dept.

The average cultivated area for paddy and OFC is 83,000 ha in Maha season and 67,000 ha in Yala season in recent ten years from 1999/2000 Maha to 2009 Yala. The average annual total cropping intensity for the whole Project area is 176% in the past ten years. In all systems, cropping intensity during Maha season is more than 90%. Meanwhile during Yala season, cropping intensity is 78% in average and varies depending on the system and year. The average paddy yield in the entire Project area is about 4.45 t/ha in Maha season, while about 4.46 t/ha in Yala season.

2) Electricity

Since the latter half of 1990s, thermal generation increased rapidly to meet the growing electricity demand in Sri Lanka and it superseded the hydro generation in 2000. However, the Sri Lankan power system is still significantly dependent on hydropower. In the "Long Term Generation Expansion Plan 2009- 2022" issued by the Ceylon Electricity Board (CEB) in December 2008, the incremental generation in the future will be much owed to the thermal generation, while the hydropower generation remains almost at the same level as shown in Fig. S-2. The total annual hydropower generation is predicted to be 4,376 GWh until the year of 2011, and will be 4,797 GWh after 2012 by adding 421GWh from Upper Kotmale.

The present electricity power supply to the proposed dam site and its vicinity areas (including Naula) involves voltage fluctuation and sudden outage of electricity due to a long distribution line from Ukuwela and Habarana grid substations. Based on the forecast load on the existing Ukuwela and Habarana grid substations, the load of those substations exceeds 120% under outage of one transformer by 2013 and 2014 respectively. Also, due to long distribution lines, the voltage profiles at Naula and Dambulla are very poor, which also causes high power losses. According to the CEB 2006 data, the electrification level in the Naula area was 66%, and it was lower than the average of total Sri Lanka, i.e. 80% in 2006.



Source of data: CEB

Fig. S-2 Electricity Generation Source Forecast

3) Domestic and Industrial Water Supply

The National Water Supply and Drainage Board (NWSDB) plans and implements major water supply schemes in Sri Lanka, while municipalities and other organizations also implement small water supply schemes such as ground water schemes. The NWSDB Corporate Plan 2007-2011 was prepared with the assistance from JBIC (now merged with JICA) in September 2006 aiming to contribute in uplifting the living conditions of people in towns and villages by providing sufficient and safe drinking water through piped water supply schemes. In the above Plan, the development targets of water supply sector have been set; the development targets of water supply coverage and non-revenue water in 2011 are 40% and 30%, respectively.

The Project area includes four districts for domestic and industrial water supply, i.e. Polonnaruwa, Matale, Anuradhapura and Trincomalee. The present status (as of 2009) of domestic and industrial water supply sector (pipe-borne water supply) in the four districts is shown in Table S-3. Pipe-borne water supply coverage in the Project area is still at a low level compared to the target of the NWSDB Corporate Plan 2007-2011.

Table S-3 Present Status of Domestic and Industrial Water Supply Sector in the Project Area

No	District	Water Production (MCM/year)	Amount of water Supply (m^3/day)	Population Served (person.)	Non-Revenue Water (%)
1.	Matale	18.2	40,500	234,000 (48%)	19%
2.	Anuradhapura	15.2	33,500	219,000 (25%)	20%
3.	Trincomalee	14.5	25,000	156,000 (33%)	37%
4.	Polonnaruwa	4.5	10,000	60,000 (15%)	20%

Source of data: National Water Supply and Drainage Board

In the FS2001, demands for domestic and industrial water supply from the Moragahakanda reservoir in the four districts, Matale, Anuradhapura, Trincomalee, and Polonnaruwa, was projected to be 92.4 MCM per year at 2030 based on the population and individual water demand forecast as shown in Table S-4. This figure has been officially agreed between the MASL and NWSDB, and a new reservoir is required to be developed to satisfy this demand.

Table S-4 Water Demand in the Project Area (2030) projected by NWSDB

Unit: MCM

No	District	Current Water Supply Amount from Mahaweli	Water Demand in 2030 in FS2001 (Increment)
1.	Matale	6.9	31.2 (24.3)
2.	Anuradhapura	10.4	15.0 (4.6)
3.	Trincomalee	9.1	34.2 (25.1)
4.	Polonnaruwa	2.3	12.0 (9.7)
Total		28.7	92.4 (63.7)

Source of data: National Water Supply and Drainage Board

03. Necessity and Priority of the Project

As described in the previous section, agriculture is still the dominant sector in terms of both economic and employment aspects in Sri Lanka. The national agriculture policy gives priority to sustainable food supply, especially paddy. The national development target has been set that the agriculture sector as a whole is to grow at an average rate of over 5%. To achieve the target, increase of cultivated area resulting from increase of irrigation facilities and increase in productivity is essential.

The “Mahinda Cintana Vision for the Future”, published in 2010, says that the current food reserve is not sufficient and required to be raised, because to maintain adequate buffer stocks is of paramount importance to ensure price stability especially during off seasons. Furthermore, the GOSL has agricultural plans aiming at reaching the self sufficiency target in producing cereals to replace imports so that the foreign exchange savings can be released for new developments.

The cultivated area under the Mahaweli Authority accounts for almost 18% of the entire paddy cultivated area and 24% of whole paddy production in Sri Lanka. However, the cropping intensity in the Project area is unstable due to water shortage during Yala season. Moreover, the paddy yield in the Project area is not satisfactory, despite that the canals and gates are well developed and maintained. Developing new water resources is required to increase the agricultural production.

Meanwhile, water demand for domestic and industrial purposes has been increasing in Anuradapura, Trincomalee, Matale, and Polonnaruwa districts in the Project area in recent years due to population growth and industrialization. In some areas, groundwater is used for local water supply schemes, but has caused health problems. It is urged to develop a new water source to secure the quantity and quality of water in the Project area.

The present condition of electricity supply in the Naula area is not stable because there are neither electricity sources nor substations nearby. The Moragahakanda Power Station would contribute to the improvement of quality and reliability of electricity supply to the local residents as well as steady electricity supply to the national grid.

As to the water resources in the Amban River Basin, during every flood season, approximately 700 MCM of water flows to the sea, because no large reservoir exists other than the Bowatenna Reservoir having a capacity of only 50 MCM on the Amban River to receive the flood water. To utilize the flood water and secure the irrigation and domestic and industrial water supply in North Central Province (NCP), the Moragahakanda Dam with a capacity of 520 MCM is required to be developed.

The Moragahakanda Dam was proposed by JICA in the feasibility study on the Moragahakanda Agricultural Development Project in the 1970s, but the Project has not been realized yet, because, in the meantime, hydropower generation projects on the Mahaweli River have been given priority, and NCP has suffered from a severe water shortage, especially during the dry season. Thus, it has been desired to develop the Moragahakanda Dam to solve the water shortage problem in NCP.

In the ten-year development framework of "Mahinda Chintana 2006-2016", the Moragahakanda Development Project is defined as a priority project. In "Mahinda Cintana 2010" also, the strategic importance of water as a natural resource is emphasized, and it shows a plan to supply additional water to the tanks of the Northern and North Central provinces under the Moragahakanda and other Mahaweli projects.

Thus, the Moragahakanda Development Project is the most important and highest priority project in the water resources sector in Sri Lanka.

04. Objectives of the Project

The objectives of the Project are: 1) to provide irrigation water to Systems H, I/H, M/H, G, D1, D2, and KHFC in order to raise the cropping intensities and standard of living of farmers in the areas; 2) to supply additional domestic and industrial water to the districts of Matale, Anuradhapura, Trincomalee, and Polonnaruwa; and 3) to improve the electricity supply by generating hydroelectric power.

05. Overall Project Configuration Proposed in FS2002

In the Supplementary Report for the Feasibility Study of Moragahakanda Development Project, September 2002, the following overall project configuration for the Moragahakanda Development Project was recommended:

i) Construction of a 65 m high concrete main dam and two saddle dams (fill dams), forming a reservoir with full supply level (FSL) at 185m asl and an area of 29.5 km^2 at FSL, and a 20 MW hydropower station with a transmission lines;

ii) Extension of the upper LB branch canal of the Kaudulla scheme in Irrigation System D1, the host area for the families who will be displaced by the Moragahakanda Reservoir;

iii) Compensation and resettlement package for the displaced families; and

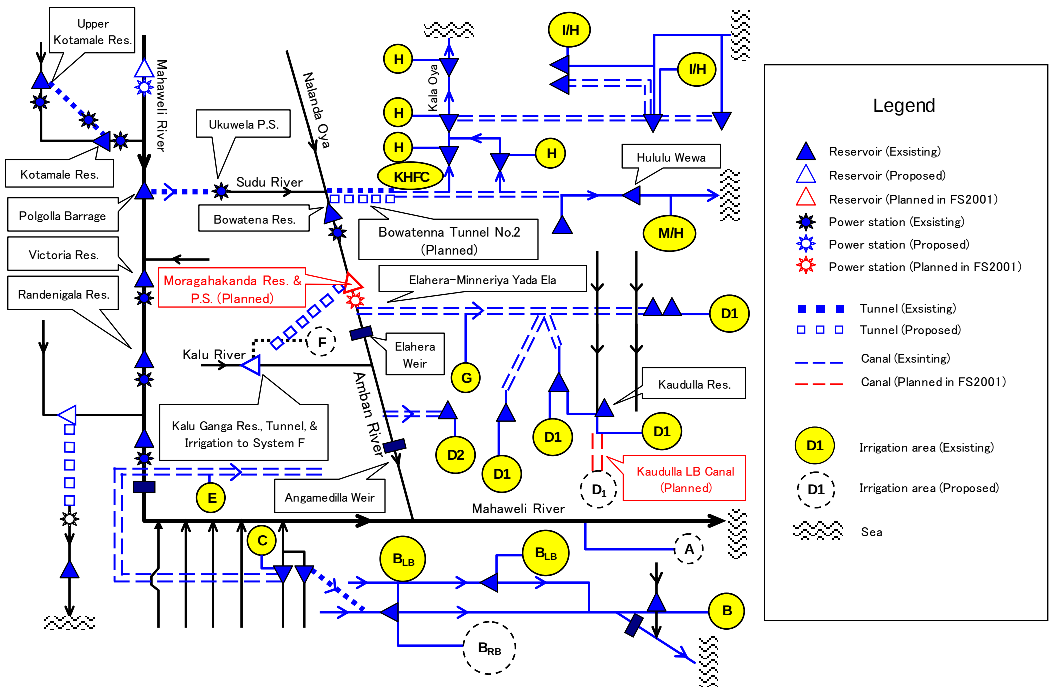
iv) Accompanying Environmental Management Action Plan.

The above project components have been reviewed in this survey. The reviewed features of the each project components are described in the following sections.

06. Water Balance Planning

1) General

In cooperation with the MASL, a series of water balance simulation was carried out for assessment of the water balance and water use planning and review of the feasibility of the Project. This was undertaken through the simulation from the viewpoints of cropping intensities of existing irrigation systems, namely Systems H, I/H, M/H, D1, D2, G, and the Kandalama-Huruluwewa Feeder Canal (KHFC) Scheme (refer to Fig. S-3), water diversions, irrigation water issues, domestic and industrial water use, hydropower generation, and reservoir behavior.



Source of data: MASL and FS2001

Fig. S-3 Schematic Diagram of the Related Mahaweli System

2) Simulation Cases

In this Survey, the simulation models, ARSP for simulating the overall system performance, and AIDM for computation of irrigation demand for respective irrigation systems, which the MASL has been using for the water balance planning since 1986, were used. The simulation was conducted for the following cases, wherein the earliest likely commissioning of the Project is in 2017, and based on the hydrological data for last 40 years (1968/1969-2007/2008):

i) Case-A: Without Project, (Period: 2011-2016/Pre-Operation)
ii) Case-B: With Project, (Period: 2017-2021/Operation Years 1-5)
iii) Case-C: With Project, (Period: 2022-2040/Operation Years 6-24)

Case-A covers the entire pre-operation phase of the Project, while Case-B and C cover the operation phase of the Project after completion of the Moragahakanda Reservoir.

In Case-B and C, the Moragahakanda Hydropower station with a capacity of 15 MW was applied, and the future demands of irrigation water, domestic and industrial water, and hydropower generation in the entire system were incorporated.

The average cropping intensity of the total Project area in Case-B and C was raised to 190% from the current 176%, because the irrigation water supply is expected to be increased after implementation of the Moragahakanda reservoir.

In computing the demand series for the future case in Case-C, the cropping pattern using more short-term varieties of paddy was adopted, because the trend of introducing the high yielding short-term varieties of paddy among farmers is expected to grow with the availability of more reliable irrigation water supply from the Project. In this simulation case, the possibility of saving water for future use was considered. This water will be utilized for further expansion of irrigation, future increase of demand of domestic and industrial water in the Project area, or other purposes.

3) Results of Water Balance Simulation and Water Use Plan

As a result of the water balance simulations, the water use plan is presented in Table S-5, and the simulated monthly reservoir volume, power outlet flow, bottom outlet flow and spillway release of the Moragahakanda reservoir for the analysis period of 40 years of Case-B, which is the most critical case in the water balance simulation, is shown in Fig. S-4.

4) Verification of Appropriateness of Capacity of the Moragahakanda Reservoir

i) Fig. S-4 shows that the number of occurrence of drop down of reservoir water level to the MOL, which is corresponds to 48 MCM of reservoir volume, does not exceed eight times over the 40 year simulation period. It is judged that the capacity of the Moragahakanda Reservoir can guarantee 80% dependability, which was the criterion of reliability, and at the same time, its capacity is appropriate as well.

ii) As shown in Table S-6, the overall cropping intensity of the Project area can be raised from the current 176% to 190% (MASL's target) after construction of the Moragahakanda Reservoir. An additional area of 16,000 ha including 1,420 ha of new development in the Kaudulla Left Bank extension area can be cultivated.

iii) The Moragahaknada Reservoir will make it possible to satisfy the future demand of domestic and industrial water of Anuradapura, Trincomalee, Matale, and Polonnaruwa districts (about 90 MCM in Case-C).

iv) As shown in Table S-5, the result of Cases -B and -C show that the Moragahakanda Reservoir is able to limit the quantity of diversion at Polgolla to 875 MCM/year, which has been agreed among all water user groups, due to the storage and regulation of the Moragahakanda Reservoir. As a result, the targeted national power generation, 4,376 GWh, will be maintained.

Table S-5 Water Use Plan

Operation	Station	Without Project	With Project		
		Case-A	Case-B	Case-C	
		2011	2017	2022	2040
Diversion (MCM/year)	Polgolla	954	873	808	823
	Bowatenna	666	674	628	638
	KH Feeder Canal	213	217	203	203
	Huruluwewa	59	69	68	68
	Kandalama	38	40	37	37
	Dambulu Oya	453	457	424	435
	Nachchaduwa	80	94	91	94
	Nuwarawewa	42	41	42	44
	Tisawewa	16	18	17	17
	Elahera	635	687	655	658
	Minneriya	342	381	373	375
	Giritale	79	75	69	69
	Kaudulla	104	150	154	156
	Kantale	95	94	95	96
	Angamedilla	337	322	300	301
Spill (MCM/year)	Elahera	229	76	83	83
	Angamedilla	515	385	408	408
	Polgolla	1132	1212	1277	1262
	Kotmale	1	1	1	1
	Bowatenna	23	22	22	22
	Kandalama	5	4	6	6
	Kalawewa	85	74	87	86
	Nachchaduwa	13	12	14	14
	Nuwarawewa	0	0	0	0
	Tisawewa	0	0	0	0
	Huruluwewa	1	0	1	1
	Minneriya	0	0	0	0
	Giritale	0	0	0	0
	Kaudulla	11	9	12	11
	Kantale	28	7	11	11
	Parakrama Samudra (PSS)	0	0	0	0
Power Outlet (MCM/year)	Moragahakanda	-	699.1	681.5	689.5
Bottom Outlet (MCM/year)	Moragahakanda	-	39.8	23.7	21.4
Spill (MCM/year)	Moragahakanda	-	23.8	33.1	30.0
Hydropower Generation (GWh/year)					
All Hydropower Stations		4247	4348	4378	4375
Bowatenna		64	53	50	50
Moragahakanda *1		-	66	67	67
Domestic and Industrial Water Supply (MCM/year)					
Matale	Sudu River	5.0	5.9	7.8	10.4
	Dambulu Oya	1.8	3.8	8.7	19.3
Anuradhapura	Nuwarawewa/Tisawewa/Thuruwila	10.2	10.6	11.9	14.9
Polonnaruwa	Kaudulla/Minneriya	0.0	1.6	3.5	7.9
	Parakrama Samudra (PSS)	2.1	2.2	3.0	4.0
Trincomalee	Kantale	9.1	9.0	9.1	9.1
	Mahaweli River	0.0	5.1	11.3	25.1
	Total	28.2	38.2	55.3	90.7

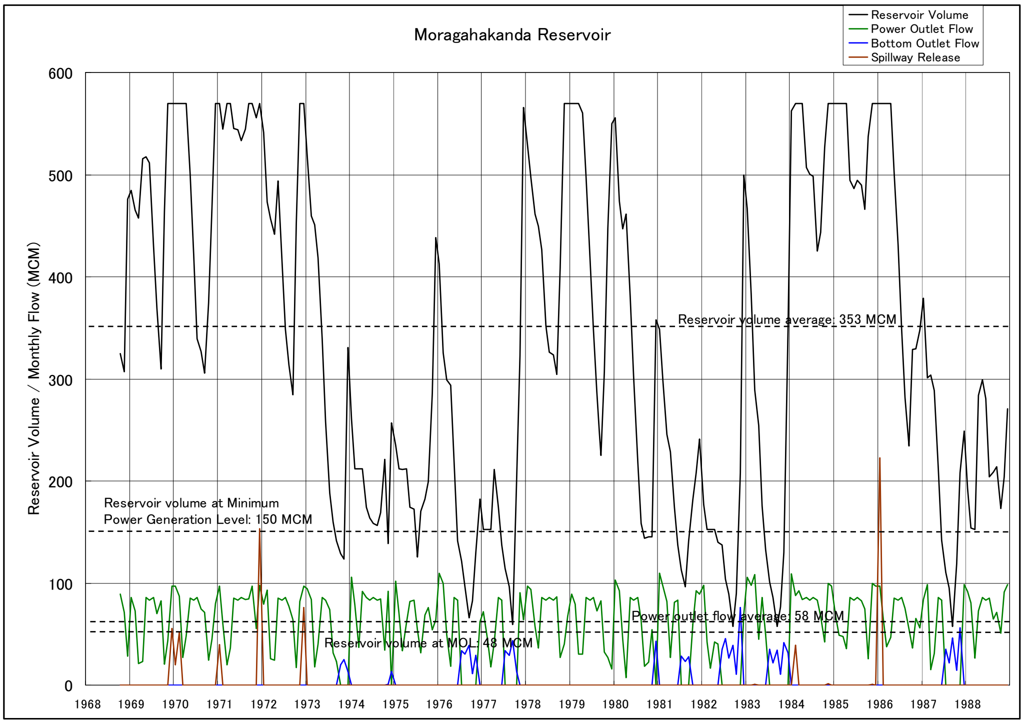
Prepared by the JICA Survey Team

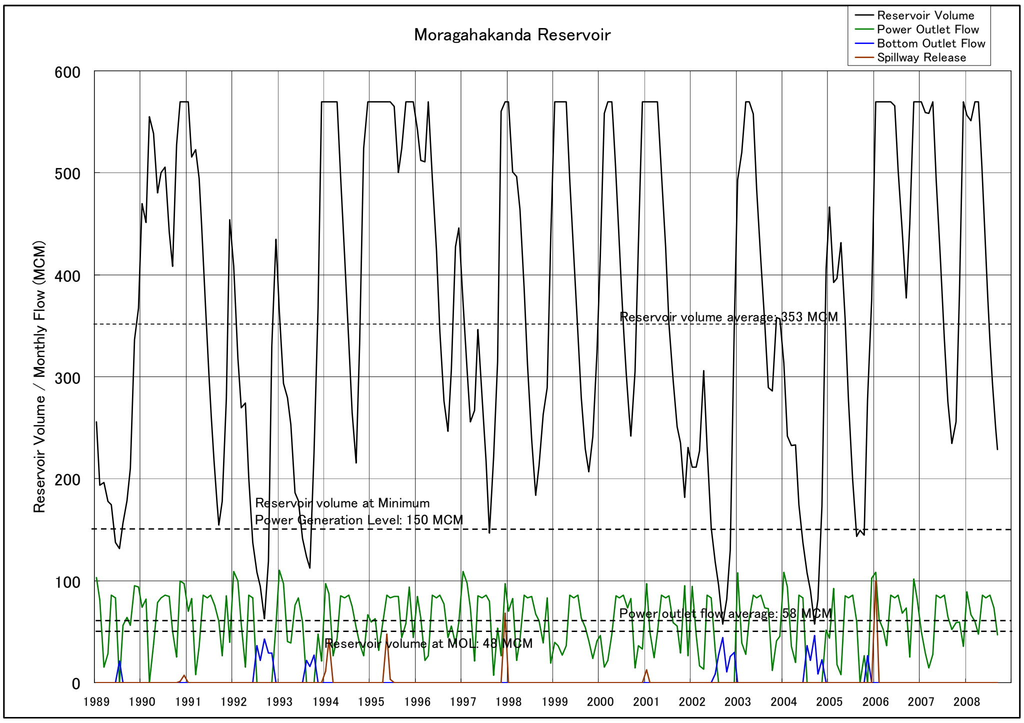
Note: *1: Hydropower generation capacity of Moragahakanda Power Plant: 15 MW

Table S-6 Increment of Cropping Intensity and Cultivation Area

Case	Cropping Intensity (%)			Cultivation Area (1,000 ha)		
	Maha	Yala	Total	Maha	Yala	Total
Without-Project	98	78	176	83	67	150
With-Project	100	90	190	87	79	166
Increment	2	12	14	4	12	16

Prepared by the JICA Survey Team





Prepared by the JICA Survey Team

Fig. S-4 Simulated Reservoir Behavior (Case-B)

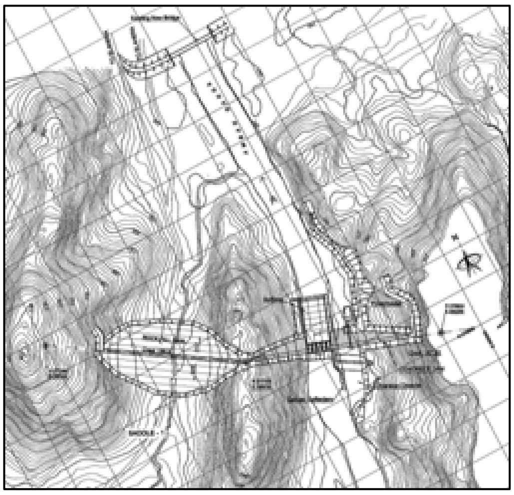
07. Review of Dam and Hydropower Planning

1) Dam Layout

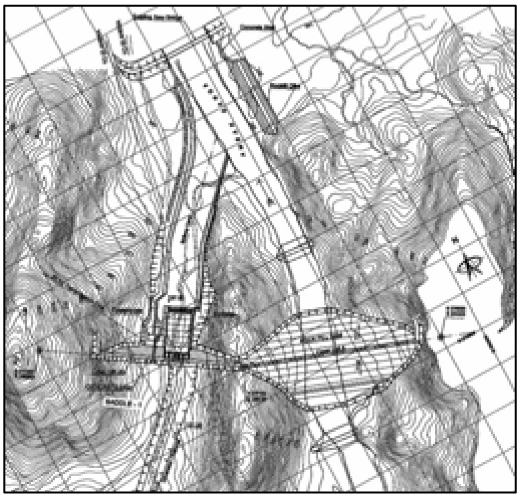
The full supply level (FSL) and the minimum operation level (MOL) of the proposed Moragahakanda reservoir are 185.0 m and 155.0 m asl, respectively. Those levels were selected in the FS 2001 and are judged to be adequate in the present study based on the updated water balance simulations. The reservoir can store water of 520 MCM in the space between FSL and MOL. Meanwhile, river water level at the proposed dam site is around 138 m asl under normal condition.

On the left bank ridge of the proposed dam site, there are two saddle areas named Saddle-1 and Saddle-2. Type of dam selected in the FS2001 is: a) concrete gravity RCC dam in the river valley; b) clay-core rockfill dam in the saddle-1; and c) homogeneous earthfill dam in the Saddle-2. The Saddle-2 dam is presently under construction by the MASL.

After the last feasibility study was conducted in 2001, some unit costs for construction have highly increased. The type and arrangement of dams selected in FS2001 are not necessarily most economical at present. Hence, it is necessary to review the dam layout based on the present price level. The following two layouts shown in Fig. S-5 are compared to select an appropriate dam layout.



Layout-1 (similar to FS2001 layout)



Layout-2 (similar to FS1979 layout)

Fig. S-5 Dam Arrangement

Results of technical and economical assessments made on both layouts in this Survey are shown in Table S-7. As seen in this table, the Layout-2 has various advantages to reduce the construction risk, time, and also cost compared with the Layout-1. Therefore, the Layout-2 is selected as the most appropriate dam layout.

Table S-7 Comparison between Layout-1 and Layout-2

No.	Description	Layout-1	Layout-2
	Dam in river valley Dam in saddle-1	RCC dam Rockfill dam	Rockfill dam RCC dam
1	Construction difficulty	River diversion in river channel is not easy.	River diversion to saddle-1 area is easy.
2	Construction period	45 months	42 months
3	Civil work construction cost	USD 85.2 million	USD 79.6 million

Prepared by the JICA Survey Team

2) Appurtenant Structures

Other structures reviewed in this Survey include spillway, bottom outlet, intake and powerhouse, and river diversion facilities. Regarding the spillway, the type and discharge capacity in the FS2001 design are judged to be adequate. Type of bottom outlet gates (two lanes) is changed to a simple jet-flow type with opening diameter of 1.6 m from the roller gate with opening size of 1.8 m by 2.0 m in FS2001. The river diversion facilities are elaborated so as to fit the new dam layout. Open channels are excavated in up and downstream directions in Saddle-1 area and six conduits (5m x 5m each) are provided through the lower part of concrete dam. Those conduits are plugged with concrete after the dam has been completed, but the bottom outlet facilities are installed in two of the six conduits. The powerhouse is located at the downstream toe of the concrete dam as proposed in FS2001.

3) Capacity of Hydropower station

The installed capacity of the hydropower station selected in FS2001 is 20 MW. In consideration of the latest projection of the downstream water demands, the 20 MW capacity seems to be excessive since rates of flow to be released are not always sufficient to generate 20 MW. To seek the optimal capacity of the hydropower station, a series of water balance simulations covering 40 years was performed applying four different generation capacities, i.e. 7.5MW, 10MW, 15MW and 20MW. As shown in Table S-8, the energy generation largely increases with the increase of installed capacity up to the 15MW capacity, but energy increment is only minimal for capacity over 15MW. Construction cost and energy benefit estimated for each case of generation capacity are as follows:

Table S-8 Comparison of Installed Capacity

Description	Unit	Installed Capacity			
		7.5 MW	10 MW	15 MW	20 MW
- Construction cost (intake and powerhouse)	M USD	8.8	11.3	15.6	20.0
- Energy benefit in 50 years (present value)	M USD	29.4	37.1	45.3	46.9
- Benefit minus Cost (B-C)	M USD	20.6	25.8	29.7	26.9

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The value of B-C (net present value) is the highest at generation capacity of 15 MW. Therefore, the installed capacity of the Moragahakanda Hydropower Station is selected to be 15 MW.

In case of a single 15 MW unit, the turbine is not operable when the required reservoir release flow is less than 10.5 m^3/s because of hydraulic troubles on the turbine at low flow. Duration of turbine stoppage due to such low flow is 24 % per annum. If two units of 7.5 MW are installed, one of two turbines is operable down to low flow of 5.25 m^3/s. Use of two 7.5 MW units can reduce annual turbine stoppage duration to 13%. Owing to the increase of turbine operation duration in low flow, the two-7.5 MW scheme is 2.1 GWh larger in annual energy production than the single 15 MW unit. The additional energy in 50 years corresponds to the economic value of USD 1.4 million in terms of present value. Meanwhile, cost increase by change from the single 15MW to the two 7.5 MW is estimated only at USD 0.3 million. Use of two 7.5MW units is more beneficial than single unit of 15 MW. Therefore, the two-7.5MW scheme is adopted for the Moragahakanda Hydropower Station. Estimated annual energy production is 66.3 GWh.

4) Generating Equipment and Transmission Line

Two units of 7.5 MW generating units are to be installed in the powerhouse. The selected turbine is Kaplan type turbine since it covers a wider range of discharge variations than Francis turbine and shows higher overall efficiency for wide range of discharge and head. However, due to hydraulic troubles foreseen in low head operation, the allowable lowest reservoir level for turbine operation is set at 165.0 m asl though the minimum operation level (MOL) is 155.0 m asl. The rated head for turbine is set at 40 m that equals the FS2001 design.

The transmission lines proposed in FS2001 were 42 km long 132 kV lines to Habarana SS. However, at Naula town near the project site, a new 132/33kV substation is planned to be constructed by the Ceylon Electricity Board (CEB) and scheduled to be commissioned in 2011. Therefore, 15 km long 33kV transmission lines are to be provided from the Moragahakanda powerhouse to the Naula SS.

5) Project Cost in FS2001

The project cost estimated in FS2001 is USD 102.62 million including costs for compensation, resettlement and environmental management. However, as basic data for unit costs for civil works are not presented in the FS2001 report, review of the cost estimate from the basic data is not possible at present. In order to update the project cost, it is necessary to apply statistical data of consumer price index in the international markets and Sri Lanka as well. Indirect cost component in civil works estimated at 20 % of the total cost in FS2001 is considered to be acceptable.

08. Proposed Project

1) Dams and Hydropower Station

The salient features of the proposed dams (the main dam and two saddle dams) and a hydropower station of the Project are summarized in Table S-9.

Table S-9 Salient Features of Dam and Hydropower Station of the Project

	Descriptions	Unit	Present Study (2010)	Previous FS (2001)
1	River and Hydrology at Dam Site			
	Catcment Area	km^2	768	768
	Mean Annual Flow (self catchment)	m^3/s	24.6	24.6 (Year 1949-98)
	Dam Design Flood (p=1/1,000)	m^3/s	3,797	3,797
2	Reservoir			
	Full Supply Level (FSL)	m asl	185.00	185.00
	Minimum Operation Level (MOL)	m asl	155.00	155.00
	Volume at FSL	MCM	569.9	569.9
	Active Storage	MCM	521.3	521.3
3	Main Dam			
	Type	-	Rockfill dam	RCC dam
	Crest Elevation	m asl	188.5	187.0 (or 188.0)
	Crest Length	m	465	463
	Maximum Height	m	61	65
	Dam Volume	m^3	1,380,000	368,000
4	Saddle Dam No. 1			
	Type		RCC dam	Rockfill dam
	Crest Elevation	m asl	187.5	188.0
	Crest Length	m	365	361
	Maximum Height	m	51.5	42
	Dam Volume	m^3	171,000	674,000
5	Saddle Dam No. 2			
	Type	-	Earthfill dam	Earthfill dam
	Crest Elevation	m asl	188.5	188.0
	Crest Length	m	374	374
	Maximum Height	m	21.5	21
6	Spillway			
	Type	-	Gated weir with chute and stilling basin	Gated weir with chute and stilling basin
	Design outflow	m^3/s	3,797	3,778
	Number of bays	-	5	5
	Type of gate	-	Radial gate	Radial gate
8	River Diversion Conduits			
	Type		Horizontal holes (D-shape) in dam	Horizontal holes in dam
	Number of bottom outlets		6	-
9	Intake & Penstock			
	Type	-	Bellmouth with horizontal penstock	Bellmouth with inclined penstock
	Number of intakes	nos.	2	1
	Diameter of penstock pipe	m	2.5	3.91
10	Powerhouse			
	Type	-	Reinforced concrete building at dam toe	Reinforced concrete building at dam toe
	Number of generating units		2	1
	Installed capacity	MW	7.5 x 2 = 15	20
	Maximum discharge per unit	m^3/s	21	50
	Annual energy production	GWh	66.3	45.0
11	Transmission Line			
	Voltage	kV	33	132
	Length	km	15	41.8

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i) Dams and Appurtenant Structures

The selected types of dams are rockfill dam in the river valley and concrete gravity dam in the Saddle-1 as shown in Fig. S-6.

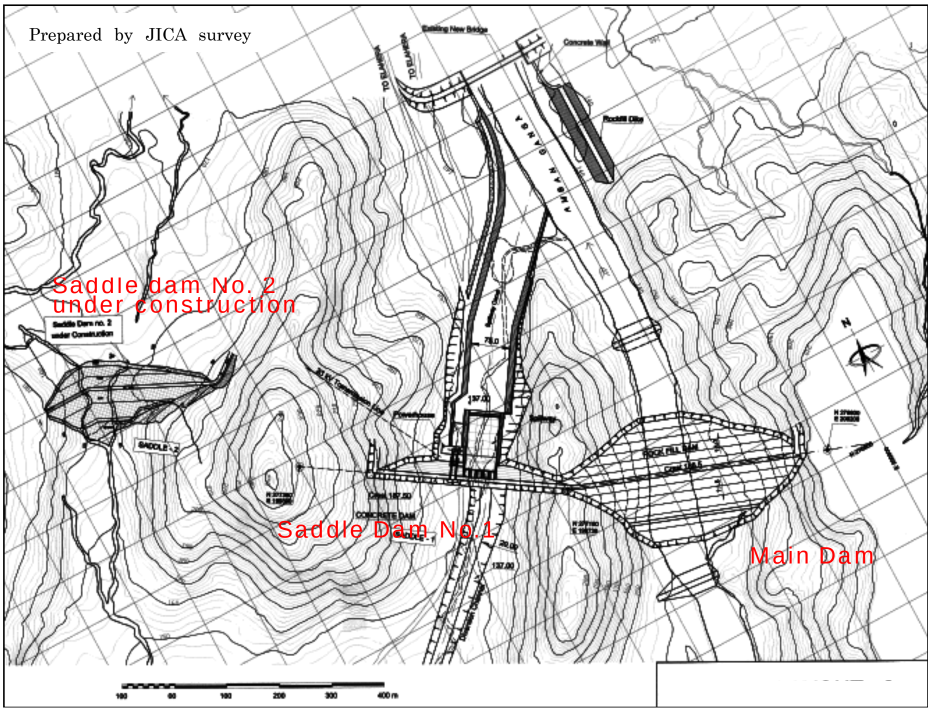

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Fig. S-6 Layout of Dams Selected in the Present Study

The required dam crest elevation calculated referring to the Japanese criteria is 188.5 m asl for the fill type dam and 187.5 m asl for the concrete dam. Both elevations are 0.5 m higher than those in FS2001. The crest level of the Saddle-2 dam being constructed is proposed to be raised to 188.5 m asl. Dam types and heights are shown in Table S-10.

Table S-10 Main and Saddle Dams

Dam	Type of dam	Height (m)
Main Dam	Clay core rockfill dam	61.0
Saddle Dam No. 1	Concrete (RCC) gravity dam	51.5
Saddle Dam No. 2	Homogeneous earthfill dam	21.5

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To study sediment accumulation in the reservoir, sediment flow rate in the Amban River has to be estimated. The rate is estimated at 340 m^3/km^2/year referring to the studies for the past similar development projects in Sri Lanka. The estimated sedimentation rate is same as that of FS2001. Sediment deposit in the Moragahakanda Reservoir, which will accumulate in 100 years, is estimated at 23.2 MCM that is only 4.1 % of the original reservoir volume. Thus, the reduction of reservoir volume due to sedimentation will be very little.

The concrete gravity dam in the Saddle-1 has the volume of 0.17 million m^3. This dam will be constructed by roller compacted concrete (RCC) method for reducing construction cost and time. RCC will contain 150 to 200 kg/m^3 of cementitious materials (cement and flyash or pozzoran). Cement manufacturing firms in Sri Lanka are importing flyash (and pozzoran) at present and selling blended cements in domestic market. It is expected that there is no serious difficulty in using RCC for the concrete dam. The rockfill dam in the river valley, of which typical section is shown in Fig. S-7, has a volume of 1.4 million m^3. Rock materials are expected to be obtained from the quarry site located on right bank just downstream of the dam site.

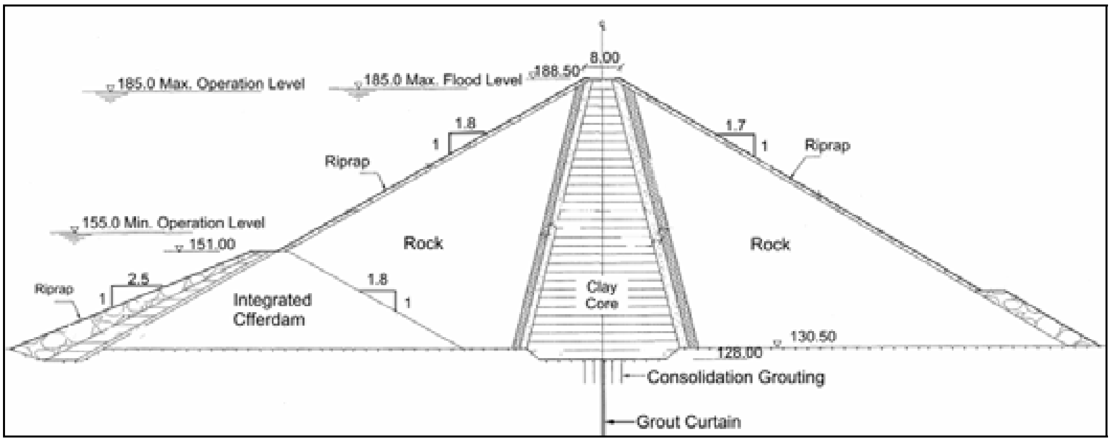

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Fig. S-7 Typical Section of Rockfill Dam

The spillway headwork is located on the concrete dam as shown in Fig. S-8. It is capable of discharging the flood flow of 3,797 m^3/s with a return period of 1,000 years at the reservoir level of FSL. The headwork is equipped with five radial gates (W9.7m x H11.0m each) to control outflow discharge. Energy of high velocity flow discharged from the headwork is dissipated by the 58.5 m wide horizontal apron type stilling basin located at downstream toe of the dam. The stilling basin is designed against the 100-year flood (2,880 m^3/s) allowing minor damages to the downstream structures at larger floods.

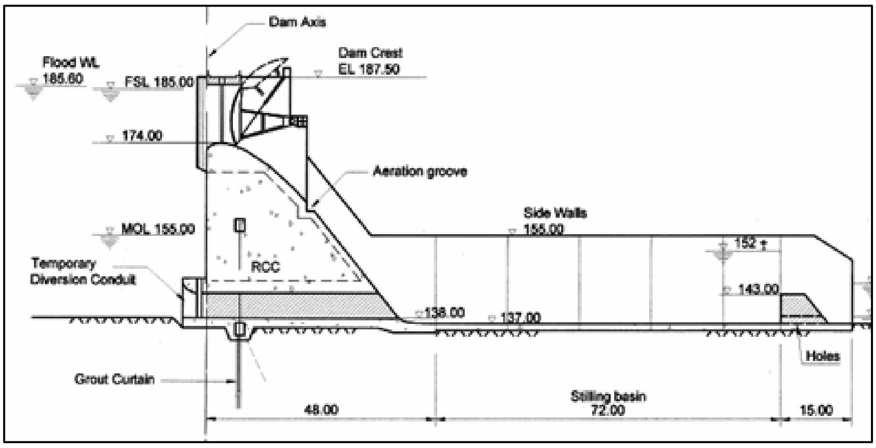

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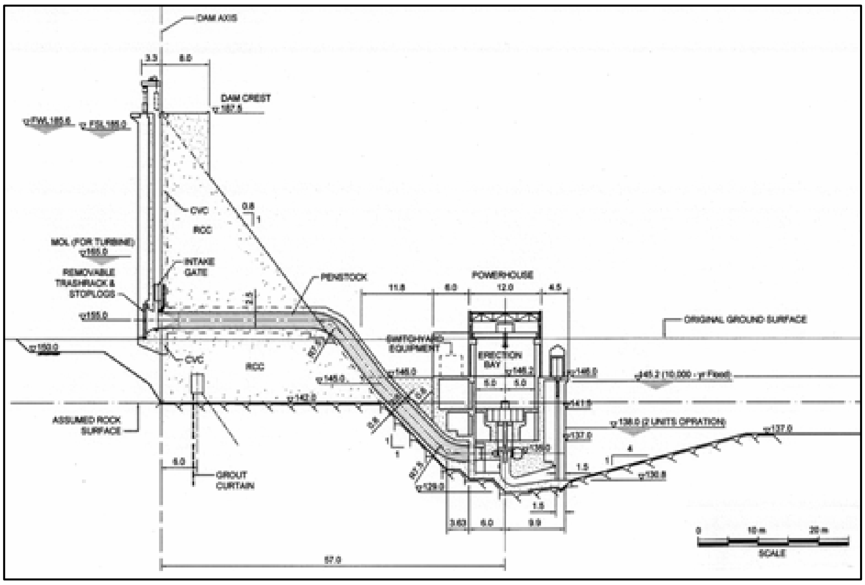
Fig. S-8 Spillway Section in Concrete Dam

An excavated 75 m wide discharge channel is extended in a 450 m long stretch from the stilling basin to the downstream river. The channel joins the river slightly upstream of the existing new road bridge. Turbulent flow at the junction may cause reduction of flow capacity and scouring damages to the bridge piers. Concrete guide walls and river training structures are additionally required to protect the bridge that was newly constructed about 800 m downstream of the dam site.

For river diversion during construction, six horizontal conduits (section of 5m x 5m each) are provided across the lower part of concrete dam in spillway section. Design discharge for the river diversion is a recorded maximum flood flow of 1,605 m^3/s. It is estimated that the reservoir water level reaches 149.5 m asl at the flood. The diversion conduits are plugged with concrete after completion of the dams. Two conduits out of six are utilized for the permanent bottom outlet.

The bottom outlet is set at 142.5 m asl in center elevation. It comprises 2 lanes of steel pipe conduit equipped with service gate and maintenance gate. Those pipes and gates are installed in two diversion conduits at a final stage of dam construction. The service gate is a 1.6 m diameter jet-flow type gate and maintenance gate is slide type gate. All hydraulic and control equipment for the gates are accommodated in gate chambers provided in dam body. The bottom outlet can release water of 50 m^3/s in total at a reservoir level of MOL. Emergency reservoir drawdown from FSL to MOL is possible within 2.5 months in dry season by use of the bottom outlets only. This period can be shortened to 2.0 months if the generating units (15 MW) are operated additionally.

The powerhouse is located at downstream toe of the saddle-1 concrete dam. It houses 2 units of 7.5 MW generating equipment. Two isolated water intakes of bell-mouth type are provided on the upstream face of the dam. Each intake is equipped with removable tarshrack and shutdown gate. One set of stoplogs is provided for two intakes. From each intake, a 2.5 m diameter steel penstock pipe is extended to the powerhouse to lead water to a turbine. The powerhouse building is a reinforced concrete construction with width of 22.5 m, length of 42 m and height of 27 m. Powerhouse yard ground level is set at 146.0 m asl taking into account the maximum river water level at a 10,000-year flood. Fig. S-9 shows the profile of intake and powerhouse.



Prepared by the JICA Survey Team

Fig. S-9 Profile of Intake and Powerhouse

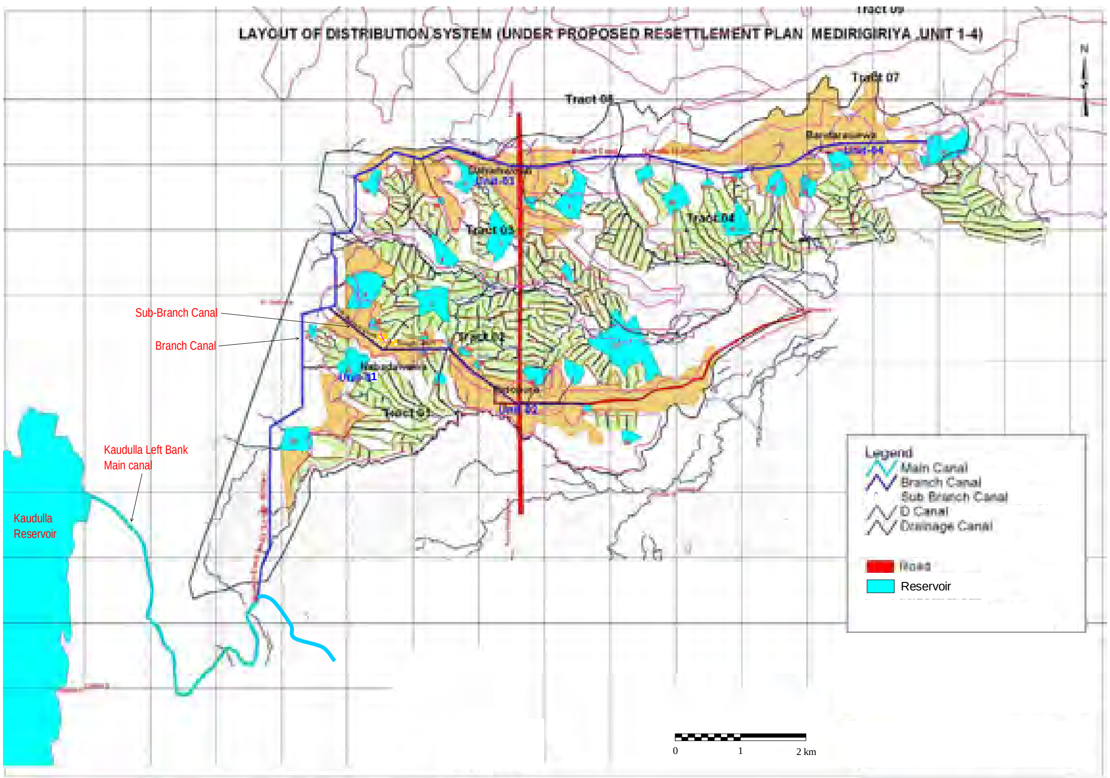
ii) Hydropower Station and Transmission Lines

The selected hydropower plant consists of two units of 7.5MW vertical shaft Kaplan turbine directly coupled with the synchronous generators having an unit capacity of 8.82MVA each at a power factor of 0.85. Turbine distributor center elevation is set at 135.0 m asl taking into account the tail water level of 138 m asl. Outdoor switchyard is located on backyard floor of the powerhouse building. A 17.6MVA step-up transformer (33/11kV) for two generators and breaker and switching equipment are installed there.

A single circuit 33kV transmission line is extended from the outdoor switchyard to the CEB's new substation at Naula. The transmission line is by steel tower type with length of 15 km to the Naula SS and it passes over north margin of the Moragahakanda reservoir.

2) Irrigation Canal Facilities at Kaudulla Left Bank Extension Area

The MASL and ID have planned that the Kaudulla Left Bank Branch Canal with sub-branch canal are to be diverted from the main canal to supply irrigation water to the Kaudulla Left Bank extension area of 1,420 ha (3,500 acres) in time, in some part of which the people will be evacuated from the Moragahakanda reservoir area (see Fig. S-10).



Source of data: MASL and Irrigation Dept.

Fig. S-10 General Layout of Kaudulla Left Bank Extension Area

The ID has carried out the improvement work for the existing Kaudulla Left Bank Main Canal since October 2009 to increase its flow capacity, and is supposed to be completed it by the end of October 2010 by using the national budget of the GOSL. Some portions of the new branch canal with a sub-branch canal, on-farm development, and rehabilitation of the existing farm ponds are also supposed to be implemented by the government by using the national budget.

The salient features of the proposed works at the Kaudulla Left Bank extension area are summarized in Table S-11.

Table S-11 Salient Features of Works at Kaudulla Left Bank Extension Area

Description	Unit	Improvement of Main Canal	New Construction of Branch Canal	New Construction of Sub-branch Canal	New On-farm Development
Type of lining	-	Unlined (Earth)	Unlined (Earth)	Unlined (Earth)	-
Length	km	6.4	16.5	4.4	-
Design discharge (Max.)	m^3/s	9.5	2.8	0.6	-
Irrigation Area	ha	4,800	1,420	280	1,420

Prepared by the JICA Survey Team

3) Agricultural Extension Services, and Establishment and Strengthening of FOs

Agricultural extension services, and establishment and strengthening of farmers' organizations (FOs) in the resettlement irrigation areas are required to be included in the Project components in order to assist the farmers in smooth resettlement through realization of efficient water management, sustainable O&M, and enhancement of agricultural production.

The targeted farmers include not only the farmers to be resettled from the Moragahakanda reservoir area but also the farmers in the existing settlement in the same irrigation areas, i.e. Kaudulla Left Bank Extension Area of System D1, and Kalu Ganga Left and Right Bank Areas of System F, so as to accelerate harmonization between the resettled farmers' agricultural activities and the existing agricultural activities in and around the resettlement areas.

The outline and schedule of activities of agricultural extension services are shown in Table S-12 and Fig. S-11 respectively.

Table S-12 Outline of Agricultural Extension Services

Target Area and Families		
1.	Kaudulla Left Bank extension area (System D1):	1,420 ha
2.	Kalu Ganga Left Bank area (System F):	950 ha
3.	Kalu Ganga Right Bank area (System F):	1,100 ha
	Total Area:	3,470 ha
	Total Families:	6,000 households
Required Subjects		
Advanced agricultural extension services		
(1)	Newly developed innovative technology packages for nursery management for paddy and horticultural crops	
(2)	Improved cultivation techniques for high value horticultural crops	
(3)	Integrated Pest Management (IPM) methods developed for horticultural crops	
(4)	Post harvest technologies to processing, packing and grading for minimizing losses and wastages and improving product quality for paddy and horticultural crops	
(5)	Appropriate irrigation system for both highland and lowland farming for horticultural crops	

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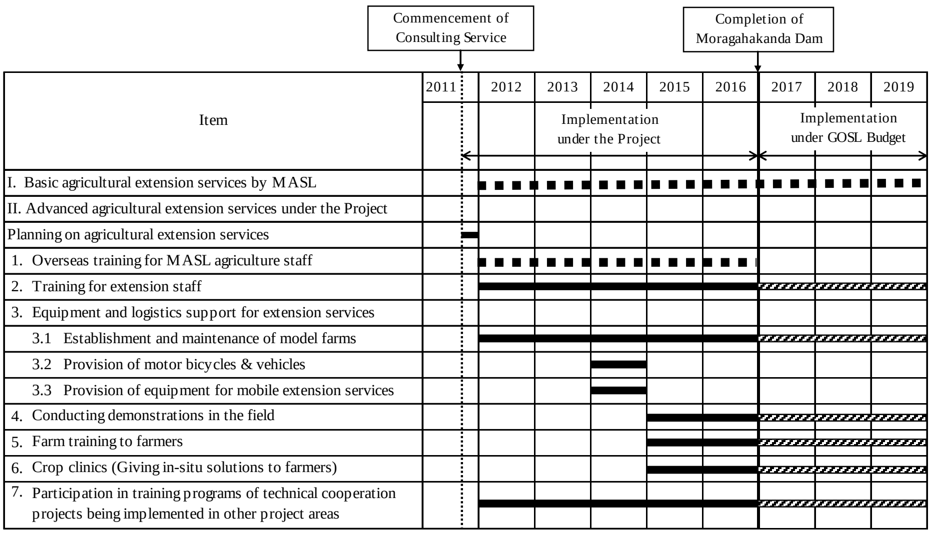

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Fig. S-11 Schedule of Activities of Agricultural Extension Services

The outline and schedule of activities of establishment and strengthening of FO are shown in Table S-13 and Fig. S-12 respectively.

Table S-13 Outline of Establishment and Strengthening of FO

Target Area and Families		
1.	Kaudulla Left Bank extension area (System D1):	1,420 ha
2.	Kalu Ganga Left Bank area (System F):	950 ha
3.	Kalu Ganga Right Bank area (System F):	1,100 ha
	Total Area:	3,470 ha
	Total Families:	6,000 households
Required Subjects		
(1)	Organizational management	
(2)	Water management	
(3)	O&M of irrigation facilities	

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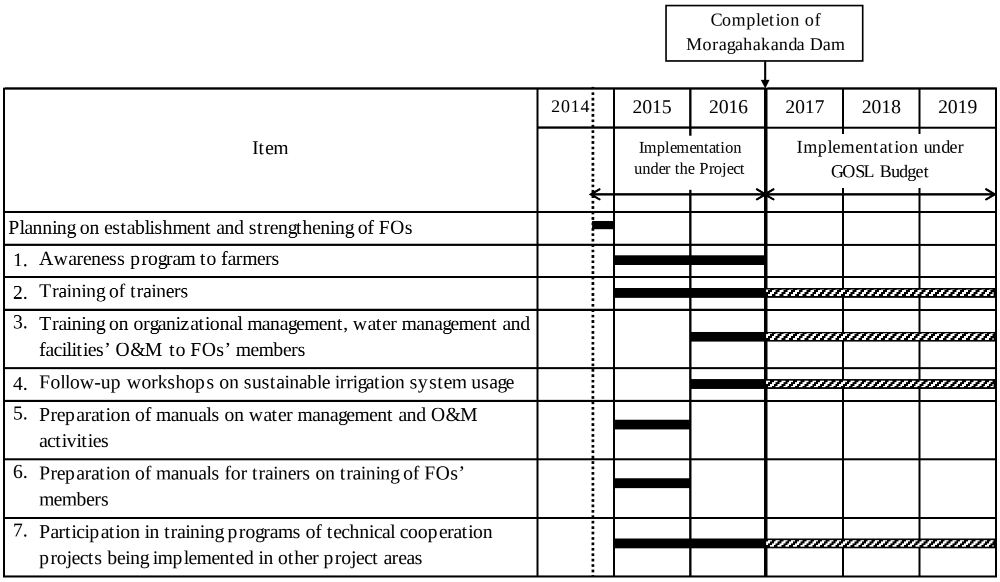

Prepared by the JICA Survey Team

Fig. S-12 Schedule of Activities of Establishment and Strengthening of FOs

4) Project Cost

i) Total Investment Cost

The initial investment cost for the Project is estimated at JPY31.4 billion consisting of JPY 16.9 billion for FC portion and LKR. 18.4 billion for LC portion as shown in Appendix D-1 and summarized in Table S-14.

Table S-14 Initial Investment Cost

Unit: Million

Designation	FC (JPY)	LC (LKR)	Total (JPY)	Eligible (JPY)	Non-eligible (JPY)
1. Construction Cost	9,098	3,474	11,842	11,465	377
1.1 Moragahakanda Dam	8,576	3,084	11,012	10,701	311
1.2 Kaudulla Left Bank Extension Area	522	390	830	764	66
2. Procurement Cost	300	0	300	300	0
3. Irrigation and Social Infrastructure for resettlement	1,714	592	2,182	1,951	231
4. Land acquisition and Compensation	0	3,227	2,549	0	2,549
5. Income Restoration Assistance Programmes and others	0	254	201	201	0
6. Environment Management Plan	0	1,000	790	790	0
7. Price Escalation	1,440	3,149	3,927	3,091	836
8. Physical Contingency	1,215	1,151	2,125	1,780	345
9. Consulting Services	1,496	1,323	2,541	2,541	0
10. Price Escalation for Consulting Services	189	553	626	626	0
11. Physical Contingency for Consulting Services	168	188	317	317	0
12. Interest During Construction	1,086	0	1,086	1,086	0
13. Commitment Charge	169	0	169	169	0
14. Administration Cost	0	1,700	1,343	0	1,343
15. VAT	0	1,767	1,396	0	1,396
Grand Total	16,875	18,378	31,393	24,317	7,076

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The MASL has begun to implement the irrigation and social infrastructures in System F (left bank of the Kalu River), and Kaudulla Left Bank Extension Area for the resettled people by the national budget since 2007, and will continue the same works by the Project budget in parallel with the implementation of the Project so that the infrastructures in the above areas will be completed before commencement of the resettlement.

ii) Construction Cost

The construction cost of Moragahakanda dam consists of civil works, hydro-mechanical works, hydro-power equipment, and transmission lines. The civil works include the main dam, saddle dams No.1 and No.2, appurtenant structures, and a powerhouse. The saddle dam No.2 has been constructed by the MASL since 2007 and is going to be completed in 2010, and hence its cost is out of scope of the loan amount.

The construction works in Kaudulla Left Bank Extension Area comprise construction of the left bank branch canal, improvement of the left bank main canal, rehabilitation of the existing farm ponds, and on-farm development. Some of these construction works have been started by the Irrigation Department, and the loan will not cover the costs of the works that are carried out by the Irrigation Department. Table S-15 shows the breakdown of the construction cost.

The on-farm development including field canal development will be carried out by the Project's budget and the beneficiaries are not expected to bear any costs either in financial or non-financial terms, while the farmer's contribution is expected for the formation of contour bunds during on-farm development operation.

Table S-15 Construction Cost of Civil Works

Unit: Million

Designation	FC (JPY)	LC (LKR)	Total (JPY)	Eligible (JPY)	Non-eligible (JPY)
1. Moragahakanda Dam					
1.1 Civil Works (Main dam, Saddle dam No.1, others)	6,195	2,723	8,346	8,346	0
Civil Works (Saddle dam No2, Diversion road)	398	219	571	260	311
1.2 Hydro-Mechanical Works	1,015	142	1,127	1,127	0
1.3 Hydro-Power Equipment	841	0	841	841	0
1.4 Transmission Line	127	0	127	127	0
Sub-Total 1	8,576	3,084	11,012	10,701	311
2. Kaudulla Left Bank Extension Area					
2.1 Civil Works (Work other than below)	478	358	761	761	0
Civil Works (Work to be done by GOSL)	42	31	66	0	66
2.2 Mechnical Euipment and Steel Structures	2	1	3	3	0
Sub-Total 2	522	390	830	764	66
Total	9,098	3,474	11,842	11,465	377

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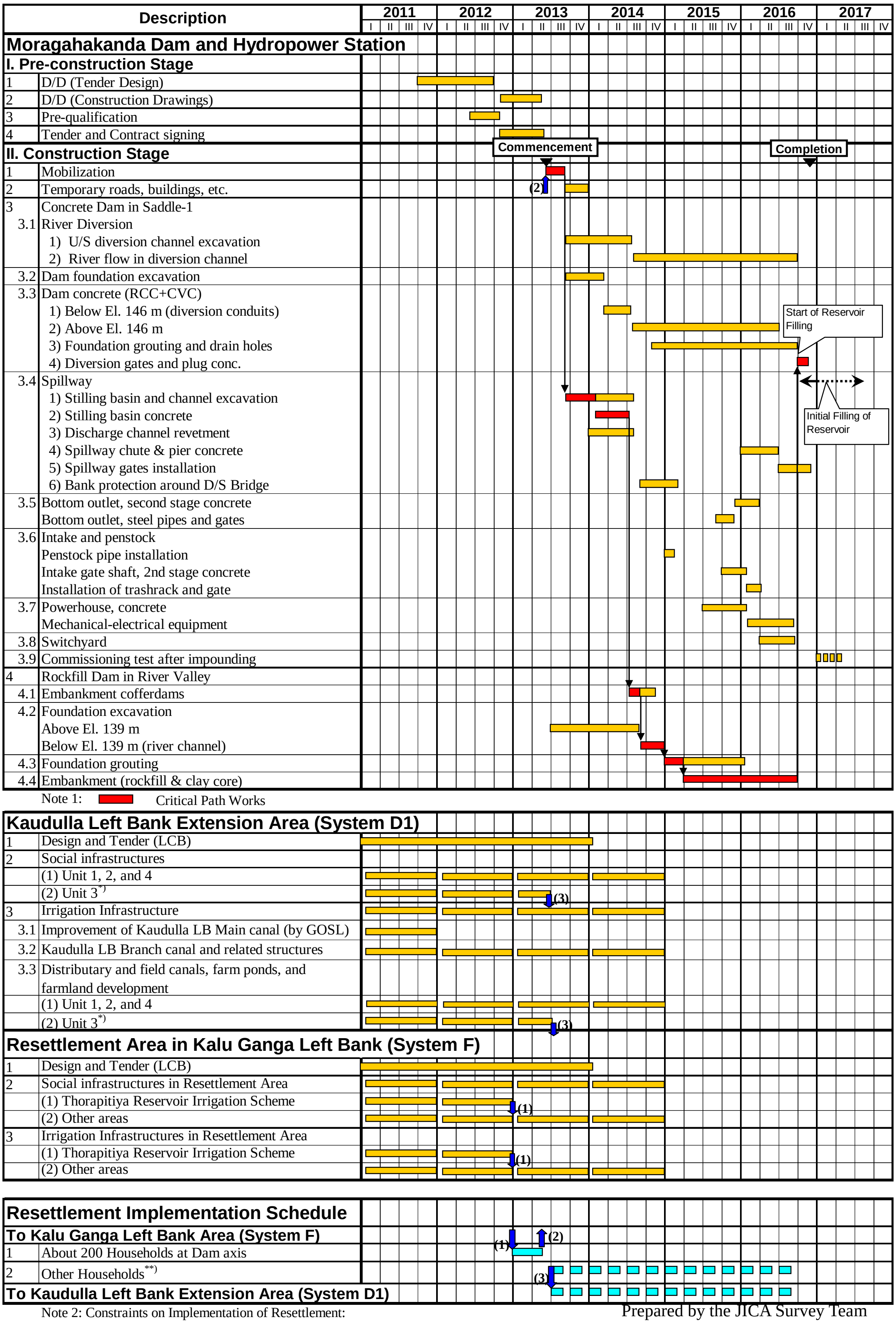
5) Implementation Schedule

The overall works of the Project include pre-construction works consisting of detailed design, prequalification, and tender, and construction works comprising construction of the Moragahakanda Dam and hydropower station, irrigation facilities in Kaudulla Left Bank Extension Area, and social infrastructure in Kaudulla area and System F. The consulting services are assumed to be commenced in October 2011, and then construction works of dam will be carried out from June 2013 to December 2016. The irrigation and social infrastructure in Kaudulla Left bank Extension Area (System D1) and Left and Right bank of Kalu Ganga Area (System F) have been carried out by the MASL and ID, and will be continued to be carried out by local contractors under the JICA loan from 2011. Fig. S-13 shows the overall implementation Schedule.



Note 2: Constraints on Implementation of Resettlement:

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(1) About 200 households at dam axis will start to be resettled after completion of Thorapitiya Reservoir Irrigation Scheme in System F.

(2) After completion of resettlement of about 200 households at dam axis, construction of the Moragahakanda Dam will start.

(3) About 300 households will start to be displaced to System D1 after completion of infrastructures in Unit 3 of Kaudulla Left Bank Extension Are

Note 3:

*): Unit 3 is the area where displaced people from Moragahakanda (about 300 households) are to be resettled

**): Resettlement of "other households" to System F (about 1,000 households) will commence following the resettlement of the initial 200 households, in accordance with the progress of development of irrigation and social infrastructure. They can visit their original place and continue cultivation there, until the irrigation and social infrastructure in System F is fully developed and the reservoir filling starts.

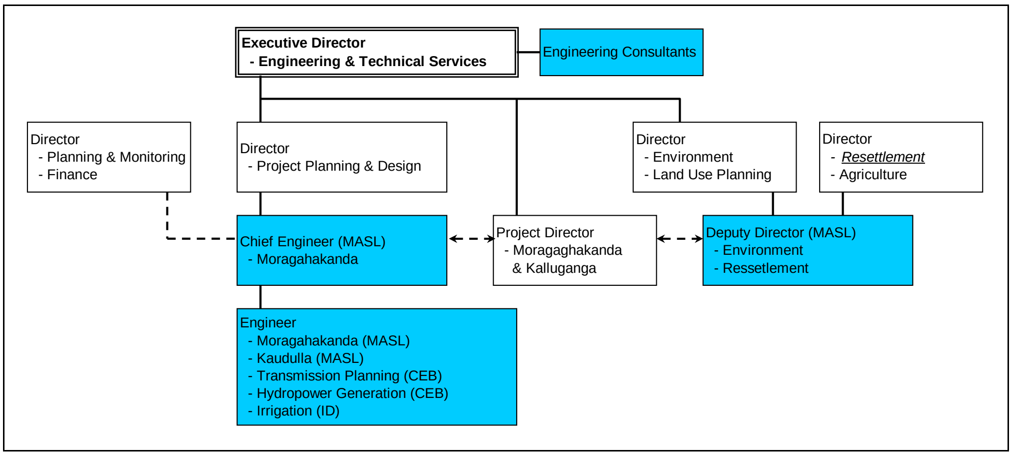
Fig. S-13 Overall Implementation Schedule of Moragahakanda Development Schedule

09. Organization of the Project

1) Project Implementation Structure

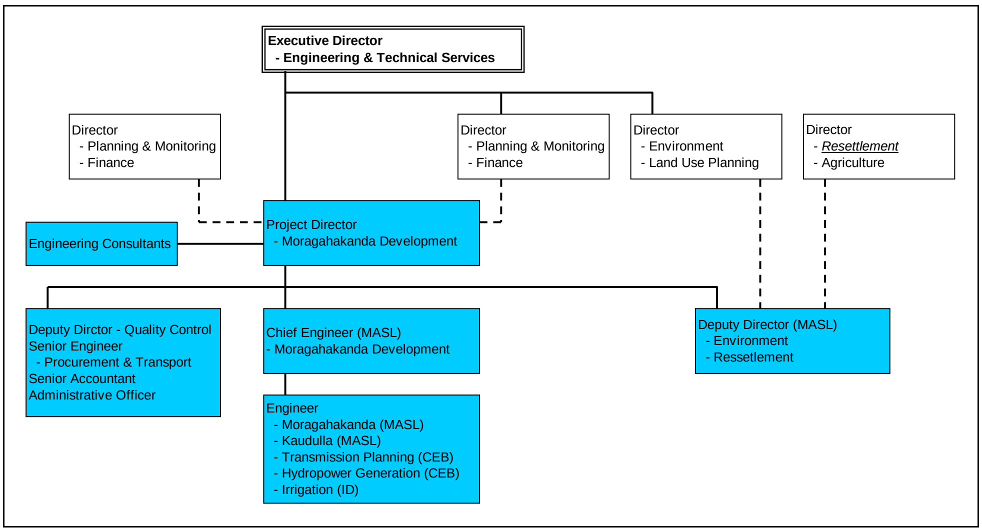
In the project implementation structure, the MASL will play a key role in coordinating the related agencies besides its direct involvement in the activities. The ID and CEB will be involved in planning, design, construction, and O&M of the Project. Input from the NWSDB, such as data related to the domestic and industrial water demand, is required in the planning stage, but no direct role of the NWSDB is expected in the project implementation.

The Project Implementation Unit (PIU) will be established to coordinate and direct the Project. There will be two PIU frameworks; one is responsible for the design and tender stage, and the other is for the construction stage of the implementation of the Project, as shown in Fig. S-14 and S-15.



Prepared by the JICA Survey Team, Note: Shaded position shows newly proposed position

Fig. S-14 Proposed Organization Structure of PIU in Design Stage



Prepared by the JICA Survey Team, Note: Shaded position shows newly proposed position

Fig. S-15 Proposed Organization Structure of PIU in Construction Stage

2) Project O&M Structure

i) Water Management System

The water management for the Mahweli development scheme is handled by the Water Management Secretariat (WMS) of the MASL. In determination of water allocation from the Mahaweli River system, the WMS prepares water allocation plan based on the water balance simulation and coordinates all water users such as the MASL and ID, CEB, and NWSDB to make consensus in the Water Management Panel (WMP), which is held twice a year. Water management for the Project also involves the above mentioned stakeholders for distribution of water. Hence, the water management system of the Project area will be coordinated under the responsibility of WMS.

ii) Dam/Reservoir

The organizational arrangement for the O&M of the Moragahakanda reservoir will be carried out by the Moragahakanda O&M unit under the Headworks Administration, Operation and Maintenance (HAO&M) Unit of the MASL. The proposed organization chart and positions for dam and reservoir O&M is shown in Fig.S-16.

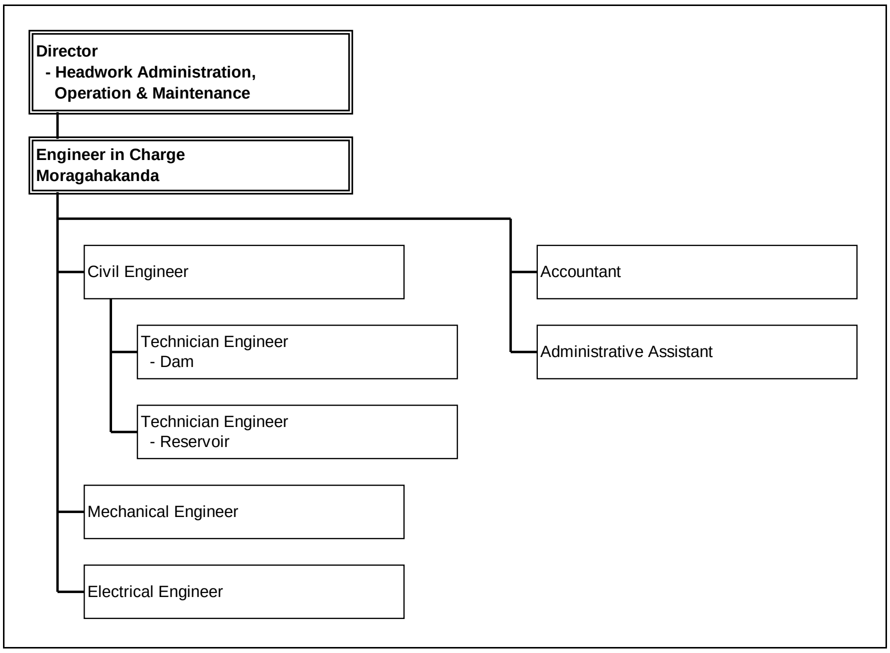


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Fig. S-16 Proposed Organization Structure of Dam and Reservoir O&M

iii) Irrigation System

The O&M responsibility of irrigation systems under the MASL and ID are summarized Table S-16.

Table S-16 Proposed Share of Responsibility for Irrigation System

Activities \ Level	Moragahakanda Dam/Reservoir Headworks	Reservoir Headworks	Main Canals/ Branch Canals	Distributary Canals	Field Canals
Irrigation Schemes under MASL (System H)					
Preparation of annual O&M plan	HAO&M	HAO&M	RPM	RPM	DCFO
Preparation of cropping schedule	-	-	WMP	RPM	DCFO
Operation of facilities	HAO&M	HAO&M	RPM	RPM	DCFO
Maintenance work	HAO&M	HAO&M	RPM	DCFO	DCFO
Irrigation Schemes under ID (System I/H, M/H, HFC, G, D1 and D2)					
Preparation of annual O&M plan	-	RDI	RDI	RDI	DCFO
Preparation of cropping schedule	-	-	WMP	RDI	DCFO
Operation of facilities	-	RDI	RDI	RDI	DCFO
Maintenance work	-	RDI	RDI	DCFO	DCFO

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Notes: HAO/M: Headworks Administration, Operation and Maintenance Unit
WMP: Water Management Panel, RPM: Resident Project Manger, MASL
RDI: Regional Director of Irrigation, ID, DCFO: Distributary Canal Farmers Organization

iv) Hydropower Plant

The role of the CEB in all projects under the Mahaweli development schemes that included hydropower generation is to take over the facilities related to hydropower generation and transmission lines, the O&M of which facilities are entirely to be carried out by the CEB, while the MASL carries out the O&M of the reservoir and headworks and issues the water for the hydropower generation to CEB.

Construction works for hydropower generation plant will be carried out by the MASL and that of transmission lines will be carried out by the CEB using the funds to be provided through the MASL. The daily water issues for this purpose is decided at the weekly water management panel meetings held at the WMS.

The same procedure is proposed to be continued in the case of the O&M of the hydropower station and transmission lines under the Project. Proposed share of responsibility of the Project by the MASL and CEB is shown in Table S-17.

Table S-17 Share of Responsibility of the MASL and CEB (Proposed)

Facility	Construction	Holding of assets	O&M Responsibility	License of operation
Dam/Reservoir	MASL	MASL	MASL	MASL
Power plant	MASL	CEB	CEB	CEB
Transmission lines	CEB	CEB	CEB	CEB

Prepared by the JICA Survey Team

10. Project Evaluation

Economic evaluation was carried out to assess the economic viability of the Project from a national economic point of view. In order to evaluate the Project, indicators such as the economic internal rate of return (EIRR), benefit-cost ratio (B/C), and net present value (NPV or B-C) are calculated.

1) Economic Project Cost

Based on the estimated financial project cost, the economic project cost was calculated by using the conversion factors, i.e. standard conversion factor (SCF) of 0.9 and shadow wage rate (SWR) for unskilled labor of 0.7.

The total economic project cost was estimated to be about LKR 23,103 million, while the financial cost is LKR 39,739 million as shown in Table S-18. The annual O&M cost is totally LKR 74.5 million. The total replacement cost, which is assumed to be expended in the 30th year after completion, is LKR 2,349.3 million.

Table S-18 Economic Capital Cost of the Project

Financial Cost			Economic Cost		
Foreign Portion (JPY million)	Local Portion (LKR million.)	Total Cost (LKR million)	Foreign Portion (JPY million)	Local Portion (LKR million.)	Total Cost (LKR million)
16,875	18,378	39,739	13,431	6,101	23,103

Prepared by the JICA Survey Team

2) Economic Project Benefits

For calculation of the project benefits, only direct benefits of irrigation, power generation, domestic and industrial water supply, and fishery are counted and no indirect and intangible benefits are taken into account. Annual project benefits of each sector are calculated as shown in Table S-19. An amount of 50 to 60 MCM/year of water to be saved from improvement of the irrigation water use from 2022 could be flexibly utilized for the future increased water demand. However, it is not included in the benefit because no decision has been made on the usage of the saved water.

Table S-19 Annual Economic Benefits of the Project

Unit: million LKR

Sector	Agriculture	Hydropower	Water Supply	Fishery
Annual Economic Benefits	2,684	578	870	46

Prepared by the JICA Survey Team

3) Economic Evaluation Results

EIRR was calculated from the cash flow table to be 10.6% with LKR 1,232 million of NPV and 1.08 of B/C, as summarized in Table S-20.

Table S-20 Result of Economic Evaluation

EIRR (%)	Net Present Value (LKR million)			B/C
	Benefit	Cost	NPV (B-C)	
10.6	17,602	16,370	1,232	1.08

Prepared by the JICA Study Team

The EIRR results indicate that the project is viable in terms of national economy.

4) Annual Farm Income

The annual farm income after implementation of the Project will increase to approximately LKR 149,000 per annum compared to current condition, LKR 110,000 per year in average farm household, 0.91 ha. This result showed the Project has the positive impact increasing the net farm income for individual farmers.

5) Operation and Effect Indicators

Operation and effect indicators for the Project are proposed in Tables S-21 and S-22.

Table S-21 Operation Indicators

No.	Indicators	Current (2010)	Target (2018)
Irrigation and Agriculture			
1.	Area benefited by the Project (ha)	-	87,278 ha
2.	Cultivated area by crops (ha)	Paddy (Maha): 81,200 ha Paddy (Yala): 54,400 ha	Paddy (Maha): 84,800 ha Paddy(Yala): 66,700 ha (Increment 15,900 ha)
3.	Sufficiency rate of O&M cost (%)	Irrigation: 78% Dam/Reservoir: 60%	Irrigation: 85% Dam/Reservoir: 65%
4.	Annual total volume of inflow to the reservoir (MCM/year)	-	560 MCM/year
5.	Annual total volume of water release through intake facilities (MCM/year)	-	550 MCM/year
6.	Volume of sedimentation in the reservoir (m^3/km^2/year)	-	340 m^3/km^2/year
Power Generation			
7.	Unplanned outage hours (hours/year or days/year)	-	48 hrs / year
8.	Capacity factor (%)	-	50%
Domestic and Industrial Water Supply			
9.	Population served (persons)	669,000 persons	877,000 persons
10.	Amount of water supply (m3/day)	108,000 m^3/day	143,000 m^3/day

Prepared by the JICA Survey Team

Table S-22 Effect Indicators

No.	Indicators	Current (2010)	Target (2018)
Irrigation and Agriculture			
1.	Production volume of major crops (t/year)	Paddy (Maha): 361,300 t Paddy (Yala): 242,600 t	Paddy (Maha): 407,000 t Paddy (Yala): 313,500 t (Increment 116,600 t)
2.	Yield of major crops per unit area (Rainy season, Dry season) (t/ha)	Paddy (Maha): 4.45 t/ha Pady (Yala): 4.46 t/ha	Paddy (Maha): 4.8 t/ha Paddy (Yala): 4.7 t/ha
3.	Gross annual average farm income (LKR/year/household)	LKR 110,000 /year	LKR 130,000 /year
Power Generation			
4.	Net electric energy production (GWh/year)	-	66.3 GWh/year
5.	Maximum output (MW)	-	15MW (2 x 7.5 MW)
Domestic and Industrial Water Supply			
6.	Percentage of Population Served (%)	29%	35%

Prepared by the JICA Survey Team

6) Greenhouse Gas Emission Mitigation

Greenhouse gas (CO_2) emission mitigation amount was calculated based on "Guidelines for Formation of the Climate Change Project in the Electric Energy Sector (JBIC, 2008)". The emission factor of thermal power plants in Sri Lanka based on the current power generation characteristics was estimated to be 1.611 kg- CO_2/kWh. As a result, 106,800 ton-CO_2 (or 1.611 x 66,300 MWh) can be reduced with the construction of a hydropower plant as part of the Project.

11. Environmental Considerations

1) Assistance provided to the MASL's EIA Revision

The EIA-related documents for the MADP has been prepared sequentially over a number years since the original EIA was prepared in 1998 because the implementation of the Project was postponed over a period of many years.

To fulfil the conditions of the EIA approval, the supplementary reports/documents were prepared as shown in Table S-23. These documents were reviewed by the Survey Team between Jan. – June 2010, and the technical assistance was provided to the MASL to elaborate and modify the Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP).

Table S-23 Major EIA-related Reports/Documents Reviewed by the Survey Team

No.	Document Title	Remarks
1	EIA of Moragahakanda Agricultural Development Project, Final Report.	EIA report dated October 1998. Not adequate for a project to be developed in 2011.
2	Moragahakanda Project Supplementary EIA Vol. 2	Maps - TEAMS, 1997
3	Moragahakanda Project Supplementary EIA Vol. 3	Photos - TEAMS, 1997
4	EIA/'Environmental Clearance' related documents.	Ministry of Agriculture approval of the EIA dated 26th October 2001 with additional environmental and social conditions. Further conditions applied with extension of the Environmental Clearance, firstly on 16th March 2006, and then again on 26th October 2007 (until 25th October 2010).
5	Biodiversity Assessment of the Moragahakanda Agriculture Development Project	IUCN, June 2007. Comprehensive and detailed study of biodiversity in the project area by a well respected organisation. Useful mitigation measures proposed which were accepted by MASL and written into the WMP (below).
6	Final Report, Comprehensive Watershed Protection Management Plan and Mitigatory Plan	USJ, June 2007 Review of issues and development of a range of mitigation measures to protect the watershed, the river and the surrounding wildlife areas. Recommendations for mitigation accepted by MASL.
7	Total Environmental Mitigation Plan	Separate undated MASL document. Will be updated and expanded by the Survey Team.
8	Summary of the Environmental Monitoring Plan	Separate undated MASL document. Will be updated and expanded by the Survey Team.
9	Water Management Panel Document - Water Management Secretariat, MASL	Seasonal Operating Plan, Maha 2008/9 (for whole Mahaweli Scheme)

No.	Document Title	Remarks
10	Feasibility Study Moragahakanda Development Project - Locations of Borrow Areas & Quarry Sites (August 2001)	Separate map (taken from Supplementary Report).
11	Drainage Plan	Separate undated MASL document, largely concerned with drainage of the new construction / access road.
12	MOU between MASL & Irrigation Dept	On the irrigation water supply for the downstream users
13	Detailed Geological Study With Respect to the Land Stability of Moragahakanda Agricultural Development Project	National Building Research Organisation, November 2008. Indicates mostly low risk of landslides. Advocates tree-planting, etc., as recommended in the WMP.
14	Moragahakanda Agricultural Development Plan	Development Division, MASL - August 2007. Includes specific plans for agricultural development in the resettlement areas in System F (Kalu Ganga) and D1 (Medirigiriya).
15	CEA Letter re Transmission Line	EIA not required for proposed transmission line and hydropower plant.
16	MoU between MASL and Dept. Wildlife Conservation on Elephant Management Action Plan	Action plan and budget on the elephant management of Moragahakanda and Kalu Ganga Agricultural Extension Project

Source of data: MASL

2) Preparation of the Addendum to the EIA-related Documents

The additional documents which are necessary to meet the JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002) were identified by the Survey Team and were prepared. The addendum consists of (1) the updated EMP, (2) the updated EMoP including a monitoring form, (3) descriptions of the impact assessment, (4) JBIC Environmental Checklists, and (5) public consultation records (for the first 4 items, see Section F.18, F.19, F.3, F.5 of Appendix F respectively).

3) Summary of the Supplemental Survey for the EIA-related Reports (Sub-contracted Work)

The supplemental survey for the existing EIA-related reports was conducted by the JICA Survey Team as a sub-contracted work, which are summarized in Table S-24. The work consists of (1) translation of the relevant documents, (2) interviews with wildlife management experts in Sri Lanka; and (3) preparation of the updated EMP and EMoP. The work was completed in June 2010.

Table S-24 Summary of the Supplemental Survey

No.	Task	TOR	Summary of the Survey Results
1	Translation of relevant documents in Sinhala into English	One report on the public consultation, one report on the consent letter collection and the MoU were translated from Sinhalese into English.	(1) The numbers of public awareness activities has been conducted by the MASL since 2007. (2) The consent letters were obtained from the potential resettlers in June 2009. (3) The MoU on water provision for the downstream user was signed by the Dept. of Irrigation and the MASL.
2	Hearings/interview with wildlife management experts in Sri Lanka	Targeting 3 environmental NGOs, 3 academicians and 3 governmental organizations.	(1) The respondents in all three groups of experts confirmed that the project planning has included sufficient actions to address potential impacts of the Project on wildlife, and has taken adequate steps to avoid human-wildlife conflict that may arise during the construction and operation of the Project.
3	Preparation of updated EMP and EmoP	To be updated to meet the requirements of JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002) (e.g. responsible org., monitored parameters, monitored locations, methodology, timeframe, frequency and budget).	The major changes made by the update were as follows: [EMP] (1) Addition of mitigation measures relating to construction activities; (2) Addition of standards to be met by mitigation measures; (3) Quantification of mitigation measures that were previously only qualitative, where appropriate; and (4) Revision of environmental management costs. [EmoP] (5) Addition of monitoring related to construction activities; (6) Addition of monitoring of environmental quality (e.g. water quality, noise and vibration, air quality, etc.); (7) Addition of environmental quality standards to be addressed within monitoring; and (8) Revision of monitoring costs.

Prepared by the JICA Survey Team

12. Social Considerations

1) Assistance Provided to the MALS's RIP Revision

The resettlement-related documents, namely (1) the draft RIP report, (2) an inventory survey report, (3) 2 socio-economic surveys of MADP (potential resettlers) and System F (one of the potential host communities), (4) a summary of public consultation activities, and (5) maps of resettlement sites were collected during the 1st filed survey between January and February 2010. The comments and recommendations on the draft RIP reports were prepared by the Survey Team based on the review results of the above-mentioned documents and the results of the site visit on between 2-4 February 2010 and 24-25 April 2010.

2) Major RIP Contents to be Revised

Based on the review of the Survey Team, Six major contents in the draft RIP were revised to meet the JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002) as shown in Table S-25.

Table S-25 Major Items Revised in the Draft RIP Report

No.	Item	Remarks
1	Potentially displaced persons in the newly changed transmission line alignment	✓ There are 24 landowners whose land will be affected by the transmission line (but no resettlement is expected), and the survey result was included in the RIP report.
2	Potentially displaced persons in the irrigation area in System D1	✓ There were additional 9 households to be affected and displaced by the branch canals in System D1, and the results was added in the draft final RIP report.
3	The Entitlement Assurance Letter and the Consent Letters	✓ The consent letters from most potential resettlers were collected in June 2009, and the process and latest results were included in the RIP report.
4	Entitlement Matrix	✓ It was suggested to revise the compensation policy for land since initially the compensation for land at the market value in accordance with the Land Acquisition Regulations 2009. ✓ In the draft final RIP report (as of July 2010), it was revised accordingly and includes the compensation for land which is equivalent to the full replacement cost (i.e. the market value and the transaction cost) as defined by the National Involuntary Resettlement Policy of Sri Lanka and the WB's Operational Policy (OP) 4.12 Involuntary Resettlement.
5	Resettlement Schedule	✓ Since the Project needs to be synchronised with the Kalu Ganga Development Project for the resettlement in System F, the more practical phase-wise resettlement schedules for the families to be displaced from the dam axis, the rest due to the reservoir area, the elephant corridor, the deviated road and the branch canal alignment of System D1 was included in the draft final RIP report. ✓ More details on availability of social infrastructures (especially, irrigation water supply and domestic and industrial g water supply) in the resettlement sites were included in the draft final RIP report.
6	Public Consultation for the RIP	✓ The records of the past public consultation on resettlement were compiled as much as possible. ✓ In some meetings, the data required by the JBIC Guidelines for Confirmation of Environmental and Social Considerations was not prepared. ✓ Thus, it was suggested the MASL to organise additional public consultation meetings on 17 July 2010 and to prepare the necessary records (e.g. the agenda, distributed handouts, venues, dates, participants' lists, and pictures). ✓ It was also suggested that the entitlement package, planned schedule, available social infrastructure in the resettlement sites and grievance redress mechanism in the draft RIP report need to be well explained to PAPs in the future public consultation meetings.

Prepared by the JICA Survey Team

3) Summary of the Supplemental Survey for the RIP Report (Sub-contracted Work)

The supplemental survey for the existing draft RIP report was conducted by the JICA Survey Team as a sub-contracted work (see Table S-26). The work consists of (1) interviews with stakeholders on resettlement, and (2) preparation of the resettlement brochure. The work was completed in June 2010.

Table S-26 Summary of the Supplemental Survey

No.	Task	TOR	Summary of the Survey Results
1	Hearings/interviews with stakeholders on resettlement including potential resettlers	Targeting 5 local governmental officers, 6 community leaders, 32 potentially displaced persons and 5 CBO (Community-Based Organisations or self-help organizations)	(1) Mixed results were obtained. (2) Thirteen out of 16 stakeholders responded the provided public consultation was sufficient. Additionally, 30 out of 32 potentially displaced responded they have received a copy of the entitlement package document, and 28 out of 32 answered the information available was sufficient, even though 4 expressed it was unsatisfactory because of no information on the exact date to move to a resettlement site, unsatisfactory valuation results, no reliability of the information and no proper awareness.
2	Preparation of the resettlement brochure	A draft prepared by the MASL was translated into English and Tamil. 2,150 copies will be printed (2,000 in Sinhala, 50 in Tamil and 100 in English)	(1) Compensation for land which is equivalent to the full replacement cost (i.e. market value and transaction cost) is proposed. (2) Compensation for structures at the replacement cost without any depreciation was originally proposed. (3) Compensation for crops at the market rate is proposed. (4) Available social infrastructures in the resettlement sites, the resettlement schedule, and grievance redness system, further information disclosure and contact information of the MASL officers in charge are explained.

Prepared by the JICA Survey Team

13. Recommendations

Based on the survey results, the Survey Team recommends the following items.

(1) Additional Geological Investigations for Detailed Design

- An additional geological investigation along the dam axis and reservoir area, which is going to be carried out by the MASL before the detailed design stage, and geological drillings on the foundation of powerhouse, stilling basin, etc, in the detailed design stage.

(2) Investigation on Construction Materials

- Field and laboratory tests on quantity and quality of embankment materials and concrete aggregates from the riverbed, existing borrow area, and the proposed quarry site.
- Availability of good quality materials, such as cement, fly ash, admixtures, and quality of the river water from the Amban River to be used for mixing concrete and grout materials.

(3) Hydraulic Model Test for Design of Spillway and Water Channel

A series of hydraulic model test is required to be conducted during the detailed design to determine the following design:

- Shape of spillway training walls and chute
- Width and Depth of the stilling basin

- Layout of water channel
- Protection for the existing bridge and

(4) Verification of Factors Used in the Water Balance Simulation Model

In the water balance simulation, some factors that make the simulation model more accurate and realistic are used. Those factors are not derived theoretically, but determined based on observations of river and canal flows. It is therefore recommended that those factors be verified in the detailed design stage to ensure the water balance simulation results.

(5) Water Balance Simulation for Future Water Use

The water balance planning in this Survey was prepared based only on the planned Moragahakanda Reservoir and present water demands. However, the idea of future water supply to Vanni (northern areas of Sri Lanka) as well as North Central Province from the Moragahakanda Reservoir and other Mahaweli projects (including the Kalu Ganga Reservoir) through a planned North Central canal is announced in the "Mahinda Cintana 2010". It is therefore recommended that a water balance simulation be carried out incorporating the future developments on Mahaweli system and future water demands in the detailed design stage, if the above idea of future water supply is developed to a formulation stage by then.

(6) Saving Irrigation Water

The Agriculture Department, MASL and ID are requested to promote spreading the cropping pattern with short-term varieties of paddy among farmers, so as to save water for further extent of irrigation area, future increase of demand of domestic and industrial water in the Project area, or other purposes.

(7) Detailed Planning of Soft Components

It is reminded that detailed planning on agricultural extension services, and establishment and strengthening of FOs to be included in the Project components, is to be made in the consulting services for the smooth and successful implementation, prior to its implementation, as described in this Report.

(8) Project Cost

The MASL and ID are requested to finalize the design and cost estimate of irrigation and social infrastructures at Kaudulla Left Bank extension area and Kaku Ganga area as much as possible, so as to make more accurate cost estimate for a loan arrangement, by the time of expected Appraisal of the Project.

(9) O&M of Hydropower Station

The Survey Team proposes the same procedure of O&M of the Hydropower Station of the Project as the current practice taken between the MASL and CEB. Meanwhile, some alternative schemes are also proposed as the future options as described in Chapter 5.

It is recommended that the MASL have a discussion with the CEB on O&M of the Hydropower Station as early as possible.

(10) EIA Documentation

All documents that have been prepared since the original EIA was prepared in 1998 should be formally adopted as addenda to the original EIA report. This could be done when the Environmental Clearance is again extended, and it is recommended that the MASL should mention this in the application for approval extension, which will be made on 25 August 2010.

(11) Cost and Schedule of the Mitigation Measures for the Archaeological Remains

The cost estimate of the detailed study and the preservation work identified in the Archaeological Impact Assessment (AIA) report prepared by the Department of Archaeology in 2009 should be included in the EMP and EMoP and the schedule needs to be incorporated in the overall project implementation schedule.

(12) Further Consent Letter Collection

The consent letters from the rest of affected people, which is 1% or six more households, need to be further collected as much as possible before the JICA’s loan appraisal mission.

(13) Inclusion of the Additional Potential Resettlers

The newly identified affected people in the transmission alignment (24 landowners) and in System D1 (nine households affected by the branch canal) need to be fully included in the RIP report in terms of the scale of the resettlement and land acquisition, the resettlement site plan, and the budget before its submission to JICA in July 2010

(14) Compensation Policy at Full Replacement Cost

The compensation policy needs to be equivalent to the international standards of the replacement cost consisting of the market value and the transaction costs and without any depreciation for the asset.

(15) Resettlement Monitoring Form

The monitoring form on resettlement needs to be prepared by MASL based on the monitoring form on resettlement included in the updated EMoP and included in the final RIP report before the loan appraisal of JICA. The monitored items shall include the progress of land acquisition and compensation payment and changes in livelihood of the resettlers and host communities.

(16) Organisation of the Public Consultation Meetings

The public consultation meetings explaining on the entitlement packages, the social infrastructure in the resettlement site, the schedule, and the grievance redress mechanism needs to be organised at the village level as early as the draft RIP is finalised (expected in early July 2010). It is also suggested to explain the environmental and social impacts of the Project and proposed major mitigation measures (i.e. major items in the EMP and EMoP) during the same public consultation meetings.

(17) Resettlement Schedule

The detailed resettlement schedule by phase needs to be prepared in accordance with the progress of other relevant projects, namely the Kalu Ganga development project for availability of irrigation water in System F and the Medirigiriya Water Supply Scheme for availability of drinking water in System D1.

(18) Distribution of the Resettlement Brochure

It is suggested that one copy of the resettlement brochure be delivered to each affected household by the MASL in early July 2010.

PREPARATORY SURVEY
ON
MORAGAHAKANDA DEVELOPMENT PROJECT

FINAL REPORT

VOLUME I MAIN REPORT

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Not to be disclosed until the contract agreements for all the works and services are concluded.

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Abbreviations

ADB	Asian Development Bank
AIM	Area-increment Method
ATPP	Alternative Thermal Power Plant
CBO	Community-based Organizations
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CECB	Central Engineering Consultancy Bureau
CI	Cropping Intensity
CIF	Cost, Insurance and Freight
CPI	Consumer Price Indices
CRIEPI	Central Research Institute of Electric Power Industry
CSG	Cemented Sand and Gravel
CVC	Conventional Concrete
DCFO	Distributary Canal Farmers' Organization
DS	District Secretary
EARM	Empirical Area Reduction Method
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMAP	Environment Management Action Plan
EMoP	Environment Monitoring Plan
EMP	Environment Management Plan
EMYE	Elahera-Minneriya Yoda Ela
F/S	Feasibility Study
FC	Foreign Currency
FIDIC	Fédération Internationale Des Ingénieurs-Conseils or International Federation of Consulting Engineers
FIRR	Financial Internal Rate of Return
FO	Farmers' Organization
FOB	Free on Board
FSL	Full Supply Level
GDP	Gross Domestic Product
GEVR	Grout-enriched Vibratable RCC
GHG	Greenhouse Gass
GOJ	Government of Japan
GOSL	Government of Sri Lanka
HAO&M	Headworks Administration, Operation and Maintenance
ICB	International Competitive Bidding
ICOLD	International Commission of Large Dams
ICTAD	Institute for Construction Training and Development
ID	Irrigation Department
IMD	Irrigation Management Division
IUCN	International Union for Conservation of Nature and Natural Resources
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
KFAED	Kuwait Fund for Arab Economic Development
KHFC	Kandalama-Huruluwewa Feeder Canal
LAA	Land Acquisition Act
LC	Local Currency
LCB	Local Competitive Bidding

LHG	Low Humic Gley (Soil)
MADP	Mahaweli Agricultural Development Project
MASL	Mahaweli Authority of Sri Lanka
MCP	Mahaweli Consolidation Project)
MEA	Mahaweli Economic Agency
MECA	Mahaweli Engineering and Construction Agency
MKDP	Moragahakanda and Kalluganga Development Project
MOL	Minimum Operation Level
MoU	Memorandum of Understanding
MRRP	Mahaweli Restructuring and Rehabilitation Programme
MRR	Monthly Review Report
NCP	North Central Province
NEDECO	Netherlands Engineering Consultants
NGO	Non Governmental Organization
NIRP	National Involuntary Resettlement Policy
NPV	Net Present Value
NWSDB	National Water Supply & Drainage Board
O&M	Operation and Maintenance
ODA	Official Development Assistance
OFC	Other Field Crops
PAA	Project Approving Agency
PAP	Project Affected Person
PEACE	Pro-poor Economic Advancement and Community Enhancement Project
PIU	Project Implementation Unit
PMU	Project Management Unit
PPP	Private Power Producer
PRA	Participatory Rapid Appraisal
PSS	Parakrama Samudra
PUCSL	Public Utilities Commission of Sri Lanka
RAP	Resettlement Action Plan
RBE	Reddish Brown Earth
RCC	Roller Compacted Concrete
RDI	Regional Director of Irrigation
RIP	Resettlement Implementation Plan
RPM	Resident Project Manager
SCF	Standard Conversion Factor
SEA	Sustainability Energy Act
SOP	Seasonal Operation Plan
SPPA	Small Power Purchase Agreement
SRR	Seasonal Summary Report
SWR	Shadow Wage Rate
TOR	Terms of Reference
UNDP	United Nations Development Programme
VAT	Value Added Tax
VESP	Voluntary Early Separation Package
WB	World Bank
WMP	Water Management Panel
WMS	Water Management Secretariat

Measurement Units and Currency

mm	millimetre(s)
cm	centimetre(s)
m	meter(s)
km	kilometre(s)
m^2	square metre(s)
km^2	square kilometre(s)
ha	hectare(s)
acre(s)	acre(s), 1 acre = 0.4047 ha
L	liter
m^3	cubic meter(s)
MCM	million cubic meter(s)
g	gram(s)
kg	kilogram(s)
t	ton(s) or tonne(s), 1 t = 1,000 kg
s	second(s)
hr or h	hour(s)
d	day(s)
N/m^2	newton per square m (=Pa)
Pa	Pascal
mm/d	millimetre per day
m/s	meter per second
m^3/s	cubic meter(s) per second
kV	kilo Volt
MVA	mega Volt-ampere
MW	mega Watt
GWh	giga Watt-hour(s)
˚C	degrees Celsius
HP	horsepower
JPY	Japanese Yen
LKR	Sri Lanka Rupee
USD	United States of America Dollar

Exchange Rate:

USD 1.0 = JPY 90.5 (March 2010)

USD 1.0 = LKR 115 (February 2010)

CHAPTER 1 INTRODUCTION

1.1 Authority

The Preparatory Survey for the Moragahakanda Development Project (the Project) was commenced in December 2009 in accordance with the Terms of Reference contained in the Implementation Program for the Moragahakanda Development Project agreed between the Mahaweli Authority of Sri Lanka (MASL) and the Japan International Cooperation Agency (JICA) in October 2009.

1.2 Background of the Project

The contribution of the agriculture sector to the gross domestic product (GDP) of Sri Lanka has decreased in the past 20 years, and was 12.1% in 2008. However, the agriculture sector is still an important source of employment since it provides livelihood to 31.3% of the total employment in Sri Lanka and the major income source to the rural people, which accounts for about 70% of the total population in Sri Lanka. About 95% of the people who are below the poverty line live in the north eastern provinces, dry areas, and plantation areas. The major issues for poverty alleviation particularly in the dry areas include mitigation of water shortage, development of agriculture infrastructure, and promotion of crop diversification.

With the assistance provided by the United Nations Development Programme (UNDP) and Food Agriculture Organization (FAO) in the years between 1965 and 1968, the Government of Sri Lanka prepared the Master Plan of the Mahaweli Development Programme, which targeted the development of irrigation water resources, hydropower generation, and domestic and industrial water with water sourced from the Mahaweli River and other regional rivers. Subsequently, it commenced implementation of the prioritized projects proposed in the master plan. In 1977, the Accelerated Mahaweli Development Programme was prepared. Hence, the MASL was established in order to increase the rice self-sufficiency ratio, meet the increasing electricity demand, create the job opportunities for the unemployed youth, and facilitate the overall development. After establishment of the programme and MASL, the development was remarkably progressed. The facilities that have been constructed so far are five large-scale dams (i.e. Komtale Dam, Victoria Dam, Randenigala Dam, Rantambe Dam, and Maduru Oya Dam), three headworks (i.e. Polgolla, Minipe, and Bowatenna), hydropower generation plants with a total capacity of more than 670 MW, irrigation development of approximately 200,000 ha, and relevant facilities such as roads, schools, hospitals, and townships.

The Project is planned to increase agricultural productivity, provide safe domestic and industrial water, and improve the livelihood of local residents in the central dry zone by constructing a multi-purpose dam for irrigation, water supply, and power generation with the expansion of the irrigation system in North Central Province. Since priority was given to the development of hydropower generation in the upstream of the Mahaweli River in these decades, as mentioned above, water distribution to the northern central dry zone was not realized, and hence water shortage has become more serious. Therefore, it has been recognized that the implementation of the Project is an urgent issue.

Upon request by the Government of Sri Lanka, JICA conducted the feasibility study on the Moragahakanda Agricultural Development Project in 1979, and also conducted a follow-up study, which updated the plan in 1988. Lahmeyer International carried out the feasibility study on Moragahakanda Development Project (FS2001) was undertaken by under the Kuwait Fund for Arab Economic Development (KFAED). Under these circumstances and the long-term technical assistance provided by JICA, the Government of Sri Lanka has requested the Government of Japan to provide loan assistance for the Project.

1.3 Objective of the Project

The objectives of the Project are: 1) to provide irrigation water to Systems H, I/H, M/H, G, D1, D2, and KHFC in order to raise the cropping intensities and standard of living of farmers in the areas; 2) to supply additional domestic and industrial water to the districts of Matale, Anuradhapura, Trincomalee, and Polonnaruwa; and 3) to improve the electricity supply by generating hydroelectric power.

1.4 Scope of the Survey

The scope of the preparatory survey is as follows:

TOR1: Review of the necessity and background of the Project

TOR2: Review of the feasibility of the Project

TOR3: Assessment of the Project implementation framework

TOR4: Assessment of the Effect of the Project

TOR5: Clarification of legal framework for the land acquisition and involuntary resettlement

TOR6: Assistance for the revision of the draft RIP

TOR7: Assistance for the revision of the documents required for environmental considerations

The preparatory survey team recommends the implementation program for the Project that would possibly be financed through a JICA ODA loan.

1.5 Major Activities of the Survey

Nippon Koei Co., Ltd. has conducted the preparatory survey in close collaboration with the MASL for seven and a half months from the beginning of December 2009 to the mid-July 2010. The major activities of the Preparatory Survey are as follows:

(1) 1st Home Office Work in Japan (Early Dec. to Late Dec. 2009)

- Review and analysis of the existing data and information.

- Preparation and submission of the Inception Report.

(2) 1st Field Survey in Sri Lanka (11th of Jan. 2010 to 6th of Mar. 2010)

- Presentation and discussion on the Inception Report.

- Collection of data and information on the necessity and background of the Project, project implementation framework, legal framework on resettlement, and land acquisition.

- Study of the feasibility of the Project including water balance study, review of existing basic design of dam and irrigation facilities, etc.

- Assistance in revising the draft RIP and environmental considerations documents.

(3) 2nd Home Office Work in Japan (Early Mar. to Mid-Mar. 2010)

- Additional study of the dam design and project implementation schedule.

- Preparation and submission of the Interim Report.

(4) 2nd Field Survey in Sri Lanka (22nd of Mar. to 3rd of Apr. 2010)

- Presentation and discussion on the Interim Report.

- Review of EIRR and FIRR, the operation and effect indicators and the amount of GHG (CO_2) emission reduction.

- Collection of additional information and data.

(5) 2nd Field Survey on Environmental and Social Considerations in Sri Lanka (22nd of Apr. to 11th of May)

- Additional review of environmental and social considerations and field interview.

(6) 3rd Home Office Work in Japan (Late Apr. to Late May 2010)

- Finalization of the economic and financial analysis.

- Preparation of the operation and effect indicators and estimation of the amount of GHG (CO_2) emission reduction.

- Preparation and submission of the Draft Final Report.

(7) 3rd Field Survey in Sri Lanka (Early June 2010)

- Presentation and discussion on the Draft Final Report.

- Collection of additional data and information.

(8) 4th Home Office Work in Japan (Mid-Jun. to Mid Jul. 2010)

- Preparation and submission of the Final Report.

This report describes the results of the overall review of the existing feasibility study report prepared in 2001 (FS2001) carried out by referring to the latest information and updating the data obtained through review of water balance planning with current irrigation area and cropping patterns of each system, review of existing basic design and cost of Moragahakanda Dam and Kaudulla LB Canal, and presents the proposed project, project implementation framework, project evaluation, and assessment of environmental and social considerations, which were conducted during the survey period for eight months from December 2009 to July 2010.

CHAPTER 2 NECESSITY OF THE PROJECT

2.1 National Policy of Relevant Sectors in Sri Lanka

2.1.1 Agriculture

(1) Present Conditions of the Agriculture Sector in Sri Lanka

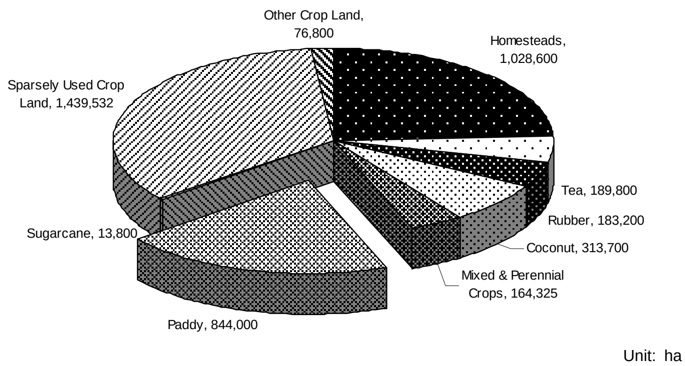
Agriculture is the dominant and most important economic activity in Sri Lanka. The share of agriculture sector accounted for 12.1% of the total gross domestic product (GDP) of LKR 2,365,500 million in 2008. Although the contribution from the agriculture sector to GDP, which used to be 28% of the total GDP in early 1980s, has been declining, the agriculture sector still plays a vital role in Sri Lanka's economy. In addition, more than 30% of the total employment depends on agriculture for livelihood. It is the main source of livelihood for the rural population, which accounts for about 70% of the total population in Sri Lanka. Table 2.1.1 shows the share of each sector in GDP and employment in year 2008.

Table 2.1.1 Share of Each Sector in GDP and Employment (2008)

Sector	GDP (million LKR)	Employment (person)
Agriculture	285,897 (12.1%)	2,344,000 (32.7%)
Industry	672,790 (28.4%)	1,888,000 (26.3%)
Service	2,406,814 (59.5%)	2,943,000 (41.0%)
Total	2,365,500 (100.0%)	7,175,000 (100.0%)

Source of data: Central Bank of Sri Lanka Annual Report 2008

Out of the 65,610 km^2 (6,561,000 ha) total area of Sri Lanka, the area of agriculture including homesteads and sparsely used crop lands is about 42,540 km^2 (4,254,000 ha) in 2007 according to Land Use & Policy Planning Division, Ministry of Land. The plantation crops such as tea, rubber, and coconut are recognized as one of the major crop groups in Sri Lanka, and the allocated area for plantation crops extends to 687,000 ha or about 16% of the total agricultural land. The remaining agricultural area is for the non-plantation smallholding cultivations, which extends to about 2,538,000 ha (60%). Paddy is the most prominent among the non-plantation crops with its area for cultivation covering 844,000 ha in year 2007. Details on the agricultural land use in Sri Lanka are shown in Fig. 2.1.1.



Source of data: Land Use & Policy Planning Division, Ministry of Land

Fig. 2.1.1 Agricultural Land Use in 2007

The agricultural area under the Mahaweli Authority of Sri Lanka (MASL) accounts for about

18% of the total rice cultivated area, and 23% of the total rice production in year 2007. Table 2.1.2 shows the share for rice cultivated area and production in the whole area under MASL.

Table 2.1.2 Share of Rice Cultivated Area and Production in the Area under MASL

Year	Cultivated Extent (1000 ha)	Production (1000 ton)
2001	132 (16.6%)	598 (22.7%)
2002	139 (16.4%)	629 (22.0%)
2003	145 (14.8%)	634 (20.7%)
2004	137 (17.6%)	640 (24.4%)
2005	151 (16.1%)	708 (21.8%)
2006	153 (16.8%)	725 (21.7%)
2007	148 (18.1%)	735 (23.5%)

Source of data: Statistical Hand Book 2007, Mahaweli Authority of Sri Lanka
Note: Mahaweli Area includes System B, C, G, H, Uda Walawe, and L.
Total irrigable area in 2007/08 is approx. 97,000 ha.

(2) National Policies

Vision for Agriculture Sector

The ten-year development framework (2006-2016) for the agriculture sector seeks to achieve the following vision according to "Mahinda Chintana (Vision for a New Sri Lanka)" published by the Department of National Planning, the Ministry of Finance and Planning in 2005:

> "An agriculture sector contributing to regionally equitable economic growth, rural livelihood improvement and food security through efficient production of commodities for consumption, for agro-based industries and for exporting competitively to the world market."

The goals of the agriculture policy are to achieve sustainable earnings, food security, and higher income for those who are dependent on this sector, to reduce the cost of living of the population as a whole, and to provide an adequate diet at affordable prices for the poor.

Agriculture Policy

One of the focused points described in "Mahinda Chintana" is to transfer the agriculture sector from the subsistence sector to a commercially oriented and highly productive sector that will bridge the gaps between the agriculture sector and other sectors. Therefore increasing the productivity of tree crop/export agriculture, which is becoming more competitive in the international market, is identified as an important strategy in the policy. It is expected to create exportable surplus and/or import substitute products, and to improve accordingly the balance of payments of the country.

"Mahinda Chintana" has given priority to the improvement of processing, marketing, and down streaming activities to enhance additional values to agricultural products. It can also create more job opportunities in rural areas, and thereby, reducing urban migration.

The non-plantation crop sector in Sri Lanka, which is also referred to as the domestic food production sector, has been also given priority in "Mahinda Chintana". Rice is the most major food crop, which accounts approximately 25% of the consumer food basket, about 30% of the total grain consumption, and nearly 50% of the calorie intake of the country. The government policy in "Mahinda Chintana" for promoting rice production consists of three key elements, namely guaranteed price scheme, fertilizer subsidy, and concessionary bank loans. In addition, the government has continued facilitating the paddy purchasing program by means of a special credit arrangement made through the divisional secretariats.

Development Target

The ten-year development framework in "Mahinda Chintana" has set the development targets in the agriculture sector. During the planned period (2006-2016), the agriculture sector as a whole is planned to grow at an average rate of over 5%. The growth will result from a combination of increase in the extent area for agricultural production and improvement of its productivity. Growth rates of the extent area and the productivity that are required to achieve the overall growth rate of 5% are shown in Table 2.1.3 according to the ten year development framework of "Mahinda Cintana".

Table 2.1.3 Target Growth Rates of Extent and Productivity

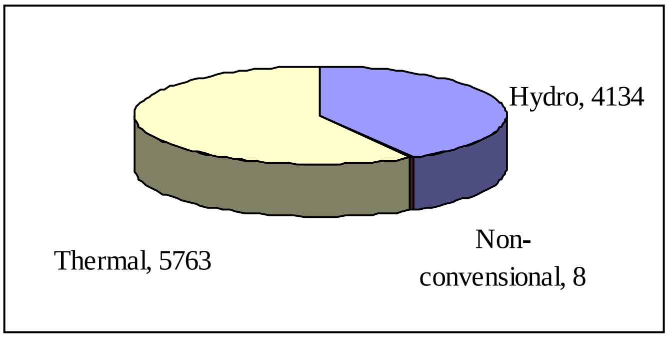
	Rate of Increase for the ten-year period (2006-2016)	
	Extent Area Increase	Productivity Increase
Non Plantation Sector		
- Paddy	0.1%	10.0%
- Field Crops, Vegetables, Fruits etc.	0.8%	25.0%
Plantation Sector		
- Tea	0.1%	20.0%
- Rubber	2.0%	5.0%
- Coconut	5.0%	20.0%

Source of data: Mahinda Chintana: Vision for a New Sri Lanka A Ten Years Horizon Development Framework 2006 - 2016 Discussion Paper

2.1.2 Electricity

(1) Present Condition of Electricity in Sri Lanka

In the early stage of the electricity demand in the country, electricity was mainly supplied by hydropower generation and the contribution from thermal generation was minimal. Since the latter half of 1990s, thermal generation increased rapidly to meet the growing electricity demand and superseded the hydro generation in 2000. At present, the thermal generation share is higher than that of hydrogeneration as shown in Fig.2.1.2. Among the total generation, the electricity generated by Private Power Producer (PPP) including small hydro facilities shares around 40% in recent year.



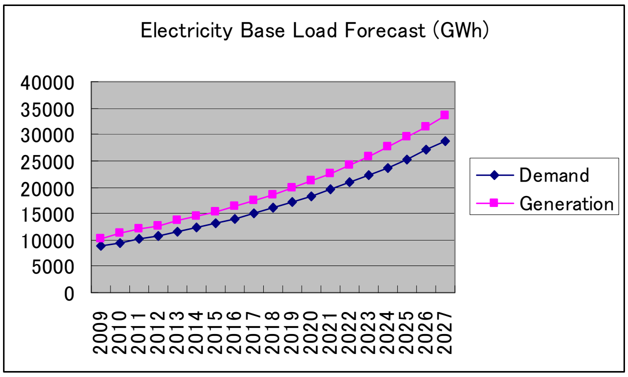
Source of data: CEB: Statistical Digest 2008 and Annual Report 2007
Note: "Non-conventional" includes solar power, wind power etc.

Fig.2.1.2 Electricity Generation in Sri Lanka 2008 (GWh)

However, the Sri Lankan power system is still significantly dependent on hydropower. Consequently, it is difficult to assess the energy generating potential of hydropower to a higher degree of accuracy, due to the multi purpose nature of some reservoirs, which have to satisfy the downstream irrigation requirements as well. This affects the operation pattern of hydropower generating station, which is determined by weekly consultation among relevant parties, i.e. Irrigation Department, Ceylon Electricity Board (CEB), and water development authorities.

(2) Future Projection

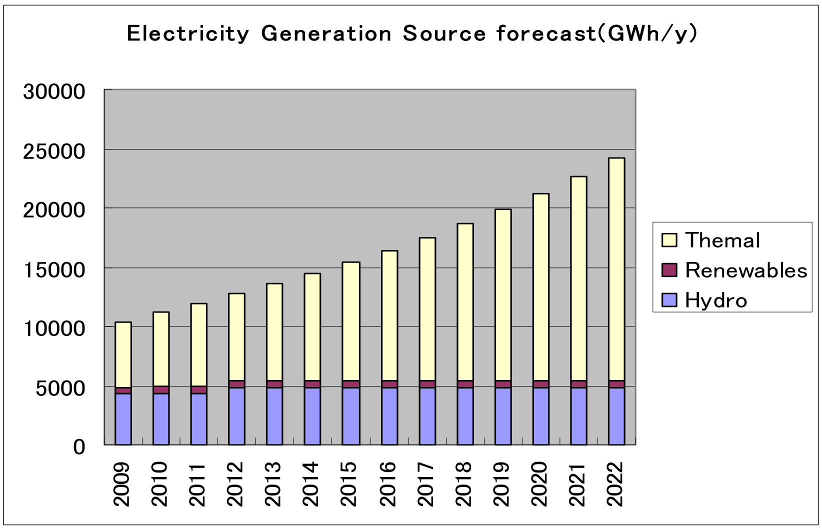
The CEB issued its "Long Term Generation Expansion Plan 2009-2022" in December 2008. According to the plan, Table Ad.2 Base Load Forecast-2008, updated is as illustrated in Fig.2.1.3.



Source of data: CEB

Fig.2.1.3 Electricity Base Load

In this forecast, the average demand growth rate of 6.63% and the average generation growth rate 6.64% are adopted. Also, the Electricity Generation Source (2009-2022) as shown in Fig.2.1.4 indicates that the incremental generation in the future will be much owed to thermal generation, while the hydropower generation remains almost at the same level. It is noted that the total annual hydropower generation will be 4,376GWh until the year of 2011, and will be 4,797GWh after 2012 by adding 421GWh from Upper Kotmale.



Source of data: CEB

Fig.2.1.4 Electricity Generation Source Forecast

(3) National Energy Policy

The Government of Sri Lanka declared the "National Energy Policy of Sri Lanka" in October 2006, which indicates out the implementing strategies, specific targets, and milestones, through which the government and its people would endeavour to develop and manage the energy sector in the coming years in order to achieve its millennium development goals (MDGs by United Nations).

While ensuring a continuous supply of electrical and petroleum products, the growing economy has to manage the strategic balance between indigenous energy resources and imported fossil fuels. The energy utilities are required to be strengthened further to improve their service quality, and also the country's diversity of energy services needs to be increased.

The National Energy Policy aims to implement the energy policy elements that are composed of the following:

i) Providing basic energy needs;
ii) Ensuring energy security;
iii) Promoting energy efficiency and conservation;
iv) Promoting indigenous resources;
v) Adopting an appropriate pricing policy;
vi) Enhancing energy sector management capacity;
vii) Consumer protection and ensuring a level (fair) playing field for all stakeholders in the energy sector;
viii) Enhancing the quality of energy services; and

ix) Protection from adverse environmental impacts of energy facilities.

The strategy to implement the fourth policy element, i.e. promoting indigenous resources is indicated in the National Energy Policy, which is quoted as follows:

> Concessionary financing will be sought to implement the remaining medium scale hydroelectric projects, which is economically, environmentally, and socially viable, but not viable under normal commercial terms.

The strategy also raises the following targets of supply-side energy efficiency:

- The transmission and distribution energy loss (the sum of technical and commercial losses) in the electricity sub-sector will be gradually brought down to the target value of less than 13.5% net generation by the end of 2009.
- The present system control procedures towards optimal operation of the integrated hydro-thermal power system will be improved by the end of 2007 to ensure maximum energy output from the hydropower system.
- Informed rehabilitation and new investment decisions will be made in the national interest to improve electricity generation, transmission, and distribution, based upon the information gathered from continuous measurement of energy entering and leaving the specific power system components.

(3) Electricity Act and Sustainable Energy Authority Act

Sri Lanka Electricity Act 2009 vests in Public Utilities Commission of Sri Lanka (PUCSL).

The function of the PUCSL is to act as an economic, technical, and safety regulator for the electricity industry in Sri Lanka. Under the Electricity Act, any person shall not generate, transmit, or distribute electricity unless a license has been granted by the PUCSL. No entity other than the CEB, a local authority or any company of which shares the government holds more than 50% shall be issued a license to generate more than 25 MW. Only the CEB shall be issued a license for transmission of electricity.

The objectives of the Sustainable Energy Authority (SEA), which was established under Act 35, shall be:

i) To identify, assess and develop renewable energy resources with a view to enhancing energy security and thereby derive economic and social benefits to the country;

ii) To identify, promote, facilitate, implement and manage energy efficiency improvement and energy conservation programs for use of energy in domestic, commercial, agricultural, transport, industrial and any other relevant sector;

iii) To promote security, reliability and cost effectiveness of energy delivery to the country, by policy development and analysis and related information management; and

iv) To ensure that adequate funds are available for the authority to implement its objects, consistent with minimum economic cost of energy and energy security for the nation.

The SEA has made a form of agreement to be enforced by the CEB and all parties that are interested in developing mini-hydro power stations. This agreement is called the Small Power Purchase Agreement (SPPA), which applied to power stations that generate up to 10 MW. This agreement is valid for a period of 20 years and standardized and non-negotiable.

The tariff for energy purchase is technology specific and also non-negotiable. All “mini-hydro” power plants are considered to be "must run facilities”, which means fully engaged, as such the plant owner will have full control over the amount and timing of energy generation.

For power generating projects larger than 10MW, there is neither standardized agreement nor standardized tariff for the sale of electricity from any renewable energy projects. Agreements and tariffs should be separately negotiated between the developer and the power purchaser.

Although the PUCSL is responsible for the overall smooth operation of the energy sector with the power to monitor and regulate its operations, empowering the PUCSL for this role until full implementation seems to be pending. In this circumstance, the two ministries of the Ministry of Power and Energy and Ministry of Petroleum and Petroleum Resources Development are virtually acting as the regulators for the respective sectors.

2.1.3 Domestic and Industrial Water Supply

(1) Present Conditions of Water Supply in Sri Lanka

The National Water Supply and Drainage Board (NWSDB) plans and implements major domestic and industrial water supply schemes in Sri Lanka, while municipalities and other organizations also implement small water supply schemes such as ground water schemes. The NWSDB is a statutory board under the Ministry of Urban Development and Water Supply, and is responsible for the development, operation, and maintenance of piped water supply and sewerage schemes for the benefit of domestic, industrial, commercial, and institutional sectors. Key statistics of the NWSDB is shown in Table 2.1.4 to view the domestic and industrial water supply sector in Sri Lanka.

Table 2.1.4 Key Statistics of the NWSDB in 2008

No.	Items	Figures
1	Piped water production (million m^3)	440
2	Pipe-borne water supply coverage (%)	32
3	Non-revenue water (%)	32
4	Domestic connections (no.)	1,078,178
5	Non-domestic connections (no.)	102,308
6	Total number of service connections (no.)	1,186,931
7	Total recurrent expenditure (LKR million)	8,907
8	Total development expenditure (LKR million)	2,5361

Source of data: National Water Supply and Drainage Board

(2) NWSDB Corporate Plan 2007-2011

The NWSDB Corporate Plan 2007-2011 was prepared with the assistance from JBIC (now merged with JICA) in September 2006. The plan aims to contribute in uplifting the living conditions of people in towns and villages by providing sufficient and safe drinking water through piped water supply schemes. The goals stated in the NWSDB corporate plan 2007-2011 are as follows:

a) To increase the water supply and sanitation coverage;
b) To improve operational efficiency;
c) To achieve customer satisfaction;
d) To increase commercial viability;
e) To ensure greater accountability and transparency;
f) Institutional development; and
g) To provide facilities and service support to rural and marginalized community.

In order to achieve the above goals, the development targets of domestic and industrial water supply sector have been set as shown in Table 2.1.5 and Table 2.1.6. The development targets of water supply coverage and non-revenue water in 2011 are 40% and 30%, respectively.

Table 2.1.5 Planned Water Supply Coverage 2006 - 2011

	2006	2007	2008	2009	2010	2011
Population (million people)	20.0	20.2	20.4	20.6	20.8	21.0
Pipe borne water supply coverage (million people)	6.2	6.5	6.9	7.4	7.9	8.4
Pipe borne water supply coverage (%)	31%	32%	34%	36%	38%	40%

Source of data: National Water Supply and Drainage Board

Table 2.1.6 Expected Non-Revenue Water to be Achieved

Unit: %

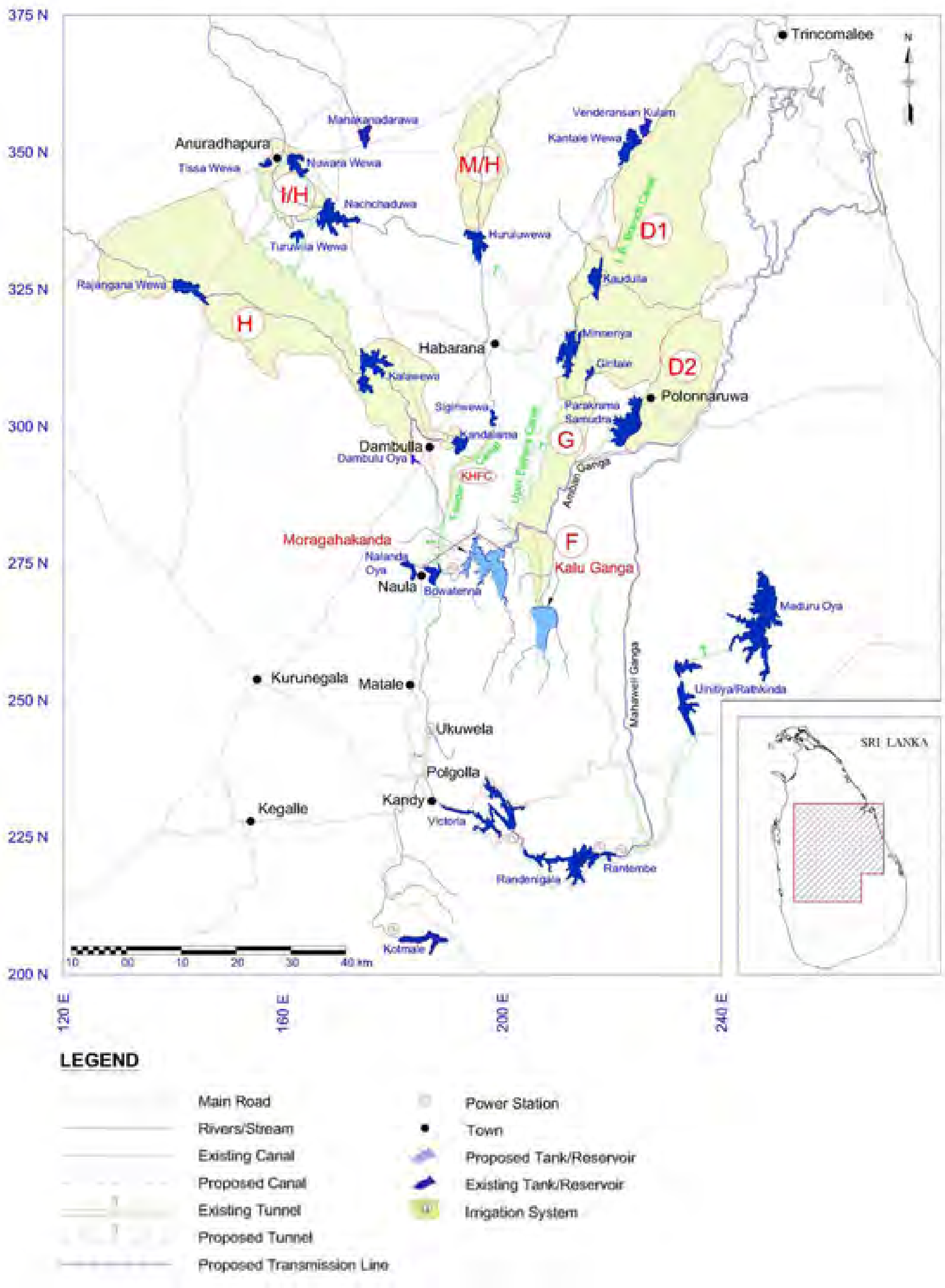
	2007	2008	2009	2010	2011
Greater Colombo	34	33.5	33	32.5	30
Western	28	28	27.5	27	26.5
North Central & North Western	23	22.5	22	21.5	21
Southern & Uva	30	29.5	29	28.5	28
Central & Sabaragamuwa	35	34	33	32.5	32
North & East	35	34.5	34	34	33
Island wide	33	33	32	31	30

Source of data: National Water Supply and Drainage Board

2.2 Present Status of Relevant Sectors in the Project Area

2.2.1 Agriculture

The benefited areas of the Project consist of seven operational systems of the MASL, namely System H, I/H, M/H, Kandalama Huruluwewa Feeder Canal (KHFC), G, D1 and D2. Locations of the systems to be irrigated by the Moragahakanda reservoir are shown in Fig. 2.2.1.



Source of data: MASL and FS2001

Fig. 2.2.1 Irrigation Systems in the Project Area

The agriculture in Sri Lanka is characterized by two monsoon seasons: the Yala season (April to September) and Maha season (October to March). In the Project area, about 70% of the annual rainfall occurs during Maha season, while the remaining rainfall during Yala season. More details about the climate are described in Chapter 3. The major crop cultivated in the Project area is paddy during both Maha and Yala seasons. Other field crops (OFC) such as chili, big onion, maize, cowpea, vegetables, and banana are cultivated mainly during Yala seasons. Meanwhile very little OFC are grown during Maha season.

The cultivated area and cropping intensity in the project area is summarized in Table 2.2.1.

Table 2.2.1 Cultivated Area and Cropping Intensity in the Project Area

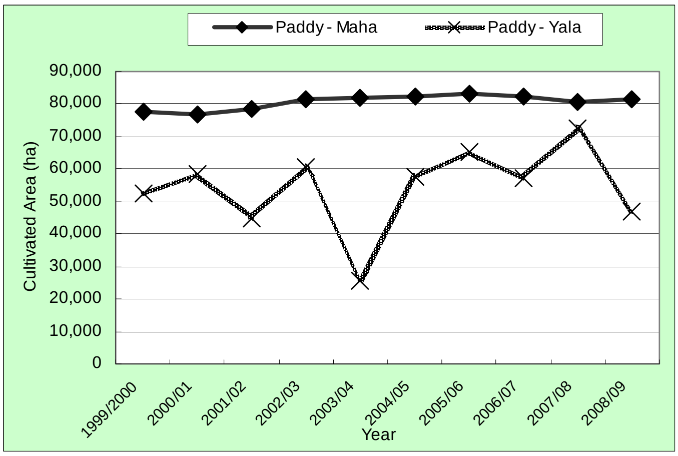
Unit: ha

	Maha Season			Yala Season			Annual Total
	Paddy	OFC	Total	Paddy	OFC	Total	
Cultivated area	81,218	2,055	83,273	54,423	12,193	66,616	149,889
Cropping Intensity	95%	3%	98%	64%	14%	78%	176%

Source of data: MASL and Irrigation Dept.

The estimated total irrigable area in the Project area in 2010 is approximately 86,000 ha. The average cultivated area for paddy and OFC is 83,000 ha in Maha season and 67,000 ha in Yala season in recent ten years from 1999/2000 Maha to 2009 Yala. The average annual total cropping intensity for the whole Project area is 176% in the past ten years. In all systems, cropping intensity during Maha season is more than 90% because enough rain is delivered by the northeast monsoon. Meanwhile during Yala season, cropping intensity is 78% in average and varies depending on the system and year (More details about the cultivated area and cropping intensity are described in Chapter 3).

Fig. 2.2.2 shows that the cultivated area during Maha season is almost stable, while that area during Yala season fluctuates vastly every year depending on the water availability, although the irrigation facility has been constructed and well maintained. Therefore it is urgent to resolve the water shortage in Yala season in the Project area to secure the sustainable paddy production as stated in the agriculture policy. Details of annual change is shown in Attachment-1.



Source of data: MASL and Irrigation Dept.

Fig. 2.2.2 Change of Paddy Cultivation Area in recent 10 years

The average paddy yield in the entire Project area is about 4.45 t/ha in Maha season, while about 4.46 t/ha in Yala season. The average yield in the Project area is higher than the national average yield of 4.2 t/ha, while the current yield of paddy is less than its potential 6.0 t/ha as estimated by the Department of Agriculture. This might be because the irrigation water supply is not stable enough during both seasons, especially during Yala season as shown in Fig 2.2.2. The paddy yield in the Project area could be increased close to its potential by supplying enough water. (More details about the yield of paddy and OFC are described in Chapter 3)

2.2.2 Electricity

(1) The CEB Power System and Construction of Naula Grid Substation

The CEB intends to enhance the power system in the near future, as shown in the CEB Power System Diagram year 2016 in Attachment-2.

The construction of the CEB Naula 132/33kV grid substation will become a reality in 2011 with funds from the Asian Development Bank. The purpose is to realize the following:

i) Allowing connection of power supply from the Moragahakanda Power Station and the Lenadora Power Station (in future) to the CEB network with the shortest distance; and

ii) Enhancing distribution power capacity for the Naula division.

As for ii) above, the CEB explained the technical objectives of construction of the 132/33kV Naula Grid Substation shown in Attachemnt-3 as follows:

i) To cater the growing demand for electricity in the Naula area by providing quality and reliable supplies and thereby relieve the load on the existing Ukuwela grid substation;

ii) To reduce distribution losses by supplying shorter distribution line; and

iii) To connect the proposed Naula Grid Substation to the national grid.

Based on the forecast load on the existing Ukuwela and Habarana grid substations shown in Attachment-3, the load of the Ukuwela and Habarana substations exceeds 120% under outage of one transformer by 2013 and 2014 respectively. Also, due to long distribution lines, the voltage profile at Naula and Dambulla are very poor, which also causes high power losses. The construction of the Naula Grid Substation can reduce the load on the Ulkuwela Grid Substation from 102% to 91% in year 2015. Furthermore, it will ensure the load security criterion for both Ukuwela and Habarana grid substations.

(2) Contribution of Power from Moragahakanda Power Station to Enhance CEB Grid and Local Electricity Access

Power supply from Moragahakanda Hydropower Station to Naula Grid Substation is expected to bring the following benefits:

i) Steady Electricity Power Supply to National Grid

The annual electricity power generation of the Moragahakanda Power Station is expected to be around 70GWh. Although this figure is not so high compared with the total national power generation of 15,402GWh for 2015, it far exceeds the 26 GWh electricity demand in Naula area in 2007. This means the surplus exceeding 26 GWh will flow into the national grid and contribute in meeting the national power demand.

ii) Improvement of Quality and Reliability of Electricity Available for Local Residents

The present electricity power supply to this area involves voltage fluctuation and sudden outage of electricity due to a long distribution line from Habarana and Ukuwela grid substations. Power supply from the Moragahakanda Hydropower Station to the new grid substation at Naula is expected to improve the present quality of electricity supply because of short transmission line and accordingly less chance of fault.

iii) Improvement of Electrification Level in this Area

According to the CEB 2006 data as shown in Attachment-3, the electrification level in the Naula area of 66% is lower than the average of total Sri Lanka, i.e. 80% in 2006. With an increase of quantitative electricity power source backed up by the Moragakahanda Power Station, the access of residents in this area to electricity will be easier and the electrification in the area will accelerate.

2.2.3 Domestic and Industrial Water Supply

(1) Present Status of Water Supply Sector in the Project Area

The Project area includes four districts for domestic and industrial water supply, i.e. Polonnaruwa, Matale, Anuradhapura and Trincomalee. The present status (as of 2009) of water supply sector (pipe-borne water supply) in the four districts is shown in Table 2.2.2.

Table 2.2.2 Present Status of Water Supply Sector in the Project Area

No	District	Water Production (MCM/year)	Amount of water Supply (m^3/day)	Population Served (person.)	Non-Revenue Water (%)
1.	Matale	18.2	40,500	234,000 (48%)	19%
2.	Anuradhapura	15.2	33,500	219,000 (25%)	20%
3.	Trincomalee	14.5	25,000	156,000 (33%)	37%
4.	Polonnaruwa	4.5	10,000	60,000 (15%)	20%

Source of data: National Water Supply and Drainage Board

Pipe-borne water supply coverage in the Project area is still at a low level compared to the target of the NWSDB Corporate Plan 2007-2011. Therefore, further development of water supply is necessary in the Project area.

The demand for both domestic and industrial water increases along with the population increase in Anuradhapura and Trincomalee areas, and local water supply schemes by using groundwater have been implemented. However, groundwater in those areas contains high concentration of fluorine and iron, and it has allegedly caused a health hazard. Hence, it is highly required to develop a new source of surface water in the Project area to supply safe water to the local residents.

(2) Water Demand Projection

In the FS2001, demands for domestic and industrial water supply from the Moragahakanda reservoir in the four districts, Matale, Anuradhapura, Trincomalee, and Polonnaruwa, was projected to be 92.4 MCM per year at 2030 based on the population and individual water demand forecast as shown in Table 2.2.3. This figure has been officially agreed between the MASL and NWSDB, and a new reservoir is required to be developed to satisfy this demand.

Table 2.2.3 Water Demand in the Project Area (2030) projected by NWSDB

Unit: MCM

No	District	Current Water Supply Amount from Mahaweli	Water Demand in 2030 FS2001 (Increment)
1.	Matale	6.9	31.2 (24.3)
2.	Anuradhapura	10.4	15.0 (4.6)
3.	Trincomalee	9.1	34.2 (25.1)
4.	Polonnaruwa	2.3	12.0 (9.7)
Total		28.7	92.4 (63.7)

Source of data: National Water Supply and Drainage Board

The Survey Team has reviewed the future water demand shown in Table 2.2.3. According to the NWSDB's internal data on the latest water demand forecast, the water demand in 2030 would be likely more than the above figure. However, those projections are still under review by the NWSDB and have not been authorized. It is accordingly recommended the figure shown in Table 2.2.3 being used for the present survey.

2.3 Necessity and Priority of the Project

Based on the national policy in Sri Lanka and the present status in the Project area described above, the necessity and priority of the Project are summarized as follows:

(1) Agriculture is the dominant sector in terms of both economic and employment aspects in Sri Lanka. The national agriculture policy gives priority to sustainable food supply, especially paddy. The ten-year development framework (2006-2016) in "Mahinda Chintana" has set the development target that the agriculture sector as a whole is to grow at an average rate of over 5%. To achieve the target, increase of cultivated area resulting from increase of irrigation facilities and increase in productivity is essential.

(2) The "Mahinda Cintana Vision for the Future", which was published after the presidential election in January 2010, says that the current food reserve is not sufficient and required to be raised, because to maintain adequate buffer stocks is of paramount importance to ensure price stability especially during off seasons. Furthermore, the GOSL has agricultural plans aiming at reaching the self sufficiency target in producing cereals to replace imports so that the foreign exchange savings can be released for new developments.

(3) The cultivated area under the Mahaweli Authority including the Project area plays an important role in production, as it accounts for almost 18% of the entire paddy cultivated area and 24% of whole paddy production in Sri Lanka. However, the cropping intensity in the Project area is unstable due to water shortage during Yala season. Moreover, the paddy yield in the Project area is not satisfactory, despite that the canals and gates are well developed and maintained. Developing new water resources is required to increase the agricultural production.

(4) It has been 30 years since JICA conducted the feasibility study on the Moragahakanda Agricultural Development Project was conducted in the 1970s, which concluded that its contribution to the agricultural development of Sri Lanka was expected to be quite large. In the meantime, hydropower generation projects on the Mahaweli River were given priority and four dams have been constructed. Despite the large potential of agricultural development in the North Central Province (NCP), the Moragahakanda Development Project has not been realized, and NCP has suffered from a severe water shortage, especially during the dry season. It has been desired to develop the Moragahakanda Dam to solve the water shortage problem in NCP.

(5) The irrigation water from the Amban River is diverted to NCP through the Bowatenna Tunnel and Elahera Anicut, for which some 875 MCM of water is diverted annually from the Polgolla Barrage. However, during every flood season, several hundred MCM of water flows to the sea, because no large reservoir exists other than the Bowatenna Reservoir having a capacity of only 50 MCM on the Amban River to receive the flood water. To utilize the flood water and secure the irrigation and domestic and industrial water supply in NCP, the Moragahakanda Dam with a capacity of 520 MCM is required to be developed.

(6) Water demand for domestic and industrial purposes has been increasing in Anuradapura, Trincomalee, and other two districts in the Project area in recent years due to population growth and industrialization. In some areas, groundwater is used for local water supply schemes, but has allegedly caused health problems. It is urged to develop a new water source to secure the quantity and quality of water in the Project area.

(7) The present condition of electricity supply in the Naula area is not stable because there are neither electricity sources nor substations nearby. The Moragahakanda Power Station would contribute to the improvement of quality and reliability of electricity supply to the local residents as well as steady electricity supply to the national grid.

(8) In "Mahinda Chintana 2006-2016", the strategic investment plan is presented, which include several new irrigation development plans in order to achieve the national development target. In the ten-year development framework of Mahinda Chintana, the Moragahakanda Development Project is defined as a priority project.

(9) The “Mahinda Cintana Vision for the Future, 2010” emphasizes the strategic importance of water as a natural resource, and shows a plan to supply additional water to the tanks of the Northern and North Central provinces under the Moragahakanda and other Mahaweli projects The Moragahakanda Development Project is defined as the most important and highest priority project in the water resources sector.

CHAPTER 3 THE PROJECT AREA

3.1 General

The Moragahakanda Development Project (the Project) consists of the following components:

(1) The Moragahakanda Dam comprising a main dam and two saddle dams with appurtenant structures and a hydro-electric to be constructed on the Amban River, a major tributary of the Mahaweli River. in Matale district in Central Province, which is located about 190 km from Colombo; and

(2) Kaudulla Left Bank Extension Area in System D1 consisting of construction of branch canal including sub-branch canals (20.9 km in total), improvement of main canal (6.4 km), and on-farm development (1,420 ha), located in Polonnaruwa district about 220 km from Colombo.

The term of “the Project area” means an area including the dam site, reservoir area, and whole irrigation areas consisting of Systems H, I/H, M/H, G, D1, D2 and Kandalama-Huruluwewa Feeder Canal (KHFC) Scheme.

This chapter presents the natural conditions, irrigation and agricultural activities in the Project area. The present progress of construction activities that are being implemented by the Mahaweli Authority of Sri Lanka (MASL) in the Project area is also described.

3.2 Natural Conditions

3.2.1 Topography and Geology

(1) General

The geologists of the Survey Team conducted site reconnaissance on the Project area and reviewed the existing geological reports (JICA’s Repot 1979, FS2001, and recent reports by local consultants) to summarize the geological data, identify geological issues that might cause serious problems to the project, and propose necessary geological investigations.

(2) Topography and Geology of Dam Sites

The general land level of the project area ranges from about 130 m to 150 m above sea level. The topography of the region is characterized by the low relief upland or ridge, and valley landscape, except for isolated monad nockes or erosional remnants, which stand 30 m to 100 m or more above the general land level. The land slopes are about 4% to 8%, and on such landscapes, the catenary of soils is observed from the ridge to the floor of the valley (FS 2001).

The Project site is underlain by Precambrian metamorphic crystalline rocks of highland series and Cambrian metamorphic rocks of Vijayan series. The foundation rocks of the Moragahakanda dam site are composed of charnockites, quartz and limestone-calc gneiss, and other gneiss (garnet-biotite-gneiss, garnetifeous gneiss or garnet gneiss).

Garnet-biotite gneiss including charnockite and quartzite, calc gneiss and garnet biotite gneiss are apparently stratified in descendant order, and these gneiss rocks form a flat folding with gently inclined limbs.

Several northeast-southwest (NE-SW) striking faults mainly with downthrown displacements up to tens of meters are anticipated based on the results of the core drilling survey. Gneiss and calc gneiss are in contact with fault at the right abutment of Saddle Dam No.1.

No general karstifications of the calc gneiss were found except for some karstic features at fault zone. Probably impure mineral constituent (containing much quartz and mica minerals) and crystalline calc gneiss is not susceptible to dissolution. Thickness of decomposed calc gneiss by weathering is 3 m to 5 m in general.

(3) Rock Classification and Strength of Dam Foundation

Rock mass of this study was classified based on Rock Mass Classification by Central Research Institute of Electric Power Industry (CRIEPI), Japan (Tanaka 1964). Criteria for rock classification of CRIEPI are shown in Table 3.2.1.

Table 3.2.1 Rock Mass Classification: CRIEPI

Grade	Description
A	The rock mass is very fresh, and the rock forming minerals and grains undergo neither weathering nor alternation. Joints are extremely tight and their surfaces have no visible sign of weathering. Sound by hammer blow is clear.
B	The rock mass is fresh and solid. There is no open joint and crack. But rock forming minerals and grains undergo a little weathering and alteration partly. Sound by hammer blow is clear.
CH	The rock mass is slightly weathered and relatively solid. The rock forming minerals and grains undergo weathering except for quartz. The rock is contaminated by limonite, etc. The cohesion of Joints and cracks is slightly decreased and rock blocks are separated by firm hammer blow along joints. Clay minerals remain on the separation surface. Sound hammer blow is a little dim.
CM	The rock mass is moderately weathered and somewhat softened by weathering, except for quartz. The cohesion of Joints and cracks is somewhat decreased and rock blocks are separated by ordinary hammer blow along the joints. Clay materials remain on the separation surface. Sound by hammer blow is somewhat dim.
CL	The rock mass is highly weathered and soft. The rock forming minerals and grains are softened by weathering. The cohesion of Joints and cracks is decreased and rock blocks are separated by soft hammer blow along the joints. Clay materials remain on the separation surface. Sound by hammer blow is dim.
D	The rock mass is completely weathered and decomposed, and remarkably soft. The rock forming minerals and grains are softened by weathering. The cohesion of joints and cracks is almost absent. The rock mass collapses by light hammer blow. Clay materials remain on the separation surface. Sound by hammer blow is remarkably dim.

Source of data: Central Research Institute of Electric Power Industry (CRIEPI), Japan (Tanaka 1964)

Mechanical properties are assumed based on the CRIEPI. Rock class of solid rock mass are as shown in Table 3.2.1. Considering the results of seismic prospecting, in-situ tests, and rock condition observation in Adit No.5 made in this study, slightly weathered rock of the dam site will fall around the upper part of CM class in the rock grade range in Table 3.2.2.

Slightly weathered rock and fresh rock zones are strong enough for dam foundation of 60 m class concrete gravity dams as well as earth core rock fill dams.

Table 3.2.2 Rock Mass Classification and Rock Parameters by K. Kikuchi, et al.

Rock Grade	Uniaxial Compress. Strength (kgf/cm^2)	Static Modulus of Elasticity (kgf/cm^2)	Modulus of Deformation (kgf/cm^2)	Cohesion (kgf/cm^2)	Internal Friction Angle (deg.)	Velocity of Eastic Wave (km/sec)
B	800 or more	80,000 or more	50,000 or more	40 or more	55-65	3.7 or more
CH	800-400	80,000-40,000	50,000-20,000	40-20	40-55	3.7-3.0
CM	400-200	40,000-15,000	20,000-5,000	20-10	30-45	3.0-1.5
CL-D	200 or less	15,000 or less	5,000 or less	10 or less	15-38	1.5 or less

Source of data: Dr.K.Kikuchi, Mr.K.Saito & Mr.K.Kusunoki, ICOLD (International Commission Of Large Dams), May,1982

(4) Expected Excavation Depth

The surface of slightly weathered rock zone is expected in dam foundation of concrete gravity dam and impervious core of rock fill dam.

Review on the results of the expected excavation depth excluding the fault zone along the dam axis proposed in FS2001 is shown in Table 3.2.3. Fault zones should be properly treated by concrete replacements, etc. depending on the rock condition of the dam foundation.

Rock conditions along the proposed dam axis are as follows:

- Overburden varies from less than 1 m to 10 m in depth;
- The surface of slightly weathered rock of right bank is likely deeper than one of left bank especially in the Main Dam and Saddle Dam No.2;
- A fault zone occurs along the right abutment of Saddle Dam No.1; and
- A fault zone along the river course at the Main Dam site is inferred from the geological incongruity between the drill holes DM-30 and DM-31.

Table 3.2.3 Expected Excavation Depth along the Dam Axis

Location	Expected Excavation Depth (m)		
	Left bank	River floor	Right bank
Main Dam	5-10	about 10	10-20
Saddle Dam No.1	13-14	about 11	9-18
Saddle Dam No.2	2-5	about 8	8-10

Prepared by the JICA Survey Team

Note:

1. These excavation lines were estimated by use of drilling survey data carried out by 2001.
2. Excavation works of Saddle Dam No.2 was completed in 2009. Excavation depth of saddle dam No.2 should be used as reference.

(5) Hydrogeological Condition of Dam Sites

Permeability of Dam Foundation

Hydrogeological conditions of the damsite are as follows:

- Most of the impervious zones at the dam sites are 10 m to 30 m deep below the ground surface.
- Fault affected areas located at the right abutment of Saddle Dam No.1and river floor of the Main Dam show pervious along the fault zones, while the depth of impervious zone is unknown.
- Since Lugeon values of the foundation rocks are not so high, foundation rocks are possibly groutable accordingly, however, their groutability needs to be ensured through in-situ tests.

Groundwater Level

i) Right Bank of Main Dam

According to FS2001 report, groundwater level above FSL (185 m) was found during the groundwater observation. However, the drill hole DN-28 is not available, and DN-27 is too shallow to guarantee stable groundwater level.

ii) Hill between Main Dam and Saddle Dam No.1

Groundwater level of the hill between the Main Dam and Saddle Dam is below FSL (185 m).

iii) Hill between Saddle Dam No.1 and Saddle Dam No.2.

According to FS2001 report, groundwater level above FSL (185 m) was found during the groundwater observation. However, the drill hole DN-23 is not available, and DN-24 is too shallow to guarantee a stable groundwater level. There are also risks of groundwater flowing down the drill hole section near the boundary of gneiss and calc gneiss.

iv) Left bank of Saddle Dam No.2

According to FS2001, groundwater level above FSL (185 m) was found during the groundwater observation. Although drill hole DN-10 was not available for monitoring groundwater level in this survey, water flow above FSL was found just downstream of Saddle Dam No.2.

Ground water level is an important factor to assess the water tightness of the dam site and to determine the grouting area. Since this survey was carried out just after the wet season, groundwater level and water flow measured at both abutments in this survey do not directly ensure a stable groundwater level. Long-term monitoring of groundwater including during dry season is necessary.

Water Tightness of Reservoir Area

Water tightness of from the right bank of the dam site to the ridge extending southeastward was studied in FS2001, because:

- Right bank of dam site and the ridge extending southeastward is relatively narrow; and
- Two faults extending in the direction of NW-SE extending are inferred at approximately 2 km and 4 km upstream of the dam site respectively based on aerial photo interpretation.

FS2001 concluded that the assumed faults would not cause water leakage according to the distribution of calc gneiss in existing geological map and ground water data.

However, site reconnaissance in this survey reveals that calc gneiss rocks extend to around the assumed fault of approximately 2 km upstream of the dam site. It is therefore necessary to ensure water tightness, to survey the distribution of calc gneiss considering FSL, and to monitor water flow especially during the dry seasons. If permanent water flow is confirmed to be above FSL, the assumed fault will not cause water leakage.

Landslide risks in Reservoir Area

Landslide risk in the Moragahakanda reservoir has never been an issue in the previous studies, and any findings or signs concerning land slide risks have not been met through site reconnaissance in this survey. Therefore, the Survey Team is of the opinion that landslide risks in the dam reservoir area are most likely low. However, in the detailed design stage, evaluation on landslide risks in the reservoir area by aerial-photographic interpretations is highly recommended to reconfirm the low landslide risks in the reservoir area.

(6) Evaluation

Moragahakanda Dam site is underlain by Precambrian metamorphic crystalline rocks composed of charnockites, quartz and calc gneiss, and other gneiss (garnet-biotite-gneiss, garnetifeous gneiss or garnet gneiss). Slightly weathered rocks and fresh rocks are suitable for the dam foundation in terms of strength. Accordingly, there are no serious problems in strength of foundation rocks.

Considerable issues of the dam site are the water tightness of reservoir and groutability of calc gneiss rocks. No general karstifications of the calc gneiss were found except for some karstic features at fault zone. Meanwhile, impervious zones (hydrogeological foundation) are confirmed except for the fault zone. Considering these evidences and the results of many drill survey, water leakage will not occur in such cases where:

- Faults zone are properly treated by grouting or other proper methods; and
- Both abutments of the dam site, where groundwater level does not exceed FSL, are

properly treated by grouting or other proper methods.

Therefore, additional geological investigations are recommended prior to the detailed design of the dam particularly to confirm 1) geological condition of the fault, 2) permeability and stable groundwater level of both dam abutments covering saddle points in the reservoir area.

A comprehensive geological study is also necessary to evaluate the results of the previous geological investigations and prepare necessary geological drawings in the detailed design stage.

3.2.2 Climate, Soil, and Hydrology

(1) Climate and Soil Conditions

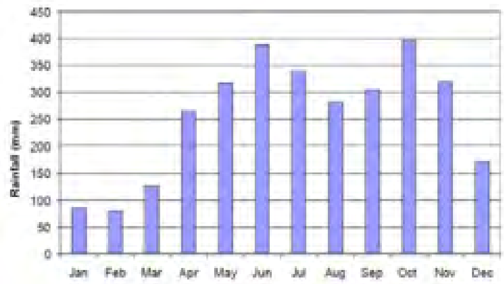
Sri Lanka is characterized by two monsoon seasons, namely Yala season (April to September) and Maha season (October to March). During Yala season, the southwest monsoon delivers more rain over the land than the northeast monsoon. These rains pour to only on the southwest area and concentrated during May to June. The Maha rains, though less in amount, cover much larger area even in the northeast dry area of the island. The Project area is located in northeast dry area, and thus, about 70% of the annual rainfall occurs during Maha season and the remaining during Yala season.

The island can be divided into wet, intermediate, and dry zones. In the wet zone, the annual precipitation is 5,000 mm to 2,000 mm, while the dry zone receives 2,000 mm to 1,000 mm. The annual rainfall in the intermediate zone falls between those of the two zones.

The typical patterns and amount of rainfall in the irrigation area and the Moragahakanda Dam site are shown in Figure 3.2.1 and Figure 3.2.2 respectivly.

Source of data: FS2001

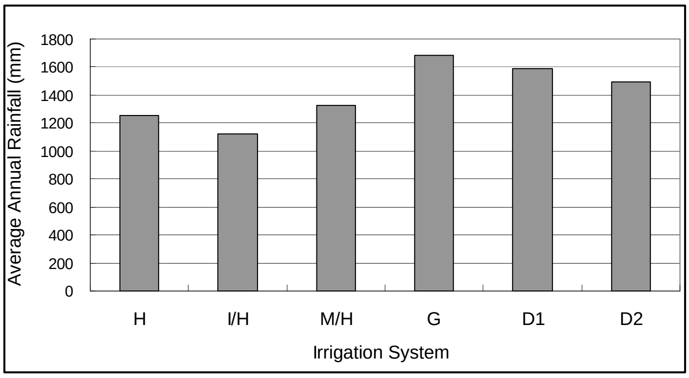
Fig. 3.2.1 Mean Monthly Rainfall (Irrigation area)



Source of data: FS2001

Fig. 3.2.2 Mean Monthly Rainfall (Moragahakanda Dam Site)

The average annual rainfall over the last 14 years (1994/95-2007/08) at each irrigation system is shown in Fig. 3.2.3.



Source of data: MASL

Fig. 3.2.3 Average Annual Rainfall of Each Irrigation System (1994/95-2007/08)

The most widespread soil groups in the benefited area of the Project are reddish brown earth (RBE), which is imperfectly drained reddish brown earth (brown sub group), and low humic gley (LHG). Alluvial and solodized solonetz soil groups are also observed in the area. These soil types can be widely observed in the dry areas in Sri Lanka. LHG is a poorly draining soil, and thus it is better suited for paddy cultivation rather than other field crops (OFC), while RBE is a well-draining soil in which both paddy and OFC can be cultivated.

Climate and soil conditions at each irrigation system are summarized in Table 3.2.4.

Table 3.2.4 Climate and Soil Condition in Moragahakanda Project Area

System	Temperature (°C) 2/			Annual Rainfall (mm) 3/			Soil Type 4/	
	Ave.	Max.	Min.	Maha	Yala	Total	LHG	RBE
H	27.3	33.4	20.8	852	398	1,250	50%	50%
I/H	27.3	33.4	20.8	787	333	1,120	100%	0%
M/H	27.3	33.4	20.8	916	409	1,325	100%	0%
KHFC 1/	26.8	32.3	20.9	N/A	N/A	N/A	40%	60%
G	28.0	37.0	21.1	1,347	339	1,686	0%	100%
D1	28.0	37.0	21.1	1,202	384	1,586	95%	5%
D2	28.0	37.0	21.1	1,204	291	1,495	100%	0%

Source of data: MASL and Natural Resource Management Centre, Department of Agriculture

Notes: 1/ Kandalama-Huruluwewa Feeder Canal
2/ Year 2008 of Methodological Station in Annuradapura, Matale and Polonnaruwa
3/ 1994/95 Maha to 2008 Yala season average
4/ LHG: low humic gley, RBE: reddish brown earth

(2) Hydrology

Several hydrological studies related to the Project have been carried out since the 1960s. In this section, some characteristics of the mean annual flow and foods at the Project site are described based on the latest study, i.e. FS2001.

<u>Mean Annual Flow</u>

According to FS2001, the natural flows at Bowatenna, of which catchment area is 512 km^2, from 1949 to 1998 were estimated based on the Elahera flows weighted by catchment area and precipitation on the two basins. A mean annual flow of 493 MCM was obtained, indicating a mean annual inflow of 283 MCM from the intervening area between Bowatena and Moragahakanda.

Table 3.2.5 Mean Annual Flow at the Project Area

Basin	Catchment Area (km^2)	Precipitation (mm)	Mean annual flow	
			(MCM)	(m^3/s)
Bowatenna	512	2101	493	15.6
Between Bowatenna – Moragahakanda	256	2196	283	9.0
Moragahakanda	768	2133	776	24.6

Source of data: FS2001

Floods

In FS2001, flood hydrographs were generated by using the HEC-1 model based on the following flood events recorded at the Elahera Hydrometric Station:

Table 3.2.6 Recorded Flood Discharge at Elahera Hydrometric Station

No.	Flood Period	Recorded Discharge (m^3/s)
1.	19 to 26 Feb. 1960	667
2.	12 to 19 Jan. 1961	647
3.	24 Dec. 1973 to 2 Jan. 1974	923
4.	17 to 26 Feb. 1964	833
5.	14 to 26 Feb. 1964	267
6.	27 Nov. to 7 Dec. 1979	624
7.	20 to 27 Nov. 1978	1605
8.	5 to 12 Nov. 1982	123
9.	5 to 16 Dec. 1982	929

Source of data: FS2001

3.3 Irrigation Systems

3.3.1 General

The operational irrigation systems in the Project area consist of the following irrigation schemes:

Irrigation System	Irrigation Scheme
H:	Kalawewa RB, Kalawewa LB, Kalawewa YE, Dambulu Oya, Kandalama
I/H:	Nachchaduwa, Nuwarawewa, Tisawewa
M/H:	Huruluwewa
KHFC:	Kandalama-Huruluwewa Feeder Canal
G:	Elahera
D1:	Minneriya, Giritale, Kaudulla, Kantale
D2:	Parakrama Samudra

The present irrigable area for each scheme is summarized in Table 3.3.1.

Table 3.3.1 Present Irrigable Area of Irrigation Schemes in the Project Area

Irrigation System	Irrigation Scheme	Irrigable Area (ha)
H	Kalawewa RB	14,000
	Kalawewa LB	6,660
	Kalawewa YE	4,720
	Dambulu Oya	2,240
	Kandalama	4,480
Sub-Total (System H)		32,100
I/H	Nachchaduwa	3,335
	Nuwarawewa	1,052
	Tisawewa	520
Sub-Total (System I/H)		4,907
M/H	Huruluwewa	4,210
KHFC	Kandalama-Huruluwewa Feeder Canal	2,250
G	Elahera	5,750
D1	Minneriya	9,099
	Giritale	3,076
	Kaudulla	5,465
	Kantale	8,880
Sub-Total (System D1)		26,520
D2	Parakrama Samudra	10,121
Total		85,858

Source of data: MASL and Irrigation Dept.
Note: Irrigable area in 2008/09

The irrigable area for each system in 1999/2000 and 2008/09 in the Project area is summarized in Table 3.3.2.

Table 3.3.2 Irrigable Area of Irrigation Systems in the Project Area

System	1999/2000	2008/09
H	32,100	32,100
I/H	4,112	4,907
M/H	4,210	4,210
KHFC[1/]	N/A[2/]	2,250
G	5,750	5,750
D1	25,154	26,520
D2	10,121	10,121
Total	81,447	85,858

Source of data: MASL and Irrigation Dept.
Notes: 1/ Kandalama-Huruluwewa Feeder Canal
2/ KHFC system was authorized officially after 2002/03 thus official data before 2002 is not available.

The irrigable area in the Project area is almost stable from 1999/2000 in all systems except for systems I/H and D1. This increase of irrigable area is due to the development of irrigation facility in Nachchaduwa scheme of System I/H and conversion of the sugarcane area to paddy field in Kantale scheme of system D1.

3.3.2 Crops and Cultivated Areas

The present irrigable area and number of farm household in the Project area are shown in Table 3.3.3.

Table 3.3.3 Present Irrigable Areas and Number of Farm Households in the Project Area

System	Irrigable Area (ha)	No. of Farm Household	Average Farm Size (ha)
H	32,100	24,958	1.29
I/H	4,907	5,693	0.86
M/H	4,210	7,000	0.60
KHFC	2,250	7,615	0.30
G	5,750	4,751	1.21
D1	26,520	32,040	0.83
D2	10,121	12,137	0.83
Total	85,858	94,194	0.91

Source of data: MASL and Irrigation Dept.

The recent ten-year average from 1999/2000 Maha season to 2009 Yala season in relation to the areas and cultivated under paddy and OFC in the Project area are summarized in Table 3.3.4. Cultivated area and cropping intensities of each irrigation scheme in the Project area are shown in Attachment-4

Table 3.3.4 Distribution of Paddy and OFC in the Project Area

Unit: ha

System	Maha season			Yala season			Annual Total
	Paddy	OFC	Total	Paddy	OFC	Total	
H	30,292	1,529	31,821	12,241	9,832	22,073	53,894
I/H	4,210	58	4,268	2,711	406	3,117	7,385
M/H	4,178	16	4,194	1,745	468	2,213	6,407
KHFC	2,033	210	2,243	716	888	1,604	3,847
G	5,214	242	5,456	4,300	536	4,836	10,292
D1	25,170	0	25,170	22,589	63	22,652	47,822
D2	10,121	0	10,121	10,121	0	10,121	20,242
Total	81,218	2,055	83,273	54,423	12,193	66,616	149,889

Source of data: MASL and Irrigation Dept.

The major crop cultivated in the Poject area is paddy for both Maha and Yala seasons. OFC are cultivated mainly during Yala season, while very little of them are grown during Maha. In systems H, G, and KHFC, OFC are cultivated over significant areas during Yala season. In particular, system H is the major OFC cultivated area. In other systems, OFC cultivation area is negligible because dominant LHG soil is not-suited for OFC cultivation. OFC commonly cultivated in the Project area are chili, big onion, maize, cowpea, vegetables, and banana.

The cropping intensities of each system in the recent ten years are shown in Table 3.3.5. Annual total average of cropping intensity for the whole Project area is 176% in the recent ten years. In all systems, cropping intensity during Maha season is more than 90% because enough rain is delivered by the northwest monsoon, while during Yala season cropping intensity is 78% in average and varies depending on the system.

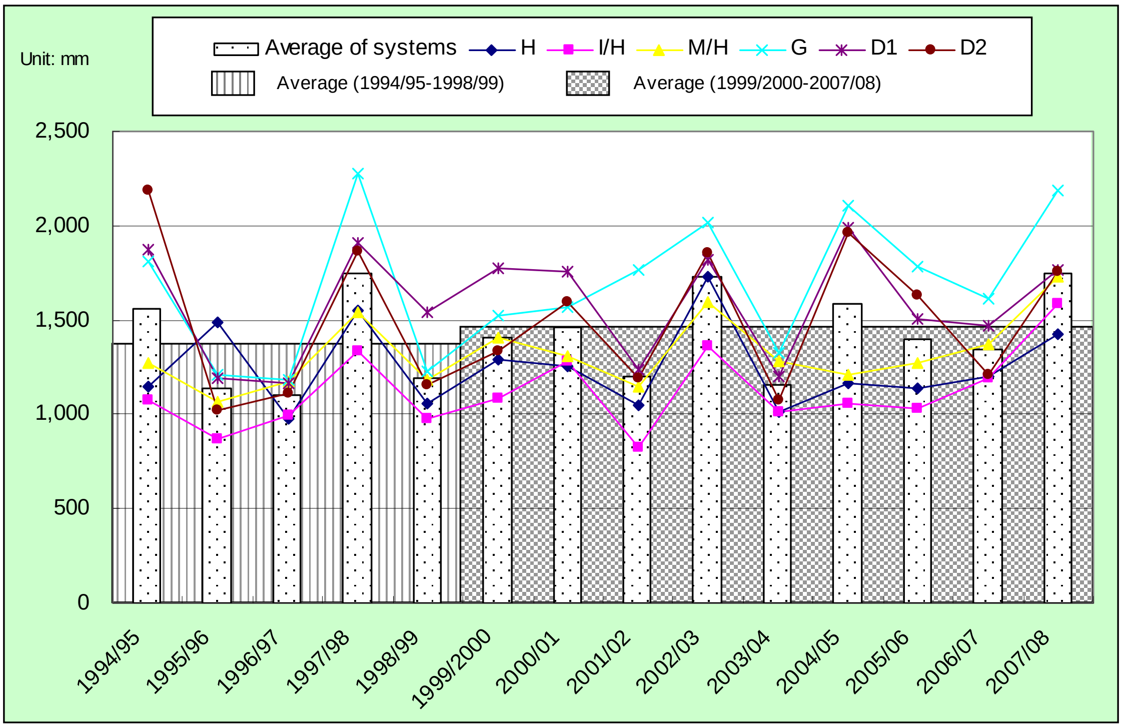
Table 3.3.5 Current Cropping Intensities in the Project Area

System	Maha season			Yala season			Annual Total
	Paddy	OFC	Total	Paddy	OFC	Total	
H	94%	5%	99%	38%	31%	69%	168%
I/H	90%	1%	91%	58%	9%	67%	158%
M/H	99%	0%	99%	41%	12%	53%	152%
KHFC	90%	10%	100%	32%	39%	71%	171%
G	91%	4%	95%	75%	9%	84%	179%
D1	97%	0%	97%	87%	0%	87%	184%
D2	100%	0%	100%	100%	0%	100%	200%
Total	95%	3%	98%	64%	14%	78%	176%

Source of data: MASL and Irrigation Dept.

The annual change of cultivated areas and cropping intensities of each irrigation system in the Project area are shown in Attachment-1.

The cropping intensity of 176% in the Project area from 1999/2000 to 2008/09 has increased by about 20% compared with the cropping intensity of 154% from 1994/95 to 1998/99. One of the reasons of such increase is attributed to the rainfall pattern in the recent ten years. The recent years experience more rainfall compared with the other period. Rainfall data in the Project area from 1994/95 to 2007/08 is shown in Fig. 3.3.1.



Source of data: MASL

Fig. 3.3.1 Annual Rainfall in the Project Area (1994/95–2007/08)

The major part of the new and existing irrigable lands in the Project falls under the control of the MASL and ID. An increase in the cropping intensity has been observed in some of these areas since FS2001 was conducted. The following could be the reason for this increase:

i) Effects of Rehabilitation Projects undertaken after 1999.

Certain areas have undergone rehabilitation through various projects during the FS2001 period and thereafter. The notable ones among these are:

a) The Mahaweli Restructuring and Rehabilitation Project (MRRP) in System H of the Mahaweli Development area which falls under the Project area. This project took place from year1998 to 2003 and was funded by the World Bank.
b) PEACE project undertaken to rehabilitate land in two regions: One in the war affected northeastern part of the country including the boarder areas in Polonnaruwa and Trincomalee which will partly be under the Moragahakanda and Kalluganga Development Project (MKDP). The other region covering the north central part of the country including Anuradhapura District part, of which reservoirs such as Nuwarawewa, Tissawewa, Nachchaduwa, and Rajangana, and other minor cascade reservoirs in I/H and H is covered by the MKDP. This project funded by JICA commenced in mid 2006 and expected to be completed by March 2011.
c) The Mahaweli Consolidation Project (MCP), which took place from 1997 to 2000 was undertaken to rehabilitate irrigation system in System G. The project was funded by EEC.

ii) Training of Farmers Organizations on Water Management

Training programs have been carried out by the MASL on awareness on the benefits of effective water management on increased cropping intensity and procedure for the water management. This has resulted in improvement of water management practice among farmers contributing toward increased cropping intensity.

iii) Effect of Improved Water Management Practices

There has been a change in water management approach during the period following the MRRP in System H. It is called by the concept of "bulk allocation", where based on the water availability, an allocation of a quantum of water for a cultivation season is agreed with each farmer organization. Meanwhile the respective farmer organization is responsible in managing allocated quantity of water for the season. The farmer organization is given an incentive by allowing them to claim any savings from the allocated quantity which they will utilize for the following season, in addition to the regular amount allocated for such season. In this way it was found that there were considerable savings during Maha season that could be used to improve the cropping intensity during the water stressed Yala season when water is deficient.

Moreover, with the handing over of responsibility of O&M of the distributary and field canals to the farmer organizations, water management has further improved, with better maintained canals resulting in reduced water losses and better organized rotational system among the farmers.

iv) Others

The improved agricultural extension services and other support services such as fertilizer subsidies resulting in increased yield and income encourages farmers to cultivate more land. These have also influenced the increase in cropping intensity.

3.3.3 Crop Yield

The present position of paddy yield from 1999/2000 to 2007/2008 in the systems under the Project and major OFC yields in 2007/2008 are shown in Tables 3.3.6 and 3.3.7, respectively.

Table 3.3.6 Averages Yields of Paddy in the Project Area

System	Ave. Yield (t/ha)	
	Maha season	Yala season
H	4.35	4.22
I/H	4.47	4.34
M/H	4.46	4.28
KHFC	3.86	3.70
G	3.94	3.66
D1	4.55	4.64
D2	4.84	4.79
Average	4.45	4.46

Source of data: Department of Census and Statistics

Table 3.3.7 Average Yields of OFC in the Project Area

Unit: t/ha

District	Chili	Maize	Big Onion	Cowpea	Brinjal
Matale	4.72	2.26	17.63	1.30	6.85
Anuradhapura	4.84	0.97	10.00	0.91	9.51
Trincomalee	4.67	2.55	12.23	1.06	6.13
Polonnaruwa	4.47	2.78	11.22	1.38	11.66
Average	4.57	2.48	15.47	1.11	7.05

Source of data: Department of Census and Statistics

The average paddy yield in the entire Project area is about 4.45 t/ha during Maha season, and about 4.46 t/ha during Yala season. The average yield in the Project area is higher than the national average yield of 4.2 t/ha. However, the current yield of paddy is still less than its potential 6.0 t/ha as estimated by the Department of Agriculture.

3.3.4 Present Conditions of Agriculture in Proposed Moragahakanda Dam Reservoir Area and Resettlement Area

The present conditions of agriculture in the proposed Moragahakanda reservoir area and resettlement area are shown in Table 3.3.8. Currently, the resettlement area for the Project is not cultivated with any crops, thus the Hattota-Amuna scheme near the resettlement area in Kalu Ganaga area is shown in the table.

Table 3.3.8 Present Crop Cultivation in Moragahakanda Dam Reservoir Area and Resettlement Area

Unit: ha

Description	Maha season			Yala season			Total
	Paddy	OFC	Total	Paddy	OFC	Total	
Moragahakanda Dam Reservoir Area 1/							
Cultivated Area (ha)	739	94	833	421	261	682	1,515
Average Yield (t/ha)	2.9	-	-	2.7	-	-	-
Hattota-Amuna Scheme 2/							
Cultivated Area (ha)	304	0	304	72	18	90	394
Average Yield (t/ha)	4.7	-	-	2.1	-	-	-

Source of data: MASL and Irrigation Dept.
Note: 1/ Dam Reservoir Area in 2004/05
2/ Hattota-Amuna in 2008/09

3.4 Organization and Management

3.4.1 Present Organization Structure of the MASL

(1) General

The MASL was established under the Mahaweli Authority of Sri Lanka Act No. 23 of 1979 with the purpose of implementing the accelerated Mahaweli development scheme.

The scheme involves integrated development of land and water resources in the Mahaweli and allied river basins, with the objectives such as to increase agricultural production, provide hydropower generation, provide settlement for landless families, generate employment and develop enterprise. The functions of the MASL are expected to carry out the following activities in relation to achieve the above objectives:

- Construction of reservoirs, hydropower houses, distribution networks and irrigation canal system;
- Land development for irrigated cultivation;
- Settlement of farming and non-farming families;
- Development of social infrastructure such as road network, townships and hamlets with basic facilities for the settlers;
- O&M of the headworks, irrigation, and social infrastructure facilities inclusive of those already existing within the area covered and newly developed by the scheme;
- Provide agricultural and social support services to settlers; and
- Develop enterprises that will help generate additional income and employment opportunities to settlers and rural population already residing in these areas.

(2) Mahaweli Restructuring and Rehabilitation Project (MRRP)

The MASL has been undergoing structural changes since its establishment. However, a major change took place in 1998 with the commencement of MRRP funded by the World Bank when restructuring became necessary with the completion of most of the construction activities, land settlement and related development works under the accelerated Mahaweli development scheme.

The objectives of MRRP are:

i) To shift the focus of the MASL from project implementation to river basin management, thereby, ensuring that the natural resources in the Mahaweli river basin/watershed are managed more efficiently, productively and in a sustainable manner; and

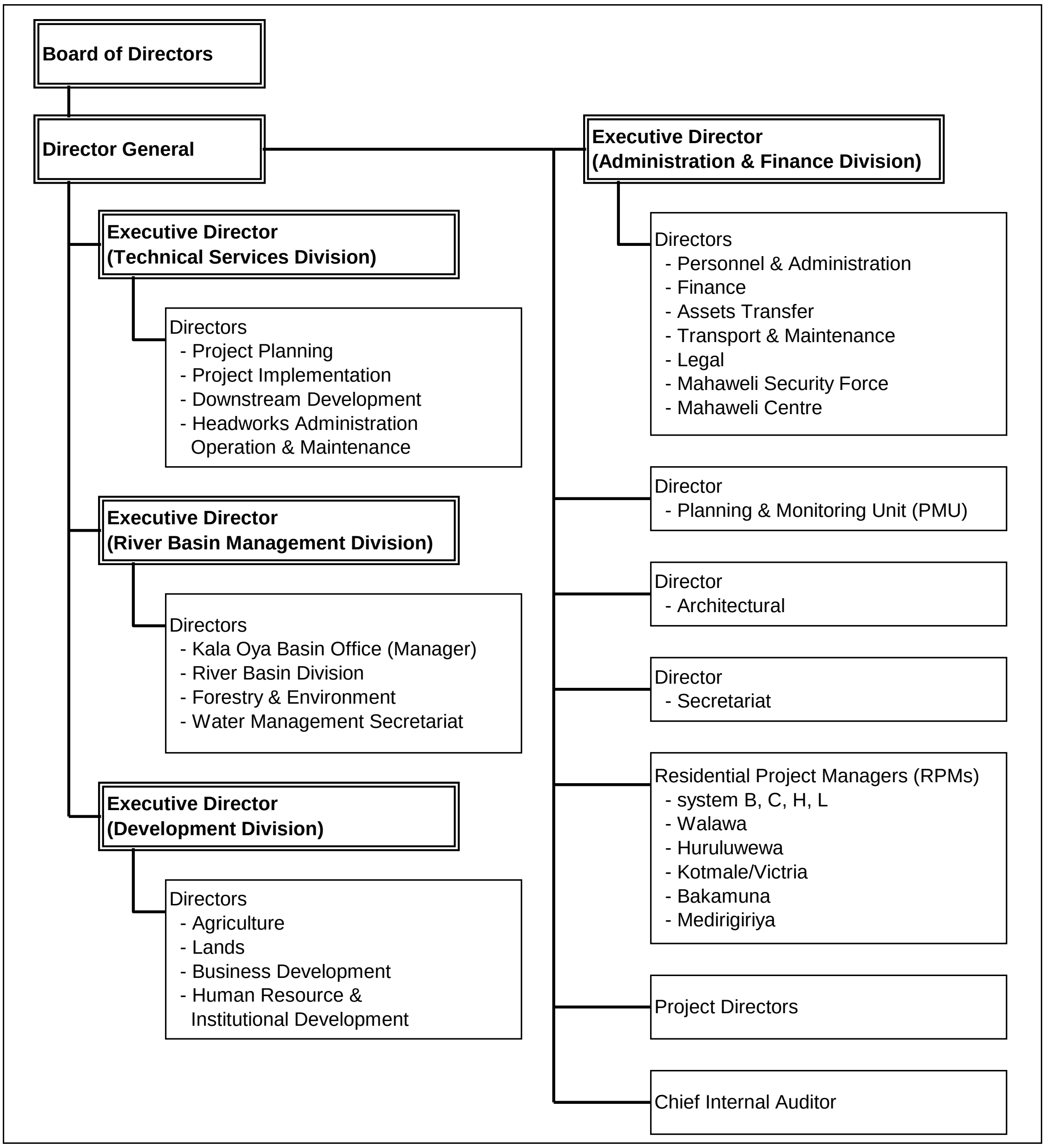
ii) To improve agricultural productivity through rehabilitation, improvement and better O&M of the irrigation facilities in System H.

Before the implementation of MRRP, the MASL was an umbrella organization constituting the Mahaweli Engineering and Construction Agency (MECA), which was responsible for the planning, design and construction of the irrigation and social infrastructure, the Mahaweli Economic Agency (MEA), which was carrying out O&M of completed irrigation and social infrastructure; and the Mahaweli Headworks Administration, Operation and Maintenance Unit (HAO&MU), which took over O&M of the completed major reservoirs and canals.

As part of the objectives of MRRP, the MASL was amalgamated into one centralized body, with the pruning down of redundant staff and redeployment and retraining of the remaining staff through the voluntary early separation package (VESP) forming a new interim structure. Through this measure, the total number of staff under all categories was brought down from about 10,800 to 4,800 in year 2000 (cf.; Mahaweli Restructuring and Rehabilitation Project, Report of the First Mid-term Review, Mahaweli Authority of Sri Lanka 17 January 2000).

(3) Organization Structure of the MASL

After completion of MRRP the process of change continued and the interim organizational structure as of year 2008 is shown in Fig. 3.4.1.



Source of data: MASL

Fig. 3.4.1 Present Organization Structure of the MASL (as of Year 2008)

The total number of staff under all categories according to the present cadre is 4,652 and the actual number available as of 2008 is 4,726 as shown in Table 3.4.1.

Table 3.4.1 Approved and Actual Staff of MASL in 2008

No.	Category	Approved	Actual
(1)	Primary Level (Unskilled) - (PL-1)	1,401	1,673
(2)	Primary Level (Semiskilled) - (PL-2)	92	77
(3)	Primary Level (Skilled) - (PL-3)	551	545
(4)	Management Assistant - Non-Technological - (MA1-2)	985	965
(5)	Management Assistant - Technological - (MA2-2)	572	478
(6)	Associate Officer - (MA-3)	241	256
(7)	Junior Manager - (JM1-1)	349	312
(8)	Manager - (MM1-1)	377	290
(9)	Senior Manager - (HM1-1) <Director>	38	39
(10)	Senior Manager - (HM1-4) <Executive Director>	4	2
(11)	Senior Manager - (HM3-2) <Director General>	1	1
(12)	Temporary Staffs	41	88
	Total	4,652	4,726

Source of data: MASL

While the head of the organization remained as the Director General with the overall responsibility for all activities under the Mahaweli development scheme, the functions were distributed to four divisions as given below, each being led by respective Executive Director.

Administration and Finance Division

The Administration and Finance Division consists of seven sub-divisions, namely, Administration, Finance, Assets Transfer, Transport & Maintenance, Legal, Mahaweli Security Force and Mahaweli Centre. It has one Executive Director, eight Directors, nine Deputy Directors, five Assistant Directors and a Legal Officer as the senior and middle managerial staff.

Technical Services Division

The Technical Services Division has Project Planning, Project Implementation, Downstream Development, Headworks Administration Operation & Maintenance as its sub-divisions, with one Executive Director, four Directors, seven Deputy Directors, and ten Assistant Directors in the senior and managerial cadre.

River Basin Management Division

The River Basin Management Division is subdivided into Kala Oya Basin, River Basin, Forestry and Environment and Water Management, making up four sub-divisions, with one Executive Director, four Directors, eight Deputy Directors and four Assistant Directors forming its senior and middle managerial cadre.

Development Division

The Development Division has Agriculture, Lands, Business Development, and Human Resources and Institutional Development as its four sub-divisions, with four Directors, four Additional Directors, six Deputy Directors and 11 Assistant Directors as its senior and middle managerial staff.

In addition to the four divisions, Planning and Monitoring Unit, Architectural Unit, Resident Project Managers, Director for Secretariat and Special Projects, Project Directors, Internal Audit Unit and the companies under MASL, come directly under the Director General.

(4) New Proposal for Restructuring of the MASL

A proposed structure for adoption during the next five to ten years was prepared in 2009 (cf.: The Scheme of Recruitment, Promotion and Absorption of Present Employees, Amended Final Report May 26, 2009 by K. B. Sirisena, Management Consultant).

The structure of this new proposal with subsequent modifications is shown in Fig. 3.4.2 and described as follows:

i) The four main divisions will be reduced into two, as Engineering and Technical Services Division, and Development Division each having a respective Managing Director as given below:

Engineering and Technical Services Division

- Project Planning and Design
- Project Implementation
- Headworks Administration, O&M and Dam Safety
- Riverbasin Planning and Management
- Environment
- Land Use Planning

Development Division

- Agriculture
- Lands
- Enterprise Development
- Human Resources and Institutional Development

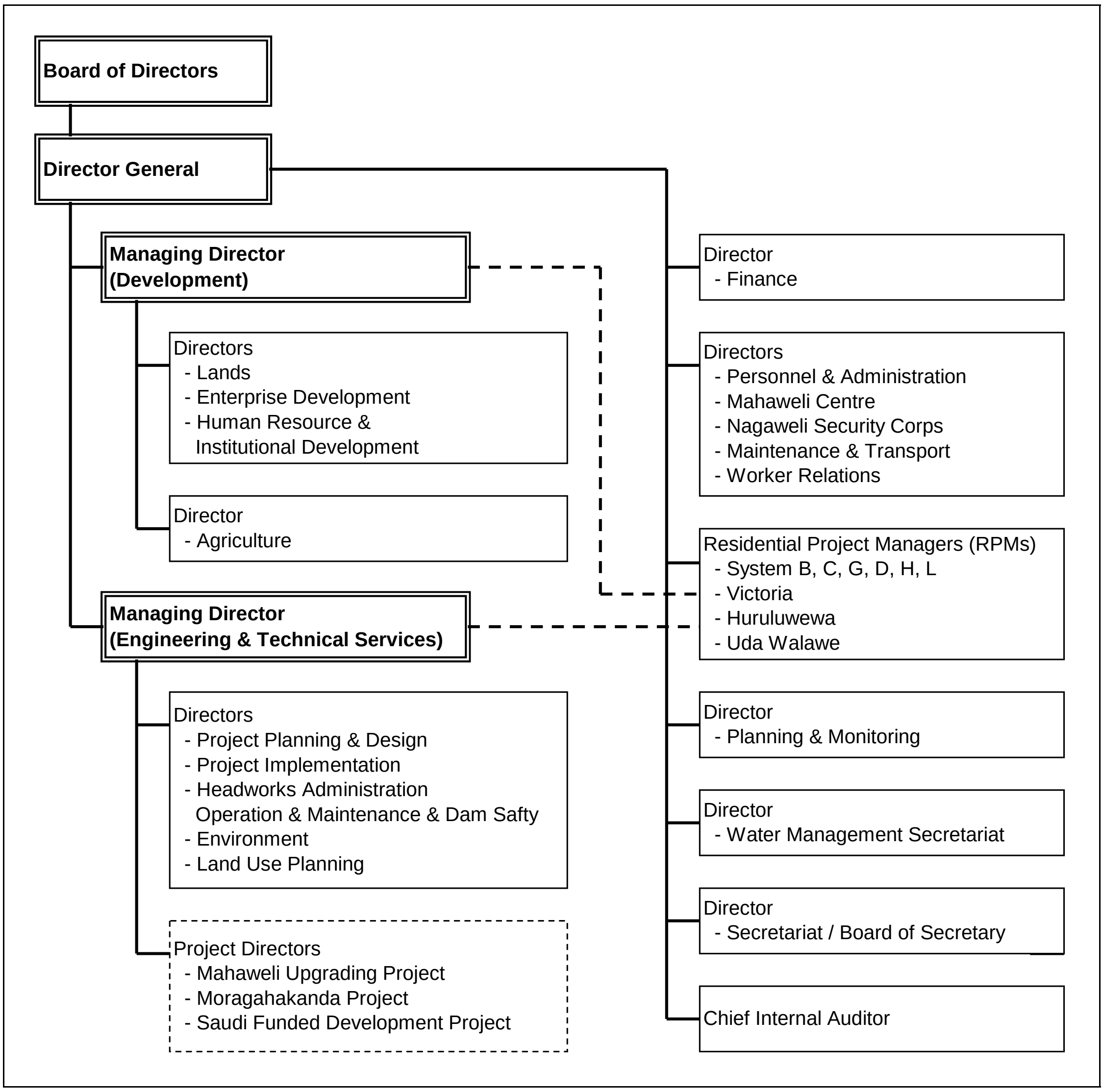
Each of the above sub-divisions under the two divisions will be headed by Directors with appropriate staff consisting of Deputy or Assistant Directors, Engineers and other professional and support staff as deemed necessary.

ii) There will be five units directly under the control of the Director General. The units shown in the organizational chart will be headed by Directors for each unit, and with Deputy or Assistant Directors, Engineers, and other professional and support staff as deemed necessary.

iii) There will be nine Residential Project Managers (RPM) with necessary staff under them to handle O&M and routine development activities under their respective systems.

iv) There will be a unit headed by the Chief Internal Auditor to carry out internal auditing on a regular basis.

Organizational chart of the MASL proposed by the scheme of recruitment, promotion and absorption of present employees is shown in Fig. 3.4.2.



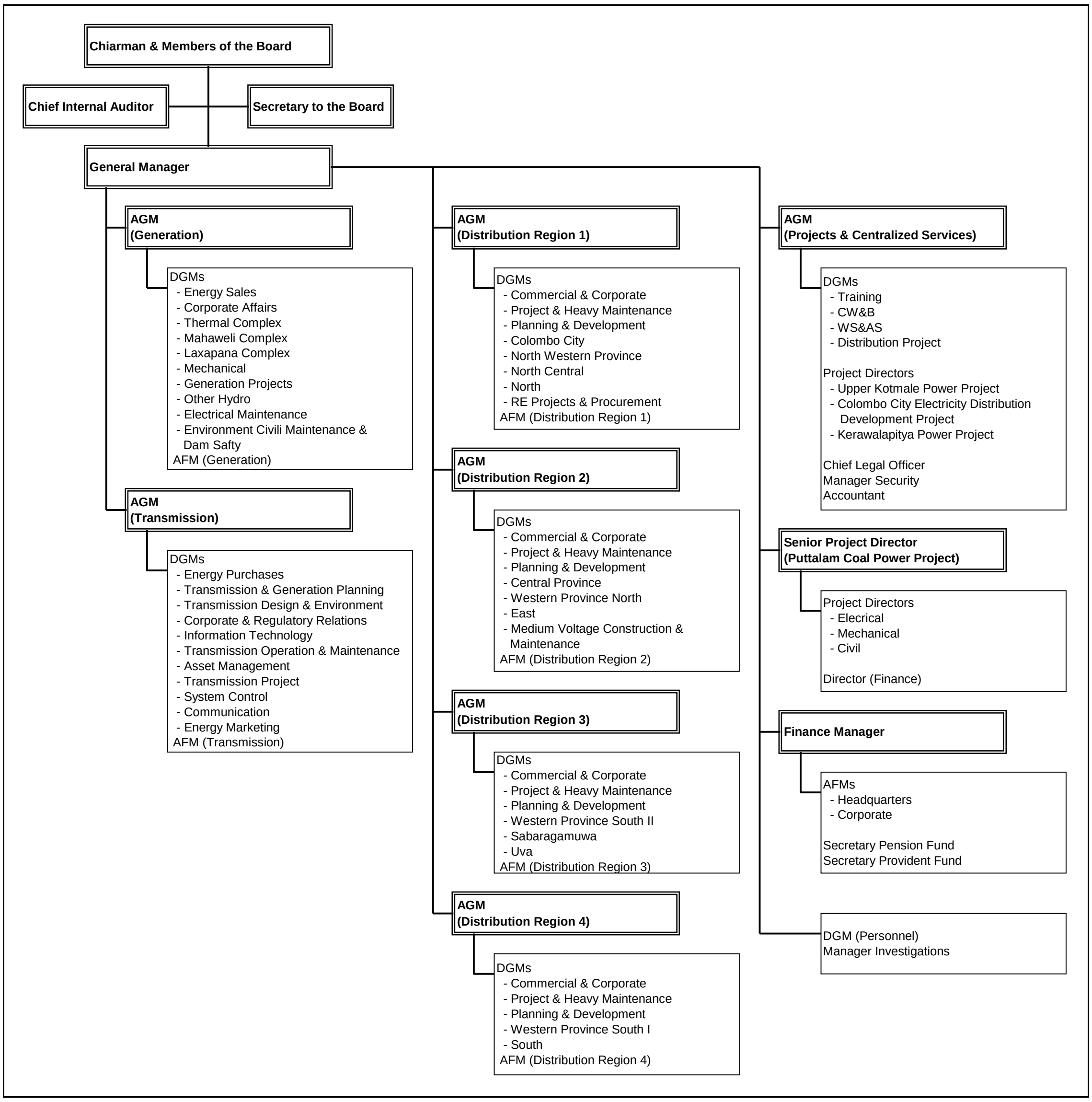
Source of data: MASL

Fig. 3.4.2 Proposed Organization Structure of the MASL by Scheme of Recruitment, Promotion, and Absorption of Present Employees

3.4.2 Related Organizations for the Project Implementation and O&M

(1) Ceylon Electricity Board (CEB)

The execution framework of the CEB comes under the General Manager assisted by seven Additional General Managers. The line of hierarchy of the unit linked to the MASL for the Moragahakanda powerhouse and transmission line comes under the Additional General Manager (Transmission) and flows down to Deputy General Manager (Transmission and Generation Planning). Two Chief Engineers, one handling Transmission Planning, while the other Generation Planning, act as link personnel between the CEB and the MASL for the Project. Present organization chart of the CEB is shown in Fig. 3.4.3.

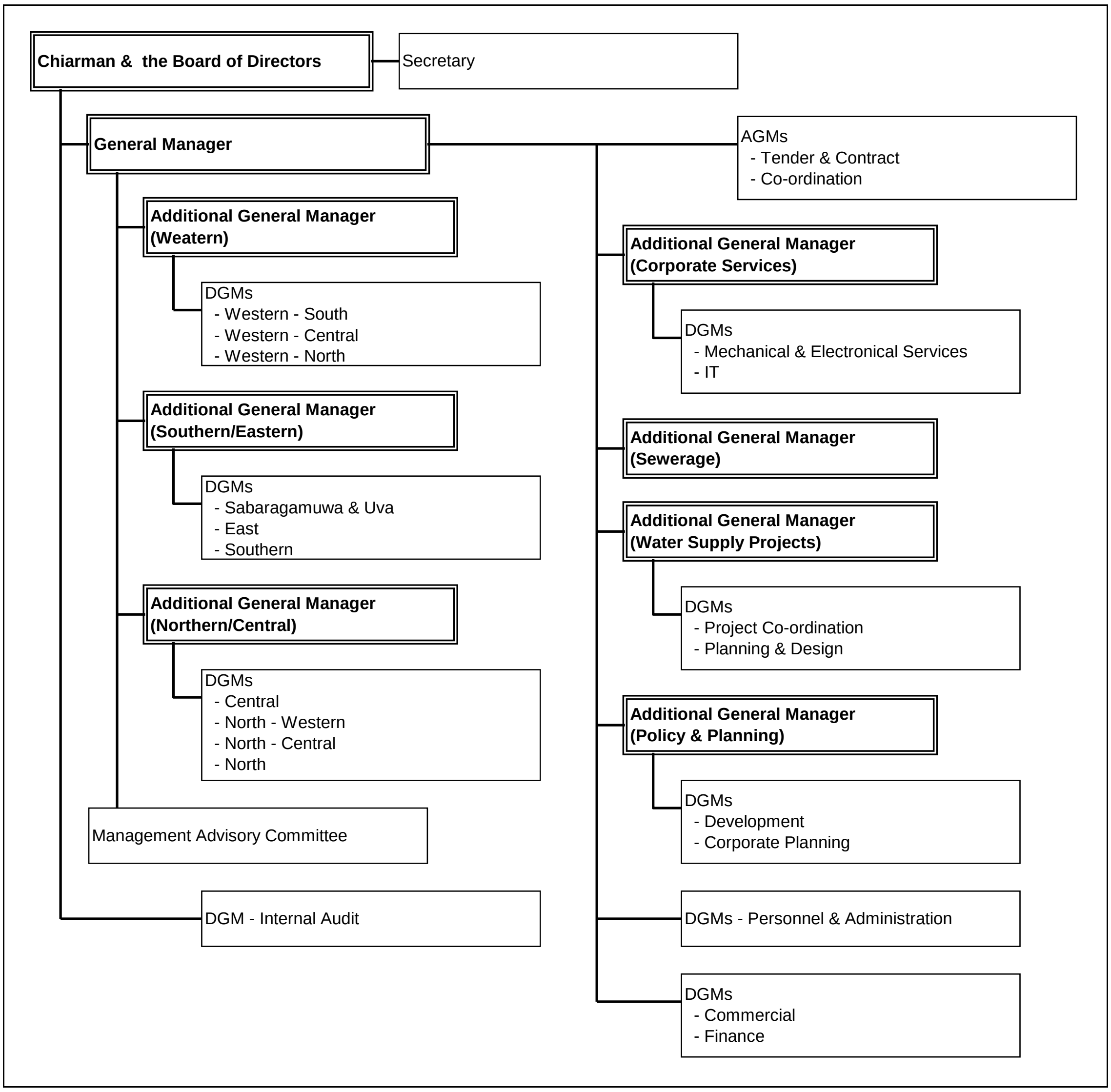


Source of data: Ceylon Electricity Board

Fig. 3.4.3 Present Organization Structure of the CEB

(2) National Water Supply and Drainage Board (NWSDB)

The chief executive for the NWSDB is the General Manager. The personnel acting as link with the MASL is the Deputy General Manager for Planning & Design, who works under the Additional General Manager for Water Supply Projects. Present organization chart of the NWSDB is shown in Fig. 3.4.4.



Source of data: National Water Supply and Drainage Board

Fig. 3.4.4 Present Organization Structure of the NWSDB

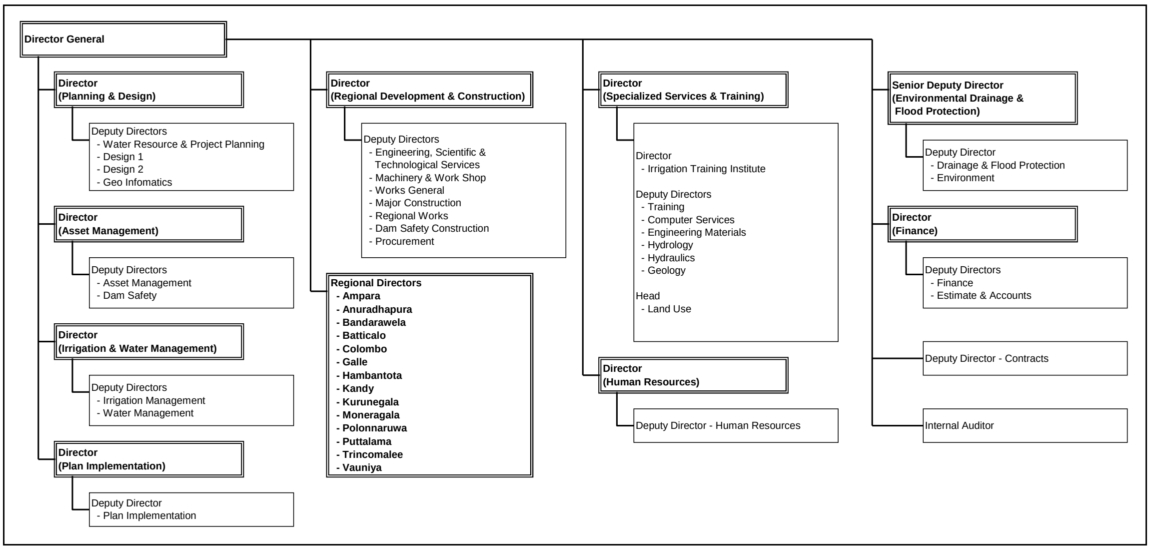
(3) Related Agencies for O&M for Irrigation System

Irrigation Department (ID)

The ID handles all major (above 600 ha) and medium (80 ha to 600 ha) trans-provincial irrigation works in Sri Lanka, except those declared as areas under the Mahaweli development scheme.

The ID carries out O&M of headworks and canal systems up to the secondary system outlets while farmer's organizations are responsible for the secondary canals below the tertiary canal system.

Present organization chart of the ID is shown in Fig. 3.4.5.



Source of data: Irrigation Department

Fig. 3.4.5 Present Organization Structure of Irrigation Department

Irrigation Management Division (IMD)

The IMD handles the institutional support system for the farmer's organizations for major and medium irrigation works, except those under the MASL. The division also serves as coordinator among the related organizations on matters related to irrigation management activities.

Agrarian Services Department

Agrarian Services Department is responsible for institutional development activities of minor irrigation works in the country. The department continues to handle all minor irrigations works (below 80 ha) and provides the institutional support services.

Provincial Councils

Provincial Councils are responsible for the major and medium irrigation works that are entirely confined within the province. Although the minor irrigation works are also identified to be under their responsibility, the Agrarian Services Department still continues to manage them.

The provincial irrigation department is responsible for all O&M of the irrigation headworks and main canal system identified under the provincial council system.

(4) Farmers' Organizations (FOs)

i) General

The FOs have been established under the provisions of Agrarian Development Act, No. 46, 2000. The institutional structure of FOs is stipulated in clauses 43 to 50 in part V of the Act. Another related Act that recognizes and empowers the FOs is the Irrigation (Amended) Act No.13, 1994. It empowers FOs to impose a levy on the allotment for O&M purpose, and to make the formation of the Project Management Committees comprising all stake holders including FOs to manage all project management activities.

Although there are stipulations in the above Act on establishment of farmers' federations of district, provincial, and national levels, they are not practically effective as there is not much mutual cooperation at these levels, and hence only a few federations were established, which are not very effective. Presently only the Dstributary Canal Farmers' Organizations (DCFOs) have been accepted by both of the MASL and IMD as the appropriate farmers' organization to effectively handle the O&M activities and manage the system well. According to the Agrarian Development Act, there has to be a minimum number of 25 members in a FO and such requirement could be met at the DCFOs level.

The DCFOs are guided by a commonly accepted constitution, which was originally prepared by the Department of Agrarian Services and adapted to suit the respective FOs. According to these guidelines, the office bearers of a DCFO consist of a president, a vice president, a secretary, a deputy secretary, a treasurer, and representatives from all field canals (FCs) under the DCFO. They are usually selected through an election by the DCFO members; members nominate the candidates for the above posts and vote for selection if there are more than one candidate nominated for one post at the yearly meeting of the DCFO where all members are entitled to participate.

ii) Farmers' Organizations in the Project Area

The farm lands under the Project are under two different organizations, i.e. the MASL and Irrigation Management Division (IMD). Farmers' Organizations in Systems H, KHFC and G are under the purview of the MASL, while those in Systems I/H, M/H, D1 and D2 are under the purview of the IMD. The procedures related to the formation and management of FOs between the MASL and IMD are almost same.

In general, the FOs are formed based on their distributary canals. There are Distributary Canal Farmers' Organizations (DCFOs) in systems H, I/H, M/H, G, D1 and D2. However, the FOs in system KHFC do not have such base as there are no appropriate distributary canals system in KHFC area. Table 3.4.2 shows the current numbers of the FOs in the Project area.

Table 3.4.2 Numbers of FOs in the Project Area

System	No. of farmer families	No. of Field Canal Groups	No. of Farmers' Organizations
H	24,969	2,459	299
I/H	5,393	361	34
M/H	7,000	212	16
KHFC	7,615	-	57
G	4,751	475	41
D1	32,040	1,113	101
D2	12,137	350	33
Total	93,985	4,970	581

Source of data: MASL and Irrigation Management Division (IMD)

There are totally 581 FOs in all seven systems to be benefited by the Project as shown in Table 3.4.2, and almost all farmers belong to the FOs. They are encouraged to be members of the FOs so as to take advantage of subsidies for fertilizer, which are provided only through the FOs. It is considered that the FOs in the Project area are generally functioning satisfactorily since they have taken over the canal with responsibility for O&M of the canals.

iii) Responsibility and Functions of FOs

Responsibilities and functions of the FOs are:

- O&M of the distributary canals and field canals,
- Water management of distributary canals and field canals ensuring availability of irrigation water to individual farmstead,
- Preparation of seasonal cultivation plans and deciding cropping patterns with relevant officers,
- Organizing supplying of chemical fertilizer and pesticides to farmers at reasonable prices,
- Organizing marketing of agricultural products,
- Coordinating with state and private sector banks to provide cultivation loans,
- Reduction of monopoly of middle man in marketing,
- Organizing community participatory programs such as Sramadana (donation of labor) programs with farmers,
- Collecting LKR 250 - 500 per ha per season from each member farmer to raise a fund to carryout minor repairs of distributary canals and field canals and to pay wages for the water controller of the respective distributary canals,

- Coordinating with private companies to sign forward contract agreements with farmers to cultivate high value field crops,
- Providing micro credits for member farmers from the funds of the FOs,
- Supporting to conduct agricultural extension and training programs for the farmers,
- Mediating to solve the problems of individual farmers and farmer groups,
- Mediating to settle disputes among the farmers,
- Coordinating with line agencies and private sector organizations for obtaining services, and
- Organizing religious and social functions in the area.

Once the FOs take over their canals from the MASL or IMD, the O&M becomes their responsibility. The O&M activities include all regular maintenance and minor repairs, which are to be carried out by them with their own funds. The FOs are also empowered to provide loans to the members from their own deposits, and the profit from the loan can be used for the O&M. The FOs also carry out contract works in major repairs of their canal systems under MASL or ID, and the profits from those contracts are also used for O&M.

There is no definite border between major and minor repairs. In general, the minor repairs are carried out with only manual input and basic materials such as cement, sand and earth and without any heavy equipment and reinforcement works. The major repairs that need heavy equipment, reinforced concrete works, and repairs of all types of gates are carried out by the MASL or ID. The demarcation of repairs to be undertaken by the parties concerned is determined in the Project Management Committee meetings where all parties participate.

FOs both under the MASL and IMD collect membership subscriptions, generally around LKR 100/- per member. Apart from this, they collect an O&M fund from the members, of which fee is depending on the FOs and also the yield during the previous season. It is usually in a range between LKR 250 and LKR 500 or equivalent paddy per ha per season.

iv) Regulations of FOs and Agreements between FOs and MASL and IMD

The FOs are guided by their constitution, which are almost same among the FOs.

The contents of the constitution are generally as follows:

1. Basic information
2. Purposes of the FOs
3. Powers vested on the FOs
4. Activities to be performed by the FOs
5. Types of membership
6. Eligibility for membership

7. Procedures for obtaining membership
8. Registration of membership and maintaining the register of members
9. Rights and responsibilities of the member
10. Nominating a nominee in case of death of the member
11. Expiration of membership
12. Cancellation of membership
13. Funds of the FOs
14. Using funds of FOs
15. General assembly
16. Meetings of the General Assembly
17. Powers to call the meetings of General Assembly
18. Notice for meetings of General Assembly
19. Eligibility to participate in meetings of General Assembly
20. Quorum expected for meetings
21. Presiding the meetings
22. Decisions by the General Assembly
23. Powers of the General Assembly
24. Reports of meetings of General Assembly
25. Field canal group
26. Working committee
27. Sub committees of the FO
28. Disbursing funds of the FO
29. Auditing of FO's accounts
30. Fiscal year
31. Changing the constitution

Memorandum of Understanding (MOU) between FOs and the MASL or IMD are signed when the distributary and field canals are taken over by the FOs, which is generally follows a rehabilitation of the canal system. Usually there are two MOUs. The first one is signed after the completion of the respective canals and it is an agreement for joint O&M by the FO and MASL/IMD for the initial six months. The second one is signed at the end of the six-month joint O&M and the FO has taken the complete responsibility of the canal system.

3.4.3 Assessment of Technical and Financial Capacity of the MASL

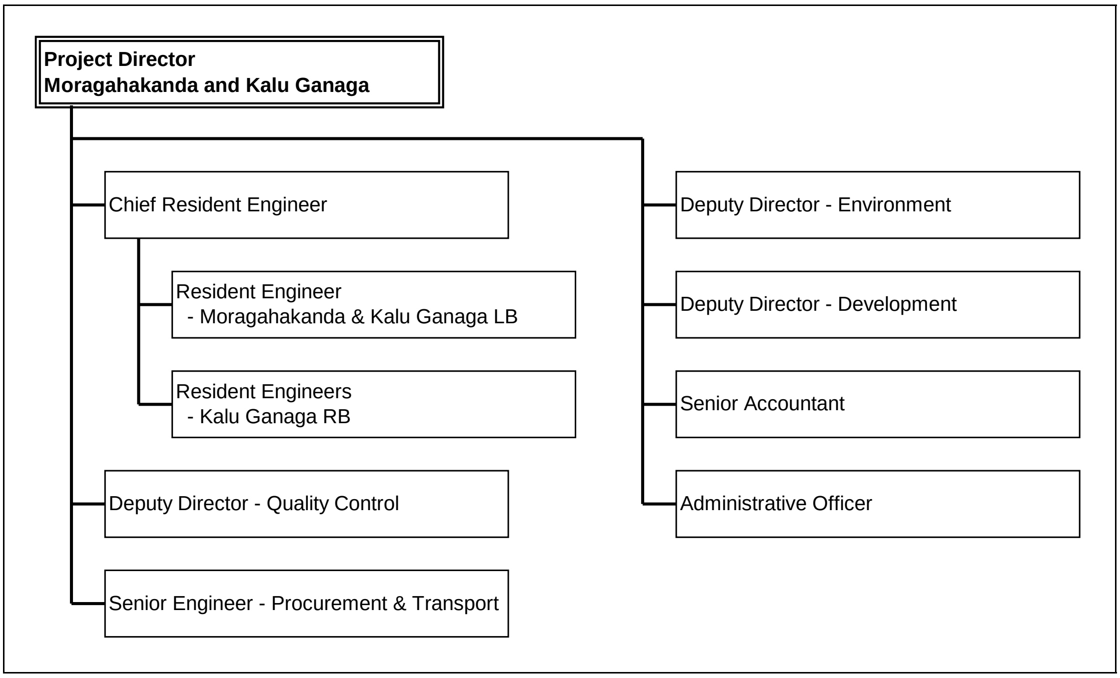
(1) Technical Capacity

Current Status for Project Implementation

Since its establishment, the MASL has been acting as the implementing agency for all irrigation and power development projects under the Mahaweli development scheme. The MASL has been carrying out the projects by employing consortiums of international and local consultancy and construction organizations for design and construction. It also coordinates activities through a unit headed by a Project Director.

The MASL has already placed such a unit at the Moragahakanda Dam site, which is presently engaged in the construction of Saddle Dam No.2 as well as other preparatory activities such as access roads, development of the irrigation and social infrastructures in the resettlement areas by using the provisions of budgetary allocations from the local funds.

The current organizational structure under the Project Director is given in Fig. 3.4.6.



Source of data: MASL

Fig. 3.4.6 Organizational Structure of Moragahakanda & Kalu Ganga Project Office

The senior level staff consists of four Deputy Directors, one being the Chief Resident Engineer, the others responsible for Quality Control, Environment, and Development, and a Senior Engineer for Procurement and Transport, a Senior Accountant, and an Administrative Officer. The Chief Resident Engineer is assisted by two Resident Engineers, i.e. one is handling the ongoing construction works under the Moragahakanda Development Project and the irrigation and social infrastructure works on the Left Bank of the Kaluganga Development Project, and the other is responsible for the irrigation and social infrastructure works on the right bank of the Kaluganga Development Project. Presently there are a total of 23 engineers engaged for these works headed by two Resident Engineers. In addition, there are three engineers engaged in quality control activities under the supervision of the Deputy Director of Quality Control.

The current number of staffs in the project office is shown in Table 3.4.3. The required and the available number of staff at the Moragahakanda and Kalu Ganga project office currently are 230 and 207 respectively.

Table 3.4.3 Current Number of Staffs of the Project Office

	Positions	Required	Available
(1)	Project Director	1	1
(2)	Deputy Directors/sectional heads	7	7
(3)	Officers	39	34
(4)	Assistant Staff	92	79
(5)	Supporting Staff	91	86
	Total	230	207

Prepared by the JICA Survey Team

Technical Capacity for Project Implementation

According to the above mentioned current situation, the technical capacity of the MASL for the implementation of the Project is considered to be sufficient with the following reasons.

i) The MASL has enough experience for the role of coordinating activities in similar projects in the past.

In the implementation stage of the Project, the function of the MASL will be limited to the overall coordination and monitoring of the Project, and checking and certifying of documents of engineering consultants and contractors. Supervision of construction work will be designated to engineering consultants with a separate group of staff including counterpart staff of the MASL. With this project implementation structure, the MASL carried out many development projects in Mahaweli area such as Kotomale, Victria, System C, and Udawalawe.

ii) Current organization and staff can be utilized for the project implementation

Staff of Moragahakanda and Kalu Ganga Development Project Office is presently engaged directly with the ongoing activities such as the Naula-Elahera road deviation in the stretch going under water, and in the social and irrigation infrastructure development activities under Kalu Ganga Development Project. Part of this staff will be available to support the Project in the construction stage as most part of the on-going works they are involved in will be completed by the time the construction works on the Moragahakanda Dam commence.

(2) Financial Capacity

Budget Allocation for the MASL and Moragahakanda Development Project

Funds to meet the capital and recurrent expenditures of the MASL to meet the expenditure according to the annual budget approved by the Government of Sri Lanka (GOSL) are made available through the government treasury. Allocations for recurrent expenditure of the MASL come from the local funds of GOSL. The annual allocations over the past have been adequate for this purpose. Funds for projects under the MASL are covered by both local and foreign funds. Major projects with potential for an impressive socio-economic enhancement impact but require large scale investments, which are implemented by the MASL mostly depend on foreign funds together with a local component and are channeled through the government treasury.

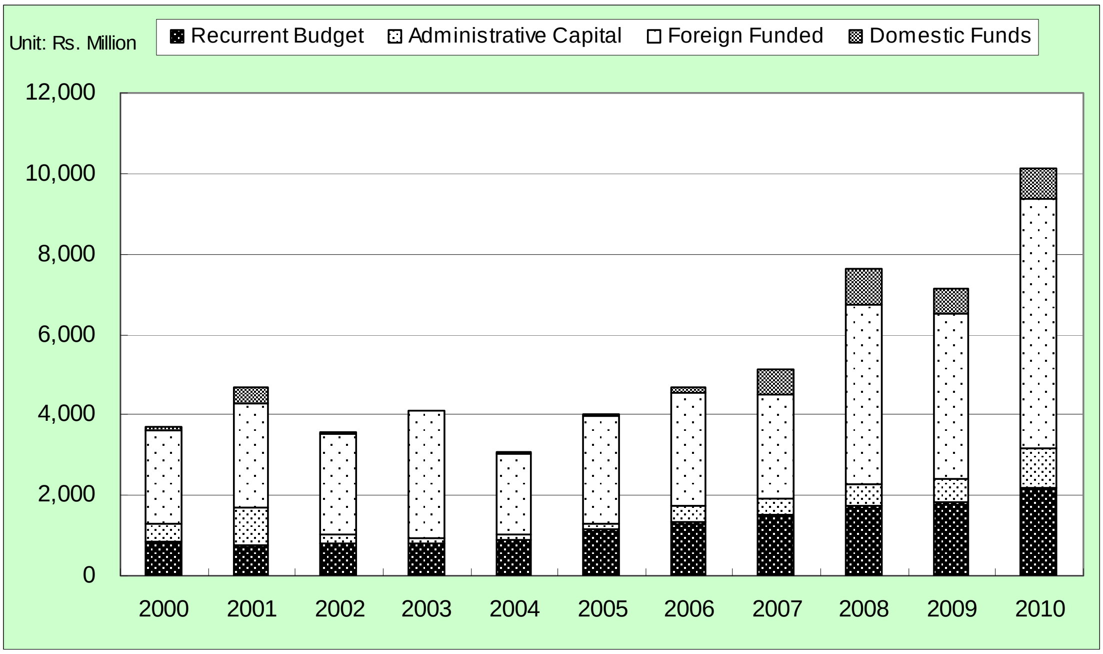
Total budget allocation of the MASL for the year 2009 is approximately LKR 7,144 million. Allocation of the expenditure under the various components as indicated above for the recent ten years is shown in Table 3.4.4 and Fig. 3.4.7:

Table 3.4.4 Annual Budget Allocation of the MASL

Unit: LKR million

Year	**Total**	Foreign Funded	Domestic Funds	Administrative Capital	Recurrent Budget
2000	3,686	2,320	87	435	844
2001	4,702	2,610	399	921	773
2002	3,550	2,481	45	202	823
2003	4,112	3,142	26	139	805
2004	3,087	2,029	39	126	894
2005	4,016	2,639	62	152	1,164
2006	4,673	2,822	119	389	1,343
2007	5,115	2,582	621	380	1,532
2008	7,627	4,465	902	534	1,727
2009	7,144	4,087	629	592	1,836
2010	10,142	6,168	786	1,004	2,184

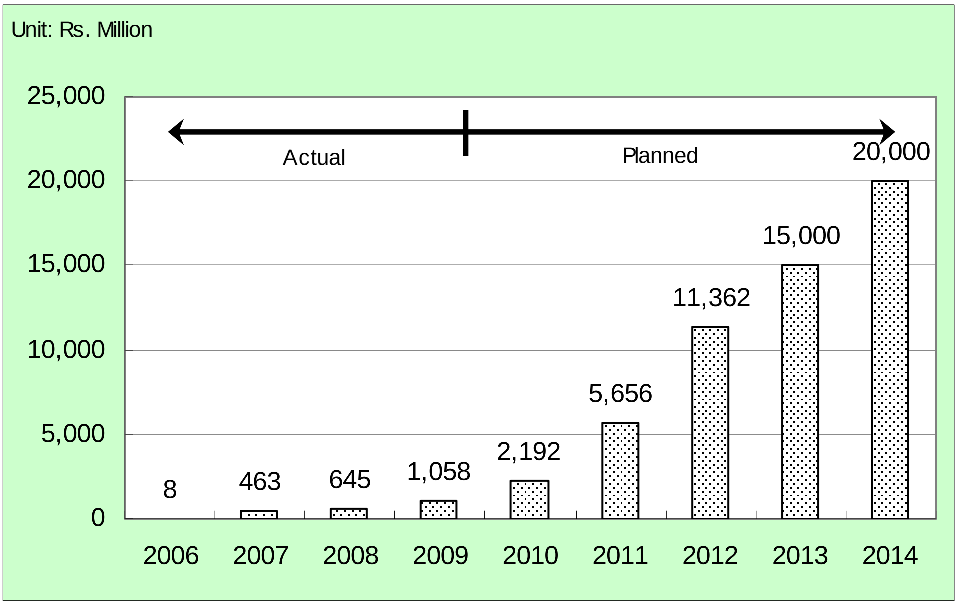
Source of data: MASL



Source of data: MASL

Fig. 3.4.7 Annual Budget Allocation of the MASL

For Moragahakanda and Kalu Ganga Development Projects, about LKR 2,161 million from local fund and LKR 13 million have been allocated up to 2009 by the MASL. A total of LKR 63,543 million is planned to be allocated in the future. Actual and future plan of budget allocation for the Moragahakanda and Kalu Ganga Development Projects is shown in Fig. 3.4.8.



Source of data: MASL

Fig. 3.4.8 Annual Budget Allocation for Moragahakanda and Kalu Ganga Development Projects

Financial Capacity for Project Implementation

According to the current budget status and future plan, sufficient provision for the ongoing activities related to the Project and for the staff recruited for this purpose has been made annually under the budget up to now, as the government has included the Moragahakanda and Kaluganga Development Projects in its policy declaration known as ‘Mahinda Chintanaya’. As the government has explicitly expressed its commitment and priority to the Project by its ceremonial inauguration in January 2007, it continues to meet the budgetary requirements of MASL related to the Project.

3.5 Present Progress of the Project

3.5.1 Moragahakanda Development Project

(1) General

The Moragahakanda - Kaluganga Development Project Office was inaugurated on 25th January 2007. Since then, the Project Office has been carrying out the following investigation and construction works on force account under annual budget of GOSL:

i) Investigation Works (Completed)

- Dam axis survey
- Borrow pit survey
- Geological Investigation

ii) Construction Works

- Project Office (640 m^2) and Residence (122 m^2 x 30 houses)
- Saddle Dam No.2 (Earthfill, H=20 m, V=140,000 m^3)
- Diversion Road up to sub base level (W=7 m, L=38.5 km)
- Bridge over Amban River (W=7.4 m, L=28 x 4=112 m)
- Construction of irrigation and social infrastructure in System F and System D
  - Village tanks
  - Water canals into resettlement areas
  - Community facilities

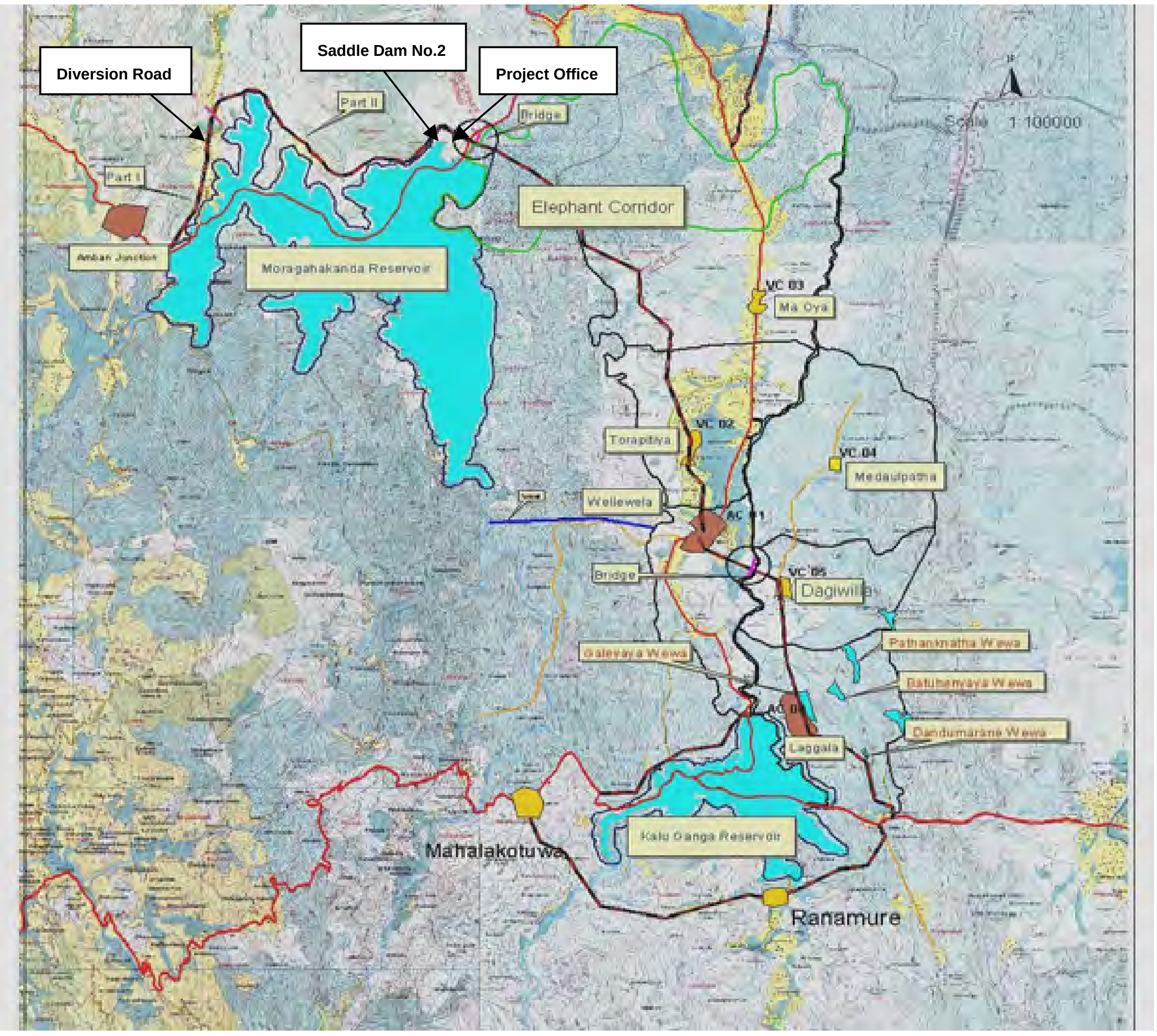
iii) Land Acquisition and Resettlement

- Collection of Socio Economic Data
- Organize Awareness, Training, Coordinating Committee Meeting and other meetings
- Conducting PRA Programmes
- Preparation of RIP
- Land Acquisition and Resettlement Activities
- Women Development Activities
- Creation of Job Opportunities

iv) Environmental Conservation and Water shed Management

- Bufferzone Conservation
  - Demarcation of the bufferzone by concrete post at an interval of 30 m
  - Tree planting programme
- Wildlife Conservation Programme
  - Habitat Enrichment
  - Establishment of electric fence and elephant corridors
- Rural watershed development programmes in the catchment area

- Biodiversity protection and improvement
- Environmental awareness



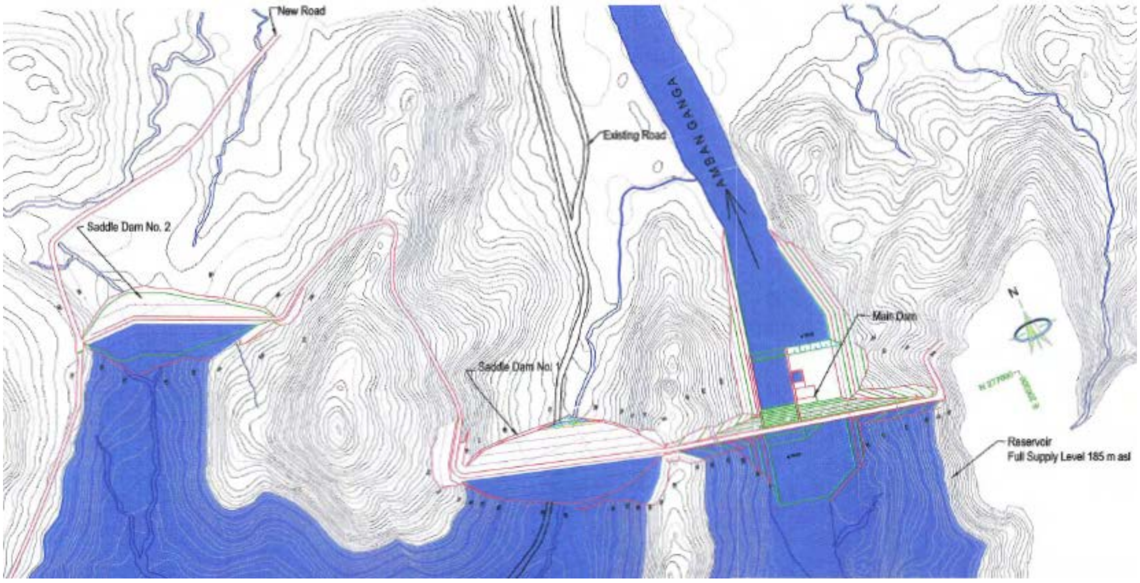
Source of data: MASL

Fig. 3.5.1 Location Map of the Project

(2) Construction Works

i) Construction of Saddle Dam No.2

In FS2001, it was proposed that the Moragahakanda Dam consisted of three dams, i.e. the Main Dam (RCC), Saddle Dam No.1 (Rockfill), and Saddle Dam No.2 (Earthfill) as shown in Figure 3.5.2.



Source of data: FS2001

Fig. 3.5.2 Plan of Main Dam, Saddle Dam No.1 and Saddle Dam No.2

The Saddle Dam No.2 has been under construction by MASL since 2007. its The main features are as follows:

- Dam Type: Homogeneous Earthfill
- Crest Elevation: 188 m asl
- Crest Width: 6.5 m
- Upstream Slopes: 1v : 3.0h
- Downstream Slope: 1v : 2.5h
- Crest Length: 274 m
- Maximum Height: 20 m
- Volume: 140,000

The present progress of the construction of Saddle Dam No.2 is more than 80% completed as of the end of June 2010. The remaining height of the dam embankment is about 8 m. The construction is supervised by the Project Office, and the quality of the construction works is well controlled by carrying out regular field and laboratory tests.

It is noted that the above crest elevation decided in FS2001 is 0.5 m lower than the crest elevation of the rockfill dam recommended in Sub-section 4.4.1. item (4) of this report because the design standards are different.

ii) Other Related Structures

a. The Diversion Road:

Construction of the 13.5 km Kumbiyangahaela-Moragahakanda Road is on-going, which is planned to be constructed up to gravel sub-base layer. The base course and asphalt surface layers are expected to be constructed under the JICA loan in the Project. The present progress is about 90%, and it is expected to be completed in a few months.

b. Bridge over the Amban River

A pre-stressed concrete continuous beam bridge (4 spans of 28 m per span) has been completed over the Amban River, about 800 m downstream of the main dam to serve as access to System F, which was inaugurated by the President in March 2010.

c. Office and Residential Buildings

A project office at downstream of the dam site and a number of residential buildings around the same area have been under construction, of which progress is currently about 99%.

d. Community Facilities and Village Tanks in System F (Resettlement area)

Community service centers, access roads, and farm ponds are being constructed in System F, downstream of Kalu Ganga, where the people are to be moved from the Moragahakanda and Kalu Ganga reservoirs. Irrigation facilities at the left bank of System F are under design by the MASL, and their construction is expected to be started within the year. It is expected that the construction of the community and irrigation facilities in System F will be covered by the JICA loan from 2011.

e. Community Facilities in System D1 (Resettlement area)

Construction of service centers and access roads in the resettlement are in System D1 has been started since 2007, which is expected to be covered by the JICA loan from 2011.

3.5.2 Kalu Ganga Development Project

(1) General

According to the "Executive Summary of Moragahakanda and Kalu Ganaga Development Project, January 2006" prepared by the MASL, the proposed Kalu Ganga Development Project consists of the following components:

- Palegama Dam, a 67 m high center core rockfill dam with two saddle dams;
- A transfer canal and tunnel of 13.1 km long with a discharge capacity of 15 m^3/s flowing to the Moragahakanda Reservoir;
- Development of 975 ha of new land of irrigation in the Kalu Ganaga basin;
- Second Bowatenna tunnel with a discharge capacity of 25 m^3/s;

- Upgrading of the Huruluwewa Feeder Canal;
- A 7.0 km transfer canal of 13.5 m^3/s capacity between Yan Oya and Malwatu Oya basins;
- A 7.5 km link canal of 5.0 m^3/s capacity between Eru Wewa and Mahakanadarawa Wewa;
- A resettlement action program for an estimated 458 families displaced by the reservoir and construction of a new township; and
- An accompanying environmental management action plan.

(2) Consultant Services

The MASL selected Lahmeyer International GmbH and associates as the consultant for preparation of detailed design and tender documents, and their consultant services have been started since the beginning of June 2010.

(3) Funding Arrangement

Some international donors have agreed to finance the Kalu Ganga Development Project. The present status of the funding arrangement is as follows:

Table 3.5.1 Funding Arrangement of Kalu Ganga Development Project

Source of Fund	Amount	Status
Kuwait Fund for Arab Economic Development (KFAED)	KWD 10 Million (= about USD 35 Million)	Signed agreement on 9th March 2009
Saudi Fund	USD 46 Million	Approved by SF Board. Signing of agreement is expected in 2010.
OPEC Fund	USD 16 Million	Confirmed. Signing of agreement is expected in 2010.

Prepared by the JICA Survey Team

CHAPTER 4 REVIEW OF THE PROJECT PROPOSED IN FS2001

4.1 General

A series of feasibility studies on Moragahakanda Development Project and Kalu Ganga Development Project was conducted under the Kuwait Fund for Arab Economic Development (KFAED) and a number of reports were submitted from 2001 to 2004.

The Survey Team has referred to the following feasibility study reports:

i) Feasibility Study of Moragahakanda Development Project, August 2001 (FS2001);

ii) Supplementary Report for the Feasibility Study of Moragahakanda Development Project, September 2002; and

iii) Feasibility Study of Kalu Ganga Development Project, July 2004.

Report i) above, FS2001, contains the comprehensive study results on the Moragahakanda and Kalu Ganga Development Projects, while Report ii) was prepared only for the Moragahakanda Development Project based on FS2001.

The Survey Team reviewed the feasibility study report prepared in 2002 (Report ii) above). However, all the important and essential data of the feasibility study of the Project are compiled in FS2001. Thereby, in this report, FS2001 represents the feasibility study reports issued in 2001 and 2002.

This chapter presents an overall review of the feasibility study on the Moragahakanda Development Project in FS2001.

4.2 Overall Project Configuration

In the Supplementary Report for the Feasibility Study of Moragahakanda Development Project, September 2002, the following overall project configuration for the Moragahakanda Development Project was recommended:

i) Construction of a 65m high concrete main dam and two saddle dams (fill dams), forming a reservoir with full supply level (FSL) at 185m above sea level (asl) and an area of 29.5 km^2 at FSL, and a 20 MW hydropower station with transmission lines;

ii) Extension of the upper left bank (LB) branch canal of the Kaudulla scheme in Irrigation System D1, the host area for the families who will be displaced by the Moragahakanda Reservoir;

iii) Compensation and resettlement package for the displaced families; and

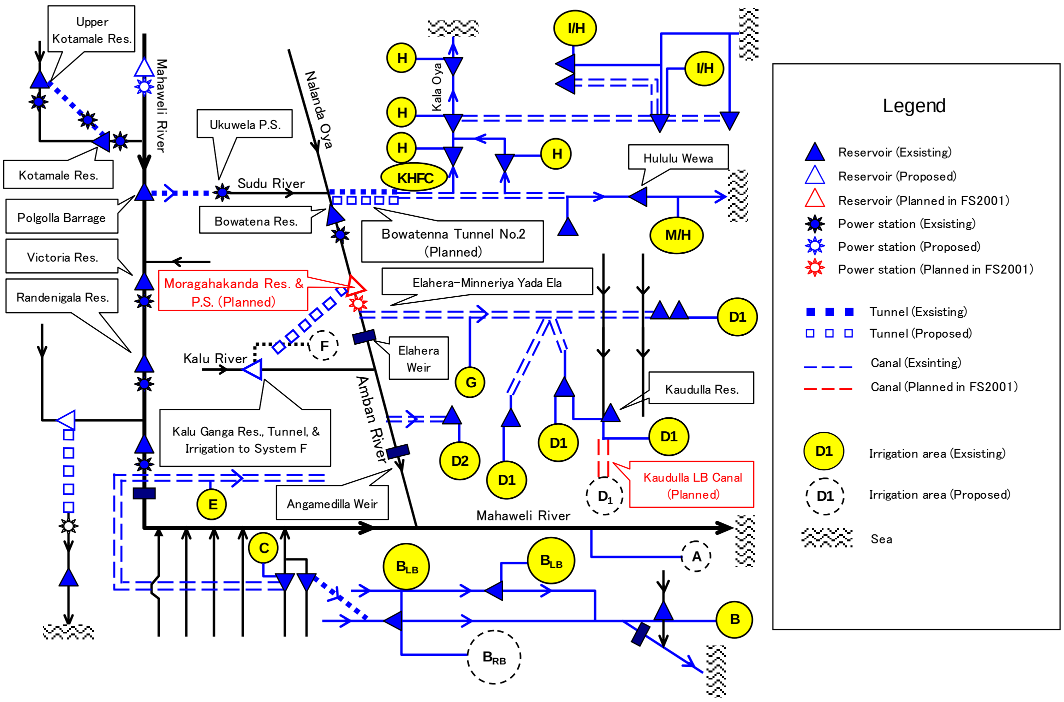
iv) Accompanying Environmental Management Action Plan.

The above project components have been reviewed in this survey. The reviewed features of the each project component are described in the following sections.

4.3 Water Balance Planning

4.3.1 General

In cooperation with the MASL, a series of water balance simulation was carried out for assessment of the water balance and water use planning and review of the feasibility of the Project. This was undertaken through the simulation from the viewpoints of cropping intensities of existing irrigation systems, namely Systems H, I/H, M/H, D1, D2, G, and the Kandalama-Huruluwewa Feeder Canal (KHFC) Scheme (refer to Fig. 4.3.1), water diversions, irrigation water issues, domestic and industrial water use, hydropower generation, and reservoir behavior.



Source of data: MASL and FS2001

Fig. 4.3.1 Schematic Diagram of the Related Mahaweli System

The allocation of water from the Mahaweli River system to all water user groups, namely the MASL, Irrigation Department (ID), National Water Supply and Drainage Board (NWSDB), and Ceylon Electricity Board (CEB), is decided in seasonal meetings. Water allocations at macro level for irrigation, hydropower generation, and domestic and industrial purposes from the main rivers and reservoirs are decided with the consensus of all agencies of water users during the Water Management Panel held before the start of every cultivation season, i.e. twice a year. Similarly, micro level allocations of water are decided also with the consensus of all agencies of water users during the resident project manager (RPM) or district secretary (DS) level meetings, which are also conducted before the start of every cultivation seasons. In addition, weekly water management meetings are regularly held to coordinate the water allocation plans with the participation of the representatives of all water user groups.

The water allocations are computed through the water balance simulation, which is the same simulation model used in this Survey, for every season, and expressed as cultivable areas in case of irrigation water, as volumes in case of domestic and industrial water, and as generated energy in case of hydropower generation, in order to achieve a consensus of all water users flexibly. In this way, the water rights of the water users are practically guaranteed instead of legally fixing the allocations of water use.

4.3.2 Water Balance Simulation System Applied in this Survey

In FS2001, the simulation model SYSIM, which is used regularly by the CEB for preparing the annually-issued long term generation expansion plan, was used for the water balance planning. SYSIM has an advantage of modeling the complete national integrated power and water supply system including thermal power system with the sophistication of switching from hydro base to thermal base or vice versa depending on the stored energy in the hydropower system. However, in this Project, all allocations of water in the “with Project” simulation cases are for irrigation, domestic and industrial water supply, and no water is particularly allocated to the hydropower generation portion, though the proposed power plant is expected to supply about 0.7% of the annual national power demand. This Survey concentrates mainly on the irrigation system operations to be realized through the construction of the proposed Moragahakanda Reservoir at the Amban River.

In this Survey, the water balance simulation system consisting of the ACRES Reservoir Simulation Program (ARSP), which is for simulating the overall system performance, and Irrigation Demand Model (AIDM), which is for the computation of irrigation demand for respective irrigation systems, was utilized for the water balance planning. This system has been regularly used by the Water Management Secretariat (WMS) of the MASL since 1986 for preparing the six monthly seasonal operation plans (SOPs), monthly review reports (MRRs) and seasonal summary reports (SSRs) in connection with the operational planning of Mahaweli River, Kelani River, Kalu River, Walawe River, Amban River, Kala Oya, Malwatu Oya, Yan Oya, Kantale Oya and Maduru Oya basins.

One of the advantages of ARSP is that each reservoir can be modeled individually in the simulation. For example, Nuwarawewa, Tisawewa, and Nachchaduwa in System I/H are modeled as three separate reservoirs whereas these three reservoirs are modeled in a combined reservoir in SYSIM. Similarly, in SYSIM, Kalawewa, Dambulu Oya, and Kandalama in System H, and Minneriya and Giritale in System D1 are also modeled as combined reservoirs. Hence, ARSP is considered to be the most suitable simulation model for the purpose of this Survey.

ARSP computer model is a general multipurpose and multi-reservoir computer model developed by the ACRES International Ltd. A major advantage of this model is its flexibility in allowing the user to make structural and operating policy changes by modifying the input data rather than by changing the computer program itself. The main features of the Mahaweli water resources management system is represented in the model by nodes and links. The entire system is shown in Attachment-5.

AIDM computer model sets the irrigation demand time series for all committed irrigation systems in all river basins receiving water from the Mahaweli River basin including the Walawe River basin. This time series is going to be the input to ARSP. This model simulates the monthly irrigation demands and return flows of an irrigation scheme over a period, for which the rainfall time series is loaded to the program. It considers the cropping conditions (extent of crops, varieties, planting dates and staggering of planting), climate (average monthly potential evapo-transpiration of a reference crop) and losses (field and system losses expressed as efficiencies, percolation and seepage rates from paddy fields).

The data bases for the above models was established by NEDECO (Netherlands Engineering Consultants) from 1949 to 1981, and had been updated by ACRES International Ltd. up to 1984 based on the stream flows and rainfall data. Since then the databases was updated by the WMS of the MASL based on the rainfall runoff regression analysis because many of the river gauges set in the Mahaweli River basin were submerged after the construction of reservoirs under the Accelerated Mahaweli Development Program.

4.3.3 Water Balance Simulation

(1) Simulation Cases

A series of simulation runs was carried out to examine the effects of various changes imposed on the existing system, such as improved water duties, improved cropping patterns to the existing irrigation systems in the Amban River basin, and additional large storage reservoir in the Amban River.

In this Survey, wherein the earliest likely commissioning of the Project is assumed to be in 2017, the following cases were adopted:

i) Case-A: Without Project, Year 1-6 (Period: 2011-2016/Pre-Operation)
ii) Case-B: With Project, Year 7-11 (Period: 2017-2021/Operation Years 1-5)
iii) Case-C: With Project, Year 12-30 (Period: 2022-2040/Operation Years 6-24)

Case-A covers the entire pre-operation phase of the Project, and Case-B, while C cover the operation phase of the Project after completion of the Moragahakanda Reservoir.

In Case-B and C, the Moragahakanda Hydropower station with a capacity of 15 MW was applied, and the future demands of irrigation water, domestic and industrial water, and hydropower generation in the entire system were incorporated.

The conditions on irrigation water demands of the above cases are described as follows:

i) Case-A: Without Project, Year 1-6 (Period: 2011-2016/Pre-Operation)

Water demand series based on the last ten year average of CI and cropping patterns are assumed to represent the current case, i.e. "Without Project". The current practice of the farmers is to cultivate long-term and medium-term varieties of paddy during Maha season, and medium-term and short-term varieties of paddy during Yala season.

ii) Case-B: With Project, Year 7-11 (Period: 2017-2021/Operation Years 1-5)

With the operation of the Moragahakanda Reservoir, all of the irrigation systems in the Amban River basin would get access to increased supply of water. Hence the extent of cultivation under both Yala and Maha seasons would increase. A reasonable set of values has been assumed as achievable water duties of the irrigation systems and tested in the simulation run. The CI of irrigation systems has been raised to 200% in the Amban River basin, and up to 180% in the adjoining basins. An additional area of 1,420 ha of new farm land under Kaudulla Scheme has also been included in this simulation. The starting dates were advanced wherever practicable to catch inter monsoon rains to get the benefits of increased effective rainfall and reduced overall water usage.

iii) Case-C: With Project, Year 12-30 (Period: 2022-2040/Operation Years 6-24)

In computing the demand series for the future case, the similar cropping pattern to Case-B was adopted with the exception of using more short-term varieties of paddy. The trend of introducing the high yielding short-term varieties of paddy among farmers is expected to grow with the availability of more reliable irrigation water supply from the Project. The Agriculture Department, MASL, and ID also have a strategy to launch a joint campaign to promote the cultivation of short-term varieties of paddy among farmers. In this simulation case, the possibility of saving water for future use was considered. This water will be utilized for further expansion of irrigation, future increase of demand of domestic and industrial water in the Project area, or other purposes.

Prior to the above simulations, some water balance simulations have been carried out under the condition of the above Case-B in order to determine the hydropower generation capacity of the Moragahakanda Power Plant, assuming different capacities of 7.5, 10, 15 and 20 MW. The detailed description on the determination of the hydropower generation capacity is given in Sub-section 4.5.1, "Capacity of Hydropower Station".

(2) Data Required for Water Balance Simulation

The following data are required for the water balance simulation:

i) Meteorological and hydrological data;
ii) Inflow data;
iii) System characteristics;

iv) Irrigation water demand;

v) Domestic and industrial water demand;

vi) Hydropower demand; and

vii) Present operation status of the dams located upstream and downstream of the proposed Moragahakanda Dam.

The details of the above data are described as follows:

1) Meteorological and Hydrological Data

The meteorological and hydrological data required for the water balance simulation were prepared from various previous studies including the following:

i) Implementation Strategy for Accelerated Mahaweli Development Program by NEDECO in September 1979,

ii) Trans-basin diversion study on Evaluation of Options for Diversion at Polgolla to the Amban River by Electrowatt and Zulsgitter et al in March 1986,

iii) Mahaweli Water Resources Management Project by ACRES International Limited in 1986,

iv) Feasibility Study on Kalu River Reservoir and Agricultural Extension Project by Central Engineering Consultancy Bureau (CECB) in March 1992,

v) Feasibility Study of Moragahakanda Development Project by Lahmeyer et al in August 2001 and September 2002, and

vi) Feasibility Study on Kalu River Development Project by Lahmeyer et al in July 2004.

To make the simulations more conservative and realistic, the period of hydrological data for this simulation was limited to the last 40 years, i.e. the initial wet spells from late 1950s to 1960s are skipped and the driest spell in the early 1970s is included. The hydrologic time series of October 1968-Septemcber 2008 with updated meteorological and hydrological data prepared by adding the latest data of October 1999-Septemcber 2008 to the data in FS2001 were used together with the corresponding irrigation demand time series derived from AIDM.

Rainfall time series consists of the data from 1968 to 2008. Meanwhile, a set of long term monthly average evaporation data of a nearby meteorological station was used for the evaporation from the reservoirs.

In establishing the rainfall reference database, the WMS has been using the historic monthly rainfall data from 147 rainfall stations in the concerned river basins. The Theissen polygon method was used for generating areal rainfall series.

The relevant rainfall data are attached in Appendix B-1 of “APPENDIX B: WATER BALANCE”.

2) Inflow Data

The ARSP model requires monthly flow data at all control points in the macro system and irrigation subsystems as well. For generating a complete set of inflow series, a computer program (HEC-4) was used based on the areal rainfall series at all control points.

The WMS has been applying the flow-rata factors at all control points to the inflow time series in its planning processes in order to make more realistic flow patterns since the theoretical inflow time series possibly include the following errors:

i) Errors in calculation of catchment area;
ii) Unknown water diversion in the upstream of the control points; and
iii) Ground water seepage towards the adjacent basins due to geological formations such as lime stone strata.

The flow-rata factor at each control point is determined by comparing the computed inflow series at a control point with the historic inflow series at the same point derived through water balance study for the period from 1984 to 2008 based on the discharge records.

These flow-rata factors derived for the year 2005/2006 and 2008/2009 by the WMS from their operation planning studies are presented in Attachment-6. By using the flow-rata factors, it is possible to carry out more accurate and realistic water balance simulations.

The relevant inflow data are attached in Appendix B-2 of “APPENDIX B: WATER BALANCE”.

3) System Characteristics

The characteristics of the reservoirs, hydropower plants, conveyance canals and tunnels being used by the WMS, MASL, ID, and CEB for their short-term, and long-term operational planning as well as daily operation activities, are summarized in Attachment-7.

4) Irrigation Water Demand

Monthly water demands for the entire irrigation systems including Systems H, I/H, M/H, G, D1, D2, and KHFC of the Project area for Cases-A, B, and C were computed for 40 years (1968-2008) using the AIDM computer program.

In order to design cropping patterns, assumptions were made regarding the agricultural progress in the Project Area without the Project as well as with the Project. Through discussions with the MASL, the assumptions were given as follows:

i) Assumptions for the “Without Project” Cropping Pattern

a) There will be no new major development programs in the Project.
b) Present agricultural support services will continue.
c) Overall cropping intensity in the area will not increase.
d) There will be no change in the types of crops cultivated.

ii) Assumptions for the “With Project” Cropping Pattern

a) There will be no new major development programs in the Project area.

b) Present agricultural support services will continue.

c) Systems with low cropping intensities at present will take major strides with the first issue of water from the Project.

d) Because of the awareness on the progress of project work, farmers will be ready and able to achieve the maximum cropping intensity possible in each case, during the first year of water issue.

e) Farmers will invest better in their agriculture and obtain higher yields, because of the reduction of risk.

f) The time of planning will also be advanced gradually to better synchronize with the periods of rainfall enabling greater economy in water issues from the reservoir.

g) Farmers would also realize the need to improve their farmer organizations and be able to plan crop production to improve the prospects for marketing their produce.

iii) Assumptions for the “With Project “Cropping Intensities

a) System D2: 200% (currently satisfied)

b) System D1 and G: 200%

The cropping intensities of these systems could be increased to 200% with an additional new area in System D1.

c) System H, I/H, M/H and KHFC: 180%

Further increase of the cropping intensity in the above systems would be constrained by the capacities of the existing Bowatenna Tunnel No.1 and Kandalama-Huruluwewa Feeder Canal.

In FS2001, a higher percentage of other field crops (OFC) was assumed to be cultivated in Systems H, KHFC and G, where availability of RBE soil is high, while a lesser percentage of OFC was assumed in Systems I/H, M/H, and D1, in which availability of RBE soil is negligible. Some farmers of systems I/H, M/H, and D1 were cultivating OFC due to insufficiency of water for cultivating paddy in the entire area although the soil type is not so suitable for OFC. The introduction of cultivating OFC was also a trend to supplement the farmers’ income. The cropping patterns incorporating the situation above were applied in future cases of FS2001.

In these years, the government’s subsidies for procurement of fertilizer for paddy cultivation have largely encouraged the farmers to cultivate paddy. Besides this trend of cultivating paddy among farmers, the assumption of paddy cultivation to the maximum extent is more conservative in terms of water balance planning because of the higher water consumption of paddy than OFC. Therefore, the future cropping patterns adopted in the water balance simulation in this Survey did not include any cultivation of OFC in the existing areas of Systems I/H, M/H, D1, and D2 at all. On the other hand, the current extent of cultivation of OFC in Systems H, KHFC, and G was maintained without increase even in the future cases. Based on the cropping patterns adopted in this Survey, the irrigation water demands (water duties) were calculated for the respective systems.

The CI and water duties, and cropping patterns and system efficiency in computing the irrigation water demand of each case are shown in Attachment-8 and Attachment-9 respectively.

A very important issue addressed in this simulation was the ability of the Mahaweli System to provide irrigation water with acceptable reliability to the irrigation systems under the Mahaweli Project. The acceptable reliability criterion adopted by the MASL is a three-level definition of irrigation water supply shortage as follows:

- An ‘irrigation failure’ is assumed to have occurred in a given simulated year if the sum of the Yala season deficits in an irrigation system, as a whole, exceeded 5% of the total Yala demand. In an operating situation, such a shortage would probably be accommodated by ‘tightening up’ on water deliveries resulting to no significant agricultural losses.
- A ‘significant irrigation failure’ is assumed to have occurred in a given simulated year if the sum of the Yala season deficits in an irrigation system, as a whole, exceeded 10% of the total Yala demand. In an operating situation, such a shortage would probably result in agricultural losses, either planned (Yala crop cut-backs) or unplanned.
- A ‘total irrigation failure’ is assumed to have occurred in a given simulated year if the sum of the Yala season deficits in an irrigation system, as a whole, exceeded 20% of the total Yala demand. In an operating situation, such a shortage would probably result in total agricultural losses, either planned (Yala crop cut-backs) or unplanned.

The criterion of ‘acceptable’ reliability is then defined by incorporating the frequency of occurrence of such failures as follows:

i. Less than 20% in the case of ‘irrigation failure’,
ii. Less than 10% in the case of ‘significant irrigation failure’, and
iii. Less than 5% in the case of ‘total irrigation failure’.

With this definition of acceptable reliability, the system simulation model has been used to determine the irrigation area which could be supported in each irrigation system, given the constraints imposed by water availability. The above-mentioned same criteria are being adopted by the WMS in its planning processes.

5) Domestic and Industrial Water Demand

The monthly water supply demands of Matale, Anuradhapura, Polonnaruwa, and Trincomalee districts for year 2011, 2017, 2022, and 2040 are shown in Table 4.3.1. The demands for the year 2011 are applied in the "without Project" situations and the demands for the year 2017, 2022 and 2040 are applied in the "with Project" situations. As to the water demands for the year 2040, the forecasted annual water supply demands of the above four districts for the year 2032 were used in the simulations.

- It is assumed that the final demand targets are applicable to the year 2040 situation and with the implementation of Moragahakanda Reservoir the water demand would increase gradually. Both the cropping plans defined under Cases-B and C would aim at saving water through improvement of cropping patterns in order to allocate sufficient water to meet the increasing demand of domestic and industrial water supply in the above four districts.
- It is also assumed that the demand of domestic and industrial water supply is not a hard constraint and deficits during the dry spell have to be shared by the water users which would be coordinated for the various districts at project coordinating committee levels and also during water panel meetings.

Table 4.3.1 Seasonal Domestic and Industrial Water Demand

(Unit: m^3/s)

District	Station	2010/2011				2017			
		Oct-Mar	Apr-Sep	Avg.	Total (MCM)	Oct-Mar	Apr-Sep	Avg.	Total (MCM)
Matale	Sudu River	0.137	0.187	0.162	5.1	0.157	0.214	0.186	5.9
	Dambulu Oya	0.049	0.067	0.058	1.8	0.113	0.154	0.134	4.2
Anuradhapura	Nuwarawewa/Tisawewa/ Thuruwila	0.278	0.380	0.329	10.4	0.289	0.396	0.342	10.8
Polonnaruwa	Kaudulla/Minneriya	-	-	-	0.0	0.043	0.059	0.051	1.6
	Parakrama Samudra	0.060	0.083	0.071	2.3	0.062	0.084	0.073	2.3
Trincomalee	Kantale	0.245	0.334	0.290	9.1	0.245	0.334	0.290	9.1
	Mahaweli River	0.000	0.000	0.000	0.0	0.136	0.186	0.161	5.1
Total		0.769	1.050	0.910	28.7	1.044	1.427	1.236	39.0
District	Station	2022				2040			
		Oct-Mar	Apr-Sep	Avg.	Total (MCM)	Oct-Mar	Apr-Sep	Avg.	Total (MCM)
Matale	Sudu River	0.209	0.286	0.247	7.8	0.279	0.381	0.330	10.4
	Dambulu Oya	0.251	0.343	0.297	9.4	0.557	0.762	0.660	20.8
Anuradhapura	Nuwarawewa/Tisawewa/ Thuruwila	0.322	0.439	0.381	12.0	0.402	0.549	0.476	15.0
Polonnaruwa	Kaudulla/Minneriya	0.095	0.130	0.113	3.6	0.212	0.289	0.251	7.9
	Parakrama Samudra	0.082	0.113	0.098	3.1	0.110	0.150	0.130	4.1
Trincomalee	Kantale	0.245	0.334	0.290	9.1	0.245	0.334	0.290	9.1
	Mahaweli River	0.302	0.413	0.358	11.3	0.672	0.918	0.795	25.1
Total		1.506	2.058	1.782	56.2	2.476	3.384	2.930	92.4

Source of data: National Water Supply and Drainage Board (NWSDB)

There are two major abstraction points proposed for Matale. One is directly from the Sudu River at Matale, carrying diverted water from Polgolla, while the other is from Dambulu Oya en-route from Bowatenna Diversion to Kalawewa. The points of abstraction to Anuradhapura District are Nuwarawewa, Tisawewa and Thuruwila, which are being fed by Kalawewa Right Bank Canal through Nachchaduwa. Similarly, the proposed points of abstraction to Polonnaruwa district are from Kaudulla, Minneriya and Parakrama Samudra (PSS) which are being fed by Elahera-Minneriya Yoda Ela (EMYE) from the Elahera Anicut and Yoda Ela feeding PSS starting from Angamedilla in the Amban River. The point of major abstraction to Trincomalee is from the main Mahaweli River, which is close to the city and has to be fed by the releases from the Minipe Anicut during the lean periods together with the irrigation needs of System A. The other abstraction point is from the Kantale Reservoir, in which additional abstractions are stopped due to lack of water to existing cultivations.

6) Hydropower Demand

The energy demand projections for years 2011, 2017, and 2022 were obtained from Fig. 2.1.4 (Sub-section 2.1.2). Since the increase in energy demand is not expected to make any effect to the existing hydropower system even after 2011 from Fig. 2.1.4, the same energy demand of 4,376 GWh was used from 2011 to 2040 cases.

In computing energy generation, the energy produced by hydropower stations in Kelani, Kalu and Walawe river systems were taken into consideration in addition to that produced by hydropower stations in the Mahaweli River system. Since the energy from thermal generation is not considered in this simulation, it targets to satisfy the national energy demand from the hydropower generation, i.e. 4,376 GWh per annum, of which the monthly demand is given in Table 4.3.2.

Table 4.3.2 National Hydropower Demand

(Unit: GWh)

Description	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Hydropower Generation Planned	371	432	425	343	276	328	352	371	345	404	373	355	4,376

Source of data: Ceylon Electricity Board (CEB)

7) Present Operation Status of the Reservoirs Located Upstream and Downstream of the Proposed Moragahakanda Dam

The present operation status is such that about 60% of the inflow into the Amban River system occurring during the three months period from November to January is being diverted to the downstream reservoirs through the Bowatenna Tunnel and Elahera-Minneriya Yoda Ela canal at their maximum possible capacities. In most times, the inflows to these downstream reservoirs occurring during the period from December to January spill over under the present operation. During Yala seasons, heavy diversion is needed at Polgolla to supplement the water issues to Systems H, I/H, M/H and KHFC. Due to hydrologic variability these diversions are neither reliable nor sufficient in both time and space. This happens mainly due to the non availability of large storage in the Amban River, although the Kotmale Reservoir, which is located at upstream of Polgolla on the Mahaweli River, is functioning partly as a large storage for the Amban River system.

(3) Calibration of Water Balance Simulation System

As the initial step of this simulation, the simulation model has been calibrated to confirm that the simulation model represents the existing system's configuration, which comprise the existing energy demands, water duties, cropping patterns, cropping intensities, etc. The model parameters have been adjusted through iterations until model outputs are as close to the actual conditions, i.e. diversions, energy generation, reservoir behavior, etc. as possible. These are routinely conducted through the simulations for the preparation of seasonal operation plans (SOPs) by the WMS. This kind of calibration is vital to obtain accurate and realistic simulation results.

4.3.4 Results of Water Balance Simulation

As a result of the water balance simulations, the water use plan is presented in Table 4.3.3, the simulated monthly reservoir volume, power outlet flow, bottom outlet flow and spillway release of the Moragahakanda reservoir for the analysis period of 40 years of each simulation case is shown in Attachment-10, and the cropping intensities, water issues and water duties, and the average annual water balance in the Amban River of each simulation case are summarized in Attachments-11 and 12, respectively.

(1) Verification of Appropriateness of Capacity of Moragahakanda Reservoir

i) The criterion applied to the water balance simulation is 80% dependability. In other words, the frequency of drop down of the reservoir water level to the minimum operation level (MOL) must be less than once per five years.

Attachment-10 (1), which is the most critical case (Case-B), shows that the number of occurrence of drop down of reservoir water level to the MOL (48 MCM of reservoir volume) does not exceed eight times over the 40 years simulation period. It is judged that the capacity of the Moragahakanda Reservoir can be guaranteed with 80% dependability, and therefore appropriate.

ii) The following advantages of the Moragahakanda Reservoir also verify the appropriateness of its capacity:

a. As shown in Table 4.3.4, after construction of the Moragahakanda Reservoir, the flood water in the Amban River, most of which is currently directed to the sea, can be stored and utilized for irrigation, and the overall cropping intensity of the Project area can be raised from the current 176% to 190% (MASL's target). An additional area of 16,000 ha including 1,420 ha of new development in the Kaudulla Left Bank Extension Area can be cultivated.

b. The Moragahaknada Reservoir will make it possible to satisfy the future demand of domestic and industrial water of Anuradapura, Trincomalee, Matale, and Polonnaruwa districts (about 90 MCM in Case-C).

Table 4.3.3 Water Use Plan

Operation	Station	Without Project	With Project		
		Case-A	Case-B	Case-C	
		2011	2017	2022	2040
Diversion (MCM/year)	Polgolla	954	873	808	823
	Bowatenna	666	674	628	638
	KH Feeder Canal	213	217	203	203
	Huruluwewa	59	69	68	68
	Kandalama	38	40	37	37
	Dambulu Oya	453	457	424	435
	Nachchaduwa	80	94	91	94
	Nuwarawewa	42	41	42	44
	Tisawewa	16	18	17	17
	Elahera	635	687	655	658
	Minneriya	342	381	373	375
	Giritale	79	75	69	69
	Kaudulla	104	150	154	156
	Kantale	95	94	95	96
	Angamedilla	337	322	300	301
Spill (MCM/year)	Elahera	229	76	83	83
	Angamedilla	515	385	408	408
	Polgolla	1132	1212	1277	1262
	Kotmale	1	1	1	1
	Bowatenna	23	22	22	22
	Kandalama	5	4	6	6
	Kalawewa	85	74	87	86
	Nachchaduwa	13	12	14	14
	Nuwarawewa	0	0	0	0
	Tisawewa	0	0	0	0
	Huruluwewa	1	0	1	1
	Minneriya	0	0	0	0
	Giritale	0	0	0	0
	Kaudulla	11	9	12	11
	Kantale	28	7	11	11
	Parakrama Samudra (PSS)	0	0	0	0
Power Outlet (MCM/year)	Moragahakanda	-	699.1	681.5	689.5
Bottom Outlet (MCM/year)	Moragahakanda	-	39.8	23.7	21.4
Spill (MCM/year)	Moragahakanda	-	23.8	33.1	30.0
Hydropower Generation (GWh/year)					
All Hydropower Stations		4247	4348	4378	4375
Bowatenna		64	53	50	50
Moragahakanda *1		-	66	67	67
Domestic and Industrial Water Supply (MCM/year)					
Matale	Sudu River	5.0	5.9	7.8	10.4
	Dambulu Oya	1.8	3.8	8.7	19.3
Anuradhapura	Nuwarawewa/Tisawewa/Thuruwila	10.2	10.6	11.9	14.9
Polonnaruwa	Kaudulla/Minneriya	0.0	1.6	3.5	7.9
	Parakrama Samudra (PSS)	2.1	2.2	3.0	4.0
Trincomalee	Kantale	9.1	9.0	9.1	9.1
	Mahaweli River	0.0	5.1	11.3	25.1
	Total	28.2	38.2	55.3	90.7
	Run No.	A30A	A21A	A22A	A23A

Prepared by the JICA Survey Team

Note: *1: Hydropower generation capacity of Moragahakanda Power Plant: 15 MW

Table 4.3.4 Increment of Cropping Intensity and Cultivation Area

Case	Cropping Intensity (%)			Cultivation Area (1,000 ha)		
	Maha	Yala	Total	Maha	Yala	Total
Without-Project	98	78	176	83	67	150
With-Project	100	90	190	87	79	166
Increment	2	12	14	4	12	16

Prepared by the JICA Survey Team

c. As shown in Table 4.3.3, the result of Cases-B and C show that the Moragahakanda Reservoir is able to limit the quantity of diversion at Polgolla to 875 MCM/year, which has been agreed among all water user groups, due to the storage and regulation of the Moragahakanda Reservoir. As a result, the targeted national power generation, 4,376 GWh, will be maintained.

(2) Other advantages of the Moragahakanda Reservoir

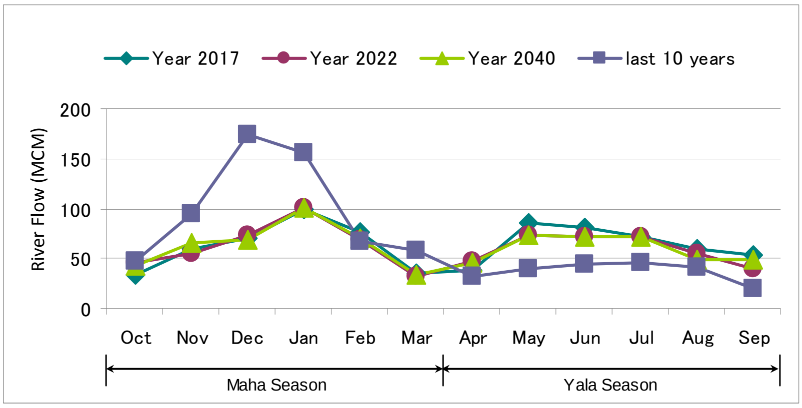
The following advantages of the Moragahakanda Reservoir are also to be expected based on the results of the water balance simulation:

i) As shown in Attachment-11, implementation of the Moragahakanda Reservoir results to 100% cultivation in all the irrigation systems in the Project area during Maha seasons, and 100% cultivation in Systems D1, D2, and G, and 80% cultivation in Systems H, I/H, M/H, and KHFC Schemes during Yala seasons. In this simulation, it is assumed that increase of water availability in the irrigation systems will increase the water duties (= cultivated area (ha)/water issue (MCM)) which would also increase the total cultivated area.

ii) Introducing the cropping pattern of high yielding short-term varieties of paddy in all irrigation systems would be a hard task for the MASL and ID. However, if such cropping pattern can be realized as simulated in Case-C, the result shows that an amount of 50 to 60 MCM/year of water would be saved at Polgolla between 2022 and 2040. The saved water could be flexibly utilized for the future increased demand of irrigation water, domestic and industrial water, or other purposes.

The above effects can be seen in Table 4.3.3 and Attachment-12.

iii) Another advantage of the Moragahakanda Reservoir is that the water flow in the Amban River can be regulated and subsequently made more constant throughout the year, which can be seen in Fig. 4.3.2 that shows the water flows at Elahera for the last ten years and the simulation results.



Prepared by the JICA Survey Team

Fig. 4.3.2 Comparison of Last 10-Year River Flow at Elahera with Simulated Flows

(3) Operational Plan of the Proposed Moragahakanda Reservoir and Other Relevant Reservoirs

The results of the water balance simulations for the "with Project" condition (Cases-B and C) show that the operation of the Amban River system would be greatly improved by implementing the Moragahakanda Reservoir. As mentioned above, in the "with Project" case, the quantity of diversion at Polgolla can be reduced to 875 MCM/year from 954 MCM/year resulting from Case-A (without Project). The flood water in the Amban River system can be stored and regulated in the Moragahakanda Reservoir, and thereby the spillage at the downstream reservoirs can be reduced. For example, the spillage of Kantale can be reduced from 28 MCM/year to 11 MCM/year in the case of the with Project simulation. During the Maha seasons, the water will be supplied to the irrigation system from the downstream reservoirs, while during Yala seasons, water will be supplemented from the Moragahakanda Reservoir through the downstream reservoirs.

4.4 Main and Saddle Dams

4.4.1 Layout of Dams

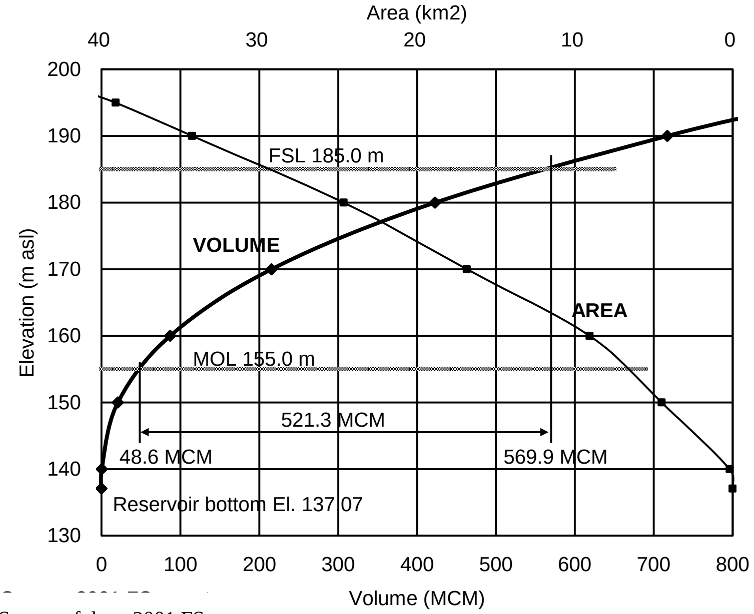
(1) General

In the present Survey, the following principal features of the Project, which were recommended in the FS2001 report, are regarded as the fixed conditions:

- Full Supply Level (FSL) of Moragahakanda Reservoir: El. 185.0 m asl
- Minimum Operation Level (MOL) of Moragahakanda Reservoir: El. 155.0 m asl
- Design flood for dam (1,000 year return period): Qmax = 3,797 m^3/s
- Safety check flood for dam (10,000 year return period): Qmax = 4,749 m^3/s

The reservoir storage capacity between FSL and MOL indicated in the FS2001 report is approximately 520 MCM which was reviewed in the present survey and justified to be adequate for downstream irrigation and domestic and industrial water supply purposes as mentioned in Section 4.3 (water balance planning).

The Survey Team recalculated the reservoir storage volume based on the reservoir area data shown in the FS2001 report by applying the usual average contour area method instead of modified prismoidal formula applied in the FS200 report, and found no significant difference between the recalculated reservoir volume and the FS2001 reservoir volume. The FS2001 volume curve shown in Fig. 4.4.1 is thus used in the present study.



Elevat'n (m asl)	Area (km^2)	Volume (MCM)
137.07	0.00	0.0
140	0.19	0.3
150	4.50	20.7
160	9.06	87.1
170	16.85	215.5
180	24.66	422.6
190	34.25	717.2
195	39.10	900.6

These curves show volume and area before sedimentation.

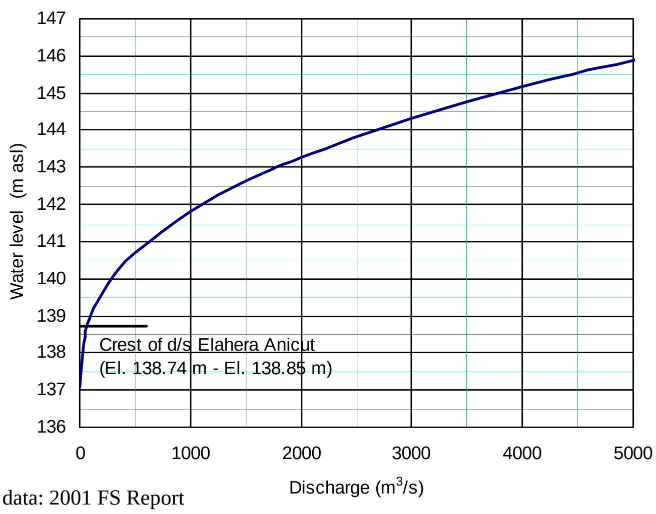
Source of data: 2001 FS report

Fig. 4.4.1 Area-Volume Curves of Moragahakanda Reservoir

The tail water level (Hw) at arbitrary discharge (Q) at the dam site is defined by the following equation which was shown in the 2001 FS report:

$$Hw = 137.07 + 0.3329 * Q^{0.3848}$$

As the Elahera Anicut (weir) is located 2.3 km downstream of the Moragahakanda Dam site, river bed degradation is not expected to occur between the dam and the anicut. The tail water rating curve calculated from the above equation is shown in Fig. 4.4.2.



Source of data: 2001 FS Report

Fig. 4.4.2 Tailwater Rating Curve at Dam Site

At the Moragahakanda Dam site, there are two saddle areas on the left bank ridge of the Amban River, which are called Saddle-1 and Saddle-2. These saddle areas are located approximately 0.3 km and 1 km away from the river course at the main dam site, respectively.

The ground elevation of each saddle bottom is as follows:

Lowest ground surface elevation

Saddle-1: 151 m asl

Saddle-2: 178 m asl

Dam height above the ground at Saddle-2 will be about 10 m only. A homogeneous earth-fill type dam is presently under construction at Saddle-2 by the MASL's own work force. Therefore, layout and design of the Saddle-2 dam are excluded from the review subjects of the present study.

(2) Original Layout of Dams in FS2001

In the FS2001 report, numerous cases of dam configuration were studied considering different full supply levels of the reservoir and different types of dam such as roller compacted concrete (RCC) gravity, clay-core rockfill, asphalt-core rockfill and homogeneous earthfill. With respect to the four representative layouts for the reservoir FSL of 185.0 m asl, civil work costs estimated in the FS2001 are as follows:

Table 4.4.1 Civil Work Costs for Alternative Layouts Presented in FS2001

	Description	Unit	Layout No. in FS 2001			
			031	**034**	**017**	**010**
1)	Reservoir Full Supply Level	m asl	185.0	185.0	185.0	185.0
2)	Dam type					
	In river valley		RCC	RCC	Rock fill	Rockfill
	In Saddle-1		Rockfill	RCC	RCC	Rockfill
3)	Civil work direct cost					
	River diversion	10^6 US$	2.9	2.9	3.5	10.1
	Dam in river valley	10^6 US$	17.5	17.5	10.2	10.1
	Dam in Saddle-1	10^6 US$	7.1	12.9	13.4	7.0
	Spillway	10^6 US$	0.8	0.8	3.0	3.1
	Powerhouse	10^6 US$	0.7	0.7	0.7	0.7
	Sub-Total	10^6 US$	29.0	34.8	30.8	31.0
4)	Civil work indirect cost (40%)	10^6 US$	11.6	13.9	12.3	12.4
5)	Total Civil Work Cost	10^6 US$	**40.6**	**48.7**	**43.1**	**43.4**
	Cost ratio		1.00	1.20	1.06	1.07

Source of data: 2001 FS report, Appendix H RCC = roller compacted concrete

Layout No. 031 was lowest in cost and Layout No. 017 has the second lowest cost. In the FS2001 report, Layout No. 031 was finally selected as the most economical design. The selected layout is as follows:

FS2001	Dam in River Valley	Dam in Saddle-1
- Type of dam	RCC gravity dam	Clay-core rockfill dam
- Dam crest level (*)	187.0 m asl	188.0 m asl

Note: (*) referred to Table 3.10 in FS2001 report (main report)

Axis of the dams selected in the FS2001 is almost straight through both dams and passes over the point where ground level of Saddle-1 bottom is highest in elevation. This axis is more or less identical as in the design of the JICA's feasibility study of 1979.

(3) Alternative Layouts of Main Dam and Saddle-1 Dam

Various unit costs for dam construction have changed after the last feasibility study was carried out in 2001. Some unit costs increased highly but others did not. Therefore, the Survey Team considers that it is necessary to review the dam layout based on the present price level to find the most appropriate dam layout. For reviewing the dam layout, the following two alternative layouts of dam are considered. Their technical aspects are assessed and construction costs are estimated for comparison:

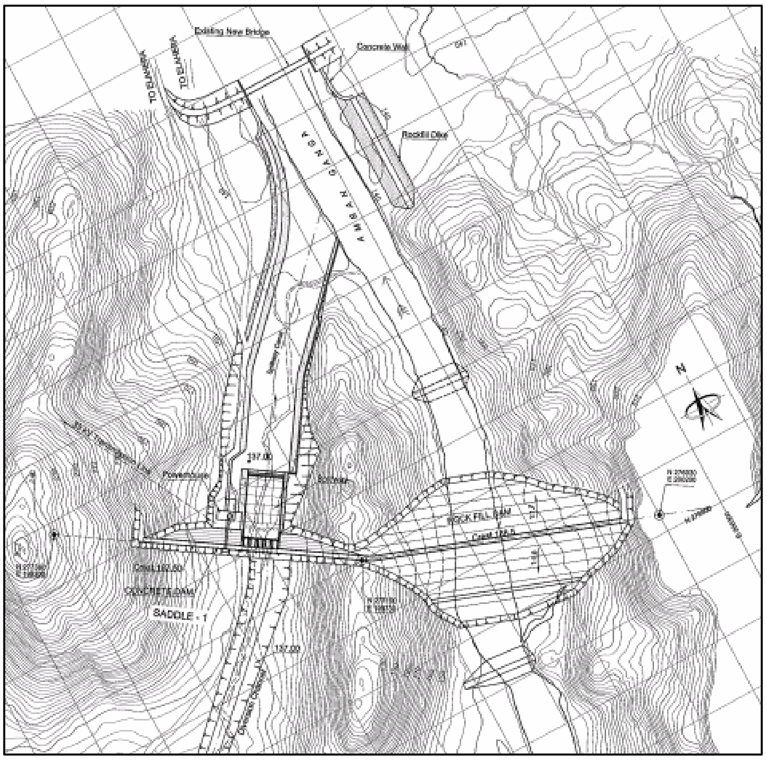
Layout 1: RCC dam in river valley and rockfill dam in Saddle-1 (Layout 031 in FS 2001)

Layout 2: Rockfill dam in river valley and RCC dam in Saddle-1 (Layout 017 in FS 2001)

Both layouts preliminarily designed by the Survey Team are illustrated in Figs. 4.4.3 and 4.4.4. The dam axis taken for both layouts is almost identical to that shown in the FS2001 while the direction of dam axis on Saddle-1 is slightly changed so that the dam axis perpendicularly crosses the abutment faces. The Saddle-2 dam is not taken into account in this review.

Prepared by the JICA survey team

Fig. 4.4.3 Dam Arrangement - Layout 1



Prepared by the JICA survey team

Fig. 4.4.4 Dam Arrangement - Layout 2

(4) Design Considerations for Reviewing Dam Layouts

Dam Design

For reviewing dam layouts, designs of the dams are made as described in Section 5.3.1. Height and section shape of the dams designed for this dam layout selection are as follows:

	Layout 1	Layout 2
• Concrete dam	(in river valley)	(in Saddle-1)
Dam crest elevation	187.5 m asl	187.5 m asl
Lowest dam foundation level	127.5 m asl	136.0 m asl
Max. height of dam	60 m	51.5 m
Upstream slope (v:h)	1:0	1:0
Downstream slope (v:h)	1:0.82	1:0.80
• Rockfill dam	(in Saddle-1)	(in river valley)
Dam crest elevation	188.5 m asl	188.5 m asl
Lowest level (clay core)	139 m asl	127.5 m asl
Max. height of dam	49.5 m	61 m
Upstream slope (v:h)	1:1.8	1:1.8
Downstream slope (v:h)	1:1.7	1:1.7

It is noted that the dam crest elevations shown above are 0.5 m higher than those indicated in the FS2001 report since the present design is based on Japanese dam design criteria as detailed in Section 5.3.1.

For both layouts, it is considered that the concrete dam is constructed by applying the roller compacted concrete (RCC) method since the RCC contains less cement than conventional concrete and consequently results in less cost for materials and concrete cooling. Time for construction of RCC dam is shorter than the conventional concrete dam as high speed placing of RCC is possible owing to less heat generation.

Rockfill dam in both layouts is the zoned rockfill type with central clay core.

Design of Appurtenant Structures

Review of designs of spillway, bottom outlets, intake, powerhouse and river diversion is made in Section 4.4.2.

(5) Major Work Quantities of Alternative Layouts

Work quantities for construction of each layout are estimated as follows:

		Unit	Layout 1	Layout 2
i)	Excavation	m3	726,000	1,228,000
ii)	Embankment	m3	802,000	1,468,000
iii)	Concrete (including RCC)	m3	377,000	222,000

Note: Work quantities for Sadde-2 dam and access roads are not included.

As Layout 2 requires large scale excavation for the spillway in Saddle-1 area and large embankment for rockfill dam in the river valley, the quantity of earthworks (excavation and embankment) is 76% larger than that of Layout 1. Contrarily, as Layout 1 requires a large concrete dam in the river valley, its quantity of concrete (including RCC) is 70% larger than that of Layout 2.

(6) Construction Difficulty and Construction Period

< Layout 1 >

A cellular cofferdam has to be constructed in the initial phase. Steel sheet piles or other cell materials have to be imported from abroad. Timely import of these materials may not be easy because of the very short time available for material procurement. This may result in the delay of the whole work.

Temporary diversion of the river is carried out in two stages. Route of river flow is different in the two stages. Most parts of the first stage cofferdams have to be removed before the second stage diversion. Constructing and removing cofferdams during rainy season are risky. Thus, they have to be executed during the dry season. The construction time schedule is governed by the timing of river diversion works. This is another risk of work delay.

Total construction period estimated for Layout 1 is 45 months as shown in Fig. 4.4.5.

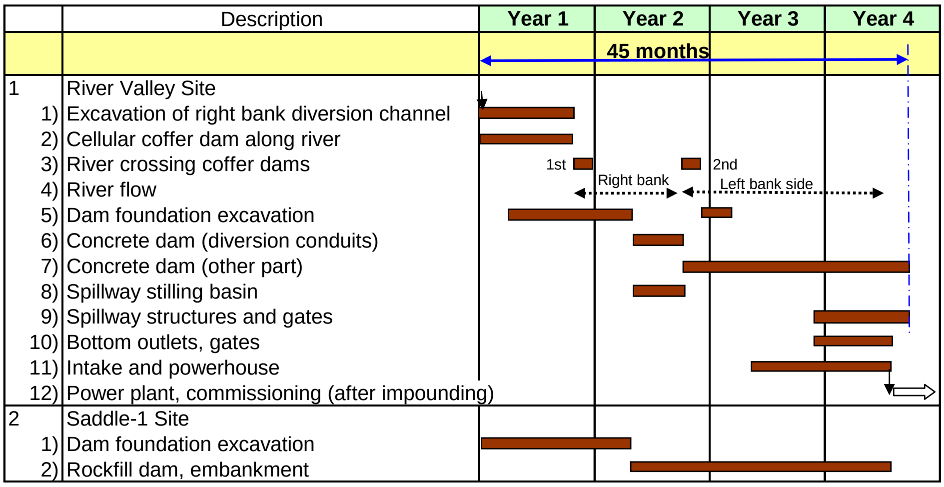


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Fig. 4.4.5 Tentative Construction Schedule for Layout 1

< Layout 2 >

In the first year of construction, river diversion facilities can be constructed under dry condition in the Saddle-1 area while the excavation quantity is large. The concrete dam construction which takes time can be started earlier in the dry Saddale-1 area. It is estimated that the rockfill dam in the river valley can be constructed within two years after completion of the diversion facilities in the Saddle-1. Construction sequence is simple and risk of work delay is small.

Total construction period estimated for Layout 2 is 42 months, i.e. 3 months shorter than that of Layout 1, as shown in Fig. 4.4.6.

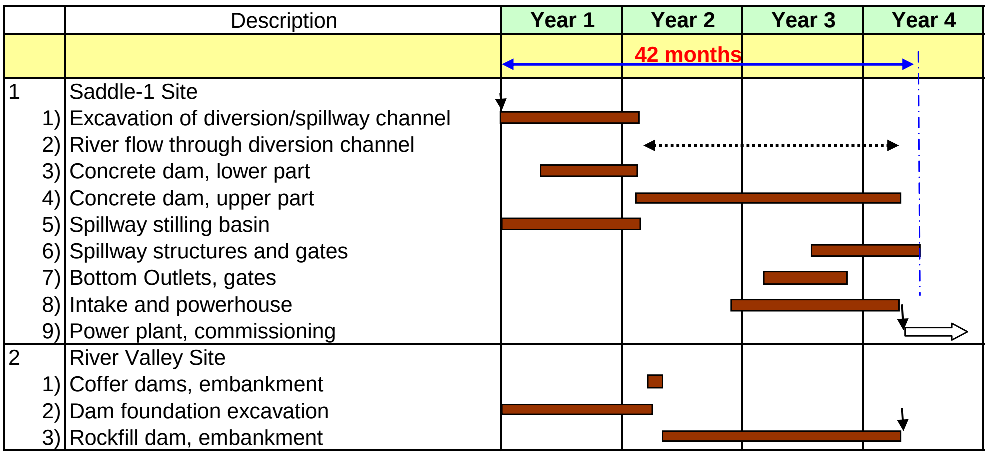

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Fig. 4.4.6 Tentative Constriction Schedule for Layout 2

(7) Construction Costs for Dam Layout Selection

In terms of costs for mechanical and electrical equipment (gates, power plant and transmission line), there is no significant difference between both layouts. Therefore, only the civil work costs of both layouts are compared for the purpose of seeking an economical layout. The costs for the civil works are estimated on the basis of estimated work quantities and updated unit costs (2010 price level) without including indirect costs, taxes and contingencies.

The estimated civil work costs of both layouts are as follows:

Table 4.4.2 Civil Work Costs of Layout 1 and Layout 2

Works	Cost (USD million)	
	Layout 1	Layout 2
1) Temporary diversion facilities	10.9	0.4
2) Concrete dam (including conduits)	41.9	23.9
3) Rockfill dam	16.9	31.2
4) Spillway and discharge channel	13.1	22.0
5) Powerhouse and switchyard	2.4	2.1
Total	85.2	79.6
Cost ratio	100.0	93.4

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The total civil work cost is USD 85.2 million for Layout 1 and USD 79.6 million for Layout 2. Layout 2 is more economical than Layout 1 by 6.6%.

Major cost differences occur in diversion facilities and spillway. Layout 1 needs expensive cellular sheet-pile cofferdam but Layout 2's diversion facility is an excavated open channel only. The spillway in Layout 2 needs a costly large scale discharge channel with bottom width of 75 m and length of about 450 m and a heavy bank protection at the downstream bridge.

(8) Selection of Optimum Dam Layout

The Survey Team finally selects Layout 2 as the most appropriate layout.

Layout 2 consists of a concrete dam in Saddle-1 and a rockfill dam in river valley. Advantages of Layout 2 compared with Layout 1 are as follows:

- Layout 2 is 6.6% lower in construction cost than Layout 1.
- Construction of Layout 2 will be completed three months earlier than Layout 1.
- Construction sequence of Layout 2 is simpler than that of Layout 1. Layout 1 needs a cellular cofferdams for river diversion, which has to be built in the initial phase of construction. There is a risk of delay in importing steel material for the cellular cofferdam. This delay directly affects the total construction time.
- From the hydraulic point of view, Layout 2 seems to be inferior than Layout 1 since the spillway outflow in Layout 2 obliquely hits the main stream of Amban River around the existing new bridge located about 800 m downstream of the dam axis. However, this problem will be solved through additional river bank protection.

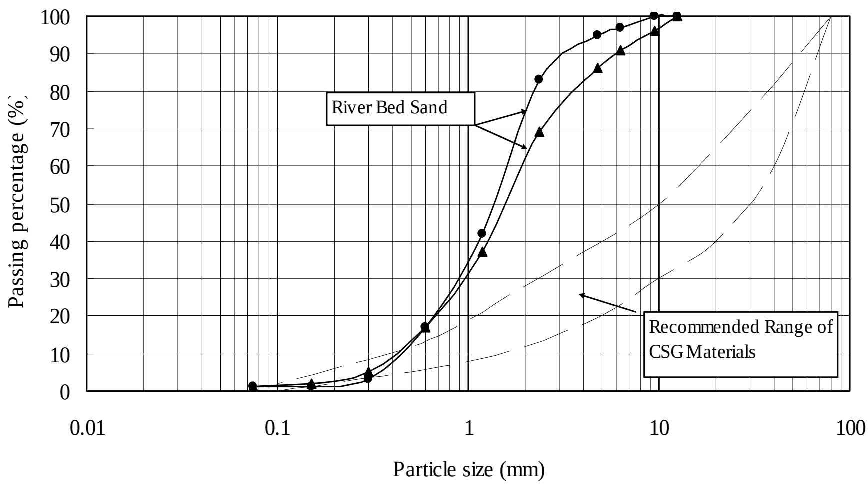
(9) Idea of Applying Trapezoidal Section CSG Dam

Dam construction using cemented sand and gravel (CSG) has recently been developed in Japan. Some water storage dams with heights of about 50 m are under construction in Japan. It is possible for the CSG dam to become an economical and prospective type of dam to replace the RCC type under the following circumstances:

- Natural sand and gravel are available in the vicinity of the dam site and they contain sufficient quantities of both sand (< 2 mm size) and gravel (> 2 mm size),
- Excessively deep excavation is required to expose sound rock for dam foundation where concrete gravity dam is desirable.

In the vicinity of the Moragahakanda Dam site, natural alluvium deposited in the river channel of the Amban River contains little amount of gravel. Most part of the river deposit is sand as shown in the gradation curves of Fig. 4.4.7, which are based on recent investigations at site.

As natural deposits of gravel sufficient for dam volume are not found in and around the Moragahakanda Dam site, it is necessary to produce gravel from quarry rock. Accordingly, unit cost of sand and gravel for CSG is almost equal to that of RCC aggregate. Cement content of CSG is 80 to 100 kg/m^3 while the content of cementitious materials (cement and fly ash or pozzolan) in recent examples of RCC dam is around 150 kg/m^3.



Prepared by the JICA survey team

Fig. 4.4.7 Gradation Curves of Actual River Deposits and Recommended CSG Materials

Fresh CSG is placed and compacted in layers (usually 0.3 m thick) with earth-moving equipment, similar to the RCC method. Upstream and downstream faces of compacted CSG are covered with thin in-situ conventional concrete (CVC) for the purpose of water sealing and protection of CSG zone. The CSG dam needs more volume of expensive CVC than the RCC dam.

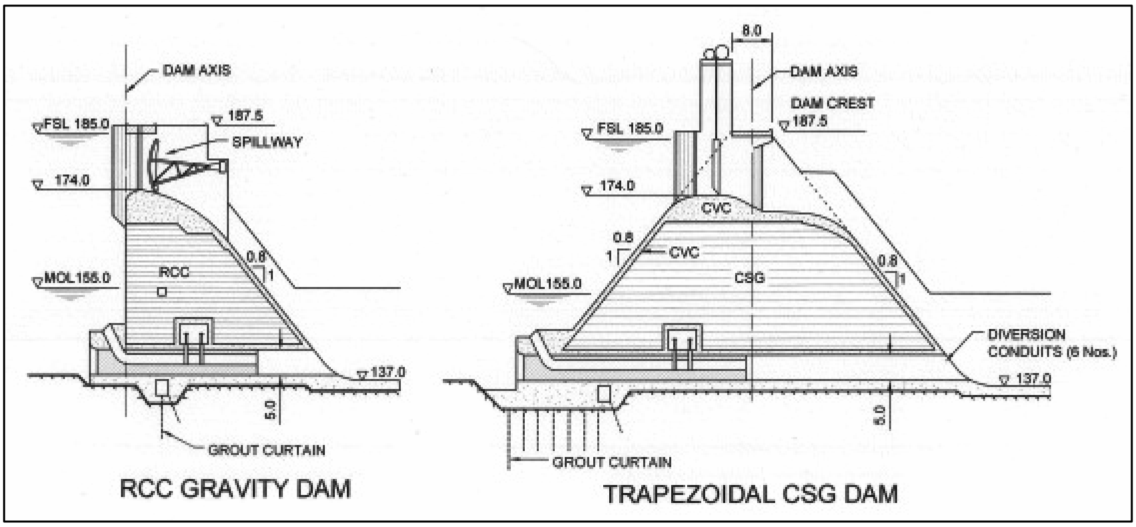


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Fig. 4.4.8 Comparison of RCC and CSG Dam Sections

Excavation depth for CSG dam foundation will be a few meters shallower than RCC dam. However, total volume of the trapezoidal section CSG dam is more than 2 times the RCC dam because both upstream and downstream slopes of CSG dam are around 1:0.8 (v:h) as shown in Fig. 4.4.8.

According to a tentative estimate by the Survey Team, total civil work costs are USD 28 million in case of RCC dam and USD 52 million in case of the trapezoidal section CSG dam, both in the Saddle-1.

In this Project, the trapezoidal section CSG dam is not economical in comparison with the RCC gravity dam. Therefore, the idea of applying the trapezoidal section CSG dam in place of the RCC dam in the Project is abandoned in the present study.

4.4.2 Appurtenant Structures

(1) Spillway

A spillway capable of discharging the 1,000-year flood (Q=3,797 m^3/s) is provided on the concrete dam, as adopted in the FS2001. The spillway headwork is of the overflow type with five radial gates. The gate size of 9.5 m (width) x 11.0 m (height) in FS 2001 is changed to 9.7 m x 11.0 m based on the re-calculation of discharge capacity as detailed in Section 5.3.1. Downstream energy dissipater is a horizontal apron type stilling basin as adopted in the FS2001.

(2) Bottom Outlets

Bottom outlet facility consists of two lanes of low level conduit equipped with discharge control gate and maintenance gate. The outlet facility is laid in the diversion conduit provided across the concrete dam for temporary river diversion purpose. The service gate (discharge control gate) designed in the FS2001 is a roller gate with opening size of 1.8 m x 2.0 m, which is capable of discharging water of 90 m^3/s in total for two gates at the reservoir level of 155 m asl. This discharge capacity was needed to evacuate full volume of reservoir water in two months for emergency drawdown when the reservoir inflow is 35.8 m^3/s (annual mean flow).

In the present review of design, it is considered that emergency drawdown during rainy season is unrealistic since it is difficult to keep water level low during high flow or flood flow. Mean inflow in the dry season is approximately 20 m^3/s. Bottom outlet having a 50 m^3/s discharge capacity at the reservoir level of 155 m asl can evacuate full reservoir water within 2.5 months in the dry season. This discharge capacity is considered sufficient for emergency drawdown as well as for discharging irrigation water during power plant shutdown. The service gate is thus changed to a jet-flow type with opening diameter of 1.6 m so that two lanes of the bottom outlet have the discharge capacity of 50 m^3/s at the reservoir level of 155 m asl.

(3) Intake and Powerhouse

The powerhouse in the FS2001 was planned to generate 20 MW through a single unit. The capacity of the powerhouse is reviewed in Section 4.5.1 and 15 MW is selected as the optimum capacity. In the present study for selection of dam layout, a single unit 15 MW powerhouse is considered. Kaplan type turbine is adopted as in FS2001 since higher turbine efficiency is expected for wide range of discharge variations compared with the Francis turbine.

Powerhouse building is located at the downstream toe of the concrete dam in Saddle-1. Power intake is built at the upstream face of the concrete dam. A concrete penstock pipe to lead the water to the turbine is laid horizontally in dam body and inclined on the downstream slope of dam. The penstock diameter for the single 15 MW unit is decided to be 3.5 m.

(4) River Diversion Facilities

In both Layout 1 and Layout 2, construction safety is governed by river diversion design for construction. In FS2001, a 20-year flood was considered for the river diversion design, in which peak discharge is 2,255 m^3/s. However, in the present comparison of dam layout, the diversion design flood is reduced to 1,000 m^3/s for the first flood season and 1,600 m^3/s for the second and third flood seasons. The reasons are listed below:

- According to the FS2001 report, the largest flood peak recorded in a period of more than 20 years was 1,605 m^3/s and the second largest flood was 929 m^3/s.
- Construction work will be completed within 3.5 years. The flood seasons to be considered are three seasons. In the first flood season, major works are foundation excavation or dam concreting at lower part in the river channel. Flood damage to the works in such low places is not serious even if inundated by flood resulting to overtopping of cofferdam.
- In the second and third flood seasons, the top level of the dam being constructed becomes high in elevation. If the dam is overtopped, flood damage is serious, particularly in rockfill dam. The flood discharge of 1,600 m^3/s is considered to be sufficiently large to keep

construction safe during the second and third flood seasons.

The river diversion scheme envisaged for each dam layout is as follows:

Layout 1 (multi-stage diversion in river)	**Layout 2** (diversion through Saddle-1)
This diversion method is the same as in FS2001 FS design. For the 1st stage diversion, a 45 m wide channel is excavated along the river on the right bank. The existing natural river channel at the dam foundation area is enclosed with cellular sheet-pile cofferdam along the river and embankment cofferdams across the river. The river is diverted through the right bank artificial channel. For the 2nd stage diversion, the 1st stage cofferdams are removed and the river is diverted through 4 conduits built in the concrete dam at river bed level. Right bank diversion channel is closed with embankment cofferdams. The diversion conduits are closed by gates when the reservoir filling is started.	In the 1st year before commencing any work in the river valley, lower part of the concrete dam and spillway stilling basin are constructed at the Saddle-1 site. A 20 m wide upstream diversion channel and a 75 m wide downstream spillway discharge channel are excavated. When the works for rockfill dam begin in the river valley, the rockfill dam foundation area is closed by upstream and downstream embankment cofferdams and river flow is diverted through the diversion channel and six conduits in the Saddle-1 site. The diversion conduits are closed by gates when the reservoir filling is started.
No cofferdams are required at Saddle-1 site.	

(5) River Bank Protection around Downstream Bridge

A new road bridge crossing over the Amban River was constructed recently approximately 800 m downstream of the dam axis. The bridge was officially opened in February 2010.

In Layout 1, the spillway is located on the concrete dam in the existing river channel. This layout does not change the river flow conditions at the bridge site.

However, in Layout 2, the spillway discharge channel extended from the Saddle-1 obliquely joins with the main river channel at the upstream of the new bridge. It is foreseen that the river flow around the bridge becomes turbulent and vortex flow during flood times. This may cause scouring damage to the bridge piers and reduction of the river flow capacity under the bridge. Therefore, to protect the bridge, it is necessary to construct concrete guide walls at the upstream side of the existing bridge abutment walls. Also the banks of river and the discharge channel upstream of the bridge need to be heavily protected with revetment such as large size rock riprap in order to avoid bank erosion and scouring.

4.5 Hydropower Generation and Transmission Line

4.5.1 Capacity of Hydropower Station

(1) General

The main purpose of the Moragahakanda Reservoir is to supply water to the downstream reaches for irrigation and domestic/industrial uses. To utilize the potential energy of the water to be released downstream, hydropower generation at the Moragahakanda Dam is planned.

In FS2001, the installed capacity of the hydropower station was selected to be 20.0 MW. While the basis of the capacity selection is not detailed in the FS2001 report, this capacity coincides with a possible maximum power output based on maximum available head of 46 m and estimated maximum water release rate of 50 m^3/s.

The requirements of water release rates vary with the downstream water demands. Therefore, the Survey Team seeks the optimum generation capacity hereunder on the basis of the water balance simulations of the Mahaweli River system.

(2) Water Balance Simulations

Water balance simulation studies to find the required outflow pattern of the Moragahakanda Reservoir were conducted utilizing the MASL's own simulation software designed for the whole Mahaweli System, details of which are explained in Section 4.3. The computer operations were performed by the MASL's specialist. Several different generation capacities of the Moragahakanda Hydropower Station were taken into account in the simulations to seek an optimum generation capacity. The simulations covered 40 years from October 1968 to September 2008.

Demand for irrigation water varies with the season and reaches its peak during dry season (May to August). Water release demand during rainy season becomes very low and sometimes is nil. However, in the initial trial and error simulations, it was found that a series of large reservoirs which exist along the main canal can store water effectively during the rainy season and release it during the dry season for irrigation. Through this effect, the Moragahakanda Reservoir can reduce the dry season outflow while the irrigation demand is high. Instead, the Moragahakanda outflow is increased during the rainy season although the irrigation demand is low. If the Moragahakanda outflow directly follows the monthly irrigation demands, dry season outflow requirement becomes excessively high while rainy season outflow requirement becomes very low. Flow without excessive fluctuation is better for operation of irrigation canal as well as for power generation. In order to increase the monthly outflow rates during the rainy season, the maximum outflow rate during the dry season (May, June, July and August) is restricted to 32 m^3/s, which was estimated based on the initial simulations to be an adequate limit to eliminate deficit of irrigation water at the downstream margin.

(3) Power Generation Mode

The idea of daily peak generation at Moragahakanda to supply power for a few hours a day is abandoned since there is no land space enough in the 2.5 km river reach between the dam and the downstream Elahera Anicut to store water for re-regulating large fluctuation of discharges between peak and off-peak times. A non-fluctuating supply of water all day long is desirable for irrigation.

(4) Generation Scales Studied

As the long-term average river flow at the dam site is around 25 m^3/s, it is considered possible to generate at least 7.5 MW continuously if the average flow is released downstream. Further, as the water release demand is likely to reach 50 m^3/s and the maximum water head is about 46 m, the upper limit of generation capacity is expected to be 20 MW. Generation capacities considered for comparison of generation scale are 7.5 MW, 10 MW, 15 MW and 20 MW.

The turbine rated head is fixed at 40 m for all cases and accordingly the maximum turbine outflows decided at the rated head are as follows:

Installed capacity (MW)	Max. limit of turbine discharge (m^3/s)
7.5	21.0
10.0	28.0
15.0	42.0
20.0	56.0

(5) Type and Efficiency of Turbine

Type of turbine selected in FS2001 is Kaplan type. As explained in the 2001 FS report, advantages of the Kaplan type compared with Francis type are as follows:

- Kaplan turbine covers a wider range of discharge variations (25% to 100%) than Francis turbine (50% to 100%).
- Kaplan turbine shows better part-load behavior and thus higher overall efficiency for wide range of discharge in comparison with Francis turbine.

Therefore, the Survey Team also selects the Kaplan turbine. The turbine efficiency for the present study is referred to the efficiency hill curves shown in the FS2001 report.

(6) Permissible Minimum Head for Turbine

It is mentioned in the FS2001 report (main report, page 3-47) that turbine operating range in terms of working head is limited to a range of about 100% to 60% of the gross head. According to the USBR data on Kaplan type turbine, the allowable range is generally between 65% and 125% of the rated head in order to avoid cavitation, vibration and other hydraulic troubles. The maximum net head is 46.0 m (= 185.0 - 138.5 - 0.5). As the average reservoir water level initially simulated is around 179 m asl, the rated head for turbine is decided to be 40.0 m (= 179.0 - 138.5 - 0.5). The permissible minimum head is thus 26.0 m (= 40 x 0.65) that corresponds to the reservoir level of 165.0 m asl.

Therefore, the minimum operation reservoir level for the turbines is decided to be 165.0 m asl. When the reservoir water level is lower than this level, power plant operation is stopped and the required release of water to the downstream area is performed through the bottom outlet.

(7) Generation Simulation Conditions

The simulation conditions taken into account are listed below:

- Four different installed capacities of 7.5 MW, 10 MW, 15 MW and 20 MW are considered. Number of generation unit is 1.
- Turbine is Kaplan type. Turbine efficiency is simplified between 93% and 91% depending on working head and discharge, referring to the efficiency curve shown in the FS2001 report.
- When the reservoir water level is lower than 165.0 m asl, turbine operation is stopped. At this time the water to meet downstream demand is released through the bottom outlet.
- Allowable maximum turbine discharge (Q) at arbitrary head is computed by:
  - When working head is lower than rated head: $$Q = Q_R \sqrt{\frac{H}{H_R}}$$
  - When working head is higher than rated head: $$Q = Q_R \frac{H_R}{H}$$

  where, Q_R : Turbine discharge at rated head
  H: Net head under consideration
  H_R: Rated head (=40.0m)
- Allowable minimum discharge for turbine operation is 25% of the turbine maximum discharge at rated head.
- Operation mode is base load operation, i.e. constant output in 24 hours.
- Loss of head in waterway is 0.7 m at maximum turbine discharge in all cases.
- Generator efficiency is 98%.

(8) Results of Generation Simulations

To seek the optimum generation capacity of the powerhouse, generation simulations (water balance simulations) were carried out considering the water demand in 2017. The results are summarized in Table 4.5.1.

Table 4.5.1 Results of Generation Simulations (1968-2008)

Description	Unit	Generation Capacity			
		7.5 MW	10 MW	15 MW	20 MW
1) Annual outflow through turbine	MCM/y	456	584	699	714
2) Release from spillway and bottom outlet	MCM/y	301	169	64	53
3) Proportion of water volume used for power generation	%	60	78	92	93
4) Average reservoir water level	m asl	175.3	175.0	175.5	175.3
5) Energy production	GWh/y	44	55	66	67
7) Plant factor (*)	%	67	63	50	38

Notes: Applied water demand is the demand in 2017.
(*) Plant factor = (Annual energy produced)/(Installed capacity x 24h x 365d)

Variations of energy production and plant factor are illustrated in Fig 4.5.1:

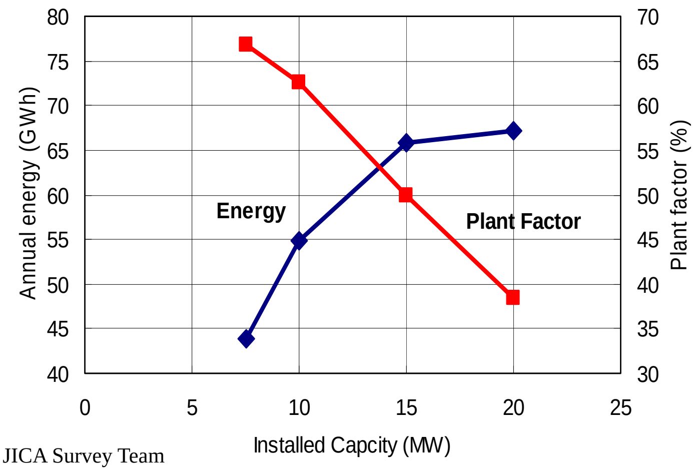

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Fig. 4.5.1 Energy Production and Plant Factor (7.5MW to 20 MW)

As seen in Fig. 4.5.1, energy production largely increases with the increase of installed capacity up to the capacity of 15 MW. Energy increment is only minimal for capacity over 15 MW. The reason is that discharge capacity of the 15MW plant is more or less coincident with the maximum requirement of water release from the Moragahakanda Reservoir. Smaller plant capacity results in large amount of water release through bottom outlets since the turbine cannot release water to meet 100% of the downstream demand. In case of a 7.5 MW plant, 40% of total outflow from the reservoir is released through bottom outlets or spillway without utilizing it for power generation, as seen in Table 4.5.1.

Operation flexibility of power plant is expressed by plant factor. To minimize operation trouble and prolong the service life of machine, generating plant has to be maintained periodically and repaired timely. It is generally said that a plant factor of 60% or lower is desirable for good maintenance. According to actual hydropower operation data in 2008 in Sri Lanka, the highest plant factor recorded was 60.2% in the Kukule River. Plant factor of the Victoria Hydropower

Station on the Mahaweli River was 32.2%. The plant factor of the 15 MW case is 50% which seems to be appropriate for flexible operation and good maintenance.

For each generation capacity, construction cost of intake and powerhouse and benefit from energy selling are roughly estimated as shown in Table 4.5.2. Benefit-Cost (B-C) values are calculated in the same table and illustrated in Fig. 4.5.2.

Table 4.5.2 Economic Comparison to Select Optimum Generation Capacity

	Description	Unit	Generation Capacity			
			7.5 MW	10 MW	15 MW	20 MW
1	Construction Cost					
	Civil works (Intake & powerhouse)	M USD	2.9	3.8	4.6	5.4
	Gates and penstocks (HM)	M USD	1.2	1.4	2.2	2.9
	Generating equipment (EM)	M USD	4.7	6.1	8.8	11.7
	[C] Total	M USD	8.8	11.3	15.6	20.0
2	Power Benefit					
	Annual energy selling (*1)	GWh	43	54	65	66
	Annual energy benefit (*2)	M USD	3.1	3.9	4.8	4.8
	PV of 50-year benefit (*3)	M USD	30.7	38.7	47.6	50.0
	PV of O&M and replacement costs (*4)	M USD	1.3	1.6	2.3	3.1
	[B] Net Benefit, =(*3)-(*4)	M USD	29.4	37.1	45.3	46.9
3	Benefit - Cost, [B] - [C]	M USD	20.6	25.8	29.7	26.9

Notes:

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(*1): 98% of annual energy produced
(*2): Tariff per kWh = 0.074 USD/kWh
(*3): PV = present value, discount rate = 10%, Annuity cost factor (acf) = 9.915
(*4): Annual O&M cost = 0.25% of civil cost, 1.5% of E/M cost, acf=9.915
Replacement cost = 90% of HM and EM costs after 30 years (present worth factor = 0.057)

As seen in Fig. 4.5.2, the generation capacity of 15 MW is most economical since its net present value (B-C) is the highest.

Based on the above technical and economical assessments, the optimum generation capacity of the Moragahakanda Hydropower Station is decided to be 15 MW.

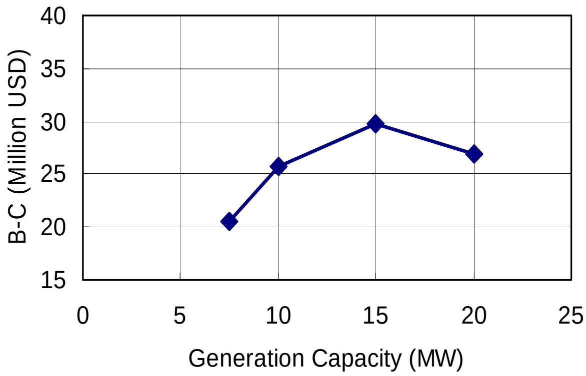

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Fig. 4.5.2 Net Present Value (B-C) of Different Generation Capacities

(9) Number and Capacity of Generating Units

All the above discussions are made for a single unit scheme.

In case of a single 15 MW turbine, its operation is not possible when the downstream water demand is less than 10.5 m^3/s because the turbine cannot be operated by a discharge less than 25% of the turbine maximum discharge (42 m^3/s) as stated in (4) above. Fig. 4.5.3 shows the duration curve of the total outflow through the turbine and bottom outlets calculated by simulation of a single 15 MW operation.

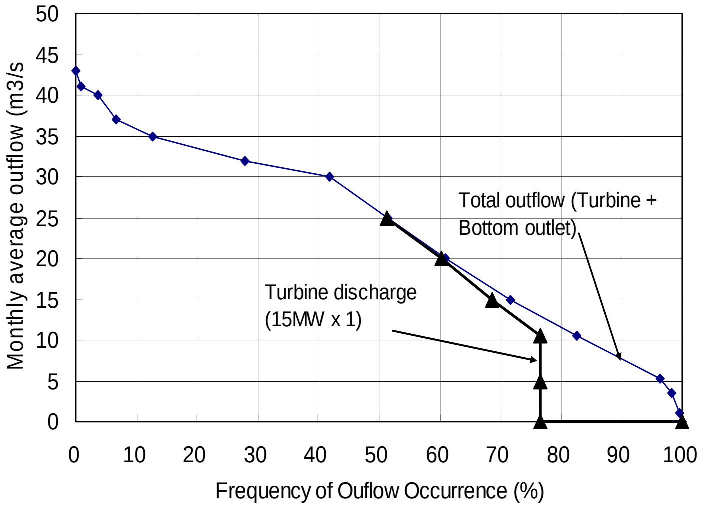

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Fig. 4.5.3 Duration Curves of Total Outflow and Turbine Outflow (15MW x 1)

As seen in Fig. 4.5.3 power generation has to be stopped for about 24% of time (average of 88 days in one year) since water release demand is smaller than 10.5 m^3/s.

To utilize the outflow water effectively for power generation, a scheme of two 7.5 MW units is compared with the single 15 MW scheme. A 7.5 MW turbine is operable when the discharge is larger than 5.25 m^3/s. Fig. 4.5.4 shows the duration curve of monthly total outflows through the turbine and bottom outlets calculated by simulation of the two 7.5MW scheme operation.

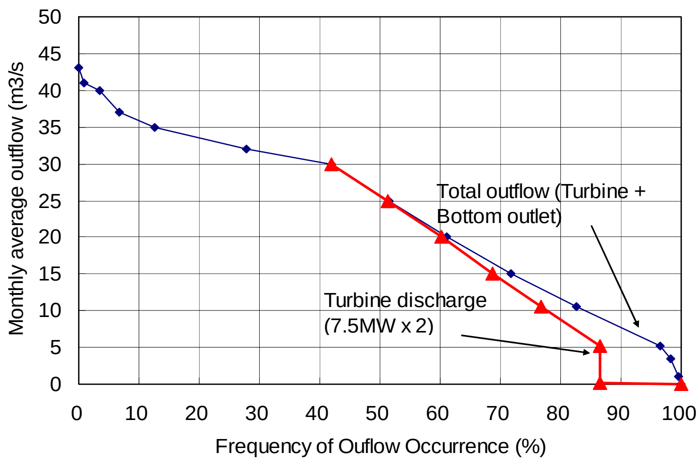

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Fig. 4.5.4 Duration Curve of Total Outflow and Turbine Outflow (7.5MW x 2)

As seen in Fig. 4.5.4, in case of the plant consisting of two 7.5 MW units, the time period during which turbine is not operable decreases to about 13 %, i.e. 47 days in one year on average.

Another scheme of three 5.0 MW units is conceivable for the 15 MW powerhouse. The 5.0 MW turbine can be operated until the outflow decreases down to 3.5 m^3/s. However, according to trial and error simulation, the operable time period of the turbine only increases by a small amount, i.e. only about 1% more than that of the case of two 7.5 MW units. Due to the lower turbine efficiency of a 5.0 MW plant compared to the 7.5 MW plant, increase of energy production is not expected in the three 5.0 MW scheme. Therefore, the plan of three 5.0 MW units is discarded.

Generation simulations of "Case-1: single 15 MW scheme" and "Case-2: two 7.5 MW scheme" were carried out using the results of water balance simulation of the 15 MW case (monthly reservoir water levels and outflows). Since efficiency of smaller turbine is lower than larger turbine, it is estimated that the efficiency of the 7.5 MW unit is 0.5% point lower than that of the 15 MW turbine. The results of generation simulations (Case-1 and Case-2) are detailed in Appendix C-6. Duration curves of monthly outputs simulated for Case-1 and Case-2 are shown in Fig. 4.5.5.

As seen in Fig. 4.5.5, monthly power outputs of both cases are not different in most of the time, i.e. 75% of the time. However, the power output becomes nil for about 23% of the time in Case-1 and for about 13% of the time in Case-2. The annual energy output of Case-2 is thus larger than Case-1 by 2.1 GWh/year (=66.3 - 64.2) as calculated in Appendix C-6. As the value of electric energy is 0.074 USD/kWh, this additional energy corresponds to annual benefit of 0.15 million USD. Consequently, the total benefit in a 50-year service life is USD 1.4 million (after reduction of O&M and replacement costs) in terms of present value calculated with 10% discount rate (annuity cost factor of 9.915).

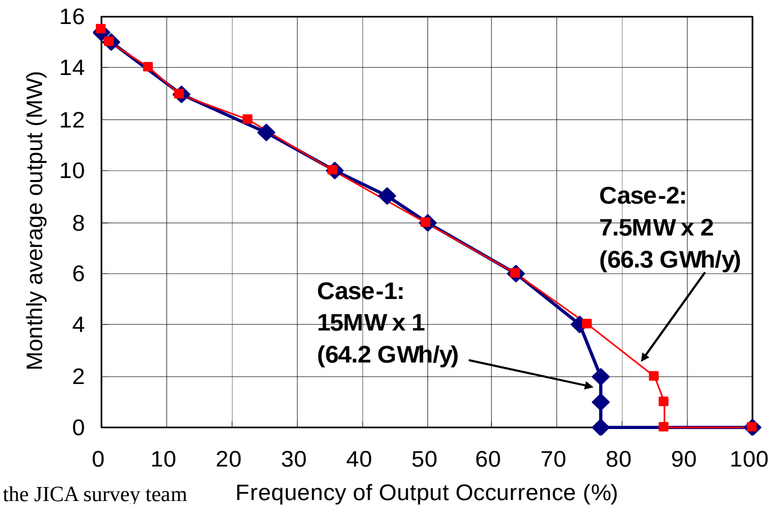

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Fig. 4.5.5 Frequency Curves of Monthly Power Outputs (Case-1 and Case-2)

Construction costs of the single 15 MW scheme and the two 7.5 MW scheme including powerhouse and intake are roughly estimated as follows:

	Unit	15 MW x 1	7.5 MW x 2
- Civil works (powerhouse and intake)	M USD	4.6	4.8
- Gate and penstock	M USD	2.2	1.8
- Generating equipment	M USD	8.8	9.3
Total	M USD	15.6	15.9

The scheme of two 7.5 MW units is slightly more expensive compared with the single 15 MW scheme. However, the difference is only USD 0.3 million.

The increased cost (USD 0.3 million) for using two 7.5 MW units in place of the single 15 MW unit is small in comparison with the increased benefit of USD 1.4 million in 50 years as estimated above. The scheme of two 7.5 MW units is more economical than the scheme of single 15 MW unit. Therefore, the scheme of two 7.5 MW units is selected for the Moragahakanda Hydropower Station.

(10) Amount of Annual Energy Production

As calculated in Appendix C-6 and indicated in Fig. 4.5.5, the selected scheme (2 x 7.5MW) can produce electric energy of 66.3 GWh/year on average under the projected water demand for 2017.

The water balance simulations applying the other water demands projected for 2020 and 2040 showed amounts of energy production similar to the 2017 energy amount. Therefore, it is considered that the annual energy production at the Moragahakanda Hydropower Station is 66.3 GWh on average in 50 years.

(11) Possibility of Peaking Generation

The above discussions take into account the continuous base load operation. When the downstream water demand is lower than 5.25 m^3/s, the 7.5MW turbine is not operable because the discharge is smaller than the allowable minimum limit of turbine discharge. The time period for which the power generation has to be stopped is about 13% of the simulated 480 months as seen in Fig. 4.5.5.

Peaking generation is practiced for several hours a day in the existing Bowatenna Hydropower Station located upstream of the Moragahakanda Dam site. In this practice, water is used for power generation even during low irrigation demand. Water released during peak time is stored naturally in the downstream river channel of the Amban River. The fluctuating flow due to peaking generation is more or lees regulated to uniform flow by the river channel storage effect. The irrigation area of System G located along the Elahera Canal immediately downstream of the Elahera Anicut is likely to have no effective re-regulation ponds. The monthly water demand in System G is 4.51 m^3/s on average according to the FS2001 report. While the Bowatenna Hydropower Station is operated during peak time only in low flow seasons, continuous supply of uniform water to System G is possible at present through the effect of river channel storage.

For the Moragahakanda Hydropower Station, the river channel storage capacity between the Elahera Anicut and the powerhouse is calculated as follows:

Elahera Anicut overflow crest elevation:	138.74 m asl (d/s) and 138.85 m asl (u/s)
River bed elevation at powerhouse:	137.0 m asl
River channel water surface area:	75 m wide and 2,300 m long
Depth of effective storage in river channel:	1.0 m (assumed)
Storage capacity in river channel:	172,500 m^3 (=75 x 2300 x 1)

Through this storage, the Moragahakanda Hydropower Station can operate for at least 12 hours (2 x 6 hours) a day by the turbine flow of 5.25 m^3/s even when the daily average release is 2.625 m^3/s. The 6-hour storage requirement is approximately 56,700 m^3 (= 2.625 x 6 x 3,600) which is within the river channel storage capacity calculated above. Therefore, it is considered that the Moragahakanda Hydropower Station can be operated under daily peaking mode (2 x 6 hours) even when the outflow demand is less than 5.25 m^3/s as long as the daily average demand is larger than 2.625 m^3/s. Through such peaking generation, it is expected that annual energy production increases from 0.3 to 0.4 GWh.

4.5.2 Generating Equipment

(1) The main features of the generating equipment in FS2001 are described in Table 5.1 of the 2001 FS report. Those indicated in FS2001 are as extracted below:

- Power factor: 0.86
- Rated generating capacity: 20.9MVA
- Maximum generating output: 23.1MVA
- Generator efficiency: 98%
- Transformer capacity: 22.9MVA
- Transformer efficiency: 99%
- Average annual energy production(sent-out): 45.0 GWh

where, so called “rated generating capacity” is equivalent to “continuous rating capacity” and “maximum generating output” is equivalent to 110% of the rated generating capacity, following IEC 34, and regarded as “Short time rating” or “intermittent rating as agreed with user”. Since the nominal capacity of the turbine is 20MW, the relationship among the above figures means that the generator can be operated in power factor 0.86 only when the maximum generating capacity, i.e. short time rating, is applied (23.1MVA x 0.86 = 20MW).

As reviewed in the foregoing section, the nominal capacity of the generating equipment of the Moragahakanda Hydropower Station is selected to be two units of 7.5 MW.

(2) In the FS2001 report, the power factor of 0.86 is designated. Lower power factor means the larger electrical capacity (generator machine body) which may cause higher cost.

On the other hand, according to the "Technical Requirements for the Interconnection of General Resources" (GUIDELINE) issued by the Transmission Division of CEB, abstract of which is attached as Attachment-13, the requirements for synchronous generator is described as follows:

"All synchronous generator units must be capable of supplying rated power output (MW) at any point between the limits 0.8 lagging and 0.95 power factor leading at the generator unit terminals." "Generators shall maintain a network voltage or reactive power output as required by the System Control Centre"

This requirement may be due to the special feature of network transmission lines in this country which are composed of long overhead transmission lines (reactance element). Therefore, the capacitance element is required to maintain the system voltage.

However, after clarifying the requirements shown in the GUDELINE, the Transmission Department of CEB admitted the change of the network power structure after the start-up of the Upper Kotmale Power Station, where the system voltage will be stabilized owing to the implementation of the bigger generator capacity of Upper Kotmale (2 x 75MW) and the higher voltage transmission line (220kV). As a result, the CEB advised the Survey Team to adopt the power factor of 0.85 lagging to 0.95 leading for the new Moragahakanda Hydropower Station.

4.5.3 Transmission Line

(1) Connection from Moragahakanda Hydropower Station to Grid Substation

In FS2001, an alternative study on the power connection from the Moragahakanda Hydropower Station to the Habarana Grid Substation was carried out. The configuration of the power connection (transmission line) shown in Table 4.5.3 was proposed.

Meanwhile, the CEB sent a letter, i.e. Ref. No. GP/CE/MOR dated 15 May 2009, from the deputy general manager in charge of transmission and generation planning to the MASL to inform about its proposal for a new 132/33kV grid substation at Naula. The new grid substation was scheduled to be commissioned in 2011 with the funding from the Asian Development Bank (ADB). Attachment-14 provides the CEB Power System Map showing the locations of the Naula Grid Substation and Moragahakanda Hydropower Station. The Survey Team proposed a configuration of the transmission line based on the newly proposed grid substation at Naula.

Table 4.5.3 shows the comparison of two proposals of connection for the connection from the Moragahakanda Hydropower Station to the grid substation.

Table 4.5.3 Comparison between Proposal in FS2001 and Proposed Project

Item	Unit	Proposal in FS2001	Proposed Project In this Survey
Generation Output	MW	20	15
Connection from Moragakahanda Hydropower Station to		Habarana Grid Substaion	Naula Grid Substation
Capacity (current)	MVA(A)	22.9 (100)	17.6 (308)
Length	km	41.8	15
Voltage	kV	132	33
Conductor size(Type)	mm^2	185(Lynx)	185(Lynx)
Allowable current at daytime	A	345	345
Conductors per phase		1	1
Number of circuits		1	1
Average span between towers	m	250	250
Number of towers		167	60
Switchyard bay equipment in substation to be interconnected		132kV bay at Habarana GSS	33kV bay at Naula GSS
Estimated cost (estimated year)	US$	2,895,700 (2001)	1,400,000 (2010)

Source of data: FS2001

There are two alternative voltages for the connection between Moragakahanda and Naula, namely 132kV and 33kV. The advantages and disadvantages of the transmission line and relevant equipment of both voltages are shown below:

	132kV	33kV
Advantage	Higher reliability	1.Lower cost for tower and attachment 2.Lower maintenance cost 3.Easy maintenance of 33kV transmission lines, 33kV switchyard equipment and step-up transformer
Disadvantage	1.Higher cost of transmission line and connected equipment 2.Higher maintenance cost	

There is significant difference in estimated cost between 132kV and 33kV lines as mentioned in the above table. As can be seen in the table, the 33kV system has a lot of advantage compared with the 132kV system.

The interconnection point (boundary) between Moragahakanda Hydropower Station and the CEB transmission system is the 33kV busbar of Naula Grid Substation as shown in Attachment-15 “Proposed Single Line Diagram of Naula Grid Substation” where the interconnection point with the CEB is marked up.

The following drawings were obtained from the CEB and attached as Attachment-16 and Attachment-17 with mark-ups for clarification.

i) Attachment-16: CEB NAULA GSS: Switchyard for Feeder for MORAGAHAKANDA PS (Original CEB Dwg No. TD/CE/1/67/D/01/02 Proposed Layout for NAULA GSS)

ii) Attachment-17: CEB NAULA GSS: Single Line Diagram of Feeder for MORAGAHAKANDA PS (Original CEB Dwg No. TD/CE/1/67/00-D/02 Partial Single Line Diagram of 33kV Line Feeder Bay & 33kV Generator Feeder Bay for NAULA GSS)

The design concept and selection of equipment in the switchyard indicated in the above drawings are considered suitable for carrying power capacity and protecting the feeder for the Moragahakanda Hydropower Station. The cost of switchyard is included in the estimated cost in Table 4.5.3.

(2) Transmission Line Design and Route

The 33kV overhead transmission or distribution lines have mainly two types of option, namely i) steel tower type, and ii) concrete pole type. Comparison of these two types is shown in Attachment-18 “Comparison and Requirements of 33kV Transmission Line”.

The concrete pole is widely used for distribution lines (mainly for 100 A line) and has flexibility in terms of design and construction. As it is mostly constructed along roads, there is a risk of damage due to accidents and landslides. A 33kV distribution line with concrete poles has already been constructed along one side of the diversion road to the Project. There may be only a little room left along the road for the additional 33kV transmission line with concrete poles. As a general idea, the reliability of concrete pole type system is lower than the steel tower type system, and regarded to be unsuitable for the main power source lines, e.g. a transmission line from a power generating plant.

Therefore, the 33kV transmission line with steel towers is recommended. Its route from the Project to the grid substation at Naula shown in Attachment-19 “Route of 33kV Transmission Line” is recommended.

4.6 Irrigation Canal Facilities

4.6.1 Kaudulla Left Bank Branch Canal

In FS2001, one of the areas identified for the proposed resettlement of families to be displaced from the Moragahakanda Reservoir was an undeveloped land in the northern part of the Kaudulla Irrigation Scheme in System D1. A new branch canal diverting from the Kaudulla Left Bank Main Canal was proposed to convey water to the above area. The principal features of the proposed branch canal are shown in Table 4.6.1.

Table 4.6.1 Principal Features of Kaudulla Left Bank Branch Canal

Description	Unit	Value	
Type of lining	-	Lined (Concrete)	
Design discharge (Max.)	m^3/s	11.3	
Total length	km	10.3	
Bed slope	%	0.015	
	-	1/6667	
Roughness coefficient	-	0.0225	
Bed width	m	Section 1 (3.0 km)	2.6
		Section 2 (4.0 km)	2.4
		Section 3 (3.3 km)	1.3
Canal inside slope	-	1.0v : 1.5h	
Diversion structures	nos.	1	
Offtakes	nos.	2	
Road bridges	nos.	2	
Cross drains	nos.	9	

Source of data: FS2001

In FS2001, the concrete lining was applied for the design of canal lining and the maximum capacity of the branch canal was estimated to be 11.3 m^3/s, considering a much larger irrigable area available for development, as compared with the present irrigable area of 1,420 ha (3,500 acres).

In this Survey, an unlined canal is proposed, and the maximum capacity of the branch canal is estimated to be 2.84 m^3/s for the present irrigable area of 1,420 ha (3,500 acres), taking into account the actual site conditions and the design criteria of ID, which is managing System D1. Features other than the above have also been reviewed and revised if necessary.

The details of the reviewed features of the canal facilities are described in Sub-section 5.3.3.

4.7 Project Cost

4.7.1 Procedure of Cost Estimate in FS2001

The cost estimate of Moragahakanda Development Project in FS2001 was done with the following procedure:

i) The cost estimate of major civil works was derived from the following three components: (1) direct cost; (2) indirect cost; and (3) contingencies.

ii) Direct costs were estimated on the basis of work quantities and unit prices which comprises the equipment costs, material costs, labor costs and consumables.

iii) Indirect costs includes the preparation of the construction sites, camp installation, site administration as well as bonds, insurance and contractor profits, the total amount of which was 40% of the direct cost, i.e. 20% for site installation cost (including mobilization and demobilization, site office and camp, temporary facilities and works) and 20% for the contractor's indirect cost (contractor's overhead and profit, bonds and insurance, etc.)

iv) Contingencies were to cover both physical and financial components, which are 15% of the total of direct and indirect cost for civil works and 10% for mechanical and electrical works.

v) In estimating the direct costs of the construction works, the UCOST computer program, which elaborated the unit prices by compounding various unit rates based on the database of local and international rates of materials, equipment, and labors, was used. However, no basic data were contained in the FS2001 report. Consequently access to the database and the calculation process of the compound unit rates were no longer available.

vi) The direct cost of each work was estimated by means of multiplying the unit price with the respective work quantity. The construction cost of each element of the project, such as dam embankment, spillway, and intake, was estimated by summing up the direct costs of the respective work items and adding to it the indirect cost (20% of the total direct cost) and contingencies (10% to 15%).

vii) The construction costs of two major components, namely Moragahakanda Dam and Kaudulla Left Bank irrigation works, were calculated by totaling the respective civil work components mentioned above. Then the total construction cost of the Project was estimated by adding another indirect cost of 20%, which covers the miscellaneous expenses (charge of engineering, administration, supervision and client's own costs).

viii) The total Project costs consisted of compensation costs, resettlement costs and the cost of the Environmental Management Action Plan as well as the total construction costs of the major civil work components.

4.7.2 Estimated Project Cost

The total Project cost estimated in FS2001 is summarized in the following table:

Table 4.7.1 Project Cost of Moragahakanda Development Project in FS2001

Designation	Project Cost (USD million)
1.1 Moragahakanda Dam and Power Plant	91.47
1.2 Kaudulla Upper LB Canal Extension	3.12
1.3 Compensation	2.92
1.4 Resettlement	3.43
1.5 Environmental Management Action Plan	1.69
Total	102.62

Source of data: FS2001

Having reviewed the cost estimate prepared in FS2001, the following can be pointed out:

i) The basic data of the cost estimate, such as basic prices of materials and consumables, labour wages, depreciation costs of equipment, and their quantities in the breakdown of unit prices, were all stored in the UCOST computer program. No information about the above data is attached in the FS2001 report. Thus, it is not possible to review the basic data of the cost estimate.

ii) In the cost estimate of the civil works, general items, such as mobilization and demobilization, contractor's temporary facilities and temporary roads, site office and camp, were not included. Instead, an indirect cost of 20% of the construction cost (direct cost + indirect cost of 20%) was given. Compared with other dam and irrigation construction projects, the amount of 20% of construction cost as general items is acceptable.

iii) Contingencies are acceptable but should be adjusted according to JICA's standard.

iv) To evaluate the unit prices used in FS2001, these unit prices should be updated to 2010 level using statistical data of consumer price index of both Sri Lankan local market and international markets.

v) The procedure to estimate the project cost based on the unit prices and work quantities does not have any discrepancy and is judged to be acceptable.

CHAPTER 5 PROPOSED PROJECT

5.1 General

In this chapter, the optimal project features are proposed by making adjustments and modifications on the basic design of the Moragahakanda Dam and Hydropower Station, and the Kaudulla Left Bank Branch Canal, based on the review results described in Chapter 4. The Project implementation and operation and maintenance (O&M) frameworks are also proposed.

5.2 Overall Project Configurations

Based on the results of the design review, the Survey Team proposes the following overall project configurations:

- New construction of the Moragahakanda Dam, forming a reservoir with full supply level (FSL) at 185.5 m asl and an active storage of 520 MCM, and a hydropower station. Salient features of the dam are shown in Attachment-20.

  i) Reservoir
  Full Supply Level: 185 m asl
  Active storage: 520 MCM
  i) Main Dam
  Type: Earth Core Rockfill Dam
  Height: 61 m
  ii) Saddle Dam No.1
  Type: Roller Compacted Concrete (RCC) Dam
  Height: 51.5 m
  iii) Saddle Dam No.2
  Type: Earthfill Dam
  Height: 21.5 m
  iv) Powerhouse
  Installed Capacity: 7.5 MW x 2 units
  Max. Discharge: 21 m^3/s x 2 units
  v) Transmission Lines
  Voltage: 33 kV
  Length: 15 km

- New irrigation area development consisting of new construction of Left Bank Branch Canal, improvement of Left Bank Main Canal, and on-farm development in Kaudulla Left Bank Extension Area of System D1.

  i) Kaudulla Left Bank Branch Canal (New)
  Length: 20.9 km (including sub-branch canal)
  Design Discharge (Max.): 2.8 m^3/s

ii) Kaudulla Left Bank Main Canal (Improvement)

Length:	6.4 km
Design Discharge (Max.):	9.5 m^3/s

iii) On-farm Development

Irrigation area:	1,420 ha

The details of the above features and implementation schedule of the Project are described in this chapter. The compensation and resettlement package for displaced persons and an accompanying Environmental Management Action Plan are also included in the Project, which are discussed in Chapter 8.

5.3 Proposed Facilities

5.3.1 Dams and Appurtenant Structures

(1) Selected Optimum Dam Layout

The design in FS2001 was reviewed in Section 4.4, and the dam layout selected as the optimum configuration is shown in Fig. 5.3.1.

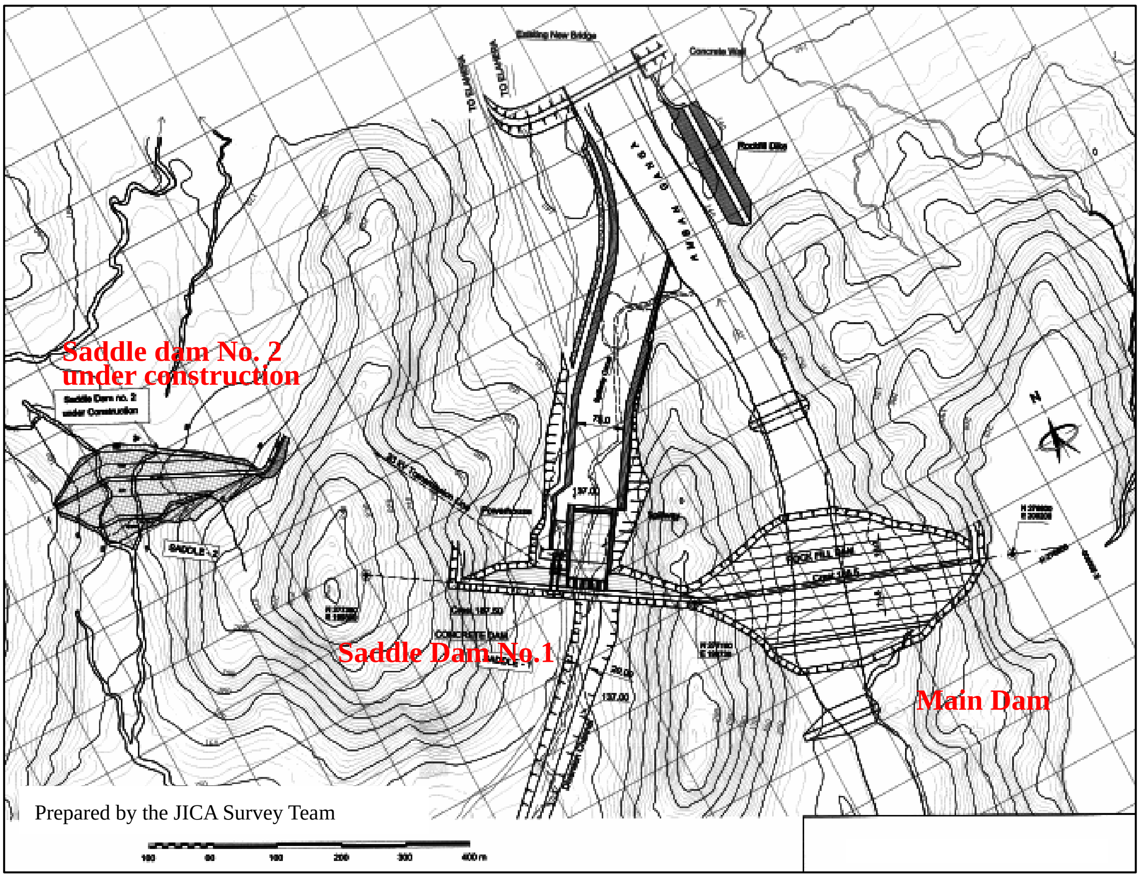


Fig. 5.3.1 Proposed Configuration of Dams

The selected type of dam in the river valley is rockfill dam with central clay core and the dam in the saddle-1 is a concrete gravity dam. Main features of the dams are as follows:

Table 5.3.1 Selected Dam Type for the Moragahakanda Dam

	Rockfill dam in river valley	Concrete dam in Saddle-1
1) Dam crest level	188.5 m asl	187.5 m asl
2) Dam height above lowest foundation	61 m	51.5 m
3) Dam crest length	465 m	365 m
4) Dam volume	1,380,000 m^3	171,000 m^3

Prepared by the JICA Survey Team

Profile of the main dam and Saddle-1 dam along the dam axis is shown in Appendix C-7.

Saddle dam No. 2 (homogeneous earthfill dam) is presently under construction by MASL's own work force. Its design crest level is 188.0 m asl at present but it is recommended to raise it to 188.5 m asl so that the same dam crest safety is provided for both saddle-1 and saddle-2 dams.

(2) Dam Crest Level

The dam crest level has been decided to meet the freeboard requirements in accordance with the Japanese dam design criteria. Main components of the freeboard are a storm wave run-up and an earthquake wave in the reservoir. The calculation for these features is shown in Appendix C-2.

The reservoir water levels to be taken into account for the freeboard planning are the normal FSL and maximum flood level (MFL). As calculated in the FS2001 report, FSL is 185.0 m asl, while MFL is 185.6 m asl at the time of the safety check flood with 10,000 years return period. Based on the calculation in Appendix C-2, the required dam crest level is decided as follows:

		Normal operation	Max. flood time
i)	Reservoir water level (m asl)	185.00	185.60
ii)	Concrete dam		
	• Wind run-up, earthquake wave and additional safety margin (m)	2.00	1.65
	• Required dam crest level: (a)+(b)	187.00	187.25
	• Adopted dam crest level (m asl)	==	187.50
iii)	Rockfill dam		
	• Wind run-up, earthquake wave and additional safety margin (m)	2.80	2.45
	• Required level of core top: (a)+(c)	187.80	188.05
	• Protective layer on clay core (m)	0.45	0.45
	• Adopted dam crest level (m asl)	==	188.50

In the present study, the dam crest level has been decided to be 187.50 m asl for the concrete dam and 188.50 m asl for the rockfill dam. These levels are 0.50 m higher than those indicated in FS2001.

Flood control is not considered in the determination of the dam crest level, because the annual economic loss due to floods is minimal although some areas near the confluence of the Mahaweli River and Amban River are inundated during the flood season every year. The Survey Team has confirmed this with the MASL.

With regard to the Saddle Dam No. 2, which is presently under construction, it is recommended that its crest level be raised to 188.50 m asl to keep the consistency of dam safety with the main and saddle-1 dams. It is noted that during construction of the embankment careful compaction is required at the embankment shoulder corners on every layer so as to avoid local embankment soil to loosen.

(3) Sedimentation in Reservoir

In Sri Lanka, sediment loads in the river systems have not been investigated in sufficient detail, perhaps due to the general geological conditions of the country which show moderate sign of erosion and deposition. Over the past three decades, a number of major river development works consisting of large reservoirs have been undertaken in the country. In all these projects, estimates of sediment yields have been made based on judgment using limited available information rather than on measured sediment transport or sediment accumulation in rivers.

Data of sediment flows studied in past development projects in the Mahaweli River basin are summarized in Appendix C-2. Design sediment inflows applied to other projects are shown below:

Reservoir	River	Design sediment inflow (m^3/km^2/year)
Bowatenna	Amban	335
Vctoria	Mahaweli	490
Kotmale	Mahaweli	180
Samanalawewa	Walawe	240
Upper Kotmale	Mahaweli	180
Kaku Ganga	Kalu (Amban)	240

In view of the previous sediment inflow studies conducted for river development projects in Sri Lanka and water diversion from the Mahaweli main stream at Polgolla to the Amban River, it is considered reasonable to adopt a sediment yield of 340 m^3/km^2/year as concluded in the FS2001 report.

Sediment inflow into the future Moragahakanda reservoir is estimated by assuming that a 10% fraction of the sediment inflow into the existing Bowatenna reservoir will be trapped in the reservoir and the rest (90%) will be released to downstream of the Moragahakanda Reservoir. The sediment inflow into the Moragahakanda is estimated as presented in Table 5.3.2.

Table 5.3.2 Estimated Sediment Inflow into Moragahakanda Reservoir

Area	Catchment	Annual Sediment Inflow	
	km^2	$m^3/km^2/year$	$m^3/year$
Below Bowatenna	254	340	86,360
Above Bowatenna	514	306 (90%)	157,284
Total	768		243,644

Prepared by the JICA Survey Team

Sediment distribution within the reservoir is estimated applying the area-increment method (AIM) or the empirical area reduction method (EARM), both developed by the US Bureau of Reclamation. In the present study, the new zero elevation of the Moragahakanda reservoir after the 100-year sedimentation was calculated by using AIM while the sediment distribution pattern in the reservoir was calculated by applying EARM. The calculations are detailed in Appendix C-2 and results are as follows:

- Depth of sedimentation (after 100 years) at upstream face of dam: 3.9 m
- New zero elevation of reservoir (after 100 years): El. 140.9 m
- Accumulated sediment deposit volume (after 100 years): 23.25 MCM
- Percentage ratio of 100-yr sediment to original reservoir capacity: 4.1%

In order to avoid the sediment deposited near the dam being swallowed, the sill elevation of the bottom outlet and the power intake has to be set at an elevation sufficiently higher than the sediment surface.

(4) Concrete Dam in Saddle-1

Dam Section Shape

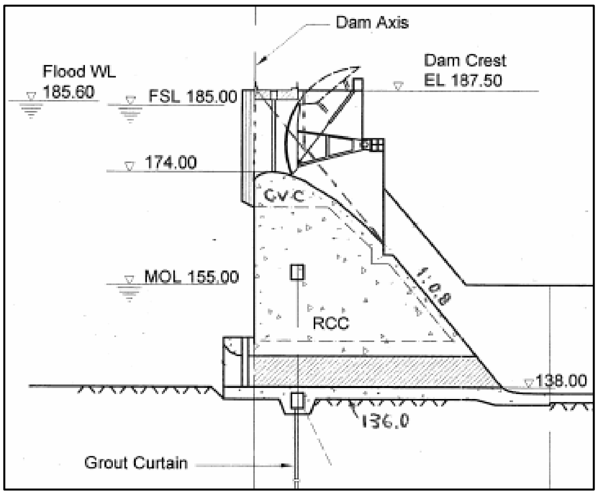
The concrete dam body has to solidly stand on foundation base without failing due to overturning or lateral sliding even under the maximum water pressure and seismic loading. Based on the preliminary stability calculations (Appendix C-3), applying a horizontal seismic acceleration of 0.1g, the shape of dam section at Saddle-1 is decided as follows:

- Dam crest level: 187.5 m asl
- Crest width: 8.0 m
- Upstream face slope: Vertical from top to bottom
- Downstream face slope: 1:0.80 (v:h) from upstream edge of dam crest

The dam with this section is stable enough without showing tensile stress on the upstream face of the dam at the time of full reservoir with earthquake. Typical section of the Saddle-1 RCC dam is shown in Fig 5.3.2.

Use of RCC for Dam

Dam type selected for Saddle-1 is concrete dam. For its construction, the RCC method is applied to the main part of the dam body, including the spillway section since the method is expected to reduce the cost and time for construction. The RCC contains less quantity of cement, i.e. in general 1/3 to 1/2 of conventional concrete (CVC). Heat generation of RCC is much less than CVC. Therefore, it is possible to place RCC speedily in layers without any cooling pipe arrangement on each layer and to widen the vertical transverse joint spacing in RCC dam. Water-tightness of RCC dam is assured by grout-enriched vibratable RCC (GEVR) placed near the upstream face of dam. Strength of RCC is sufficient for the planned dam with the usual cement content. However, CVC to be compacted by immersion vibrators is partly necessary in the RCC dam where the concrete surface is exposed to high velocity water flow or concrete requires steel reinforcement, such as in the spillway chute and piers, diversion openings, intake gate shaft, etc.



Prepared by the JICA Survey Team

Fig. 5.3.2 Typical Section of RCC Dam in Saddle-1

Fly ash or natural pozzolan is required to increase durability of concrete and improve workability during roller compaction. At present, cement manufacturing companies in Sri Lanka are importing these as well as cement clinker and selling the blended cement in the domestic market. It is expected that a new coal-fired power plant (300 MW) will be in operation in Sri Lanka from 2011. This plant will be able to supply raw flyash to the cement companies. Therefore, it is expected to use fly ash or pozzolan for the project without problem.

Construction features of RCC dams are as follows:

- Mixed RCC is transported from the mixing plant to placing spots by dump trucks or belt conveyors. RCC is placed and compacted in layers (usually 30 cm thick) by using bulldozers and vibrating rollers. No cooling pipes will be arranged on the layer surfaces.
- It is estimated that RCC will contain cementitious materials (cement and fly ash or pozzolan) of 150 to 200 kg/m^3. For pre-cooling of concrete to restrict temperature rise after placing below the allowable limit, concrete aggregates and water will be cooled before mixing and ice flakes will be mixed to the RCC if required.

- Formworks or precast panels are used to construct the make upstream face. To ensure water-tightness of concrete on the upstream face, grout-enriched vibratable RCC (GEVR) will be placed. A thin layer of fresh mortar is spread before placing a fresh RCC layer in the upstream surface zone. The RCC is then spread in the upstream face zone and compacted with immersion vibrators until the mortar bleeds up to the layer surface.
- The downstream face of the dam is built like steps with precast concrete blocks (usually 90 cm high). RCC is then placed and compacted against the precast blocks.
- Transverse contraction joints are provided across the dam body. Spacing of the joints is tentatively set to be 18 m in the spillway part and 24 m in other parts referring to the typical spacing of 20 m to 30 m in other projects. After compaction of a fresh RCC layer in a lane in the direction of the dam axis, joints are cut with a vibrating press cutter machine, and a joint separator membrane is placed in the cut joints.
- It is expected that the road portion of the dam crest having a width of 8 m is also constructed by the RCC method.

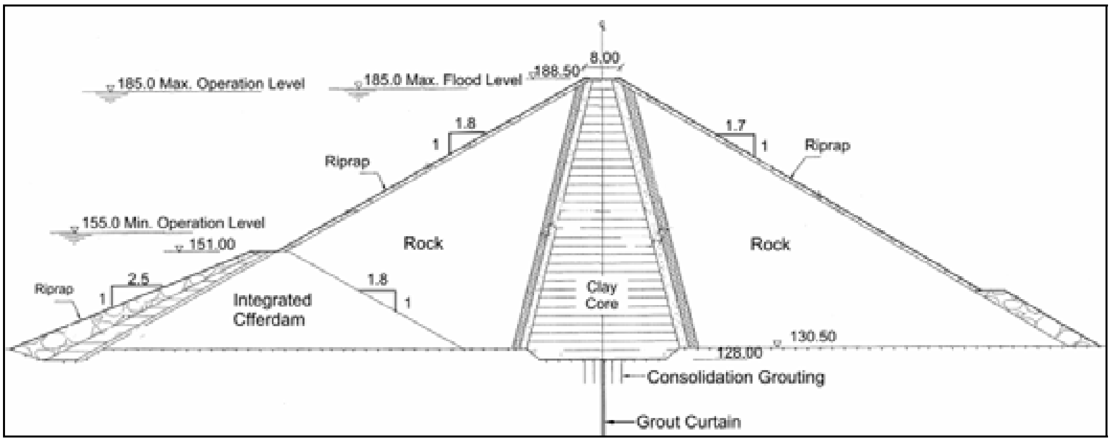
Foundation Excavation Depth in Saddle-1

As mentioned in Section 3.2.1 (Geology), the depth of required excavation for the concrete dam foundation at the Saddle-1 is set at 13-14 m on the left bank, about 11 m at the saddle bottom and 9-18 m on the right bank.

(5) Rockfill Dam in River Valley

Dam Section and Zoning

Basic dimensions, elevations and slopes of the proposed rockfill dam at the main valley are shown in Fig. 5.3.3. Crest width is 8.0 m. Upstream and downstream slopes are 1:1.8 and 1:1.7 (v:h) respectively.



Prepared by the JICA Survey Team

Fig. 5.3.3 Cross Section of Rock Dam in River Valley

It is obvious that for reasons of economy, the volume of embankment zones for which high strength rock materials are essential, i.e, rip-rap or filter and drainage materials must be kept to a minimum. The embankment will therefore be constructed using quarried rock and suitable rock from required foundation excavation areas being used to the greatest extent possible.

The embankment dam consists of the zones as listed below.

Zone	Material Type
Zone-1	Clay core
Zone-2	Transition zone - fine
Zone-3	Transition zone - coarse
Zone-4	Shell (random earth/rockfill)
Zone-5	Slope protection (rip rap)

Zone-1 provides the required impervious barrier for retention of water, while Zone-4 provides the structural strength for stability against various combinations of the induced loadings. Zone-5 provides the face support against wave run-up at the upstream and acts as protection layer in the downstream slope. Zone-2 and Zone-3 will drain out the internal seepage water while Zone-5 at the downstream acts as a protection layer.

For the design of the dam in general, the criteria that apply include:

- The dam should be stable under all probable conditions of loading, i.e. construction loading and reservoir water loading, with or without seismic loading.

- Seepage through the dam and the foundation will be limited and controlled to ensure that seepage forces do not endanger the safety of the structure.

- Settlement produced by the loads will not reduce either the structural stability or the water retention capability of the dam.

Excavation Foundation Depth

As mentioned in Section 3.2.1, the dam foundation depth required to place the clay core is estimated at 5 - 10 m on the left bank, about 10 m at the bottom of the main river valley and 10 - 20 m on right bank.

Stability Analysis

The stability of the proposed embankment dam has been analyzed in the present study. Factors of safety (FOS) along various slip circles on the upstream and downstream slopes were calculated for various loadings, such as loading at the end of construction without earthquake, loading under steady state seepage condition with or without earthquake, loading under partial pool condition with or without earthquake, and loading under sudden drawdown condition without earthquake.

The stability analyses are detailed in Appendix C-4. Three different slopes for the upstream and downstream sides were analyzed. Minimum FOS obtained for each slope with seismic loads against slope failures are listed below.

Minimum FOS for Different Slopes

Side	Slope		
	1 : 1.5	1 : 1.7	1 : 1.8
Upstream	1.05	1.15	1.21
Downstream	1.05	1.20	1.27

Prepared by the JICA Survey Team

Minimum FOS required to prevent slope failures is 1.2 according to the Japanese fill dam design criteria. From the results above, it was decided to adopt 1:1.8 for the upstream slope and 1:1.7 for the downstream slope.

Foundation Treatment

Foundation treatment in general is related to the consolidation of the foundation and/or its sealing. For the foundation conditions at the main dam site and the type of dam selected, sealing is an essential requirement to prevent excessive seepage and to provide adequate security against internal erosion and piping. A positive cut-off and sealing by grouting have been considered for the main dam. The grout curtain holes shall be taken to a depth equal to two-thirds of the hydraulic head (~ 40 m) subject to a minimum depth of 10.0 m. The post grouting permeability shall be limited to 5 Lugeons. Grout curtain will be constructed from the excavated surface without a grouting gallery since the grouting depth is shallow.

Material Sources and Embankment Work

Potential borrow area of clayey soil is located on the left bank approximately 1.5 km downstream of the dam site. Potential quarry site for rock materials is located on the right bank within 0.6 km downstream from the dam axis. Materials for transition zones will partly be collected from natural river deposits and partly from crushed rock.

Dam foundation excavation, except for an area in the river channel, is carried out before river diversion. Once the river is diverted to a diversion channel built in the saddle-1 site, the main stream of the Amban River is closed with embankment cofferdams. The main upstream cofferdam is incorporated into the body of the main rockfill dam. The dam foundation excavation in the river channel and foundation treatment (grouting) in the bottom area are carried out. No foundation gallery for grouting and draining is provided since the dam height is only about 60 m. Clayey soil for the impervious core is spread by bulldozers in the direction of the dam axis and compacted in 20-30 cm thick layers with tamping rollers. Rock for shell zones and sand and gravel for transition zones are spread by bulldozers and compacted with vibrating rollers. Layer thickness of the transition zones and shell zone will be 0.3 m and 1.0 m, respectively.

(6) Spillway

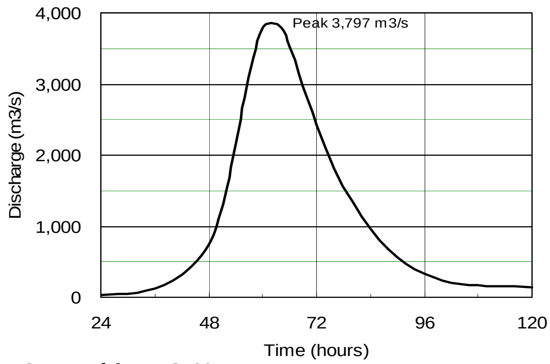
Flood Discharges

Flood discharges with different return periods estimated for the Moragahakanda Dam site in the FS2001 are shown in Table 5.3.2. Hydrograph of the 1,000-year flood given in the FS2001 report is shown in Fig. 5.3.3.

Table 5.3.3 Flood Peak Inflow Discharges at the Dam Site

Return Period (years)	Flood peak inflow (m3/s)
10	1,974
20	2,255
50	2,524
100	2,882
1,000	3,797
10,000	4,749

Source of data: FS2001 report



Source of data: FS2001 report

Fig. 5.3.4 Design Flood Hydrograph (1,000-yr flood)

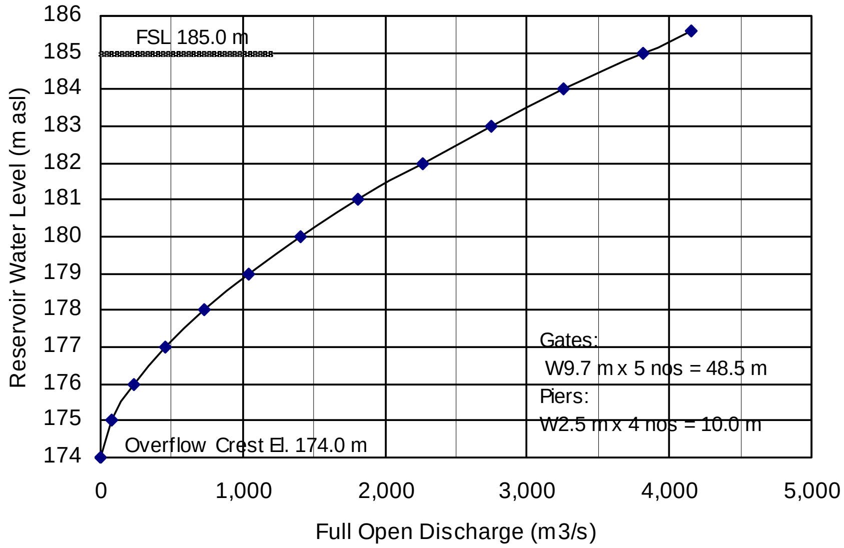
These discharges and hydrograph were elaborated in the FS2001 from daily rainfall depth analysis because of non-availability of storm measurement records. The amounts of probable flood peak discharge and flood hydrograph presented in the FS2001 report are used for review and planning of the present studies.

Spillway Headwork

Spillway headwork is located in the central part of the concrete dam in Saddle-1. Layout of the spillway is shown in Appendix C-7.

The spillway headwork is designed to discharge the flow of 3,797 m3/s (1,000-year flood) without raising the water level above the FSL of 185.0 m asl. The overflow crest ogee curve is defined so as to follow the modified Harrold curve line tangential to the downstream slope surface of the dam. Total width of the overflow bay is decided to be 58.5 m including piers taking into account the width of the downstream natural river channel. The overflow crest level has been set at 174.0 m asl which is equal to the design in FS 2001. Five sets of radial gates are installed on the overflow crest. Each gate has a width of 9.7 m and clear height of 11.0 m above the ogee crest. This gate width is based on the discharge calculation by the JICA team. It is 0.2 m wider than the FS2001 design. Width of each pier is 2.5 m.

Discharge capacity of the headwork is computed in Appendix C-5. The discharge capacity curve under the condition that all gates are fully opened is illustrated in Fig. 5.3.5.



Prepared by the JICA Survey Team

Fig. 5.3.5 Spillway Discharge Rating Curve

The spillway headwork is capable of handling the dam safety check flood (10,000-year flood) with an inflow peak discharge of 4,749 m^3/s. This flood is discharged by fully opening of all of the five gates. Through the surcharge effect in the reservoir, the reservoir water level will rise to 185.6 m asl and maximum outflow will be 4,085 m^3/s as computed in FS 2001.

Water pressure load acting on the radial gate is supported by steel girder fixed to the downstream edge of the concrete pier by tensioning tendons. Crest road bridge over each overflow bay is a concrete girder bridge with total width of 7.0 m. The load of a gantry crane to handle stoplogs is supported by the bridge.

Spillway Chute

The chute surface is faced with CVC anchored by steel dowels to the RCC dam body. Velocity of the flow over the chute exceeds 26 m/s and concrete surface is prone to be damaged by cavitations. The FS2001 report calculated the cavitation index for various discharges and mentioned that the obtained cavitation index is not critical. No aerator was designed in FS2001. However, in the present design, a simple horizontal aeration groove is provided at the toe of spillway piers to reduce the cavitation effect. It is expected that air is naturally sucked to the groove through a vertical air gap occurring behind the downstream face of the pier.

Height of the chute side walls is 6.0 m measured perpendicularly to the chute floor as mentioned in the FS2001 report.

The effect of the aerator and chute wall height needs to be verified by a hydraulic model study later in the detailed design stage.

Stilling Basin

As mentioned in Appendix R of the FS2001 report, energy dissipation downstream of the spillway chute can be achieved either by a stilling basin or by a flip bucket with plunge pool. In case of the flip bucket, a deeply excavated plunge pool (water cushion) having a width of 80 to 100 m and length of about 120 m is required downstream of the flip bucket. Turbulent flow in the plunge pool will cause severe erosion of both banks of the pool and strong fluctuation of downstream water level will affect operation of the power plant located nearby the dissipater. Therefore, a horizontal apron-type stilling basin is selected as the energy dissipater for the spillway at the Saddle-1 site.

Design discharge for the stilling basin is decided to be 2,882 m^3/s which is the flood peak with 100-year return period. As the width of the stilling basin is 58.5 m, the specific discharge is 49.5 m^3/s per meter of width. The stilling basin designed for the discharge of 2,882 m^3/s can, in general, handle its 150% of the discharge without serious adverse effects to the downstream structures while the hydraulic jump effect is not perfect. The spillway outflow at the time of the dam safety check flood (10,000-year flood) estimated in the FS2001 is 4,085 m^3/s that corresponds to 142% of 2,882 m^3/s. Therefore, it is considered appropriate that the stilling basin be designed for the 100-year flood.

The invert floor elevation of the stilling basin is decided to be 137 m asl, which is more or less equal to the downstream river bed elevation. This elevation is not low enough to generate a perfect hydraulic jump to dissipate the energy of the 100-year flood flow unless there is any backwater raising structure. The stilling basin invert has to be lowered to 128 m asl. to generate the perfect hydraulic jump without the back-water raising facility. Estimated level of foundation rock surface is about 140 m asl in the stilling basin area. Deeper excavation will result in high construction cost. Therefore, a 6-m high concrete weir is built across the downstream end of the stilling basin to raise the water level in the stilling basin and create the water depth sufficient for the hydraulic jump for the 100-year flood. The weir is constructed after completion of river diversion. Openings are provided across the weir to discharge water during operation of bottom outlets.

This arrangement of the stilling basin requires verification by hydraulic model study to be done in the later design stage.

Discharge Channel

A discharge channel is constructed by excavation of the area extending from the stilling basin to the downstream river channel. The channel has a trapezoidal cross section with a bottom width of 75 m and side slopes of 1:1.5 (v:h). This channel size is required to discharge the 1,000-year flood without excessively raising the water level at the stilling basin and powerhouse.

The toe of the channel side slope is protected with either a concrete wall founded on rock or steel sheet pile wall in order to prevent undermining of the slope by scouring due to flood flows. The slope surface itself above the base rock but below the maximum water surface is covered with rock riprap to prevent erosion.

The channel alignment is adjusted so that the flow from the channel outlet to the river does not hit obliquely the existing new road bridge. Upstream sides of the bridge abutments are protected with concrete retaining walls built along the river bank.

It is foreseen that flow conditions at the junction of the channel with the river course is turbulent. To design the bank protection, a hydraulic model study is needed during the detailed design stage.

(7) River Diversion Facilities

Design Floods for Diversion Works

The design flood for diversion structures adopted in FS 2001 is 2,255 m^3/s, which corresponds to the peak discharge inflow of a flood with return period of 20 years. Furthermore, the report shows the following flood events recorded at the Elahera Hydrometric Station:

5 to 12 November 1982	123 m^3/s
14 to 24 December 1964	267 m^3/s
27 November to 7 December 1979	624 m^3/s
12 to 19 January 1961	647 m^3/s
19 to 26 February 1960	667 m^3/s
17 to 26 February 1964	833 m^3/s
24 December 1973 to 2 January 1974	923 m^3/s
5 to 16 December 1982	929 m^3/s
20 to 27 November 1979	1,605 m^3/s

As flood records of every year were not presented in the report, it is tentatively assumed that the maximum flood that occurred in a period of 22 years from 1960 to 1982 is 1,605 m^3/s and the second largest flood is 929 m^3/s.

There are three flood seasons in the 3.5 years of construction. In the first flood season, major works will include foundation excavation and concreting in the foundation area in Saddle-1. Flood inundation or overtopping, therefore, will not cause serious damage. Hence a discharge of 1,000 m^3/s, which is a little higher than the second largest flood recorded, is selected as the diversion design flood for the first year. In the second and third flood seasons, construction of the concrete and the rockfill dams at relatively high elevations are expected to be ongoing. Flood overtopping will cause serious damages to the dams, particularly the rockfill dam, as well as to the properties downstream. Therefore, the diversion facilities for the second and third years are designed based on the recorded maximum flood of 1,605 m^3/s.

Diversion Channel

As seen in Fig. 5.3.1, a diversion channel is excavated from the left bank of the Amban River to the upstream face of Saddle-1 concrete dam, wherein diversion conduits are provided. To facilitate leading the river water to the diversion conduits during the first river closure, the invert level of the channel is made equal to the upstream river bed level assumed to be 138 m asl. The channel bottom width is set at 20 m, taking into account dry season discharges.

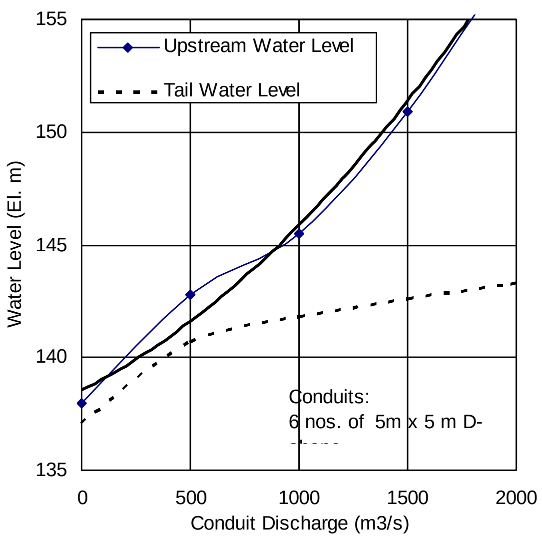
The spillway discharge channel downstream of the stilling basin serves as part of the diversion channel during main dam construction in the river valley.

Diversion Openings in the Dam Body

For the purpose of river diversion during construction of the rockfill dam in the river valley, six conduits are provided across the saddle-1 concrete dam body at river bed level as shown in Appendix- C-7. Each conduit has an inverted U-shape section 5.0 m wide and 5.0 m high and a length of about 45 m, including the inlet bell-mouth. The invert level of four conduits is set at 138 m asl. The other two conduits will be later utilized as the permanent bottom outlets. In order to keep the invert of the bottom outlets dry under normal operation condition, the invert level of the central two conduits is set at 139.5 m asl.

Discharge capacity of the six conduits is estimated as shown in Fig. 5.3.6. Flood routing result for the diversion design flood (peak 1,600 m3/s) are shown in Fig. 5.3.7.

As seen in Fig. 5.3.7, the maximum water level in the reservoir during flood is 149.5 m asl. The top of the second stage cofferdam or main rockfill dam should thus be higher than this level before the flood season comes.



Prepared by the JICA Survey Team

Fig. 5.3.6 Diversion Conduit Discharge Rating Curve

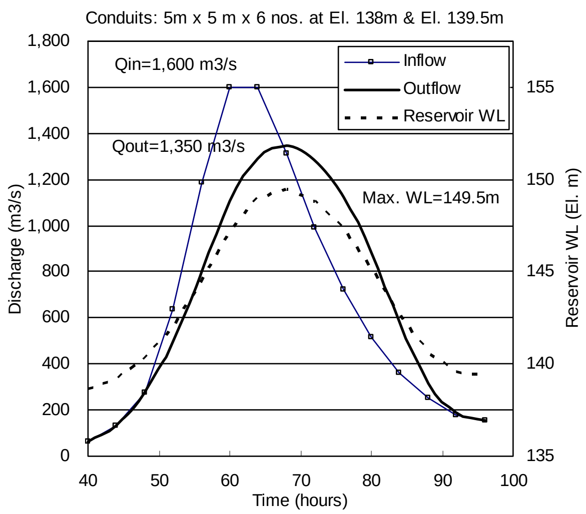


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Fig. 5.3.7 Flood Routing Result

Cofferdams

In the saddle-1 area, no cofferdam is required for dam construction. However, to protect the work area, the overburden around the dam foundation area is left unexcavated until river diversion begins.

In the river valley, primary and secondary coffer dams are required for protecting dam foundation work area. The primary cofferdams are to first divert river flow to Saddle-1 channel and protect the secondary cofferdam areas. The primary cofferdams are designed against dry season floods.

Secondary cofferdams have to have sufficient height capable of avoiding overtopping by rainy season floods. The upstream secondary cofferdam is built as part of the main dam and its crest level is set at 151.0 m asl. The upstream face of the main dam is covered with clay layer reaching to the base rock to form a temporary water cutoff. The downstream cofferdam, on the other hand, is a rock fill dam with a central clay core and its crest level is set at 143.5 m asl

(8) Bottom Outlets

The bottom outlet is provided through the concrete dam body in the spillway section for the purposes of i) releasing the reservoir water to the downstream channel for irrigation and domestic and industrial water supply when the power plant is not in operation, and ii) emergency drawdown of reservoir water level.

It is not realistic to carry out the emergency drawdown during the rainy season (or flood season). Reservoir inflow during the drawdown operation is assumed to be 20 m^3/s, which is the average inflow in the dry season. The dry season normally lasts for eight months from March to October. In consideration of the necessary works for dam maintenance after emergency drawdown, the permissible period for drawdown operation is set to be 2.5 months, starting from the reservoir full condition (FSL=185.0 m asl) and ending at the minimum operation level (MOL=155 m asl).

The number of the bottom outlet conduits is decided to be two units in consideration of the individual maintenance of the bottom outlet gates. Each bottom outlet consists of a concrete intake structure, steel pipe conduit, service gate and maintenance gate (see Appendix C-7). The service gate is jet-flow type capable of partial opening operation. The bottom outlet is installed respectively in the higher level diversion conduits with invert level of 139.5 m asl. The bottom outlet intake sill level is tentatively set at 147.5 m asl so as to minimize the silt sedimentation in front of the intake being swallowed. It may be possible to lower the intake sill level after review and confirmation of the sedimentation level during the detailed design stage.

The required discharge capacity of the bottom outlet is considered to be at least 50 m^3/s in total of the two units when the reservoir level is at MOL. This is because the future downstream water demand is assumed to reach 50 m^3/s. The diameter of the bottom outlet service gates is decided to be 1.6 m to meet this requirement. Discharge rating curves (H-Q curves) of the bottom outlet with 1.6 m diameter gates are shown in Fig. 5.3.8. When the reservoir level is at FSL, the bottom outlets can discharge water of 93 m^3/s in total for the two units.

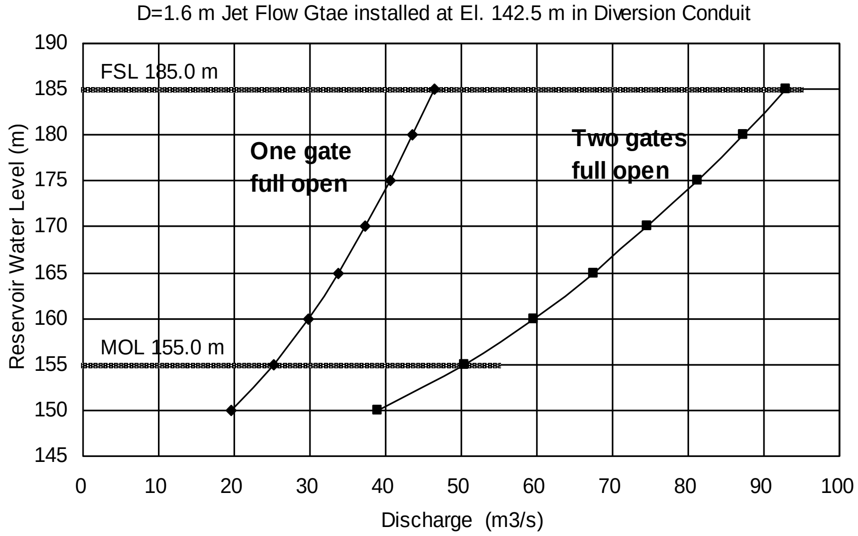

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Fig. 5.3.8 Bottom Outlet Discharge Rating Curves

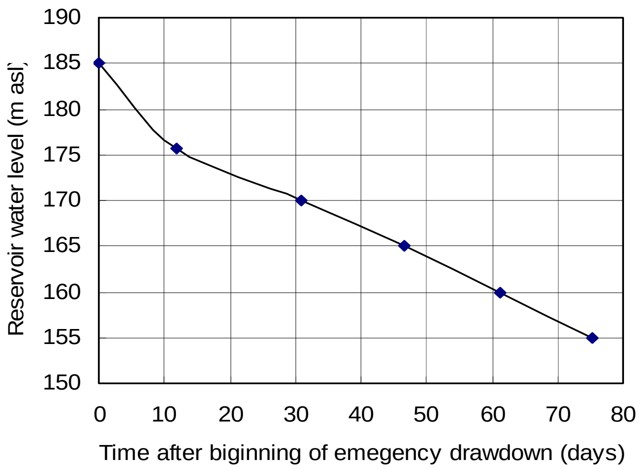

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Fig. 5.3.9 Emergency Drawdown Curve

Emergency drawdown operation is simulated considering the reservoir inflow of 20 m^3/s. The operation begins at FSL of 185.0 m asl until the water level is lowered down to 175.5 m asl, with the reservoir water released through the spillway by partial opening of gates. The rate of the spillway release is limited to 270 m^3/s in order to avoid downstream flood damages in the dray season. Once the water level has dropped to 175.5 m asl, the water release is made by the full capacity operation of the bottom outlets. The simulated drawdown curve is shown in Fig. 5.3.9. As seen in the curve, the reservoir drawdown from 185 m asl to 155 m asl is completed within 2.5 months (=75 days). Therefore, provision of two sets of 1.6 m diameter bottom outlet is an appropriate arrangement.

(9) Power Intake and Powerhouse

General

A powerhouse is located at downstream toe of the Saddle-1 concrete dam. In consideration of the access to the powerhouse and cable connection to the transmission lines, the powerhouse is located on the left bank side of the spillway stilling basin. Installed capacity of the generating units has been decided to be 15 MW (=2 x 7.5 MW) in Section 4.5.1. The layout and sections of the intake and powerhouse are shown in Appendix C-7. The turbine selected is a vertical shaft Kaplan type of which operation covers a wider range of discharge variations than the Francis turbine. However, because of the permissible minimum head limit for the turbine operation, the minimum operation level of the reservoir is set at 165 m asl for turbine operation only. When the reservoir level is lower than 165 m asl, release of water from the reservoir is done through the operation of the bottom outlets in place of stopping the turbines.

Power Intake

Water for power generation is taken from an intake structure integrated into the RCC dam on its upstream face. An intake with penstock is built independently for each generation unit to minimize the construction cost and to facilitate flexible O&M of intake facilities. If a single common intake is provided for two units, the penstock pipe becomes longer because it has to be bifurcated at toe of the dam for two units and an expensive turbine inlet valve is required for each unit in the powerhouse building. Center-to-center distance of two intakes is 10.0 m, which equals the generating unit spacing.

The intake structure is a horizontal bell-mouth type equipped with trashrack and an intake shutdown gate. The intake is connected to the horizontal penstock (steel pipe) embedded in the dam concrete. The penstock diameter is set at 2.50 m so that the maximum flow velocity in the penstock becomes around 4.2 m/s as recommended in the FS2001 report. This diameter needs to be reviewed to determine the most economical diameter in the detailed design stage. The penstock pipe outside the dam body is laid on the downstream slope of the dam and led to the turbine.

The minimum operation level of the reservoir for the Kaplan turbine is 165.0 m asl as discussed in Section 4.5.1. The intake center level is decided to be 155.0 m asl in order to prevent air entrainment into the turbine. Intake submergence at this level is sufficiently deep even if the operation level is lowered to 160 m asl in the future by turbine renovation.

The opening size of the intake with trashracks is decided to be 4.5 m by 4.5 m. This is to maintain the maximum flow velocity at the trashracks around 1.0 m/s. The trashrack is the removable type with no raking equipment. Cleaning of the trashrack panels can be done on the dam crest if necessary. The slot for the trashrack panels is utilized as the stoplog slot. When the intake gate requires maintenance, stoplogs are inserted into the slot after removing the trashrack panels. Two intake gate shafts of reinforced concrete are constructed along the upstream vertical face of the dam. The gate hoist towers are built with concrete on the dam crest level. A monorail hoist will be provided on the dam crest for the handling of the trashrack panels and stoplogs.

Powerhouse

The powerhouse building is a reinforced concrete construction. It accommodates two 7.5 MW generating units and all auxiliary equipment. Permanent ground level surrounding the powerhouse is decided to be 146.0 m asl, which is about 0.8 m higher than the tail water level at the time of the dam safety check food outflow (Q = 4,085 m^3/s).

Tail water level in normal operation is variable because of thewater level control at the downstream Elahera Anicut of which the free-overflow crest level is El. 138.74 m at right stream and El. 138.85 m at left stream of the river. For the powerhouse design, the tail water level at full operation of two units (Q=42 m^3/s) is assumed to be El. 138.0 m.

Layout of the powerhouse is shown in Appendix C-7. The approximate dimensions of powerhouse are as follows:

- Turbine setting level (center level) 135.0 m asl
- Foundation level at draft tube 129.0 m asl
- Powerhouse yard ground level 146.0 m asl
- Powerhouse building size (approximate) W22 m x L42 m x H27 m

Tailrace and Switchyard

In order to discharge water to the downstream river, a tailrace channel is extended from the draft tube outlet to the downstream end of the spillway stilling basin. The tailrace is an excavated open channel of which the bottom width is about 22 m. Side slope surface of the channel is protected by concrete facing.

An outdoor 33kV switchyard, including a main step-up transformer, is located on the powerhouse building's backyard floor. An overhead 33 kV transmission line takes off from the switchyard towards the Naula grid substation.

5.3.2 Hydropower Plant and Transmission Line

(1) The Principal Features of the Hydropower Plant and Transmission Line

The capacity of the Moragahakanda hydropower station is proposed to be 15MW, which requires only at 33kV single Lynx conductor. The principal features of the Moragahakanda Hydropower Station and transmission line connecting to the grid substation at Naula are summarized in Table 5.3.4.

Table 5.3.4 Principal Features of Moragahakanda Hydropower Station and Transmission Line

Project Feature		Unit	Value
Synchronous Generator/Step-up Transformer			
	Power factor	-	0.85 lagging
	Frequency	Hz	50
	Speed	rpm	500
	Rated generator capacity	MVA	2 x 8.0
	Maximum generator output	MVA	2 x 8.82
	Generator efficiency	%	96
	Transformer capacity	MVA	17.6
	Transformer efficiency	%	99
	Average annual energy production	GWh	66.3
Transmission Line to Naula Substation (Steel Tower Type)			
	Maximum capacity	MVA	17.6
	Maximum current	A	308
	Length	km	15
	Voltage	kV	33
	Conductor size(Lynx)	mm^2	185
	Allowable current (at 75℃)	A	345
	Conductors per phase	-	1
	Number of circuits	-	1
	Number of tower	-	60

Prepared by the JICA Survey Team

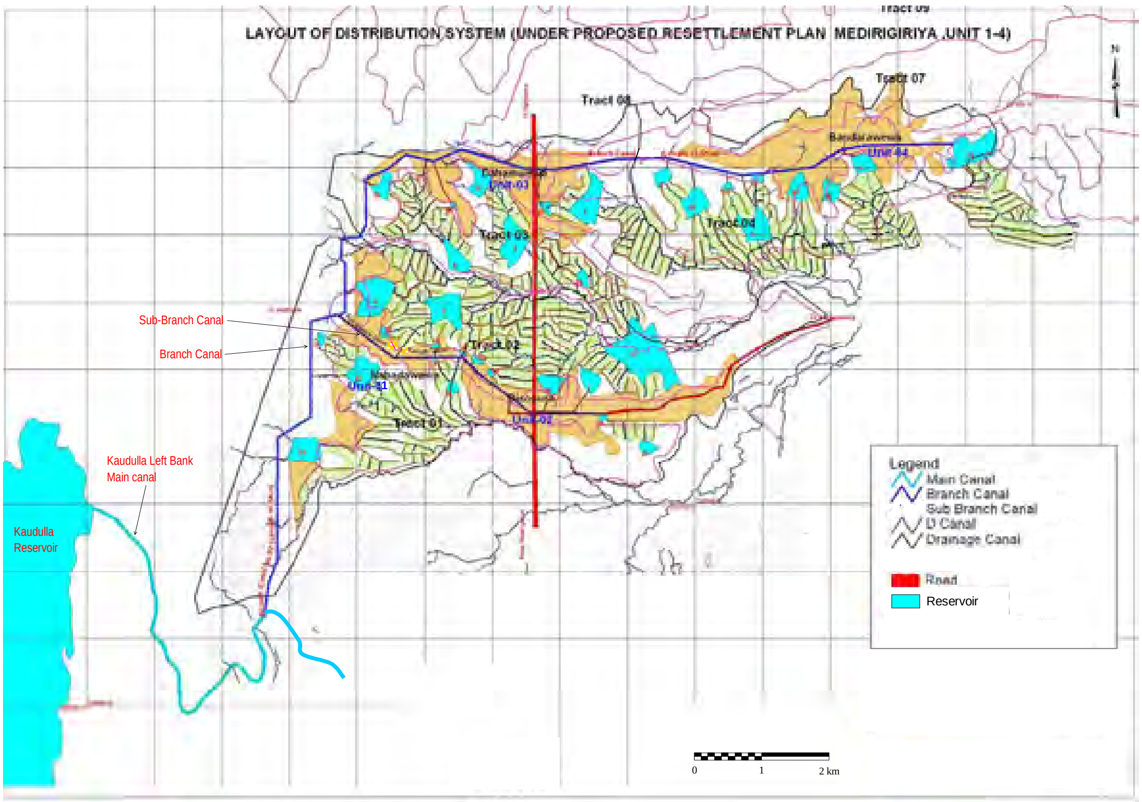
Attachment-21 “Schematic Diagram of the Moragahakanda Hydropower Station and Attachment-22 List of Electrical Equipment” shows the details of the Moragahakanda Hydropower Station, and Attachment-23 “Moragahakanda Power Station Interconnection” shows the interconnection to the CEB grid system.

5.3.3 Irrigation Canal Facilities

1) Kaudulla Left Bank Branch Canal

i) Present Condition

According to the latest planning by the MASL and Irrigation Department (ID), the Kaudulla Left Bank Branch Canal with sub-branch canal is to be diverted from the existing Kaudulla Left Bank Main Canal at the point that is 6.4 km far from the Kaudulla reservoir. The objective is to supply irrigation water to the extension area of 1,420 ha (3,500 acres) in time, of which some parts are where the people will be evacuated from the Moragahakanda reservoir area (see Fig. 5.3.10).

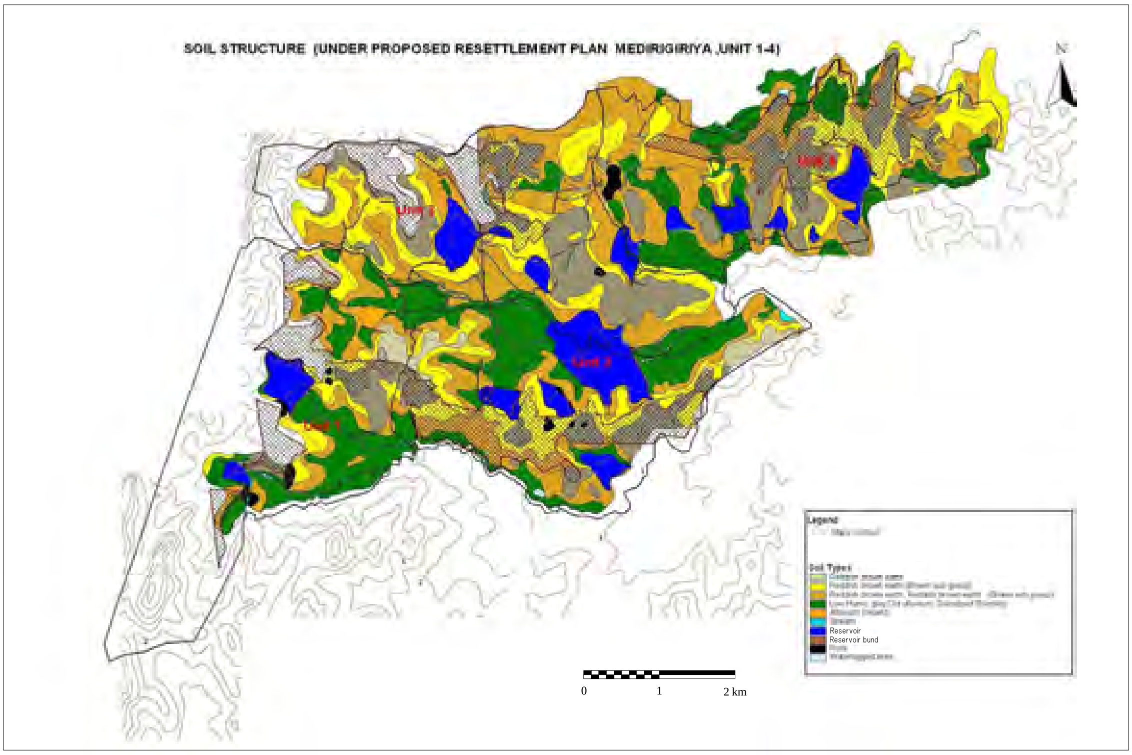


Source of data: MASL and Irrigation Dept.

Fig. 5.3.10 General Layout of the Kaudulla Left Bank Extension Area

The ID has carried out the improvement works for the existing Kaudulla Left Bank Main Canal since October 2009 to increase its flow capacity, and is supposed to be completed by the end of October 2010 by using the national budget of the GOSL. Some portions of the new branch canal with a sub-branch canal, on-farm development, and rehabilitation of the existing farm ponds are also supposed to be implemented by the government by using the national budget.

The ID is currently preparing the design of the extension area of 1,420 ha (3,500 acres) based on the actual topographic and soil conditions. The layout of the branch canal and its sub-branch canal for the extension area is completed, and the layout of the on-farm development for the extension area of 1,020 ha (2,535 acres) including the farm lands of 240 ha for the resettled farmers is completed. The soil map with contour line prepared by the ID is shown in Figure 5.3.11.



Source of data: MASL and Irrigation Dept.

Fig. 5.3.11 Soil Map of the Kaudulla Left Bank Extension Area

ii) Proposed Facilities in this Survey

The Survey Team reviewed the Kaudulla Left Bank Branch Canal proposed in FS2001 referring to the recent design of the relevant facilities prepared by the ID.

The review was made based on the actual topography and soil conditions, and the required irrigation water level. As a result, the alignment of the branch canal and its sub-branch canal prepared by the ID was confirmed to be appropriate and applied in this Survey.

The Survey Team made a preliminary design of the canal sections and related structures based on the design criteria of the ID.

The principal features of the said canals are shown in Table 5.3.5.

Table 5.3.5 Principal Features of the Kaudulla Left Bank Branch Canal

Description	Unit	Branch Canal	Sub-branch Canal
Type of lining	-	Unlined (Earth)	Unlined (Earth)
Irrigation area	ha	1,420 (3,500 acres)	284 (700 acres)
Unit diversion water requirement	lit./s/ha	2.0	2.0
Design discharge (Max.)	m^3/s	2.84	0.57
Total length	km	16.5	4.4
Bed slope	%	0.035	0.035
	-	1/2857	1/2857
Roughness coefficient	-	0.025	0.025
Bed width	m	Section 1 (5.2 km) 2.5	Section 1 (4.4 km) 1.4
		Section 2 (11.3 km) 2.2	
Canal inside slope	-	1.0v : 1.5h	1.0v : 1.5h
Offtakes	nos.	2	0
Turnouts	nos.	19	12
Regulating structures	nos.	10	5
Road bridges	nos.	2	1
Cross drains	nos.	10	2

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The related structures of the new branch canal are shown in Table 5.3.6.

Table 5.3.6 Related Structures of the Kaudulla Left Bank Branch Canal

Station (km)	Structure
0	Offtake at the Kaudulla Left Bank Main Canal (Station 6.4 km from the Kaudulla reservoir)
1.8	Cross Drain-1
2.2	Cross Drain-2
2.3	Turnout-1 / Regulating structure-1
2.8	Cross Drain-3
3.8	Turnout-2
4.3	Turnout-3 / Regulating structure-2
4.9	Cross Drain-4
5.2	Offtake to Sub-branch Canal
5.4	Turnout-4 / Regulating structure-3
6.0	Cross Drain-5
6.3	Cross Drain-6
6.9	Cross Drain-7
7.3	Cross Drain-8 / Regulating structure-4
7.4	Turnout-5
7.8	Cross Drain-9
8.4	Turnout-6
8.5	Turnout-7

Station (km)	Structure
8.6	Turnout-8 / Regulating structure-5
10.1	Road Bridge-1
10.2	Turnout-9
10.8	Turnout-10 / Regulating structure-6
11.3	Turnout-11
12.1	Turnout-12 / Regulating structure-7
12.4	Turnout-13
13.1	Turnout-14
13.2	Turnout-15 / Regulating structure-8
14.1	Turnout-16
14.4	Turnout-17
14.8	Turnout-18 / Regulating structure-9
15.2	Road Bridge-2
15.9	Cross Drain-10
16.5	Turnout-19 / Regulating structure-10

Prepared by the JICA Survey Team

Note: Station "0" is taken as the point of branching off from the existing Kaudulla Left Bank Main Canal.

The main features of the new sub-branch canal are shown in Table 5.3.7.

Table 5.3.7 Related Structures of the Kaudulla Left Bank Sub-Branch Canal

Station (km)	Structure
0	Offtake at the Kaudulla Left Bank Branch Canal (Station 5.2 km from the Kaudulla Left Bank Main Canal)
0.7	Turnout-1
1.2	Turnout-2 / Regulating structure-1
1.7	Turnout-3
1.7	Turnout-4
2.1	Turnout-5
2.1	Turnout-6
2.2	Turnout-7 / Regulating structure-2
2.2	Cross Drain-1
2.3	Turnout-8
2.4	Cross Drain-2
2.5	Turnout-9 / Regulating structure-3
3.5	Road Bridge-1
3.5	Turnout-10
4.1	Turnout-11 / Regulating structure-4
4.4	Turnout-12 / Regulating structure-5

Prepared by the JICA Survey Team

Note: Station "0" is taken as the point of branching off from the new Kaudulla Left Bank Branch Canal.

The cost estimation for the canals is given in Sub-Section 6.3 "Project Cost Estimate".

5.4 Recommendation of Project Implementation Structure

5.4.1 Proposed Project Implementation Framework

In the project implementation structure, the MASL will play the key role in coordinating the related agencies aside from its direct involvement in the activities. The ID and CEB will be involved in the planning, design, construction, and O&M of the Project. The input from the NWSDB is necessary in the planning stage, i.e. providing data related to the domestic and industrial water demand for the Project area, and thus does not have any direct role in the project implementation.

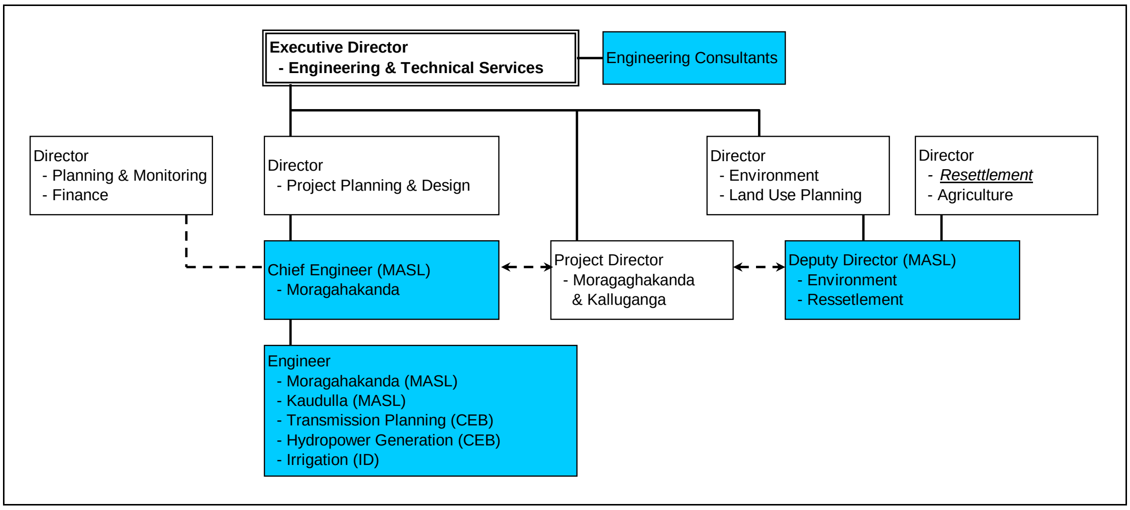
The project implementation process will also be guided by a higher level steering committee presided by the Secretary responsible for the Project, currently the Ministry of Irrigation and Water Management and representatives from main stakeholder agencies such as the Ministry of Finance and Planning, Department of External Resources, Central Environmental Authority, ID, CEB etc., who are empowered to take decisions on behalf of their respective organizations. The steering committee will ensure the smooth operation of the Project, by taking appropriate decisions on major issues that may arise during the implementation stage, meeting the requirements, and guiding the project towards achieving its objectives.

The Project Implementation Unit (PIU) will be established to coordinate and direct the Project. There will be two PIU frameworks; one is responsible for the design and tender stage, and the other is for the construction stage of the Project implementation, as described in the following sections.

In the design and construction stages, the Project will be implemented through employment of an engineering consultant, which will be procured by the MASL through a competitive bidding among international and local consulting companies. Once selected through the standard selection process adopted by the MASL, the engineering consultant will be integrated with the PIU.

5.4.2 PIU Structure

(1) Design and Tender Stage



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Note: Shaded boxes show newly proposed positions

Fig. 5.4.1 Proposed Organization Structure of PIU in the Design Stage

The organization structure proposed for the PIU for the design and tender stage is given in Fig. 5.4.1, and the details of the PIU are shown in Attachment-24. The unit comes under the control of the Executive Director, Engineering & Technical Services. The Engineering Consultant is expected to carry out the detailed design up to the tender stage and the work is to be monitored by the PIU. The Director for Planning and Design will coordinate all activities of the PIU, and will be responsible for the checking, processing, and certification of the documents and for monitoring the works of the Engineering Consultant.

Approval for payments will be done by the Director General of MASL on the recommendation of the Executive Director for Engineering & Technical Services and payments will be effected by the Director for Finance. The Directors for Environment, Land Use Planning, Resettlement, Agriculture, Planning & Monitoring and Finance will be engaged in issues related to their functions in the process. The Director for Resettlement is planned to be newly established to manage the resettlement activities for the Moragahakanda and Kalu Ganga projects.

The staff necessary to interact with the engineering consultant regarding issues related to the design of the powerhouse and transmission line will be provided by the CEB, which will be attached to the unit of the Director for Planning and Design of the MASL. This unit is responsible for checking the documents prepared by the engineering consultant with guidance from the CEB. A similar arrangement will be in place regarding the ID. The Project Director will provide necessary assistance for site investigations to the engineering consultant and will also be involved in issues within his purview.

The PIU will hold progress review meetings on a monthly basis with the participation of all relevant directors forming the PIU, representatives from the ID and CEB, the engineering consultant, and any others deemed necessary.

The Project Steering Committee meetings are arranged by the ministry responsible for the Project every two months or at anytime as required, and the Secretary of the Ministry will preside. The heads of all relevant organizations will be represented in these meetings where issues related to the smooth implementation of the Project are taken up to seek appropriate actions.

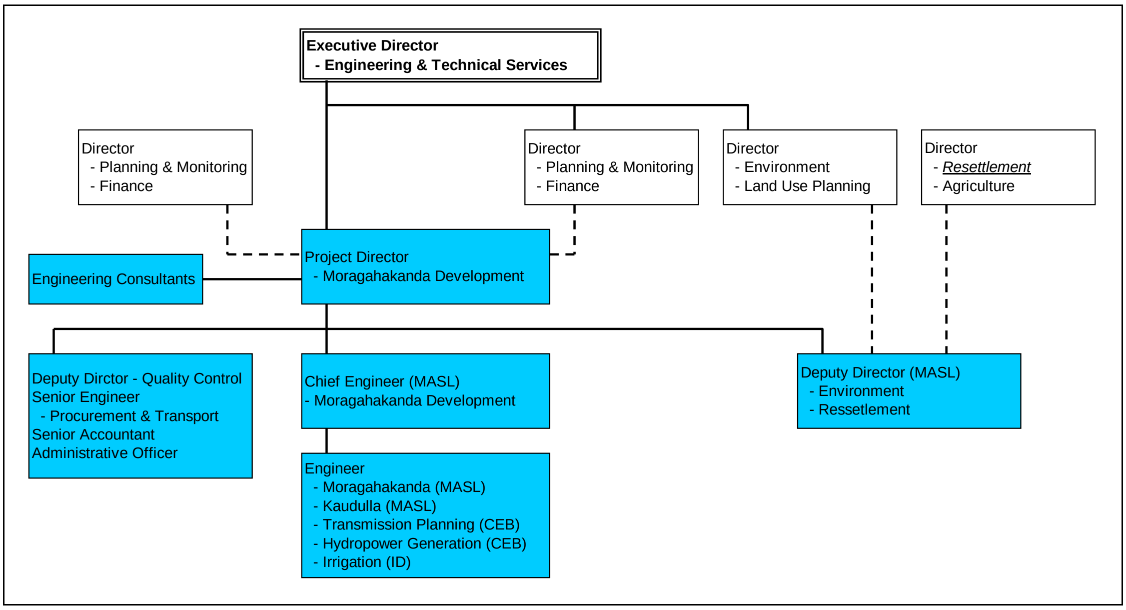
Table 5.4.1 shows the proposed staff positions and numbers required for direct involvement in the PIU in the design and tender stage.

Table 5.4.1 Proposed Positions of the PIU in the Design and Tender Stage

	Proposed Position	No. of Staff
(1)	Project Director (D/P&D)	1
(2)	Deputy Director/Chief Engineer	1
(3)	Officer	5
(4)	Assistant Staff	5
(5)	Supporting Staff	3
	Total	15

Prepared by the JICA Survey Team
Note：Excluding staff for environmental and social consideration

(2) Construction Stage



Prepared by the JICA Survey Team
Note: Shaded boxes show newly formed positions

Fig. 5.4.2 Proposed Organization Structure of PIU in Construction Stage

The organization structure proposed for the PIU for the construction stage is shown in Fig. 5.4.2 and the details are presented in Attachment-25. The major difference from that for the design and tender stage is that the coordinating role shifts from the Director for Planning &

Design to the Project Director and that the engineering consultant who will move to and be based in the dam site under the direct control of the Project Director.

Documents and bills from the contractors will be checked and processed by the engineering consultant and forwarded to the Executive Director for Engineering & Technical Services through the Project Director after further verification of them. The Executive Director for Engineering & Technical Services will then forward these to the Director General of the MASL for his approval. The documents and the bills of the engineering consultant will be processed and certified by the Project Director and forwarded to the Executive Director for Engineering & Technical Services, who will proceed with the same procedure thenceforth.

The PIU meetings will be held monthly at the MASL head office presided by the Director General of the MASL and all relevant directors will take part in the meetings. The Project Director will coordinate these meetings.

The Project Steering Committee meetings will be held in Colombo and will be arranged by the Ministry in the same manner as in the design stage. The Environmental and Social Considerations Committee will also be continued from the design stage.

The positions and numbers of the proposed staff for the PIU in the construction stage are shown in Table 5.4.2.

Table 5.4.2 Proposed Positions of PIU in Construction Stage

	Proposed Position	No. of Staff
(1)	Project Director	1
(2)	Deputy Director	2
(3)	Officer	8
(4)	Assistant Staff	4
(5)	Supporting Staff	10
	Total	25

Prepared by the JICA Survey Team
Note：Excluding staff for environmental and social consideration

5.4.3 Project Safety and Quality Control System

Safety and quality control system of the Project will be prescribed in the contract documents, which are based on the conditions of contract of FIDIC (*Fédération Internationale Des Ingénieurs-Conseils or International Federation of Consulting Engineers*). The specifications for the construction will stipulate about the detailed method of safety and quality control for each construction activity in accordance with international standards.

The contractors shall take overall responsiblity for safety and quality control of the whole Project and the engineering consultant will supervise the safety and quality on site in accordance with the conditions and specifications. The MASL as the employer will also supervise safety and quality control of the contractor and engineer through the monthly PIU meetings. The deputy director of quality control in the PIU structure presented above will be in charge of safety and quality control of the Project. The current situation of safety and quality control system of the MASL based on the JICA safety and quality control checklist is shown in the Attachment-26.

5.5 Recommendation on the Project O&M Structure

5.5.1 Proposed Project O&M Framework

The MASL will be responsible for the O&M of all facilities, except those related to power generation, which have been developed under the Mahaweli development scheme. They include the dams and reservoir, diversion structures such as weirs, conveyance systems such as tunnels and primary canal systems, etc. The Distributary Canal Farmer Organizations (DCFOs) will carry out the O&M of their respective distribution and field canals. There are other related agencies in the Project, namely the ID, CEB and NWSDB.

The irrigation systems that will receive improved irrigation water from the project are H, I/H, M/H, D1, D2, G, and KHFC irrigation schemes. Of these, I/H, M/H, D1, and D2 irrigation schemes are under the control of ID, and the rest are under the MASL. Although the new area of the Kaudulla scheme in System D1 is to be developed for resettlement of the families to be displaced from the Moragahakanda reservoir area, it is expected that O&M of the newly developed irrigation facilities will be done by the ID.

The present practice in all power-related projects under the Mahaweli development scheme is that the facilities related to hydropower generation and transmission line have been handed over to the CEB for their O&M, while the MASL carries out the O&M of the reservoir and the related headworks.

The NWSDB’s involvement in the Project is related to the planning of water management and distribution. They will develop the facilities for the purification and distribution of the water allocated for domestic and industrial needs with resources generated by them and will carry out the O&M of these facilities.

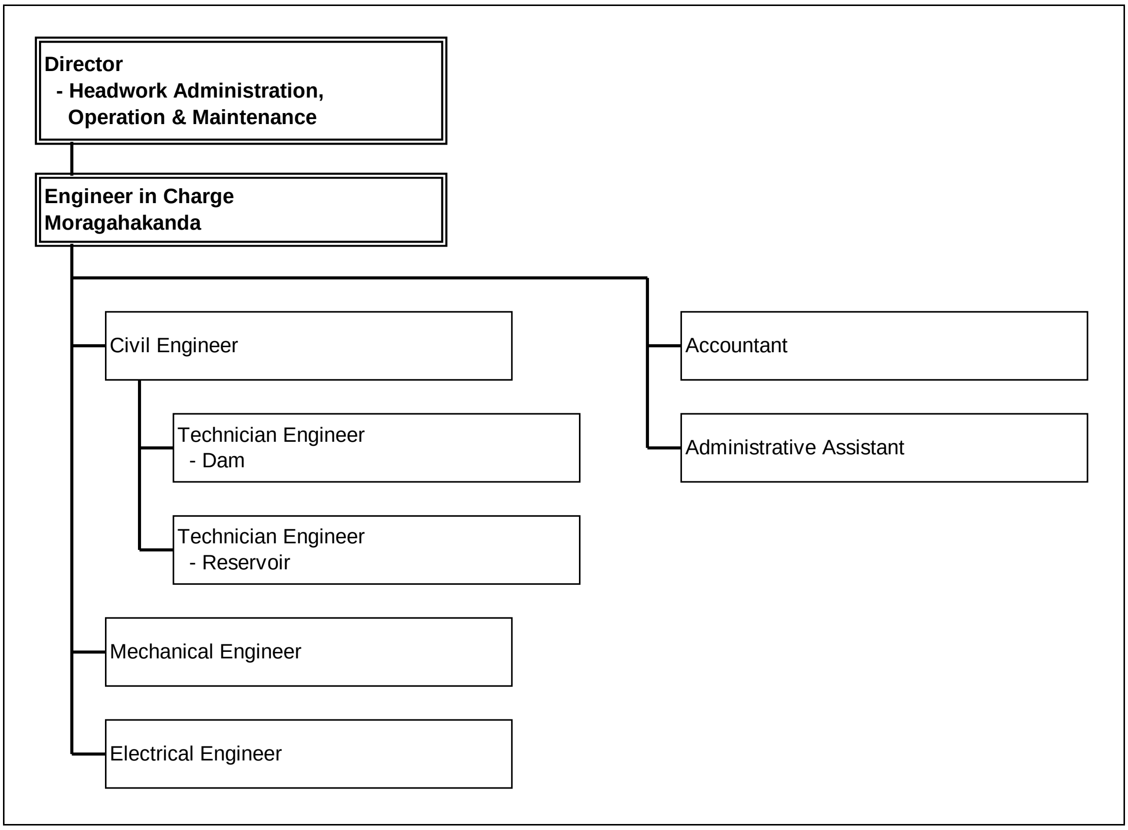
5.5.2 Water Management System of the Project Area

The water management for the Mahweli development scheme is handled by the Water Management Secretariat (WMS) of the MASL. In determination of water allocation from the Mahaweli River system, the WMS prepares water allocation plan based on the water balance simulation and coordinates all water users such as the MASL and ID, CEB, and NWSDB to make consensus in the Water Management Panel (WMP), which is held twice a year. Water management for the Project also involves the above mentioned stakeholders for distribution of water. Hence, the water management system of the Project area will be coordinated under the responsibility of WMS.

5.5.3 O&M of Dam and Reservoir and Irrigation System

Dam and Reservoir

The organizational arrangement for the O&M of the Moragahakanda reservoir will be carried out by the Moragahakanda O&M unit under the Headworks Administration, Operation and Maintenance (HAO&M) Unit of the MASL. The proposed organization chart and positions for dam and reservoir O&M is shown in Fig.5.5.1 and Table 5.5.1 respectively.



Prepared by the JICA Survey Team

Fig. 5.5.1 Proposed Organization Structure for Dam/Reservoir O&M

Table 5.5.1 Proposed Positions for the Dam/Reservoir O&M Organization

	Positions	Required No.
(1)	Engineer in Charge	1
(2)	Engineers (Civil, Electrical and Mechanical)	3
(3)	Officers	2
(4)	Technical Engineer/Engineering Assistants	2
(5)	Technical officers	8
(6)	Assistant Staff	8
(7)	Supporting Staff	26
	Total	50

Prepared by the JICA Survey Team

Irrigation System

The O&M responsibility for the irrigation systems under the MASL and ID are summarized in Table 5.5.2 below.

Table 5.5.2 Proposed Share of Responsibility for Irrigation System

Activities \ Level	Moragahakanda Dam/Reservoir Headworks	Reservoir Headworks	Main Canals/ Branch Canals	Distributary Canals	Field Canals
Irrigation Schemes under MASL (System H)					
Preparation of annual O&M plan	HAO&M	HAO&M	RPM	RPM	DCFO
Preparation of cropping schedule	-	-	WMP	RPM	DCFO
Operation of facilities	HAO&M	HAO&M	RPM	RPM	DCFO
Maintenance work	HAO&M	HAO&M	RPM	DCFO	DCFO
Irrigation Schemes under ID (System I/H, M/.H, HFC, G, D1 and D2)					
Preparation of annual O&M plan	-	RDI	RDI	RDI	DCFO
Preparation of cropping schedule	-	-	WMP	RDI	DCFO
Operation of facilities	-	RDI	RDI	RDI	DCFO
Maintenance work	-	RDI	RDI	DCFO	DCFO

Prepared by the JICA Survey Team

Notes: HAO&M: Headworks Administration, Operation and Maintenance Unit
WMP: Water Management Panel, RPM: Resident Project Manger, MASL
RDI: Regional Director of Irrigation, ID, DCFO: Distributary Canal Farmers Organization

The organizational arrangement for the O&M of the irrigation system under the MASL can be the same as the other systems under the MASL shown in the Table 5.5.2. There will be no need for change in the arrangements for O&M in the areas where the effect is only improved irrigation water. Main canals and branch canals will be maintained by the Resident Project Manager (RPM) of the MASL using the funds to be provided by the GOSL, and distributary canals will be maintained by the DCFOs through their own accumulated funds. The MASL provides funds for maintenance work to DCFOs in case of major maintenance works for distributary canals, such as improvement or upgrading of canal systems and repair works bfor natural disasters.

The ID's functions in the O&M of the irrigation systems under their purview will be almost similar to that of the MASL. The main and branch canals will be operated and maintained by the ID. The operation of the offtake gates of the distributary canals and release of water to these canals will also be carried out by ID.

The DCFOs will be responsible for the maintenance of the distributary canals and the O&M and distribution and rotation of water among the farm allotments. They will be assisted by the engineers of the MASL and ID and their staff in these functions. Depending on the irrigation system, major repairs and rehabilitation works will be carried out by the MASL and ID through the RPM and RDI. The MASL, ID, and each of the DCFOs should make written agreement on above mentioned O&M responsibility.

In the new area under the Kaudulla LB extension area, the irrigation system can be maintained by the ID, which operate the Kaudulla reservoir and canal system, since the canal system in the new area is only an extension of the existing system.

5.5.4 O&M of Hydropower Station

1) Hydropower Station and Transmission Line

As indicated earlier, the role of the CEB in all projects under the Mahaweli development schemes that included hydropower generation is to take over the facilities related to hydropower generation and transmission line. The O&M of these facilities are entirely to be carried out by the CEB, while the MASL carries out the O&M of the reservoir and headworks and issues the water for the hydropower generation to CEB.

Construction works for the hydropower generation plant will be carried out by the MASL and that of transmission lines will be carried out by CEB using the funds to be provided through the MASL. The daily water issues for this purpose is decided at the weekly water management panel meetings held at the WMS.

The same procedure is proposed to be continued in the case of the O&M of the hydropower station and transmission lines under the Project. Proposed sharing of responsibility of the Project by the MASL and CEB is shown in Table 5.5.3.

Table 5.5.3 Proposed Share of Responsibility of the MASL and CEB

	Construction	Holding of Assets	O&M Responsibility	License of Operation
Dam/Reservoir	MASL	MASL	MASL	MASL
Power Plant	MASL	CEB	CEB	CEB
Transmission Line	CEB	CEB	CEB	CEB

Prepared by the JICA Survey Team

2) Future Possibility of O&M of Hydropower Station

Before the Electricity Act 2009 and SEA Act were enacted, it had been the policy of the GOSL that O&M of all hydropower stations inbuilt with the reservoir projects of the Mahaweli Development Programme should be vested with the CEB, which reimbursed the loan of investment cost to the GOSL from collected revenue from the sale of electricity generated by the hydropower station.

Even under these situations, the entire responsibility of O&M of the dam and other appurtenances and reservoir periphery management has been entrusted upon the MASL. In this process, the MASL had to depend on the annual financial allocation received from the Treasury for the maintenance of reservoir headworks and the management of its periphery. Failing to attend to certain essential maintenance works timely and satisfactorily due to fund shortage causes further deterioration of the assets. This will subject the people and properties downstream the reservoirs to high risk condition.

However, the legitimate scheme of energy in Sri Lanka has changed by declaration of the National Energy Policy, enacting of the Electricity Act and SEA Act under the responsibility of the Public Utilities Commission of Sri Lanka (PUCSL). As recognized from the Electricity Act and SEA Act, the 15-MW generating capacity of the Moragahakanda Hydropower Station is situated in between 25 MW, more than which requires a government majority ownership, and 10MW, up to which is under standard agreement between the CEB and SEA. For projects larger than 10 MW, there is neither any standardized agreement nor standardized tariffs, and the agreement shall be separately made through negotiations. Consequently, the Moragahakanda Hydropower Station has the possibility to be a Private Power Producer (PPP) through negotiations. Meanwhile, O&M of the transmission lines will be in any case by the CEB according to the Electricity Act.

The normal procedures in applying for PPP to obtain a generation license are as follows:

Step-1: Obtain energy permit from SEA: Apply for resource verification (Form R1), apply for provisional approval (Form R2) and apply for energy permit (Form R3)

Step-2: Seek cabinet approval for PPP to run and maintain a power plant

Step-3: Obtain generation license from PUCSL

Step-4: Negotiate with the CEB for tariff

Step-5: Get approval from PUCSL for tariff

The MASL, if it has the intention to be a PPP, will be required to follow the above procedure.

The discussions which may be held on the possible scheme of O&M in the future are as follows:

i) Scheme-1

One scheme for the MASL is to establish an independent majority-owned O&M company of PPP to sell electricity produced in Moragahakanda hydropower station to the CEB. In this case, the hydropower station must be retained as the property of the MASL and may be leased to the independent company. The O&M cost will be covered by the PPP from the revenue of tariff for electricity sold to the CEB. The MASL shall reimburse the loan corresponding to the construction cost of hydropower station to the GOSL from the leasing revenue. The existing subsidiary or affiliated company of the MASL may be transferred to the PPP with enlarged scope of business. Anyhow, the PPP company must be entitled as the independent entity under company law so that the agreements can be concluded with the SEA.

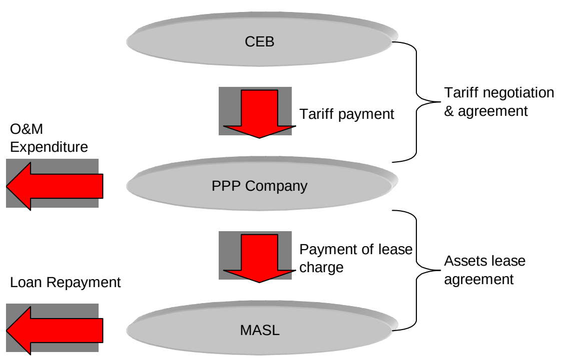


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Fig. 5.5.2 Schematic Diagram of Scheme-1

The critical point in this recommendation will be the company's human resources or its capacity for O&M. The key expertise may be recruited domestically or internationally. The retired engineers and technicians from the CEB could be the human resources acting as tutors to young engineers and technicians. Share of responsibility between the MASL and CEB under scheme-1 is shown in Table 5.5.4 and its schematic diagram is shown in Fig. 5.5.2.

Table 5.5.4 Share of Responsibility of MASL and CEB (Scheme-1)

	Holding of Assets	O&M	License of Operation	Loan Repayment
Dam/Reservoir	MASL	MASL	MASL	MASL
Power Plant	MASL	PPP	PPP	MASL

Prepared by the JICA Survey Team

ii) Scheme-2

The other probable scheme is for the MASL to directly operate and maintain the hydropower station as a PPP by getting a generation license from the PUCSL. However, as the electricity generated is sold to the CEB, the agreements including tariff have to be concluded with the CEB and SEA. The MASL will retain the hydropower station as its property and reimburse the loan to GOSL. In this case, the framework will have to be checked legally with reference to the Mahaweli Authority Act and relevant regulations. The critical point in this scheme is also human resources or its capacity for O&M, similar to Scheme-1 above. Share of responsibility between the MASL and CEB under scheme-2 is shown in Table 5.5.5.

Table 5.5.5 Share of Responsibility of MASL and CEB (Scheme-2)

	Holding of Assets	O&M	License of Operation	Loan Repayment
Dam/Reservoir	MASL	MASL	MASL	MASL
Power Plant	MASL	MASL	MASL	MASL

Prepared by the JICA Survey Team

5.6 Agricultural Extension Services, and Establishment and Strengthening of FOs

5.6.1 General

Agricultural extension services, and establishment and strengthening of farmers' organizations (FOs) in the resettlement irrigation areas are required to be included in the Project components in order to assist the farmers in smooth resettlement through realization of efficient water management, sustainable O&M, and enhancement of agricultural production.

The targeted farmers include not only the farmers to be resettled from the Moragahakanda reservoir area but also the farmers in the existing settlement in the same irrigation areas, i.e. Kaudulla Left Bank Extension Area of System D1, and Kalu Ganga Left and Right Bank Areas of System F, so as to accelerate a harmonization between the resettled farmers' agricultural activities and the existing agricultural activities in and around the resettlement areas.

The proposed components and implementation schedules of agricultural extension services, and establishment and strengthening of FOs under the Project are described in the following sub-sections.

5.6.2 Agricultural Extension Services

i) Components

The following components of the agricultural extension services are to be included in the Project:

Item	Outline
Target Area and Families	1. Kaudulla Left Bank extension area (System D1) 1,420 ha 2. Kalu Ganga Left Bank area (System F) 950 ha 3. Kalu Ganga Right Bank area (System F) 1,100 ha Total Area 3,470 ha Total Families 6,000 households
Activities	1. Technical support to be provided for extension staff for the following advanced agricultural extension services in coordination with the relevant organizations and technical cooperation projects being implemented in other project areas: (1) Newly developed innovative technology packages for nursery management of paddy and horticultural crops. (2) Improved cultivation techniques for high-value horticultural crops. (3) Integrated Pest Management (IPM) methods developed for horticultural crops. (4) Post-harvest technologies to processing, packing and grading for minimizing losses and wastages and improving product quality for paddy and horticultural crops. (5) Appropriate irrigation system for both highland and lowland farming for horticultural crops. 2. Establishment and maintenance of model farms for extension 3. Provision of mobility to extension staff 4. Conducting demonstrations in the field 5. Farm training to farmers 6. Crop clinics 7. Mobile extension services
Proposed Assistance under Consulting Services	1. Overseas training for MASL agriculture staff 2. Training for extension staff (agriculture officers and field assistants) by experts 3. Equipment and logistics support for extension services (1) Establishment and maintenance of model farms (2 sites) (2) Provision of motor bicycles and vehicles (3) Provision of equipment for mobile extension services 4. Conducting demonstrations in the field (4 seasons) 5. Farm training to farmers 6. Crop clinics (Giving in-situ solutions to farmers) 7. Participation in training programs of technical cooperation projects being implemented in other project areas

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As the plot of land that each resettled family will be given is only 0.6 ha, it would be necessary to introduce advanced technologies to realize better farm income. Therefore, the support under the Project aims at extending advanced agricultural technologies among the resettled farmers. Meanwhile, basic agricultural extension services for the resettled farmers are to be carried out by the MASL.

Under the Project, technical support for advanced agricultural technologies, training for agricultural extension staff, and procurement of necessary equipment will be provided by international and local experts through the consulting services. The MASL will conduct field demonstrations, farm training to farmers, crop clinics, and mobile extension services. The local consultants or NGOs sub-contracted in the consulting services will support the activities of the MASL.

ii) Implementation Schedule

Figure 5.6.1 shows the implementation schedule of the basic and advanced agricultural extension services.

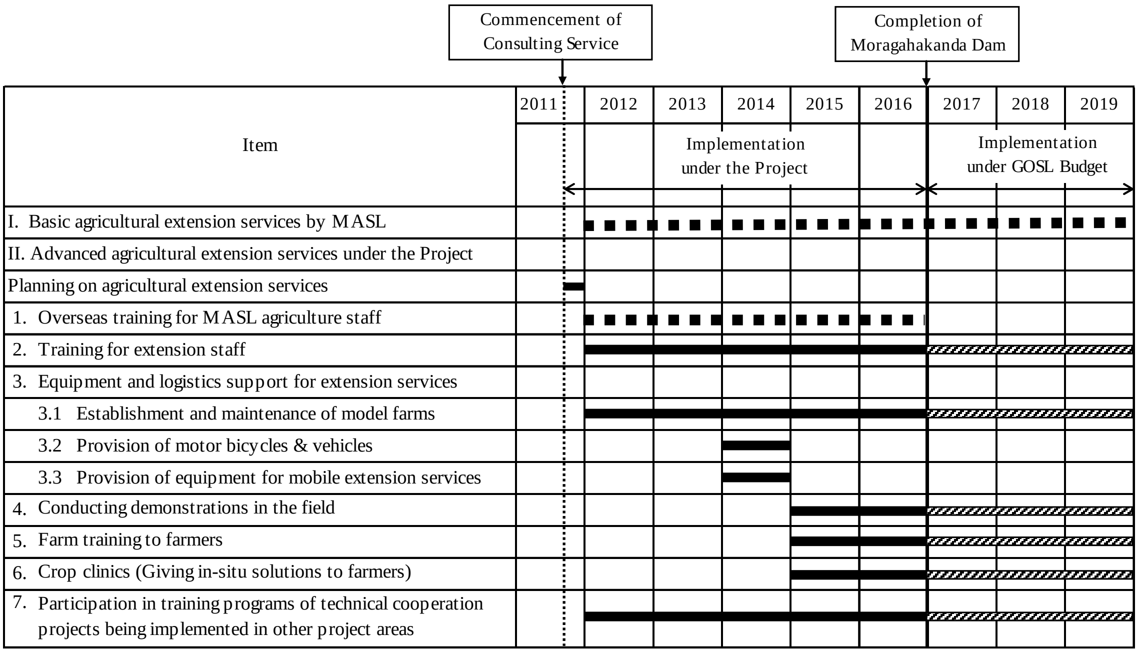

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Figure 5.6.1 Schedule of Activities of Agricultural Extension Services

5.6.3 Establishment and Strengthening of FOs

i) Components

The activities for the establishment and strengthening of FOs in the Project consist of the following components:

Item	Outline
Target Area and Families	1. Kaudulla Left Bank extension area (System D1) 1,420 ha 2. Kalu Ganga Left Bank area (System F) 950 ha 3. Kalu Ganga Right Bank area (System F) 1,100 ha Total Area 3,470 ha Total Families 6,000 households
Activities	1. Support of establishment and strengthening of FOs 2. Implementation of training programs in coordination with the relevant organizations and technical cooperation projects being implemented in other project areas
Proposed Assistance under consulting services	1. Awareness program on FO's functions and responsibilities to farmers 2. Training of trainers (Trainers to be selected from each FO) 3. Training programs on organizational management, water management and facilities' O&M to FOs' members 4. Follow-up workshops on sustainable irrigation system usage 5. Preparation of manuals on water management and O&M activities 6. Preparation of manuals for trainers on training of FOs' members 7. Participation in training programs of technical cooperation projects being implemented in other project areas

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Under the Project, technical support for establishment and strengthening of FOs will be provided by international and local experts through the consulting services. The MASL is to conduct awareness program, training of trainers, training to FOs' members, and follow-up workshops on sustainable irrigation system usage. The local consultants or NGOs sub-contracted in the consulting services will support the activities of the MASL.

ii) Implementation Schedule

Figure 5.6.2 shows the implementation schedule for the establishment and strengthening of FOs.

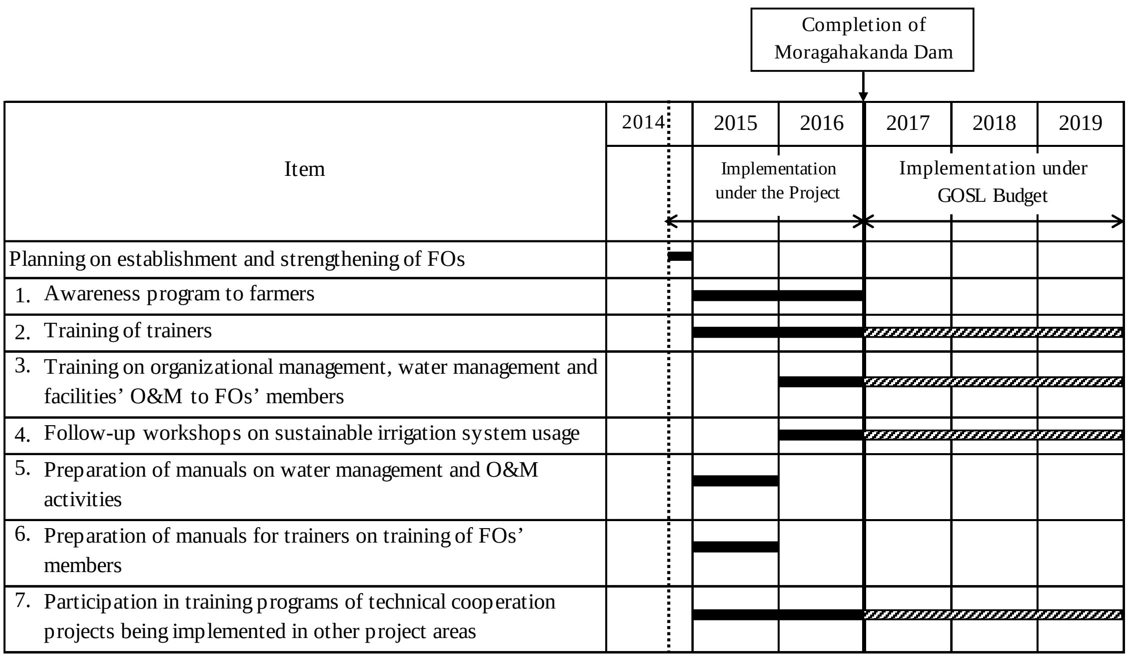

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Figure 5.6.2 Schedule of Activities of Establishment and Strengthening of FOs

5.7 Overall Implementation Schedule

The overall works of the Project include pre-construction and construction works. The pre-construction works consist of detailed design, prequalification, and bidding. The construction works include construction of Moragahakanda Dam with a hydropower station, irrigation facilities in the Kaudulla Left Bank Extension Area, and social infrastructure in Kaudulla area and System F. The overall implementation schedule is prepared based on the assumption that the loan agreement is concluded in the beginning of 2011, and the consultant services start from October 2011 as shown in Figure 5.7.1.

1) Moragahakanda Dam

It is assumed that the pre-construction and construction stages will take 20 months and 42 months, respectively, and the total Project period will be 62 months (5.2 years). After completion of the dam construction at the beginning of December 2016, the initial filling of water in the reservoir will be started. It may take several months depending on the timing and weather. When the reservoir water reaches full supply level, the final inspection on the dam, and commissioning of hydro-mechanical and hydropower equipment will be carried out.

2) Kaudulla Left Bank Extension Area

The ID has been performing improvement of the Kaudulla main canal, and the MASL also carrying out the construction of irrigation facilities in System F, and social infrastructure in System F and Kaudulla resettlement areas. These works will continue on force account until the end of 2010. The ID and MASL will make small contracts to continue those works under the JICA Loan from 2011. The ID and MASL will prepare the detailed design in parallel with the construction, and contracts will be made every year. It is assumed that all works are completed in 2014.

3) Infrastructure for Resettlement Areas

About 1,500 families are to be displaced from the Moragahakanda reservoir to the Kaudulla Left bank Extension Area (System D1) and Kalu Ganga Left Bank (System F). The social infrastructures in these areas, and irrigation facilities in the left bank of System F are currently under construction on force account by the MASL. After the JICA loan is available, the construction works will be carried out by local contractors that will be selected through local bidding. The MASL will continue to prepare the detailed design and contract documents for the remaining works, and conduct the local bidding every year.

4) Implementation Schedule of Resettlement

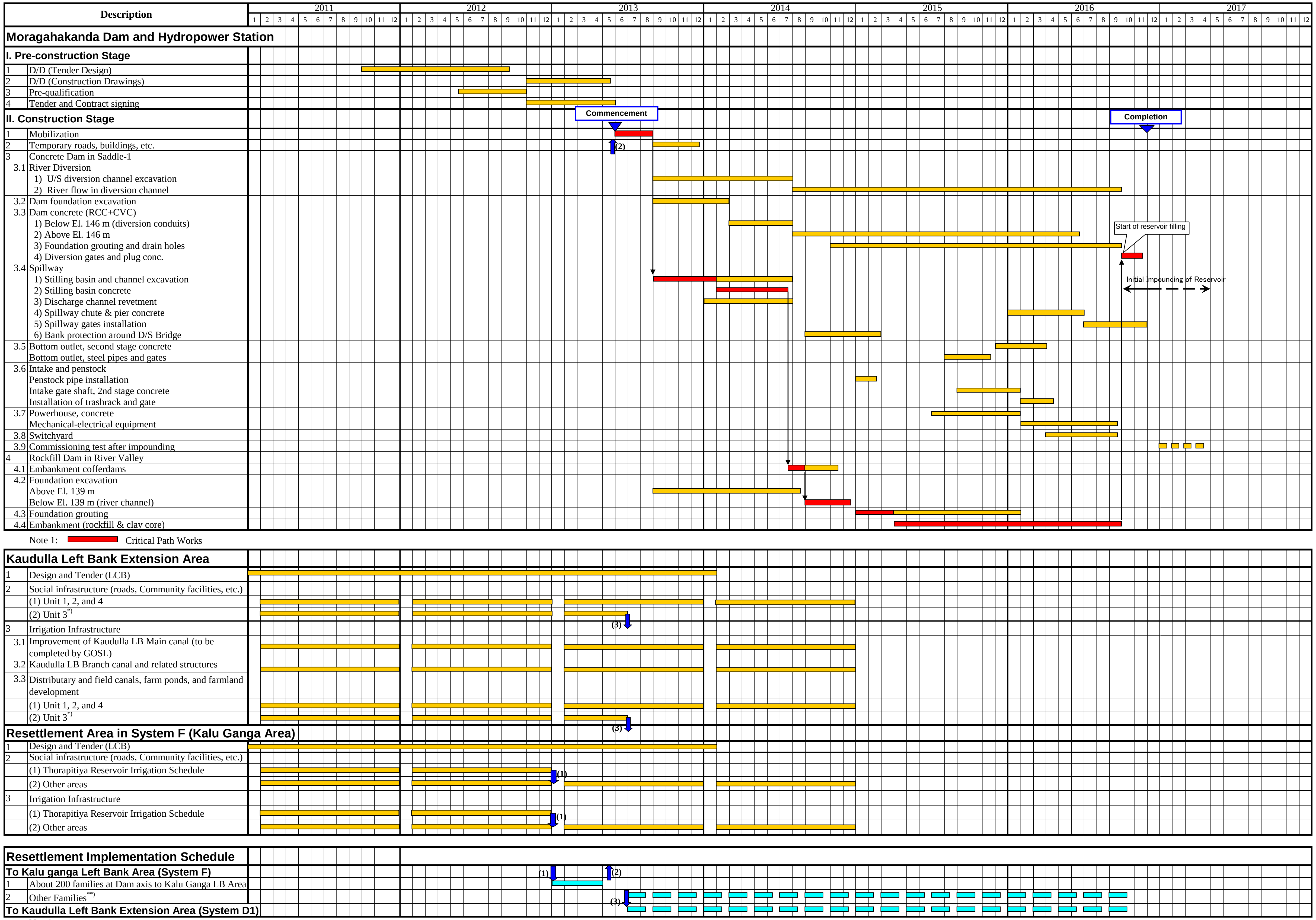
Before commencement of construction of the Moragahakanda Dam, the people living around the dam axis, about 200 families, have to move to the Thorapitiya Reservoir Irrigation Scheme at the left bank of System F. Therefore, the Thorapitiya Reservoir

Irrigation Scheme has to be completed at least some months before commencement of construction of the Moragahakanda Dam, i.e. by the end of 2012.

After that resettlement of about 1,000 families will be started to the left bank of System F, which will be implemented in accordance with the progress of construction of the irrigation and social infrastructures. Those people are allowed to continue cultivation at their original places even after resettlement.

Unit 3 of Kaudulla Left Bank Extension Area is the place where about 300 families are to be evacuated. The irrigation and social infrastructures in the unit 3 above are assumed to be completed by the mid of 2013, and then resettlement will be commenced.

All resettlement have to be completed by the mid of 2016 when the impounding of the Moragahakanda Reservoir is started.



Note2:

(1) About 200 Families at dam axis will start to be resettled after completion of Thorapitiya Reservoir Irrigation Scheme in System F.

(2) After completion of resettlement of about 200 Families at dam axis, construction of the Moragahakanda Dam will start.

(3) About 300 Families will start to be displaced to System D1 after completion of infrastructures in Unit 3 of Kaudulla Left Bank Extension Area.

Note 3:

*): Unit 3 is the area where displaced people from Moragahakanda (about 300 families) are to be resettled in accordance with the progress of development of irrigation and social infrastructu
They can visit their original place and continue cultivation there, until the irrigation and social infrastructure in System F is fully developed and the reservoir filling starts.

**): Resettlement of “other families” to System F (about 1,000 families) will commence following the resettlement of the initial 200 families,

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Fig. 5.7.1 Overall Implementation Schedule of Moragahakanda Development Project

5) Pallegama Dam (Kalu Ganga project)

According to the Feasibility Study Report for the Kalu Ganga Developemnt Project completed in 2004, the construction period of the Pallegema Dam is planned to be about three years after the pre-construction stage.

The likely overall implementation schedule of the Moragahakanda and Kalu Ganga development projects is as shown in Fig. 5.7.2, which is prepared on the assumption that the pre-construction stage of the Moragahakanda and Kalu Ganga development projects start from October 2010 and June 2010 respectively.

As seen in Fig. 5.7.2, impounding of the Kalu ganga Reservoir is scheduled to be started in the mid of 2015, and the irrigation water will be provided to the resettlement area, i.e. left bank of System F, at the end of 2015 or beginning of 2016.

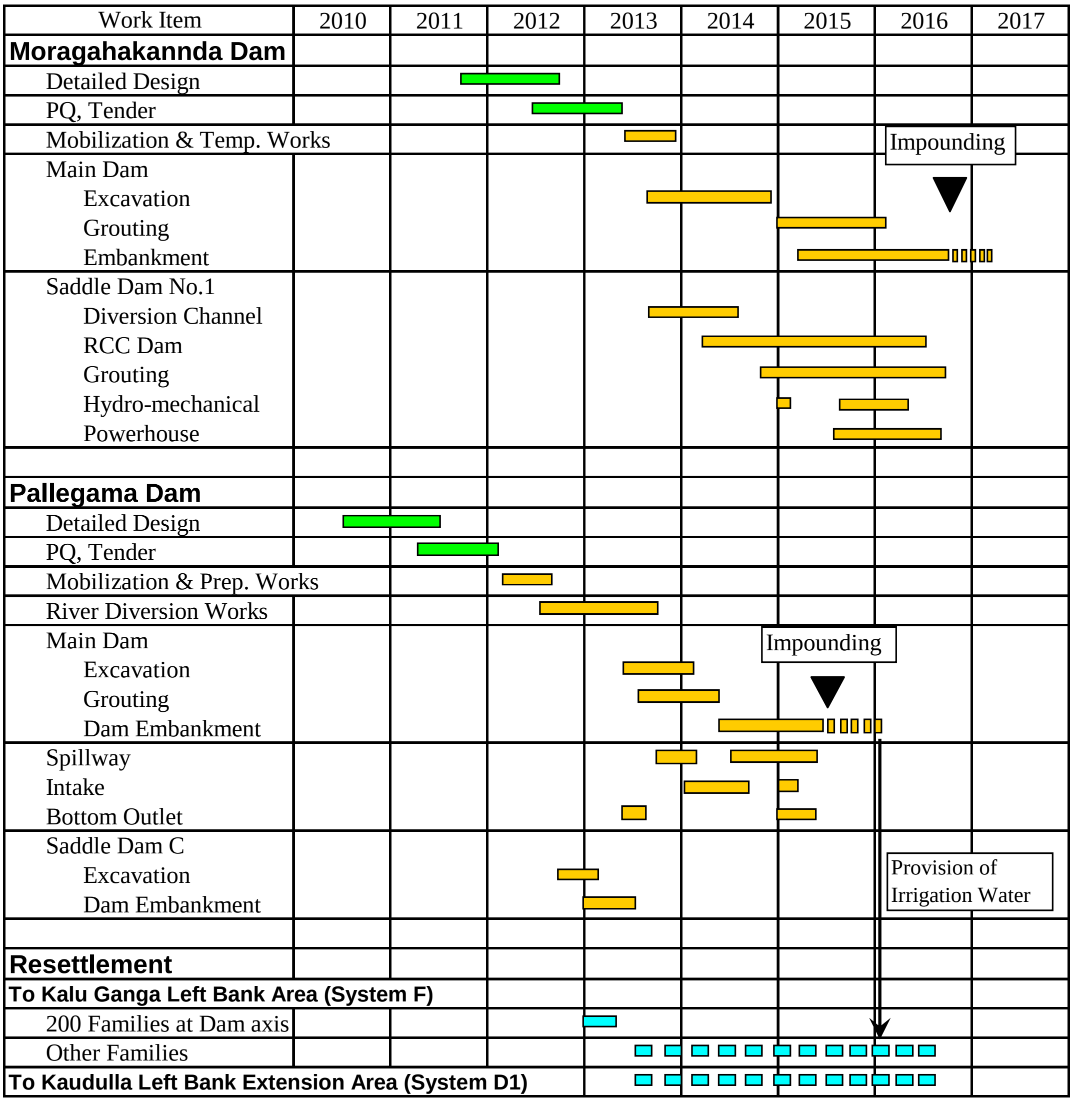

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Fig. 5.7.2 Likely Overall Implementation Schedule of the Moragahakanda and Kalu Ganga Development Project

CHAPTER 6 PROJECT COST

6.1 Basic Conditions for Cost Estimate

The project cost was estimated under the following conditions:

i) The project cost consists of the construction costs of the Moragahakanda Dam and Kaudulla Left Bank Extension Area, procurement cost, compensation and resettlement costs, cost of the Environmental Management Plan, cost of consulting services, and other miscellaneous costs.

ii) All civil works, electrical and mechanical works, and procurement of O&M equipment will be carried out by contractors selected either through international or local competitive bidding (ICB or LCB) under the responsibility of MASL.

iii) Exchange rates among US Dollar (USD), Sri Lanka Rupee (LKR), and Japanese Yen (JPY) are as follows:

- USD 1.0 = JPY 90.5 (March 2010)
- USD 1.0 = LKR 115 (February 2010)

iv) Unit prices consist of local currency (LC) and foreign currency (FC) portions. The basic concept of categories of LC and FC is the same as FS2001. All labor costs are categorized in LC, while major construction materials and equipment are in FC. The cost of transportation is assumed to be composed of 60% FC and 40% LC

v) The unit prices of civil works to be used for estimation of construction cost are the updated unit prices of FS2001. Updating of the local currency portion of the unit prices was carried out based on consumer prices indices of equipment, materials, labors, and consumables between 2001 and 2010, referring to the ICTAD indices. Updating of the foreign currency portion was done based on the average consumer price indices of developed countries as explained in sub-section 4.7. The ratio of the LC portion and FC portion of each unit price is determined referring to the cost estimate of FS2001.

vi) In the cost estimate, the direct cost of the civil works consists of only major work items. Instead, a miscellaneous cost, 10% of the total direct cost, is added to each component of the dam and irrigation works to cover all of minor work items.

vii) The cost of general items such as temporary site facilities, and the contractor's overhead and profit, is included by adding 40% of the direct cost of dam construction and irrigation construction, similar to FS 2001.

viii) Price escalation rates are assumed to be 3.1% per annum for FC and 9.0% per annum for LC.

ix) Physical contingency is 10%.

x) Value Added Tax (VAT), which is 12% according to government regulations, is included in the cost estimate.

xi) Project administration cost is 5.0% of the construction cost.

xii) Interest for civil works during construction is 1.4% and that for consulting services is 0.01%.

6.2 Updating of Unit Prices of Civil Works

1) Documents/Data Collected for Updating of Unit Prices

The Survey Team collected the following documents/data related to the updating of the unit prices in the project cost estimate:

i) Engineer's Unit Rates for Construction Works published by the Rates Committee of the Ministry of Agriculture, Development and Agrarian Services (to be applied from 01 January 2009);

ii) Contract unit rates as of January 2007 of the Upper Kotmal Hydropower Project, Lot-2 (civil works);

iii) Unit rates of as of September 2009 of the Improvements to Left .Bank Main Canal of the Kaudulla Scheme under the Moragahakanda Project;

iv) Institute for Construction Training and Development (ICTAD) Formula Method for Adjustments to Contract Price Due to Fluctuation in Prices (September 2009); and

v) ICTAD Bulletin of Construction Statistics (January 2010).

2) Price Indices

<u>Local Currency Portion</u>

The price escalation rates of construction materials, labor, equipment, and consumables between 2001 and 2010 are calculated as the average values of relevant price indices shown in ICTAD. The referred price indices from ICTAD are shown in Appendix D-8, and the summary of the price escalation rates is shown in Table 6.2.1.

Table 6.2.1 Price Indices (Local Currency Portion)

Item	Escalation from 2001 to 2010	Remarks
Equipment	2.17	
Material	2.21	
Labour	1.73	
Consumable	2.01	
Average	2.03	

Source of data: ICTAD

Foreign Currency Portion

For estimation of escalation rates for the foreign currency portion between 2001 and 2010, the annual average of consumer price indices (CPI) of developed countries published by the International Monetary Fund (IMF) shown in Table 6.2.2 are used.

Table 6.2.2 Price Indices (Foreign Currency Portion)

	Consumer Price Index (Base=Year 2000, Annual Average)									
Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada	102.5	104.8	107.7	109.7	112.1	114.4	116.8	119.6	120.0	122.1
France	101.8	103.8	106.0	108.5	110.5	112.7	114.5	118.1	118.2	119.6
Germany	101.9	103.3	104.3	106.2	108.3	110.2	112.7	115.8	115.9	117.0
Italy	102.3	105.0	107.9	110.4	112.8	115.3	117.7	121.8	122.7	124.5
Japan	99.3	98.4	98.1	98.1	97.8	98.1	98.1	99.5	98.1	96.8
United Kingdom	101.2	102.5	103.9	105.3	107.4	109.9	112.5	116.5	119.1	122.3
United States	102.8	104.5	106.9	109.7	113.4	117.1	120.4	125.0	124.6	127.3
Average	101.7	103.2	105.0	106.8	108.9	111.1	113.2	116.6	116.9	118.5

Source of data: World Economic Outlook Database, IMF, April 2010
Note: Values of CPI for 2010 are IMF's estimation

3) Updating of Unit Prices of FS2001

The unit prices of civil work items for the year 2001 (FS2001) have been updated to the prices in year 2010 by simply multiplying the aforementioned escalation rates. The unit prices for both years 2001 and 2010 are shown in Appendix D-10, D-11.

The updated unit prices have been evaluated by comparing these to the collected references listed above. Among the references, the unit prices for the Upper Kotmale Hydropower Project, which have been converted to year 2010 level, are used in evaluating the updated unit prices of dam construction. This is similar to the method of comparison compared with the updated unit prices as mentioned above. The unit prices for the Improvements to Left .Bank Main Canal of Kaudulla Scheme are useful in evaluating the updated unit prices of irrigation works. The Engineer's Unit Rates for Construction Works published by the Rates Committee of the Ministry of Agriculture Development and Agrarian Services were compared to updated unit prices of both dam and irrigation works.

6.3 Project Cost Estimate

6.3.1 Initial Investment Cost for the Project

1) Total Investment Cost

As shown in Appendix D-1 and summarized in Table 6.3.1 below, the initial investment cost for the Project is estimated at JPY 31.4 billion, consisting of JPY 16.9 billion for the FC portion and LKR 18.4 billion for the LC portion.

Table 6.3.1 Initial Investment Cost

Unit: Million

Designation	FC (JPY)	LC (LKR)	Total (JPY)	Eligible (JPY)	Non-eligible (JPY)
1. Construction Cost	9,098	3,474	11,842	11,465	377
1.1 Moragahakanda Dam	8,576	3,084	11,012	10,701	311
1.2 Kaudulla Left Bank Extension Area	522	390	830	764	66
2. Procurement Cost	300	0	300	300	0
3. Irrigation and Social Infrastructure for resettlement	1,714	592	2,182	1,951	231
4. Land acquisition and Compensation	0	3,227	2,549	0	2,549
5. Income Restoration Assistance Programmes and others	0	254	201	201	0
6. Environment Management Plan	0	1,000	790	790	0
7. Price Escalation	1,440	3,149	3,927	3,091	836
8. Physical Contingency	1,215	1,151	2,125	1,780	345
9. Consulting Services	1,496	1,323	2,541	2,541	0
10. Price Escalation for Consulting Services	189	553	626	626	0
11. Physical Contingency for Consulting Services	168	188	317	317	0
12. Interest During Construction	1,086	0	1,086	1,086	0
13. Commitment Charge	169	0	169	169	0
14. Administration Cost	0	1,700	1,343	0	1,343
15. VAT	0	1,767	1,396	0	1,396
Grand Total	16,875	18,378	31,393	24,317	7,076

Prepared by the JICA Survey Team

2) Construction Cost

The construction cost has been estimated as shown in Appendix D-2 and summarized in Table 6.3.2.

The construction cost of the Moragahakanda Dam consists of civil works, hydro-mechanical works, hydro-power equipment, and transmission lines. The civil works include the main dam, saddle dams No.1 and No.2, appurtenant structures, and a powerhouse. The saddle dam No.2 is being constructed by the MASL since 2007 and will be completed in 2010. Hence, its cost is not included in the loan amount.

Construction works in the Kaudulla Left Bank Extension Area comprise new construction of the left bank branch canal, improvement of the left bank main canal, rehabilitation of the existing farm ponds, and on-farm development. Some of these construction works have been started partly by the Irrigation Department (ID), and the loan will not cover the costs of the works that are carried out by the ID.

On-farm development, including field canal development, will be carried out through the

Project's budget and the beneficiaries are not expected to bear any costs either in financial or non-financial terms. Meanwhile, however, the farmer's contribution is expected for the formation of contour bunds during implementation of on-farm development.

Table 6.3.2 Construction Cost of Civil Works Unit: Million

Designation	FC (JPY)	LC (LKR)	Total (JPY)	Eligible (JPY)	Non-eligible (JPY)
1. Moragahakanda Dam					
1.1 Civil Works (Main dam, Saddle dam No.1, others)	6,195	2,723	8,346	8,346	0
Civil Works (Saddle dam No2, Diversion road)	398	219	571	260	311
1.2 Hydro-Mechanical Works	1,015	142	1,127	1,127	0
1.3 Hydro-Power Equipment	841	0	841	841	0
1.4 Transmission Line	127	0	127	127	
Sub-Total 1	8,576	3,084	11,012	10,701	311
2. Kaudulla Left Bank Extension Area					
2.1 Civil Works (Work other than below)	478	358	761	761	0
Civil Works (Work to be done by GOSL)	42	31	66	0	66
2.2 Mechnical Euipment and Steel Structures	2	1	3	3	0
Sub-Total 2	522	390	830	764	66
Total	9,098	3,474	11,842	11,465	377

Prepared by the JICA Survey Team

3) Cost for Hydro-Mechanical Works

Weights of major components of the hydro-mechanical works are estimated on the basis of their designs as explained in Section 5.3.1. Unit cost per weight of each equipment is estimated from the consultant's cost database of recent international contract prices for similar equipment. It is considered that these unit costs proportionally include all the contractor's indirect costs.

Total cost of each item is calculated by multiplying the estimated weight and unit cost in USD. The estimated cost includes FC components to be incurred by the contractor for the design, manufacture, and delivery of the equipment and LC components to be incurred in Sri Lanka for the storage, erection and testing of the equipment. The ratio of the FC and LC components is estimated to be 90:10.

4) Cost for Hydro-Power Equipment

Sizes and weights of major components of the electro-mechanical equipment are estimated on the basis of their designs as explained in Section 5.3.2. Unit cost per weight or per KVA of each component of the works is estimated from the consultant's cost database of recent international contract prices for similar equipment. It is considered that these unit costs proportionally include all the contractor's indirect costs.

Total cost of each item is calculated by multiplying the estimated weight or KVA and unit cost in US$. Each item cost includes FOB (Free On Board) cost, insurance/freight cost and erection cost. Insurance/freight cost component is estimated at 5% of FOB cost. Erection cost component is estimated at 20% of FOB cost except for transformers of which erection cost is estimated at 10% of FOB cost.

The estimated cost includes FC components to be incurred by contractor for design, manufacture and delivery of the equipment and LC components to be incurred in Sri Lanka for storage, erection and testing of the equipment. The LC cost is estimated at 70% of the erection cost.

5) Procurement Cost

The procurement cost for the equipment such as heavy construction equipment, speed boats, vehicles, survey instrument to be used for operation and maintenance of the Moragahakanda Dam and Kaudulla irrigation areas is estimated as CIF (Cost, Insurance and Freight) prices at Colombo as shown in Appendix D-3. The estimated costs are only FC component, since costs for in-land transportation, assembly and testing are relatively minimal and therefore, assumed to be included in the prices of the equipment.

6) Cost for Irrigation and Social Infrastructure for Resettlement Areas

The Kalu Ganga left bank area (left bank of System F) and Kaudulla Left Bank Extension Area are earmarked as the resettlement areas for the affected people. In the left bank of System F, where some 1,200 families are to be displaced from the Moragahakanda reservoir, irrigation facilities, such as farm ponds and canals, and social infrastructures such as access roads and community buildings, have been constructed since 2007 by the MASL. Likewise, in the Kaudulla Left Bank Extension Area also, where some 300 families are to be moved in, social infrastructures are being built by the MASL.

The cost for irrigation and social infrastructure for the resettlement areas includes: (i) the cost of irrigation infrastructure in the left bank of System F; and (ii) the cost of social infrastructure in both left bank of System F and the Kaudulla Left Bank Extension Area. It is assumed that 50% of the construction costs of all facilities are to be completed at the end of year 2010, while the remaining 50% will be covered by the JICA loan.

The cost estimate for irrigation and social infrastructures for the resettlement areas is shown in Table 6.3.3.

Table 6.3.3 Infrastructure for Resettlement Areas Unit: Million

No	Designation	FC (JPY)	LC (LKR)	Total (JPY)	Eligible (JPY)	Non-eligible (JPY)	Remarks
1	Infrastructure for Left Bank System F						
1.1	Irrigation infrastructure	383	128	484	460	24	95 % Loan Coverd
1.2	Social infrastructure facilities	360	121	456	406	50	89 % Loan Coverd
1.3	Main Road from Moragahakanda Bridge to Kalu Ganga	451	165	581	457	124	79 % Loan Coverd
2	Infrastructure for Kaudulla Left Bank Extension Area						
2.1	Irrigation infrastructure	—	—	—	—	—	—
2.2	Social infrastructure facilities	351	119	445	423	22	95 % Loan Coverd
2.3	Water supply for Kaudulla irrigation area	62	21	79	75	4	95 % Loan Coverd
3	Infrastructure for Ambana						—
3.1	Agriculture land development	0.6	0.2	0.8	0.76	0.04	95 % Loan Coverd
3.2	Soocial infrastructure	106	38	136	130	6	95 % Loan Coverd
4	Total Cost	1,714	592	2,182	1,951	231	

Prepared by the JICA Survey Team

7) Cost for Land Acquisition, Compensation, and Resettlement

The cost for land acquisition, compensation, and resettlement is estimated as shown in Appendix D-7 and summarized in Table 6.3.4.

Table 6.3.4 Cost for Land Acquisition, Compensation, and Resettlement Unit: Million

No	Designation	FC (JPY)	LC (LKR)	Total (JPY)	Eligible (JPY)	Non-eligible (JPY)
1	Land acquisition and Compensation (non eligible)	0	3,227	2,549	0	2,549
2	Cost for Income Restoration Assistance Programmes and others (eligible)	0	254	201	201	0
3	Total Cost	0	3,481	2,750	201	2,549

Prepared by the JICA Survey Team

8) Cost for Environment Management Plan

The cost for the Environment Management Plan to mitigate the negative impact on the environment and enhance the conservation of the reservoir and its surroundings is estimated as shown in Appendix D-6, and summarized in Table 6.3.5.

Table 6.3.5 Cost for Environmental Management Plan Unit: Million

No	Designation	FC (JPY)	LC (LKR)	Total (JPY)	Eligible (JPY)	Non-eligible (JPY)
1	Environment Management Plan	0	939	742	742	0
2	Management cost (Cost for the Management of the total programme & Monitoring cost)	0	61	48	48	0
3	Total Cost	0	1,000	790	790	0

Prepared by the JICA Survey Team

9) Cost for Consulting Services

The cost for consulting services, which covers detailed design, assistance to the government in bidding, and construction supervision, consists of remuneration and direct costs. The necessary inputs of the consulting services were estimated based on the scope of works and project period. The man-months of foreign and local experts and supporting staff are estimated as follows:

- Professional A: 422 MM
- Professional B: 1,049 MM
- Supporting staff: 1,866 MM

The direct costs include travel costs, allowances, vehicles, office running cost, costs for survey, investigations, workshops, and sub-contracts for soft components such as agriculture extension services and strengthening of farmer's organizations.

The breakdown of the cost for engineering services is shown in Appendix D-4, D-5.

10) Annual Disbursement Schedule

The annual disbursement schedule has been calculated based on the implementation plan shown in sub-section 5.7. The summary of the disbursement schedule is shown in Table 6.3.6 while its detailed breakdown is shown in Table 6.3.7.

Table 6.3.6 Summary of Annual Disbursement Schedule

Year	FC (JPY million)	LC (LKR million)	Total (JPY million)
2011	812	1,266	1,812
2012	903	2,103	2,564
2013	3,341	3,648	6,223
2014	4,233	4,484	7,775
2015	3,717	4,364	7,165
2016	3,102	2,272	4,897
2017	369	59	416
Total	16,478	18,195	30,852

Prepared by the JICA Survey Team

Table 6.3.7 Annual Disbursement Schedule

Unit: Million

Item	Total			2011			2012			2013			2014			2015			2016			2017		
	FC (JPY)	LC (LKR)	Total (JPY)	FC (JPY)	LC (LKR)	Total (JPY)	FC (JPY)	LC (LKR)	Total (JPY)	FC (JPY)	LC (LKR)	Total (JPY)	FC (JPY)	LC (LKR)	Total (JPY)	FC (JPY)	LC (LKR)	Total (JPY)	FC (JPY)	LC (LKR)	Total (JPY)	FC (JPY)	LC (LKR)	Total (JPY)
A. ELIGIBLE PORTION																								
Ⅰ) Procurement / Construction	13,320	7,921	19,578	571	397	885	588	601	1,064	3,006	1,661	4,318	3,594	2,030	5,198	3,060	1,837	4,512	2,500	1,395	3,602	0	0	0
Moragahakanda Dam (loan covered)	8,359	2,965	10,701	0	0	0	0	0	0	1,990	706	2,548	2,388	847	3,058	2,388	847	3,058	1,592	565	2,038	0	0	0
Kaudulla Left Bank Extension Area (loan cove	480	359	764	120	90	191	120	90	191	120	90	191	120	90	191	0	0	0	0	0	0	0	0	0
Procurement of O&M equipment	300	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300	0	300	0	0	0
Irrigation and Social Infrastructure (loan cover	1,533	529	1,951	383	132	488	383	132	488	383	132	488	383	132	488	0	0	0	0	0	0	0	0	0
Compensation & Resettlement (loan covered)	0	254	201	0	0	0	0	51	40	0	51	40	0	51	40	0	51	40	0	51	40	0	0	0
Enviroment Management Plan	0	1,000	790	0	109	86	0	187	148	0	187	148	0	187	148	0	187	148	0	141	111	0	0	0
Base cost for JICA financing	10,672	5,106	14,706	503	331	765	503	460	867	2,494	1,166	3,415	2,892	1,307	3,924	2,388	1,085	3,246	1,892	756	2,490	0	0	0
Price escalation	1,436	2,095	3,091	16	30	39	32	87	100	239	344	511	376	538	801	394	585	856	380	512	785	0	0	0
Physical contingency	1,211	720	1,780	52	36	80	53	55	97	273	151	393	327	185	473	278	167	410	227	127	327	0	0	0
Ⅱ) Consulting services	1,853	2,064	3,484	193	141	304	250	220	424	210	268	422	439	478	817	405	514	811	297	396	609	59	47	97
Base cost	1,496	1,323	2,541	170	117	263	214	168	347	174	188	323	353	308	597	316	304	556	225	214	394	44	24	62
Price escalation	189	553	626	5	11	14	13	32	38	17	56	61	46	127	146	52	164	181	45	145	160	10	20	26
Physical contingency	168	188	317	18	13	28	23	20	39	19	24	38	40	43	74	37	47	74	27	36	55	5	4	9
Total (Ⅰ + Ⅱ)	15,173	9,985	23,061	764	538	1,189	839	821	1,488	3,216	1,930	4,740	4,033	2,508	6,015	3,465	2,351	5,322	2,797	1,790	4,211	59	47	97
B. NON ELIGIBLE PORTION																								
a Procurement / Construction	447	4,925	4,338	12	502	408	12	930	747	13	1,014	814	13	1,105	886	0	1,192	941	0	0	0	0	0	0
Moragahakanda Dam (not loan covered)	217	119	311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kaudulla Left Bank Extension Area (not loan	42	31	66	11	8	17	11	8	17	11	8	17	11	8	17	0	0	0	0	0	0	0	0	0
Irrigation and Social Infrastructure (not loan co	180	63	230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Compensation & Resettlement (not loan cove	0	3,227	2,549	0	411	324	0	704	556	0	704	556	0	704	556	0	704	556	0	0	0	0	0	0
Base cost for JICA financing	439	3,440	3,157	11	418	341	11	712	573	11	712	573	11	712	573	0	704	556	0	0	0	0	0	0
Price escalation	3	1,054	836	0	38	30	1	134	106	1	210	167	1	293	233	0	379	300	0	0	0	0	0	0
Physical contingency	5	431	345	1	46	37	1	85	68	1	92	74	1	100	81	0	108	86	0	0	0	0	0	0
c Administration cost	0	1,700	1,343	0	101	80	0	141	112	0	352	278	0	437	345	0	396	313	0	267	211	0	6	5
d VAT	0	1,767	1,396	0	125	99	0	210	166	0	353	279	0	434	343	0	425	336	0	215	170	0	6	4
e Import Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d+e)	447	8,393	7,077	12	728	587	12	1,282	1,025	13	1,719	1,370	13	1,976	1,574	0	2,013	1,590	0	481	380	0	12	9
TOTAL (A+B)	15,620	18,378	30,138	776	1,266	1,775	851	2,103	2,513	3,228	3,648	6,111	4,046	4,484	7,588	3,465	4,364	6,913	2,797	2,272	4,591	59	59	106
C. Interest during Construction	1,086	0	1,086	12	0	12	28	0	28	88	0	88	162	0	162	228	0	228	282	0	282	286	0	286
Interest during Construction(Const.)	1,085	0	1,085	12	0	12	27	0	27	88	0	88	162	0	162	228	0	228	281	0	281	285	0	285
Interest during Construction (Consul.)	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Commitment Charge	169	0	169	24	0	24	24	0	24	24	0	24	24	0	24	24	0	24	24	0	24	24	0	24
GRAND TOTAL (A+B+C+D)	16,875	18,378	31,393	812	1,266	1,812	903	2,103	2,564	3,341	3,648	6,223	4,233	4,484	7,775	3,717	4,364	7,165	3,102	2,272	4,897	369	59	416
E. JICA finance portion incl. IDC (A + C + D)	16,428	9,985	24,316	800	538	1,225	891	821	1,539	3,328	1,930	4,853	4,220	2,508	6,201	3,717	2,351	5,574	3,102	1,790	4,517	369	47	407

Administration Cost = 5%
VAT= 12% of the expenditure in local currency of the eligible portion
Import Tax= 30%

6.3.2 Operation & Maintenance Cost

The operation and maintenance cost for the Project consists of i) civil works, mechanical equipment and steel structures, electrical equipment and transmission for Moragahakanda Dam and ii) civil works and mechanical equipment for Kaudulla Irrigation System.

The annual operation and maintenance cost for Moragahakanda Dam is assumed at 0.25% of the civil works cost, 1.5% of the mechanical equipment and steel structures cost, and 1.5% of electrical equipment cost. These factors were estimated based on the consultant's experience on similar international dam construction and hydropower generation projects with consideration of the current budget allocation for the O&M of Victria, Kotmale and Bowatena Dam by the MASL.

The O&M cost for the Kaudulla Left bank Extension Area is also estimated at 0.75% of the civil works cost, and 1.5% of the mechanical equipment and steel structures cost, which are based on O&M cost for Systems H and G.

Based on the above, the annual operation and maintenance cost for the Moragahakanda Development Project is estimated at Rs. 76.2 million in financial price. The detailed breakdown is summarized in Table 6.3.8. The O&M cost for the Moragahakanda Dam and Kaudulla Left Bank Extension Area has been discussed and agreed between the MASL and the Survey Team.

Table 6.3.8 Annual O&M Cost

Unit: LKR million.

Component	Capital Cost	Factor	O&M Cost
i) Moragahakanda Dam			
1. Civil Works	11,331	0.25%	28.3
2. Mechanical Equipment and Steel Structures	1,432	1.50%	21.5
3. Electrical Equipment and Transmission	1,230	1.50%	18.5
Sub-total	13,993		68.3
ii) Kaudulla Left Bank Extension Area			
1. Civil Works	1,051	0.75%	7.9
2. Mechanical Equipment and Structures	4	1.50%	0.1
Sub-total Cost	1,055		7.9
Total O&M Cost			76.2

Prepared by the JICA Survey Team

6.3.3 Replacement Cost

Replacement of 90% of the hydro-mechanical works of the Moragahakanda Dam, electrical and mechanical equipment for the hydro-power plant, and equipment of substation and transmission lines is anticipated after 30 years from the completion of construction. For the Kaudulla Left Bank Extension Area, the replacement of 100% of the mechanical equipment and steel structures is also anticipated. The above factors were considered in the estimation for replacement cost based on the consultant's international experience in the similar dam projects.

The replacement cost for each construction components is estimated at Rs. 2,399.7 million in financial price at 30 years after completion of construction based on the durable year as shown in Table 6.3.9. The replacement cost for Moragahakanda dam and Kaudulla Left Bank Extension Area has been discussed and agreed between the MASL and the Survey Team.

Table 6.3.9 Replacement Cost

Unit: LKR million.

Component	Capital Cost	Factor	Replacement Cost
i) Moragahakanda Dam			
1. Civil Works	11,331	0%	0.0
2. Mechanical Equipment and Steel Structures	1,432	90%	1,288.9
3. Electrical Equipment and Transmission	1,230	90%	1,107.0
Sub-total	13,993		2,395.9
ii) Kaudulla Left Bank Extension Area			
1. Civil Works	1,051	0%	0.0
2. Mechanical Equipment and Structures	4	100%	3.8
Sub-total Cost	1,055		3.8
Total O&M Cost			2,399.7

Prepared by the JICA Survey Team

CHAPTER 7 PROJECT EVALUATION

7.1 Evaluation Methodology and Assumptions

7.1.1 Evaluation Methodology

Economic evaluation is carried out to assess the economic viability of the Project from a national economic viewpoint. In order to evaluate the Project, indicators such as the economic internal rate of return (EIRR), benefit-cost ratio (B/C) and net present value (NPV or B-C) are calculated by estimating the cash outflow (costs) and inflow (benefits) on an annual basis over the project life with a certain discount rate. Sensitivity analysis is also carried out to evaluate the viability of the Project against possible adverse change in the future.

7.1.2 Basic Assumptions

The above mentioned economic evaluation indicators are estimated with the following conditions and assumptions:

a) Project life is assumed to be 50 years beginning from the year 2011;

b) All prices and costs are expressed in economic prices in Sri Lanka Rupee (LKR). Other currencies are converted to LKR using the exchange rate as of February and March 2010 for the estimation as follows:

   US$ 1.00 = JPY 90.5, LKR 1.0 = JPY 0.790, US$ 1.00 = LKR 115;

c) Discount rate of 10% is applied for calculating B/C and B-C in view of the rate used in FS2001 and many other projects in Sri Lanka;

d) Standard conversion factor (SCF) of 0.9 and shadow wage rate (SWR) for unskilled labor of 0.7 are applied for converting from financial prices to economic prices, which were applied in FS2001 and also commonly applied in the foreign funded projects in Sri Lanka;

e) For the calculation of the project benefit, only direct benefits from agriculture, power generation, domestic and industrial water supply, and fishery are counted and no indirect and intangible benefits are taken into account;

f) Transfer payment (taxes and subsidies), land acquisition, compensation, price escalation, and interest during construction are excluded for calculation of economic project cost; and

g) Investment cost which has already been spent for the Project such as Saddle Dam-2, diversion road including a bridge is considered as sunk cost, and is thus excluded from the economic cost.

7.2 Economic Project Cost

7.2.1 Capital Cost

Based on the estimated financial project cost described in Chapter 6, the economic project cost was calculated by using the aforementioned conversion factors. The total economic project cost was estimated at about LKR 23,103 million while the financial cost is LKR 39,739 million excluding interest and commitment charge as summarized in Table 7.2.1 and Table 7.2.2. Details of the economic project cost are shown in Appendix E-1.1.

Table 7.2.1 Capital Cost of the Project

(Unit: FC JPY million / LC LKR million / Total LKR million)	Financial Cost			Economic Cost		
	FC	LC	Total	FC	LC	Total
1. Procurement/Construction (Eligible Portion)						
Moragahakanda Dam (loan covered)	8,359	2,965	13,546	8,359	2,644	13,226
Kaudulla Left Bank Main Canal (loan covered)	480	359	967	480	320	928
Procurement of O&M equipment	300	0	380	300	0	380
Irrigation and Social Infrastructure (loan covered)	1,533	529	2,470	1,533	472	2,413
Compensation & Resettlement (loan covered)	0	254	254	0	0	0
Enviroment Management Plan	0	1,000	1,000	0	891	891
Sub-total	10,672	5,106	18,616	10,672	4,328	17,837
2. Procurement/Construction (Non Eligible Portion)						
Moragahakanda Dam (not loan covered)	217	119	394	0	0	0
Kaudulla Left Bank Main Canal (not loan covered)	42	31	84	42	28	81
Irrigation and Social Infrastructure (not loan covered)	180	63	291	0	0	0
Compensation & Resettlement (not loan covered)	0	3,227	3,227	0	0	0
Sub-total	439	3,440	3,996	42	28	81
3. Consulting Services	1,496	1,323	3,217	1,496	1,191	3,084
4. Price Escalation	1,629	3,701	5,763	0	0	0
5. Physical Contingency	1,384	1,339	3,091	1,221	555	2,100
6. Administration Cost	0	1,700	1,700	0	0	0
7. VAT	0	1,767	1,767	0	0	0
Total 1 ~ 7	15,620	18,378	38,150	13,431	6,101	23,103
8. Interest during Construction	1,086	0	1,375	0	0	0
9. Commitment Charge	169	0	214	0	0	0
Grand Total	16,875	18,378	39,739	13,431	6,101	23,103

Prepared by the JICA Survey Team

Table 7.2.2 Disbursement Schedule of the Project

	Financial Cost			Economic Cost		
	Foreign Portion (JPY million)	Local Portion (LKR million.)	Total Cost (LKR million)	Foreign Portion (JPY million)	Local Portion (LKR million.)	Total Cost (LKR million)
Sunk Cost	397	182	685	0	0	0
2011	812	1,266	2,294	752	449	1,401
2012	903	2,103	3,246	801	576	1,589
2013	3,341	3,648	7,877	2,946	1,288	5,017
2014	4,233	4,484	9,842	3,581	1,545	6,078
2015	3,717	4,364	9,069	2,975	1,315	5,081
2016	3,102	2,272	6,199	2,329	904	3,852
2017	369	59	526	48	23	84
Total	16,875	18,378	39,739	13,431	6,101	23,103

Prepared by the JICA Survey Team

7.2.2 Operation & Maintenance (O&M) Cost

The economic O&M and replacement costs were calculated based on the financial O&M and replacement costs estimated in Chapter 6.3.2 and 6.3.3 and the conversion factors. As shown in Table 7.2.3, the annual O&M cost is totally LKR 74.5 million. The total replacement cost, which is assumed to be expended in the 30th year after completion, is LKR 2,349.3 million.

Table 7.2.3 Annual O&M Cost and Replacement Cost

Unit: LKR million

Component	Annual O&M Cost		Replacement Cost (once 30 years)	
	Financial	Economic	Financial	Economic
Moragahakanda Dam				
1. Civil Works	28.3	27.7	-	-
2. Mechanical Equipment and Steel Structures	21.5	21.0	1,288.9	1,261.8
3. Electrical Equipment and Transmission	18.5	18.1	1,107.0	1,083.8
Sub-total	68.3	66.8	2,395.9	2,345.6
Kaudulla Irrigation				
1. Civil Works	7.9	7.6	-	-
2. Mechanical Equipment and Structures	0.1	0.1	3.8	3.7
Sub-total Cost	7.9	7.6	3.8	3.7
Total O&M Cost	76.2	74.5	2,399.7	2,349.3

Prepared by the JICA Survey Team

7.3 Economic Project Benefits

7.3.1 Agricultural Benefit

Methodology and Basic Assumptions

The benefit from irrigation water supply of the Project is the increment of net production value of crops derived from increasing cropping intensity and unit yield of paddy and other field crops (OFC) comparing the “without” and “with the Project” conditions.

Current cropping intensity of 176% of the “without Project” can be increased to 190% of the “with Project”, increase of which is equals to about 16,000 ha. Increase of cultivated areas during Maha and Yala seasons in the project area of the “without” and “with the Project” conditions can be seen in Table 7.3.1. The cropping pattern for the economic evaluation is decided based on the results of water balance simulation (Refer to Chapter 4.3.3 and Attachment-9). OFC cultivated area of the cropping pattern is based on the current conditions in System H and G (Refer to Appendix E-1.3).

Table 7.3.1 Cropping Pattern of the Without and With the Project Conditions

	Maha season			Yala season			Total
	Paddy	OFC	Total	Paddy	OFC	Total	
Without	81,373 ha 95%	1,900 ha 3%	83,273 ha 98%	55,356 ha 64%	11,260 ha 14%	66,616 ha 78%	149,889 ha 176%
With	84,802 ha 97%	2,476 ha 3%	87,278 ha 100%	66,749 ha 76%	11,836 ha 14%	78,585 ha 90%	165,863 ha 190%
Balance	+3,429 ha	+576 ha	+4,005 ha	+11,393 ha	+576 ha	+11,969 ha	+15,974 ha

Prepared by the JICA Survey Team

Crop Budget

Crop budget for paddy and six major crops, namely chili, big onion (roots and tuber), maize (cereals), vegetables, cowpea (pulses) and banana (perennial crops), which are being cultivated in Mahaweli area mainly System H and G for both “without” and “with the Project” conditions, was prepared for estimation of agricultural benefit considering the current situation of agriculture in the project area and the following conditions:

- Yields of paddy for the “without the Project” condition during Maha and Yala seasons were estimated by taking the ten-year average of paddy yield from 2000 to 2009 in the Project area based on the data from the Department of Census and Statistics. Yields of OFC are estimated based on the yield data in 2008 from Department of Census and Statistics (Refer to Chapter 3.3.4). The yield of chilies and onions, which are high value crops, is estimated about 20% less than the data mentioned in Chapter 3.3.4 considering the losses and market risk;
- About 10% increase in production of each crop estimated based on FS2001 and the current situation is anticipated due to availability of more water for irrigation and improvement of crop;
- Amount of fertilizer inputs were estimated based on the recommendations of Socio Economic Planning Centre of the Department of Agriculture;
- Financial prices of paddy and OFC were estimated considering the farm gate prices of agricultural commodities in Mahaweli system in 2009;
- Financial prices of fertilizers, seeds, and agrochemicals were estimated based on collected data from private companies and Department of Agriculture;
- Cost of plant protection, mechanization, and labor were estimated by taking present costs in Mahaweli systems;
- Economic prices for traded goods such as paddy and fertilizers were estimated based on the projected price of global commodity markets (the World Bank) considering transport and milling cost; and
- Prices of non-traded goods were calculated by converting the financial price using SCF. (Refer to Appendix E-1.2).

Summary of crop budget for major crops are summarized in Table 7.3.2. Details of the crop budget are shown in Appendix E-1.4 and E-1.5.

Table 7.3.2 Summary of Economic Crop Budget

Crop	Value of Product			Production Cost			Gross Margin (LKR/ha)
	Unit Price (LKR/kg)	Unit Yield (ton/ha)	Value (LKR/ha)	Material (LKR/ha)	Labor (LKR/ha)	Cost (LKR/ha)	
Without Project Condition							
Paddy (Maha)	29	4.45	129,050	71,223	25,704	96,927	32,124
Paddy (Yala)	29	4.46	129,340	71,223	25,704	96,927	32,414
Chili	126	3.6	453,600	67,720	149,310	217,030	236,570
Big Onion	36	12.0	432,000	106,123	132,300	238,423	193,578
Maize	27	2.5	67,500	31,308	22,680	53,988	13,513
Vegetables	23	10.0	225,000	93,339	90,720	184,059	40,941
Cowpea	72	1.1	79,200	37,080	41,580	78,660	540
Banana	27	11.0	297,000	97,688	24,570	122,258	174,743
With Project Condition							
Paddy (Maha)	29	5.25	152,250	74,818	29,484	104,302	47,949
Paddy (Yala)	29	5.00	145,000	74,818	29,484	104,302	40,699
Chili	126	4.0	504,000	67,720	158,760	226,480	277,520
Big Onion	36	13.5	486,000	106,123	146,286	252,409	233,592
Maize	27	3.0	81,000	31,308	25,704	57,012	23,989
Vegetables	23	11.0	247,500	93,339	102,060	195,399	52,101
Cowpea	72	1.5	108,000	37,080	41,580	78,660	29,340
Banana	27	12.0	324,000	97,688	28,728	126,416	197,585

Prepared by the JICA Survey Team

<u>Agricultural Benefit</u>

In accordance with the “without” and “with the Project” cropping patterns in the project area and crop budgets, annual project benefits were estimated. Agriculture production at the current dam site was deducted from the benefits of the “with the Project” condition, considering the benefit foregone by the Project. Economic benefit from agricultural development was estimated to be LKR 2,684 million per annum as summarised in Table 7.3.3. Detailed calculation of economic agricultural benefit is shown in Appendix E-1.6.

Table 7.3.3 Economic Benefit of Agriculture

Unit: LKR Million

	Paddy-Maha	Paddy-Yala	OFC	Total
Without	2,614	1,794	837	5,245
With	4,066	2,717	1,192	7,975
Production Foregone	-12	-4	-29	-46
Balance	1,440	918	326	2,684

Prepared by the JICA Survey Team

7.3.2 Hydropower Generation Benefit

Methodology and Basic Assumptions

Economic benefit of a hydropower project consists of capacity benefit (kW-value) and energy benefit (kWh-value). Generally, the capacity benefit is obtained from incremental dependable power capacity and a capacity value assumed as a construction cost of an alternative thermal power plant (ATPP), as well as fixed O&M cost. On the other hand, the energy benefit is obtained from the incremental energy and energy value assumed as variable operation cost of an ATPP (fuel cost, etc.)

The Moragahakanda Hydropower Plant aims to be a base-load power plant with a installed capacity of 15MW (7.5MW x 2). In Sri Lanka thermal power plants are operated for base-load power, while hydropower plants and gas-turbine plants are operated for peak-load power. Considering the generation characteristics and capacity of the Moragahakanda Hydropower Plant and power generation operation of Sri Lanka, diesel thermal plant for base-load power was selected as the ATPP. Comparison between the diesel and gas turbine power plants is shown in Table 7.3.4.

Table 7.3.4 Comparison of Alternative Thermal Power Plants

	Diesel (10MW)	Gas Turbine (35MW)
Capital Cost	1671.18 USD/kW	671.42 USD/kW
Construction Period	2 years	1.5 years
Service Life	25 Years	20 Years
Heat Rate	1,954 kCal/kWh	3,060 kCal/kWh
Fuel Price	0.322 US$/kg (Residual Oil)	0.638 US$/kg (Auto Disel)
Heat Content of Fuel	10,300 kCal/kg	10,550 kCal/kg
Unit Cost of Fuel	0.065 USD/kWh	0.185 USD/kWh

Source of data: Long Term Generation Expansion Plan 2009-2022 and Generation Expansion Plan 1998, CEB
Note: All prices are converted to current price with G7 CPI and Colombo CPI.

Adjustment Factors

Adjustment factors were used to adjust the difference of power generation characteristics between hydropower plant and ATPP. The economic benefit of hydropower generation is calculated using the adjustment factors. Adjustment factors in kW and kWh were calculated based on the planning of hydropower plant and current status of power generation in Sri Lanka as shown in Table 7.3.5.

Table 7.3.5 Assumption for Calculating Adjustment Factors

ATPP (Diesel)		Moragahakanada Hydropower Plant	
- Station Use (a)	3.00%	- Station Use (e)	0.60%
- Forced Outage (b)	15.00%	- Forced Outage (f)	0.55%
- Planned Outage (c)	8.30%	- Planned Outage (g)	2.00%
- Transmission Loss (d)	3.50%	- Transmission Loss (h)	3.50%
		kW Adjustment Factor	1.28132
		kWh Adjustment Factor	1.02474

Prepared by the JICA Survey Team
Note: kW Adjustment Factor = (1-(e))x(1-(f))x(1-(g))x(1-(h)) / (1-(a))x(1-(b))x(1-(c))x(1-(d))
kWh Adjustment Factor = (1-(e))x (1-(h)) / (1-(a)) x(1-(d))

Power Benefit

Power benefit (kW-value) for Moragahakanda hydropower generation was calculated in USD as shown in Table 7.3.6. As discussed in section 4.5 in Chapter 4, dependable capacity of the Moragahakanda Hydropower Plant is considered to be 0 kW. Therefore the power benefit is not included in the calculation.

Table 7.3.6 Economic Power Value and Benefit of Hydropower Generation

Power Value (kW-Value) Diesel			
- kW Construction Cost	1671.18 USD/kW	- Capital Recovery Factor	0.1102
- Service Life	25 years	- Fixed O&M Cost	13.47 US$/kW/year
- Discount Rate	10%	- Power Value (a)	197.58 USD/kW
		- Adjustment Factor (b)	1.28132
- Demandable Capacity (c)	0 kW	- Power Benefit (a) x (b) x (c)	Say USD 0

Source of data: JICA Survey Team based on Long Term Generation Expansion Plan 2009-2022 and Generation Expansion Plan 1998, CEB

Note: Capital Recovery Factor = $i \times (1+i)^n / ((1+i)^n - 1)$; i = discount rate, n = service life

Energy Benefit

Energy benefit (kWh-value) for Moragahakanda Hydropower Plant is calculated to be USD 5,026,000 as shown in Table 7.3.7.

Table 7.3.7 Economic Energy Value and Benefit of Hydropower Generation

Energy Value (kWh-Value)			
- Heat Rate	1,954 kCal/kWh	- Fuel Price (Residual Oil)	0.34 USD/kg
- Heat Content	10,300 kCal/kg	- Unit Cost of Fuel	0.065 USD/kWh
- Fuel Amount	0.190 kg/kWh	- Variable O&M Cost	0.00090 USD/kWh
		- Energy Value (a)	0.0740 USD/kWh
		- Adjustment Factor (b)	1.03474
- Annual energy generation (c)	66,300,000 kWh	- Energy Benefit (a) x (b) x (c)	Say USD 5,026,000

Source of data: JICA Survey Team based on Long Term Generation Expansion Plan 2009-2022 and Generation Expansion Plan 1998, CEB

Based on the power and energy value of the Project calculated above, the benefit from hydropower generation is estimated at USD 5,026,000 (LKR 578 million) per annum.

7.3.3 Domestic and Industrial Water Supply Benefits

Methodology and Basic Assumptions

Benefit of domestic and industrial water supply from the Moragahakanda reservoir was considered in terms of saving costs for alternative water source development such as groundwater. In determining the domestic and industrial water supply benefit, water price from alternative source was estimated based on the groundwater development scheme in the Mahaweli area. The alternative water source development cost excluded the cost of distribution pipeline to each connection. Water demand projection was also carried out according to the population increase in the districts to be served.

Water Demand Projection

Based on the domestic and industrial water supply demand projection and water balance simulation results explained in sub-section 2.2.3 (2), the additional domestic and industrial water supply amount from the Moragahakanda reservoir was estimated to be 63.7 MCM in total as shown in Table 7.3.8.

Table 7.3.8 Additional Domestic and Industrial Water Supply Amount from Moragahakanda Project

No	District	Current Water Production (MCM)	Water Production (MCM) in 2040	Additional Water Production (MCM)
1.	Matale	6.9	31.2	24.3
2.	Anuradhapura	10.4	15.0	4.6
3.	Trincomalee	9.1	34.2	25.1
4.	Polonnaruwa	2.3	12.0	9.7
Total		28.7	92.4	63.7

Prepared by the JICA Survey Team

Domestic and Industrial Water Supply Benefit

Estimated water price from alternative source for existing water users and the price of willingness to pay (WTP) for new water users are estimated at LKR 41.2/m^3 and LKR 32.1/m^3 respectively. The calculated value of alternative water source is shown in Table 7.3.9.

Table 7.3.9 Value for Alternative Water Source

Value for Alternative Water Source			
- Investment Cost	28,969,000. LKR	- Operation hrs	8 hour/day
- Service Life	20 years	- Daily Water Flow	250 m^3/day
- Discount Rate	10%	- Water Amount	91,250 m^3/year
- Capital Recovery Factor	0.1175	- Operation Cost	360,000 LKR/year
- Annualized Investment Cost	3,403,000 LKR/year	- Water Value	41.2 LKR/m^3

Prepared by the JICA Survey Team

Note: Capital Recovery Factor = i x $(1+i)^n$ / $((1+i)^n – 1)$; i = discount rate, n = service life

Benefit from domestic and industrial water supply from the Moragahakanda reservoir is calculated as shown in Table 7.3.10. The total annual net benefit from domestic and industrial water supply was estimated to be LKR 870 million in 2040. Detailed calculation of economic water supply benefit is shown in Appendix E-1.7.

Table 7.3.10 Economic Benefit of Domestic and Industrial Water Supply

Source	Water Supply ('000 m^3)	Water Price (LKR/m^3)	O&M Cost (LKR/m^3)	Total Benefit (LKR million)
Existing Water Users	19,200	(alternative) 41.2	9.13	616
New Water Users	32,000	(WTP) 20.6	9.13	368
Non-Revenue Water	12,500	-	9.13	-114
Total	63,700			870

Prepared by the JICA Survey Team

7.3.4 Fishery Benefit

Benefit in terms of fishery in the Moragahakanda reservoir was calculated based on the assumption shown in Table 7.3.11. Annual net benefit was estimated to be LKR 45.7 million.

Table 7.3.11 Economic Benefit of Fishery

Description	Unit	Amount
Anticipated Annual Average Fish Production	kg/ha	150
Reservoir Area	ha	2,900
Annual Fish Catch from the Reservoir	kg/ha	435,000
Farm Gate Price of Fish	LKR/kg	150
Production Cost	LKR/kg	45
Profit per kg	LKR/kg	105
Annual Net Income	LKR million	45.7

Source of data: Agriculture Division, MASL

7.4 Evaluation Results

EIRR was calculated from the cash flow table at 10.6% with LKR 1,232 million of NPV (B-C) and 1.08 of B/C, as summarized in Table 7.4.1. Cash flow table and economic evaluation results are shown in Appendix E-1.8. The evaluation result shows that this Project is viable in terms of the national economy.

Table 7.4.1 Economic Evaluation Results

	EIRR (%)	Net Present Value (LKR million)			B/C
		Benefit	Cost	NPV (B-C)	
The Project (Total)	10.6	17,602	16,370	1,232	1.08

Prepared by the JICA Survey Team

Sensitivity analysis results are shown in Table 7.4.2 in the cases of benefit decrease of 10% and 20% as well as cost increase of 10% and 20%, respectively.

Table 7.4.2 Sensitivity Analysis Results

Benefit	Cost		
	Base	+10%	+20%
Base	10.6%	8.7%	8.0%
-10%	8.7%	7.8%	7.1%
-20%	7.6%	6.8%	6.1%

Prepared by the JICA Survey Team

As mentioned in Sub-section 4.3.4, an amount of 50 to 60 MCM/year of water to be saved from improvement of the irrigation water use from 2022 could be flexibly utilized for the future increased water demand. However, it is not included in the benefit because no decision has been made on the usage of the saved water.

7.5 Annual Farm Income (Financial Evaluation)

Through the implementation of the Project, cropping intensity is expected to increase from 176% to 190% and yields of paddy and OFC expected to increase. In order to evaluate the change of financial viability of individual farmers through the project implementation in the Project area, annual farm income of typical farmers of “with” and “without” conditions was estimated based on the above mentioned financial crop budgets and the cropping pattern for benefit calculation. The results of net farm income estimation are shown in Table 7.5.1 and details of estimation are referred to Appendix E-1.9.

Table 7.5.1 Annual Farm Income in the Project Area

Unit: LKR

	Paddy (Maha)	Paddy (Yala)	OFC	Total in ha	Total in Ave. (0.91 ha)
Without	63,893	43,678	16,689	124,260	113,077
With	84,897	60,514	18,174	163,585	148,862
Balance	+21,003	+16,836	+1,486	+39,325	+35,786

Prepared by the JICA Survey Team

Average cultivation area is considered as 0.91 ha. The results showed the annual farm income after implementation of the Project will increase to approximately LKR 149,000 per anum compared to current condition, LKR 110,000 per year. This result showed the Project has the positive impact increasing the net farm income for individual farmers.

7.6 Operation and Effect Indicators

7.6.1 Operation Indicators

The following baseline and operation indicators are provisionally set at present. Data source and the reasons for setting the target figure of operation indicators are summarized in Appendix E-2.1.

Table 7.6.1 Operation Indicators

No.	Indicators	Current (2010)	Target (2018)
Irrigation and Agriculture			
1.	Area benefited by the Project (ha)	-	87,278 ha
2.	Cultivated area by crops (ha)	Paddy (Maha): 81,200 ha Paddy (Yala): 54,400 ha	Paddy (Maha): 84,800 ha Paddy(Yala): 66,700 ha (Increment 15,900 ha)
3.	Sufficiency rate of O&M cost (%) 1/	Irrigation: 78% Dam/Reservoir: 60%	Irrigation: 85% (LKR 6.7 million) Dam/Reservoir: 65% (LKR 44.4 million)
4.	Annual total volume of inflow to the reservoir (MCM/year) 2/	-	560 MCM/year
5.	Annual total volume of water release through intake facilities (MCM/year) 2/	-	550 MCM/year
6.	Volume of sedimentation in the reservoir (m^3/km^2/year)	-	340 m^3/km^2/year
Power Generation			
7.	Unplanned outage hours (hours/year or days/year)	-	48 hrs / year
8.	Capacity factor (%)	-	50%
Domestic and Industrial Water Supply			
9.	Population served (persons)	669,000 persons	877,000 persons
10.	Amount of water supply (m3/day)	108,000 m3/day	143,000 m3/day

Prepared by the JICA Survey Team

Remarks:

1/ Actual expenditure of O&M cost/requested budget of O&M cost (Total of the charge on the administrative agencies and that on the farmhouses, such as water charge, etc.)

2/ Annual inflow and outflow at Moragahakanda Dam

7.6.2 Effect Indicators

The following baseline and effect indicators are provisionally set at present. Data source and the reasons for setting the target figure of effect indicators are summarized in Appendix E-2.1.

Table 7.6.2 Effect Indicators

No.	Indicators	Current (2010)	Target (2018)
Irrigation and Agriculture			
1.	Production volume of major crops (t/year)	Paddy (Maha): 361,300 ton Paddy (Yala): 242,600 ton	Paddy (Maha): 407,000 ton Paddy (Yala): 313,500 ton (Increment 116,600 ton)
2.	Yield of major crops per unit area (Rainy season, Dry season) (t/ha)	Paddy (Maha): 4.45 ton/ha Pady (Yala): 4.46 ton/ha	Paddy (Maha): 4.8 ton/ha Paddy (Yala): 4.7 ton/ha
3.	Gross annual average farm income (LKR/year/household)	LKR 110,000 /year	LKR 130,000 /year
Power Generation			
4.	Net electric energy production (GWh/year)	-	66.3 GWh/year
5.	Maximum output (MW)	-	15MW (2 x 7.5 MW)
Domestic and Industrial Water Supply			
6.	Percentage of Population Served (%)	29%	35%

Prepared by the JICA Survey Team

7.6.3 Procedures for Monitoring of Operation and Effect Indicators

Project Implementation Unit (PIU) and O&M unit for Moragahakanda Dam under Headworks Administration, Operation & Maintenance (HAO&M) of the MASL will be established as the implementing and O&M agency of the Project. The MASL and its PIU and O&M unit will be responsible for compiling and monitoring information on the operation and effect indicators. Data collection will be carried out by respective O&M organizations as shown in Table 7.6.3.

Table 7.6.3 Share of Responsibility on Data Collection for the Indicators

	Indicator No.		Responsible Organization
	Operation	Effect	
Irrigation - System H - System I/H, M/H, HFC, G, D1 and D2	 No. 1,2,3 No. 1,2,3	 No. 1,2,3 No. 1,2,3	 MASL ID
Dam/reservoir	No. 4,5,6	-	O&M unit, MASL
Power Generation	No. 7,8	No. 4,5	CEB
Domestic and Industrial Water Supply	No. 9,10	No. 6	NWSDB

Prepared by the JICA Survey Team

7.7 Greenhouse Gas Emission Mitigation

Greenhouse gas (CO_2) emission mitigation amount was calculated based on "Guidelines for Formation of the Climate Change Project in the Electric Energy Sector (JBIC, 2008)". The CO_2 emission factor of thermal power plants in Sri Lanka was estimated to be 1.611 kg-CO_2/kWh based on the current power generation characteristics as shown in Table 7.7.1.

Table 7.7.1 Calculation of CO_2 Emission Factor

	Power Generation 1/		Power Production 2/	Efficiency	Carbon content	Fraction factor	CO_2 Emission factor
	GWh	Ratio	ktoe	%	tC/TJ		kg-CO_2/kWh
Oil	2336	39.3%	1238	16.2%	20.0	0.990	1.611
Gas	0	0.0%	0	0.0%	15.3	0.995	0.000
Coal	0	0.0%	0	0.0%	26.8	0.980	0.000
Others	3605	60.7%	342				
Total	5941						

Note:
- Calculated by JICA Survey Team in accordance with "Guidelines for Formation of the Climate Change Project in the Electric Energy Sector (JBIC, 2008)"
- Source of input data: 1/ Annual Report 2008, CEB, 2/ Energy Balance Sheet of Sri Lanka, International Energy Agency
- Conversion factors: 1 kWh = 860 kcal = 3.6×10^{-6} TJ = 8.6×10^{-5} ktoe

Therefore, the amount of Greenhouse gas (CO_2) emission mitigation is calculated as follows:

Greenhouse gas (CO_2) emission mitigation = 1.611 x 66,300 MWh = 106,800 ton-CO_2.

It is concluded that an amount of 106,800 ton-CO_2 can be reduced with the construction of a hydropower plant as a part of the Moragahakanda Development Project.

CHAPTER 8 ENVIRONMENTAL & SOCIAL CONSIDERATIONS

8.1 General

The purpose of environmental & social considerations work in this survey is to review the Environmental Impact Assessment (EIA) report prepared in 1998 and the draft Resettlement Implementation Plan (RIP) and assist the MASL in preparing the addendum of the EIA report and revising the RIP report as specified in the TOR of the survey. The major documents which are relevant to the EIA and RIP were collected and reviewed by the Survey Team during the first field survey. As results of the review, there are six major items to be added/updated in the EIA and draft RIP reports, namely: (1) providing supplemental descriptions of the impact assessment, (2) updating the Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP), (3) compiling the records of the public consultation meeting and the consent letters, (4) adding the newly identified affected households in System D1 and the transmission line alignment, (5) modifying the entitlement matrix, and (6) updating the resettlement schedule especially of System F, the resettlement site in Kalu Ganga. This chapter consists of six sections, namely: (1) description of the legal framework on land acquisition and resettlement; (2) assistance to the MASL in finalizing the draft RIP; (3) assistance to the MASL in preparing the addendum of the EIA; (4) summarized results of the supplemental survey, namely: interviews with wildlife management experts, improvement of the EMP and EMoP, interviews with stakeholders on resettlement, resettlement brochure preparation, and translation of the relevant documents; (5) recommendations on the EIA and RIP; and (6) JBIC Environmental Checklists.

8.2 Legal Framework of Land Acquisition and Resettlement

8.2.1 Legal Framework of Land Acquisition and Resettlement

Although the Land Acquisition Act of Sri Lanka was amended several times, it only prescribes the compensations for land, structures and crops but does not address key resettlement policy issues such as minimization of the scale of land acquisition or the number of resettlers through alternative considerations, compensation for informal land title holders, consultations with the Project Affected Persons (PAPs) and host communities, social and economic integration programs, and compensation at full replacement cost.

In 2001, the National Involuntary Resettlement Policy (NIRP) was established to provide the detailed procedure and requirements on land acquisition and resettlement which were not specified in the Land Acquisition Act. The series of guidelines on the policy were prepared with assistance from the Asian Development Bank (ADB) and World Bank (WB). Basically, the policy requires any project which causes resettlement to prepare the Resettlement Action

Plan (RAP). Specifically, the Act requires a comprehensive RAP for a project which covers 20 or more affected families and an abbreviated RAP for one that has less than 20 affected families (See Table 8.2 1 for the contents of the comprehensive and abbreviated RAP reports).

Additionally, for a project which covers 100 or more affected families, the RAP will be subject to the National Environmental Act and is considered a “Prescribed Project”, which is subject to EIA in accordance with Schedule I of Part IV-C of the National Environmental Act.

The summary of the relevant legal documents is provided in Table 8.2.2, and the procedure is shown in Figure 8.2.1.

Table 8.2.1 Contents of Comprehensive and Abbreviated RAP Reports

No.	Contents	Comprehensive RAP (20 or more affected families)	Abbreviated RAP (less than 20 affected families)
1	Project Description	X	
2	Potential Impacts of the Project	X	
3	Land Acquisition	X	X
4	Public Participation and Consultation	X	X
5	Policy and Legal Framework	X	X
6	Entitlements	X	X
7	Relocation Planning	X	
8	Rehabilitation	X	X
9	Resettlement Budget & Financing Plan	X	X
10	Phased Resettlement Implementation	X	X
11	Resettlement Management Organization	X	X
12	Monitoring & Evaluation	X	X
13	Grievance Redress and Social Mitigation Measures	X	X
14	Environmental Impacts of Resettlement	X	

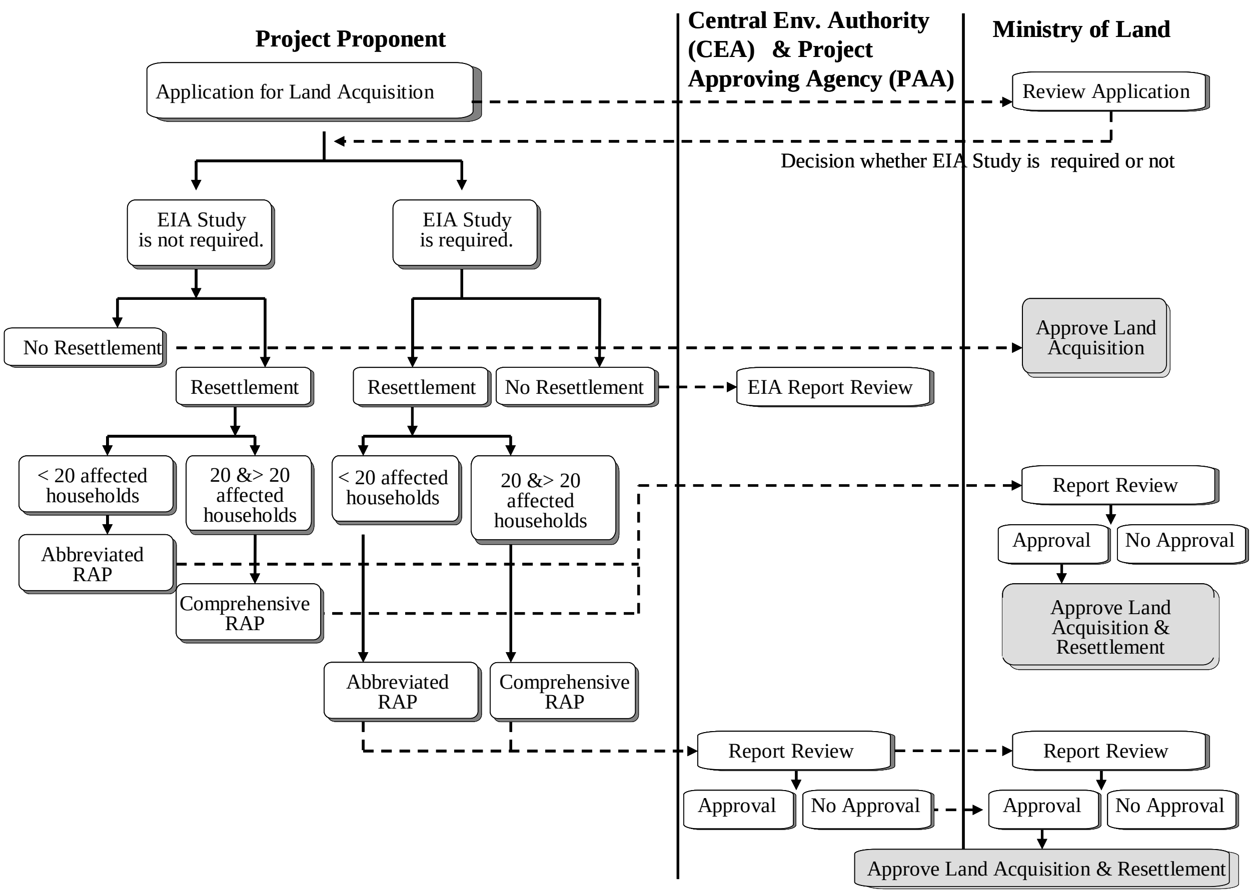
Prepared by the JICA Survey Team based on “the Guidelines for Preparing a Resettlement Action Plan (2003)”

Table 8.2.2 Legal Documents on Land Acquisition and Resettlement

No.	Name of Legal Documents	Remarks
1	Land Development Ordinances of 1935	✓ Provides for the systematic development and alienation of State land in Sri Lanka and the appointment of a Land Commissioner who shall be responsible for the general supervision and control of all government agents and land officers in the administration of State.
2	State Lands Ordinance 1949	✓ Makes provision for the grant and disposition of State land in Sri Lanka.
3	Land Acquisition Act (LAA) of 1950/1986	✓ Provides for compensation for lands, structures and crops but does not address resettlement issues.
4	State Lands (Recovery of Possession) Act of 1979	✓ Provides for the restitution of lands formerly owned by the State and unlawfully possessed or occupied.
5	Mahaweli Authority of Sri Lanka Act of 1979	✓ Establishes the Mahaweli Authority of Sri Lanka which shall be the authority responsible for the implementation of the Mahaweli Ganga development scheme. ✓ Further provides for the compulsory acquisition and possession of land in any special area.

No.	Name of Legal Documents	Remarks
6	National Environmental Act of 1980/1988	✓ Requires an approval of the Central Environmental Authority (CEA) for the project which causes involuntary resettlement exceeding 100 families other than resettlement under emergency situation.
7	Policy Guidelines on National Involuntary Resettlement of 2001	✓ To supplement the LAA, provides for resettlement issues. ✓ In line with international standards such as those of ADB and WB. ✓ Requires the compensation at full replacement cost. ✓ Requires a comprehensive RAP for the project which causes 20 or more affected families. ✓ Requires RAP with a lesser level of details for the project which causes less than 20 affected families.
8	Land Acquisition Regulations of 2008	✓ Compensation for land and assets at market value. ✓ Compensation covers the difference between the cost of reconstruction and the value of building. ✓ Compensation for disturbance based on the "value to owner" basis.
9	Circular No. 4/2008	✓ Notice for divisional secretaries and acquiring officers on the national policy for payment of compensation under the Land Acquisition Regulations of 2008. ✓ The contents are equivalent to the Land Acquisition Regulations.

Prepared by the JICA Survey Team based on the relevant legal documents and guidelines



Prepared by the JICA Survey Team based on the relevant legal documents and guidelines

Fig. 8.2.1 Resettlement and Land Acquisition Process in Sri Lanka

8.2.2 Status of Land Acquisition and Resettlement of the MADP

1) RIP Report

The census and the socio-economic survey were conducted for the Mahaweli Agricultural Development Project (MADP) in September 2008 by the Survey Department[1] in accordance with the Land Acquisition Procedure of Sri Lanka. Based on the results of the census and socio-economic survey, the draft final RIP report was prepared by the MASL in April 2009 and is expected to be finalized by the MASL in July 2010 by incorporating the comments of JICA and the Survey Team.

2) Land Acquisition Procedure after RIP Report Preparation

The MASL is currently preparing the application of Section No. 2[2], which the project proponent prepares for the application for the land to be acquired, and will submit it to the Ministry of Land and Land Development in accordance with the Land Acquisition Act of 1950.

8.3 Assistance Provided to the MASL's RIP Revision

8.3.1 Identification of the Relevant RIP-related Documents

The resettlement-related documents, namely: (1) draft RIP report, (2) inventory survey report, (3) two socio-economic surveys of MADP (potential resettlers) and System F (one of the potential host communities), (4) summary of public consultation activities, and (5) maps of resettlement sites, were collected during the first field survey between January and February 2010. The full list of the documents is provided in Section F.1 of Appendix F.

8.3.2 Identification of the RIP Components to be Revised

The comments and recommendations on the draft RIP reports were prepared by the Survey Team based on the review of results of the previously mentioned documents and results of the site visit between 2-4 February 2010 and 24-25 April 2010. Currently, the MASL has been incorporating all the comments of the MASL, JICA and the Survey Team and is planning to finalize the report in July 2010. Major items to be revised are summarized in the following Table 8.3.1.

[1] The Survey Department is a national survey and mapping organization and the oldest government department in Sri Lanka established on 2 August 1800.

[2] Upon the direction of the minister who decides that land in any area is needed for public purpose, the Acquiring Officer publishes notice under Section 2 to this effect and thereby, Authorized Officers are permitted to make investigations for selecting such land (Section 2 of Land Acquisition Act of 1950).

Table 8.3.1 Major Items Revised/to be Revised in the Draft RIP Report

No.	Item	Current Status
1	Potentially displaced persons in the newly changed transmission line alignment	✓ It was suggested to conduct the field survey to identify the potential PAPs affected by the newly changed transmission alignment. ✓ It was conducted by the Survey Department for the MASL in May and April 2010 and was included in the RIP report.
2	Potentially displaced persons in the irrigation area in System D1	✓ It was suggested to include nine households to be affected and displaced by the branch canals in System D1 in the final RIP report even though the impact might be mitigated by the review of the canal alignment in the next stage. ✓ It was included in the RIP report.
3	Entitlement assurance letter and consent letters	✓ The process and latest results were included in the RIP report. ✓ The sample entitlement assurance letter and the consent letter in Sinhala were translated into English and attached in the RIP report.
4	Entitlement matrix	✓ It was suggested to revise the compensation policy for land since initially, it was based on the compensation for land at market value in accordance with the Land Acquisition Regulations 2009. ✓ Therefore, it was suggested to include the compensation for land at full replacement cost (i.e., the market value and the transaction cost) or equivalent in the RIP report as defined by the NIRP and the WB's Operational Policy (OP) 4.12 Involuntary Resettlement. It was included in the RIP report.
5	Resettlement schedule	✓ Since the Project needs to be synchronized with the Kalu Ganga Development Project for the resettlement in System F, it was suggested to prepare the detailed and more practical phase-wise resettlement schedules for the families to be displaced from the dam axis, the rest due to the reservoir area, elephant corridor, deviated road and branch canal alignment of System D1. It will be included in the RIP report. ✓ It was suggested to provide more details on the availability of social infrastructures (especially irrigation and drinking water supplies) in the resettlement sites in the RIP report. It was included in the RIP report.
6	Public consultation for the RIP	✓ It was suggested to include the records of the public consultation on resettlement (e.g., agenda, distributed handouts, venues, dates, participants' lists, and pictures). Since some data were not available, the date, venue, number of participants and topics were included in the RIP report. ✓ It was also suggested that the entitlement package, planned schedule, available social infrastructure in the resettlement sites and grievance redress mechanism in the draft RIP report need to be well explained to PAPs in the future public consultation meetings. It was agreed with the MASL to organize public awareness programs (equivalent to public consultation meetings) in July 2010.

Prepared by the JICA Survey Team

The above-mentioned items are briefly discussed in the following sections.

1) Census Survey for the New Transmission Line Alignment

Due to the change in the transmission line alignment, the field survey was not yet conducted along the new alignment during the first field survey of the Survey Team. Although most part of the transmission line will be constructed along the deviated road and the impact of involuntary resettlement was expected to be insignificant, it was suggested to conduct the census survey so as not to underestimate the potentially displaced persons.

The census was conducted in March and April 2010 by the Survey Department and MASL on the 24 land owners, and 3.14 ha to be affected by the land acquisition for the transmission line. The details of the survey are attached in Section F.23 of Appendix F.

2) Households Physically Affected by the Branch Canal in System D1

According to the MASL, nine more households to be affected by the branch canal were identified in System D1. However, it is planned by the MASL that the alignment of the branch canal will be reviewed in the next study stage to minimize the affected persons as much as possible. However, the data of the affected persons was added by the MASL in the RIP report.

3) Entitlement Assurance Letter and Consent Letter

The consent letter form was distributed together with the entitlement assurance letter to the potential resettlers' households on 30 June 2009 (See a sample entitlement assurance letter and consent letter in Section F.24 of Appendix F). The entitlement assurance letter includes the overall compensation policy based on the Land Acquisition Regulations of 2008 and the other MASL's additional benefits.

According to the MASL, as of 5 May 2010, the signed consent letters from 1,509 households in the tank-bed area and 63 in the proposed elephant corridor out of the 1,572 households to be displaced (approximately 99%) were obtained by the MASL as shown in the following Table 8.3.2.

As for the households to be affected by the branch canal in System D1, it is planned by the MASL that the consent letter will be collected once the alignment of the branch canal is reviewed and finalized in the next study stage to avoid unnecessary confusion among the affected households.

Table 8.3.2 Number of Consent Letters Obtained by the MASL

Location	Number of Consent Letter	Remarks
Tank-bed of the proposed dam	✓ 1,509 out of 1,515 affected households	✓ Obtaining the rest of the consent letters from six affected households was requested by JICA preferably before the loan appraisal mission planned in September 2010.
Proposed Elephant Corridor	✓ 57 out of 57 affected households	✓ 100% of the consent letters were collected from the proposed elephant corridor.
System D1 (Irrigation Area)	✓ None	✓ Nine households affected by the branch canal were temporarily identified in System D1. Since the alignment of the branch canal will be reviewed in the next stage of the study to minimize the affected households, consent letters will not be obtained by the MASL during this study stage.

Source of data: MASL

4) Entitlement Matrix

The compensation policy for land in the current entitlement matrix, which is based on market value, is suggested to be modified to the replacement cost consisting of the market value and transaction costs in accordance with NIRP and the WB OP 4.12. There seems to be a discrepancy between the descriptions of NIRP and the Land Acquisition Regulations of 2008 in Sri Lanka. Even though NIRP states that compensation for the full replacement cost should be paid, the Land Acquisition Regulations mentions that the compensation for land at the market value shall be paid and "3.10 All the other expenses to the owner due to the acquisition" or "3.12 When an owner of a house or of an investment property is displaced, additional 10% payment based on market value." shall be paid "after taking into consideration the written claims made." Therefore, it is suggested to include the additional compensation of Section 3.10 or Section 3.12 for the loss of land so that the amount which is equivalent to the transaction costs can be provided to the resettlers in addition to the current compensation for land at market value.

5) Resettlement Schedule

The schedule of the resettlement needs to be updated by considering the schedule of irrigation water provision in the resettlement sites. Previously, the resettlement schedule was not prepared taking into account the schedule of the Kalu Ganga development project because they are different projects, although the resettlement site will be prepared in System F of the Kalu Ganga project site. In System F, the draft phase-wise schedule was prepared by the MASL since the gradual phased-resettlement is planned by the MASL.

Table 8.3.3 Resettlement to System F by Phases

Phase	Location	Number of Potential Resettlers	Remarks
1	Resettlers displaced from the dam axis to System F	✓ Approximately 221 households	✓ Will be initially moved to System F before the Kalu Ganga with temporary irrigation water provision from the water tanks for paddy farming during the Maha season and horticulture farming during Yala season and long-term drinking water provision from the community wells.
2	Resettlers displaced from the reservoir and other areas to System F	✓ Approximately 1,043 households	✓ Will be moved only after the irrigation water from Kalu Ganga Reservoir is available; ✓ Otherwise, there will be additional compensation for the loss of farming such as employment opportunity provision or cash compensation for the loss of employment.

Source of data: MASL

6) Public Consultation for the RIP

As for the public consultation, although the records of public consultation meetings on resettlement were not included in the draft RIP report, continuous public consultation activities have been conducted since 2006, such as Participatory Rapid Appraisal (PRA) planning and the public awareness programs by the MASL. The provisional brief summary prepared by the MASL and the Survey Team is provided in the following Table 8.3.4, and the full provisional summary is attached in Section F.26 of Appendix F. The same was added in the RIP report.

Table 8.3.4 Brief Summary of the Public Consultation Activities on RIP

No.	Date	Venue	(1) No. of participants; and (2) Type of participants	Type of Public Consultation
2006				
1	26 June 2006	D.S. Office Naula	(1) 60 Participants (2) Officers	Socio-economic survey awareness meeting
2007				
2	17 Aug. 2007	D.S. Office Naula	(1) N.A. (2) Representatives of gov't & non-gov't officers, GN officers, representatives of farmers' organization	Coordinating committee meeting
3	27 Sept. 2007	Elahera School	(1) 30 participants (2) Businessmen	Discussion on Elahera Town development
4	8 Oct. 2007	Helabagahawatta	(1) 38 participants (2) Catchment area community	Situational analysis
5	12 Nov. 2007	Maragamuwa Temple	(1) 50 participants (2) Village people	Consultation & awareness meeting
6	22, 27, 28 Nov. 2007	Elagamuwa, Kambarawa, Kadawatha, Thalagoda, Galpougolla	(1) 354 participants (2) Community members	Awareness program
7	30 Nov. 2007	Development Centre Girandurukotte	(1) 28 participants (2) Samurdhi officer, Grama Niladari, agricultural extension officers	Awareness program
8	11 Dec. 2007	Kongahawela Village	(1) 42 participants (2) Community-based organizations (CBOs) leaders and community	Awareness program
2008				
9	14-15 Jan. 2008	Kadawatha Village	(1) 98 participants; (2) Farmers, women of displaced families	Participatory rapid appraisal (PRA) program for situational analysis
10	14-15 Jan. 2008	Talagoda Village	(1) 195 participants (2) Farmers, youth, women of displaced families	PRA program for situational analysis
11	15 Jan. 2008	Galporugolla	(1) 134 participants; (2) Community members	PRA program for situational analysis
12	16 Jan. 2008	Kambarawa Village	(1) 192 participants; (2) Community members;	PRA program for situational analysis
13	17 Jan. 2008	Galporugolla Village	(1) 141 participants (2) Farmers, youth, women of displaced families	PRA program for situational analysis
14	18-19 Jan. 2008	Elegamuwa Village	(1) 172 participants (2) Farmers, youth, women of displaced families	PRA program for situational analysis
15	19 Jan. 2008	Kongahawela Village	(1) 134 participants (2) Farmers, youth, women of displaced families	PRA program for situational analysis
16	15 Feb 2008	Galporugolla Village	(1) 134 participants (2) Farming community	Awareness program

No.	Date	Venue	(1) No. of participants; and (2) Type of participants	Type of Public Consultation
17	20 Feb 2008	Hattota Amuna Laggala – Pallegama	(1) 28 participants (2) Farmer-leaders	Awareness program
18	3 Apr. 2008	D.S. Office Naula	(1) 59 participants (2) Health , Education, Police, Wildlife Department, etc.	Regional planning workshop
19	1-3 May 2008	Millagahamulatenna Village	(1) 130 participants (2) Community members	PRA program for situational analysis
20	5 May 2008	D.S. Office Laggala Pallegama	(1) 110 participants (2) Officers, farmers & political members	Coordinating committee meeting
21	29-30 May 2008	Konghawela Village	(1) 134 participants (2) Community members	PRA program for situational analysis
22	29 May 2008	Medapihilla Village	(1) 100 participants (2) Community members	PRA program for situational analysis
23	29-31 May 2008	Rajawela Village	(1) 187 participants (2) Community members	PRA program for situational analysis
24	30 May 2008	Galabada Village	(1) 37 participants (2) Community members	PRA program for situational analysis
25	1-2 June 2008	Moragolla Village	(1) 75 participants (2) Community members	PRA program for situational analysis
26	3 June 2008	Galaboda Village	(1) 55 participants (2) Community members	PRA program for situational analysis
27	30 June 2008	Millagahamullathenna Village	(1) 129 participants (2) Community members	PRA program for situational analysis
28	07Aug. 2008	District Secretariat Office - Matale	(1) 14 Participants (2) District Secretary-Matale, relevant representatives of government organizations, MASL officers	Discussions
29	14 Aug. 2008	Kambarawa & Elagamuwa villages	Not available	Awareness program
2009				
30	8 Dec. 2009	D.S. Office, Naula	1).Not available 2.) District secretary, divisional secretary, wildlife officers, forest officers, Mahaweli officers, bank officers, education officers, politicians, and other relevant officers	Not available
2010				
31	5-8 May 2010	Project site	(1) 40 participants (2) 5 local government officials, 6 local leaders, 5 CBOs and 32 potential resettlers	Interviews

Source of data: MASL

8.4 Assistance Provided to the MASL's EIA Revision

8.4.1 Identification of the Relevant EIA-related Documents

The EIA for the MADP is effectively composed of a number of reports, letters and documents which have been prepared sequentially over the years. This is not the best way to conduct an EIA, but it arose from the fact that implementation of the Project was postponed over a period of many years, during which national and international EIA expectations/requirements increased.

An EIA was conducted for the whole of the Accelerated Mahaweli Development Programme (AMDP) in 1980. A supplemental environmental report specifically concerning the MADP was then requested by the Central Environmental Authority (CEA), and conducted by the TEAMS consultancy in 1998. The resulting report (October 1998) was subsequently accepted by the Project Approving Agency (PAA), namely, the Ministry of Agriculture, Forestry, Food and Co-operative Development, as the EIA for MADP.

Since 1998, the expected content of an EIA has increased considerably. As a consequence, when PAA granted approval of the EIA on 26 October 2001, it applied a number of additional environmental and social conditions, and then applied further conditions each time the Environmental Clearance was extended, firstly on 16 March 2006 and then again on 26 October 2007 (until 25 October 2010). These conditions were a mixture of administrative requirements, specific mitigation measures, requests for further study/reports and other technical elements (For the detailed conditions, see Table 8.4.1 in the following section). All of these are items that would currently be expected to be included within an EIA for a project of this type.

As part of the compliance with the conditions of the EIA approval, two major studies/reports were conducted for the MASL, viz:

(a) Biodiversity Assessment of the Moragahakanda Agricultural Development Project, Final Report, IUCN (International Union for Conservation of Nature and Natural Resources) Sri Lanka, June 2007; and

(b) Comprehensive Watershed Protection Management Plan and Mitigatory Plan, Final Report (Vols. 1 & 2), University of Sri Jayewardenepura, June 2007.

These studies were well-executed, and the results were accepted by the MASL. The recommendations contained in these reports were then incorporated into the following two documents, which will be implemented by the MASL (See comments in Section 8.4.2 concerning the need to improve these two documents):

(a) MADP Total Environment Mitigation Plan; and

(b) MADP Summary Environmental Monitoring Plan.

It should be noted that the 1998 EIA for MADP addressed both the upstream development (dam, reservoir, etc.) and the downstream irrigated resettlement area in System D1 for PAPs displaced from the reservoir basin. However, the current expectation is that some of the PAPs (the majority) will be resettled in a further development of System F on the Left Bank of the Kalu Ganga Development Project. The development of that area is covered by the EIA for the Kalu Ganga Dam/Reservoir project, published in March 2008. It was a more comprehensive and detailed EIA study than that originally conducted for the MADP and is considered to be adequate.

A complete list of environmental and social considerations documents related to the MADP is provided in Section F.1 of Appendix F.

8.4.2 Identification of EIA Components to be Added (Including the Fulfillment of the EIA Conditions)

The MASL complied with the conditions applied to the Environmental Clearance for the MADP (see Table 8.4.1). In the table, the conditions of the EIA approval letters and the implementation status are summarized.

In addition to the items required in the EIA approval letters, there are two items added by the Survey Team. Firstly, the Total EMP and the Summary EMoP for MADP mainly cover mitigation measures for the natural environment. Then, it was suggested for the MASL to include wider items such as mitigation measures for pollution-related and social impacts as well as quantitative monitoring methods, applicable standards and specific frequency to fulfill the current international standard. Therefore, EMP and EMoP have been revised and updated as part of the JICA Survey.

Secondly, the description of the environmental impact assessment was not provided in the original EIA as it was ranked without any explanation. Explanations have therefore been included in the scoping results of the Survey Team, which were based on available publications and the results of the field visits (see Section F.3 of Appendix F).

Table 8.4.1 Summary of Technical Elements of a Combination of All Extant/Relevant Conditions Applied to MADP Environmental Clearance

No.	Conditions in the EIA Approval Letters	Current Implementation Status
1	Timber resources in the reservoir and resettlement areas to be identified by Forest Department and extracted.	The MASL to take action in consultation with Forest Department prior to commissioning of the dam.
2	Quarry and borrow sites to be mapped and approved, and licenses for extraction to be obtained.	Expected sites mapped in the Lahmeyer FS report of Aug 2001 (Drwg. No. PM-18-02). Changes in the location will be informed by the MASL to the relevant agencies. Approvals/licenses to be obtained by the MASL prior to construction.
3	Approvals to be obtained for the operation of blasting and major equipment.	Approvals/licenses to be obtained by the MASL prior to the start of construction.
4	Blasting during daytime only.	Included in EMP
5	Exposed areas to be protected from erosion by rain or from the raising of dust.	Included in EMP
6	Heavy truck movements to be approved and conducted during non-peak periods.	Included in EMP
7	Transport to be controlled to prevent dust/nuisance.	Included in EMP
8	Above conditions to be attached to construction contracts.	The MASL to act within tendering process and after selection of contractors.
9	Spoil disposal not to damage or cause nuisance to environment.	Appropriate spoil disposal methods/sites identified in the EMP.

No.	Conditions in the EIA Approval Letters	Current Implementation Status
10	Borrow pits, haul roads and temporary storage areas to be rehabilitated prior to commissioning.	The MASL to contract rehabilitation works (as they have already done for the preliminary works).
11	Comprehensive Watershed Management Plan (WMP) to be prepared and submitted prior to construction	Completed under the title of "Comprehensive Watershed Protection Management Plan and Mitigatory Plan" (USJ, 2007).
12	Soil conservation measures required within the catchment and command areas.	Included within the Comprehensive Watershed Protection Management Plan and Mitigatory Plan (USJ, 2007).
13	Agriculture Development Plan (ADP) required, including mitigation for water pollution or soil salination.	Completed by the MASL Development Division Under the title of "Moragahakanda Agricultural Development Plan, 2007".
14	Environmental flow to be provided downstream of Elahera Anicut.	Agreed by the MASL. Minimum flow rate defined in EMP.
15	Mitigation measures to be developed for water quality issues and downstream aquatic ecology.	Measures, including flow rates, defined in the EMP.
16	Detailed biodiversity study to be undertaken and mitigation measures developed for flora & fauna.	Completed under the title of "Biodiversity Assessment of the Moragahakanda Agriculture Development Project" (IUCN, 2007).
17	Moragahakanda catchment and area surrounding the reservoir to become a new protected area.	Agreed by the MASL. Details being developed in concert with the Department of Wildlife Conservation. Expected to be Nature Reserve initially and then a National Park. (Southern part is a Forest Reserve.)
18	Drainage Plan to be developed.	Brief Drainage Plan prepared by the MASL, largely concentrating on drainage culverts for the new access road. (Return drainage in the MASL irrigated areas is normally via natural watercourses, of which there are many.)
19	Land stability study to be conducted.	Issue included within the Comprehensive Watershed Protection Management Plan and Mitigatory Plan (USJ, 2007) and specifically addressed by the 'Detailed Geological Study w.r.t. the Land Stability of Moragahakanda Agricultural Development Project', National Building Research Organization, November 2008.
20	Soil/spoil not to be dumped in water bodies/courses.	Included in EMP.
21	Canal bunds and road banks to be turfed/ protected as appropriate.	Specified in Comprehensive Watershed Protection Management Plan and Mitigatory Plan (USJ, 2007). Also included in EMP.
22	Cross culverts to be provided for roads.	Included within Drainage Plan. Included in EMP.
23	Elephant corridors and extensions of protected areas to be created before construction.	Specified in Biodiversity Assessment and Comprehensive Watershed Protection Management Plan and Mitigatory Plan (USJ, 2007). Accepted by the MASL. Details being developed in concert with the Department of Wildlife Conservation. The MASL has included evacuation of the elephant corridor and construction/maintenance of electric fences in the project budget.
24	Comprehensive protected area management system to be developed.	As above.
25	Protected areas to be properly gazetted.	As above. New protected areas will be gazetted when the boundaries have been finalized.
26	Inventory of endangered medicinal plants, followed by nursery/planting.	Inventory provided in Biodiversity Assessment. Nursery/planting specified in the Comprehensive Watershed Protection Management Plan and Mitigatory Plan (USJ, 2007).

No.	Conditions in the EIA Approval Letters	Current Implementation Status
27	Road design and construction to follow guidelines stipulated by relevant authorities.	The MASL to comply, as reflected in the EMP.
28	Relocation of people to be minimized.	According to the F/S 2001, the number of potentially displaced persons was reduced by considering the alternative heights of the dam. Additionally, nine families affected by the branch canal will be reviewed and minimized by the next study stage.
29	Resettlement, compensation and income replacement program to be developed for all PAPs.	The programs were developed in the draft RIP report.
30	Resettlement plan to include those to be displaced by the proposed elephant corridor.	The draft RIP report includes 52 households in the new elephant corridor to be resettled.
31	Compensation to be paid prior to relocation.	It is addressed in the draft RIP report.
32	Damage to cultural/heritage sites to be avoided.	'Chance finds' arrangements for archaeological artifacts included in the EMP. Assistance from the Department of Archaeology will be requested.
33	Noise and vibration levels to comply with national standards.	The MASL will comply. Defined in EMP.
34	Discharge of cement, fuel, oil and plastics into water to be prevented.	The MASL will comply. Referenced in EMP.
35	Oil/water separation devices to be installed as appropriate.	The MASL will comply. Referenced in EMP.
36	Sanitary facilities with treatment to be provided at construction sites.	The MASL will comply. To be defined in EMP.
37	Environmental monitoring plan to be prepared with parameters, frequencies, responsibilities, etc.	EMoP completed by the Survey Team.
38	Monitoring committee to be established.	Committee established. Membership as specified in the second extension of the Environmental Clearance.
39	MASL budget for all the above is required.	Budgeted in EMP, EMoP, WMP and RIP.

Prepared by the JICA Survey Team
Note: See Section 8.6 below concerning the proposed status of the main EIA-related documents.

8.4.3 Further EIA Procedure

The original Environmental Approval/Clearance of the MADP, issued on 26 October 2001 by the Ministry of Agriculture, Forestry, Food & Co-operative Development, relates to '*the construction of a dam (rock-fill dam in the main dam, second saddle dam/s and concrete facing, etc.)*'. Since that approval, the Feasibility Study changed the design to include a Roller Compacted Concrete (RCC) main dam. However, the present study has returned the design to the original concept, with a rock-fill main dam, RCC (or concrete) saddle dam No. 1 and earth-fill saddle dam No. 2 (currently under construction by the MASL). Circumstantially, the original approval is valid for the presently proposed design. The approval is also '*subject to the final details being re-designed to address engineering considerations of dam construction and safety* (the letter of Ministry of Agriculture, Forestry, Food and Co-operative Development on the second EIA approval extension, "Moragahakanda Agricultural Development Project, Environmental Impact Assessment" dated on 26 October 2001*)*'. This therefore allows for the design optimization process that has been started by the present study and will be completed by the final design consultants.

The approval has been extended twice, with the second extension being valid until 25 October 2010. A further extension will therefore be required, and the MASL is planning to submit the application for the extension 60 days before expiry of the present extension. The second extension was for a period of three years. It is expected that the third extension will be for at least another three years, but it may be possible for the MASL to negotiate a longer extension.

The validity of environmental approval for projects is normally needed until the completion of construction. The MASL seeks extension until the completion of construction in the case of the MADP, too.

8.4.4 Preparation of the Addendum to EIA-related Documents

The additional documents which are necessary to meet the JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002) will not be updated but will be prepared as addendum since the EIA report has already been prepared and approved by the Government of Sri Lanka. The addendum is planned to consist of (1) the updated EMP, (2) the updated EMoP including a monitoring form, (3) descriptions of the impact assessment, (4) JBIC environmental checklists, and (5) public consultation records (for the first four items, see Sections F.17, F.18, F.2, F.5 of Appendix F, respectively).

The EMP, EMoP, and JBIC checklists will be discussed later in Section 8.5 and Section 8.7, respectively. In this section, the wildlife management program, environmental flow (as part of EMP) and public consultation on EIA will be briefly discussed.

1) Wildlife Management Program

As indicated by the attached JBIC environmental checklists, there are many environmental issues that need to be considered within a major project of this type (and they have been addressed within the checklists). Given the nature of the environment in which the dam and reservoir will be developed, conservation of biodiversity is at the forefront of these environmental issues.

There are already several protected areas in the vicinity of the project (see Sections F.6 and F.7 of Appendix F). The Minneriya-Giritale Nature Reserve is immediately to the north and the Elahera Sanctuary is to the north-east of the Moragahakanda reservoir basin. An eastern extension of the Elahera Sanctuary also provides a link to the Wasgomuwa National Park to the east. In the northern part of the Project area, there is already an arc of existing protected areas around the north and west of the System D1 resettlement area, formed by the Somawathiya and Kaudulla National Parks, which in conjunction act as an elephant corridor. (The boundary between the corridor and System D1 will be electric-fenced; see below.) In addition, there is an existing Jungle Corridor (gazetted 2004) between Kaudulla National Park and Minneriya National Park, thus forming a complete circuit of elephant habitat.

Additional protected areas are to be established as described in Table 8.4.2, principally to maintain the movements of Sri Lanka's 'flagship' animal species, the elephant. However, the elephant acts as a surrogate for the many other species in the area, so protecting the habitat of the elephant will also provide for the conservation of biodiversity more generally. The proposed additional protected areas therefore play an important part in the safeguard of wildlife/biodiversity. Their establishment, fencing and management will indicate MASL's commitment to take environmental issues seriously within the development of MADP.

Table 8.4.2 Proposed New Protected Areas in MADP[3]

No.	Proposed Protected Area	Current Status
1	Elephant Corridor - an elephant corridor between Wasgomuwa National Park and Minneriya-Giritale Nature Reserve.	This is the existing Elahera Sanctuary which links Wasgomua NP and Minneriya-Giritale NR. It will be gazetted as a Jungle Corridor in approximately 18 months, after its human occupants have been evacuated. An electric fence will protect the System F resettlement area from elephant damage.
2	Conservation Area around the Moragahakanda Reservoir.	This will allow the movement of elephants around the southern and western margins of the new reservoir and will provide some protection for the immediate watershed. It will initially be gazetted as a Nature Reserve and then possibly as a National Park if interest in the area merits it. Its eastern and western boundaries will be electric-fenced to protect neighboring communities, including the System F resettlement area.

Prepared by the JICA Survey Team

The creation of these new protected areas has been agreed between the MASL and the Department of Wildlife Conservation. Definition of their final boundaries is under discussion between the parties, and they will ultimately be gazetted as indicated in the table above. These protected areas are of critical importance to the environmental acceptability of the project. It is therefore recommended that they are gazetted within the stated timetable.

The construction of elephant-proof electric fences along some of the boundaries of the new protected areas is necessary in order to corral elephants in their movements/migration between protected areas and to prevent human-elephant conflict. The fences are thus an integral part of the plan to sustain wildlife while developing the Moragahakanda and Kalu Ganga projects. The

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[3] Under the Flora and Fauna Protection Ordinance, as amended by Act Nos. 44 of 1964, 1 of 1970, 49 of 1993 and 22 of 2009, the Department of Wildlife Conservation classifies Sri Lankan protected areas into the categories below, according to their objectives:

1. Strict Natural Reserves - SNRs are protected as pure natural systems and human activities are highly restricted. Research is allowed in SNRs under the supervision of Department of Wildlife Conservation staff and with the prior approval of the Director. People cannot live within SNR.
2. National Parks - National Parks are areas in which the public is allowed to view and study wildlife. Rules and regulations are applied for the protection of wildlife and their habitats. People cannot live within NP.
3. Nature Reserves - Wildlife viewing and studying are restricted in these areas. However, as in SNRs, scientific research is encouraged under the supervision of Department of Wildlife Conservation staff. These areas differ from SNRs in that traditional human activities are allowed to continue, but people cannot live within NR.
4. Jungle Corridors – Jungle Corridors are designed to provide a protected physical link between two protected areas to facilitate the movement of elephants. People must not live within such corridors.
5. Refuges (no longer used).
6. Marine Reserves – Not applicable to MADP.
7. Buffer Zones – Semi-protected areas established between protected areas and the surrounding lands.
8. Sanctuaries - Sanctuaries ensure the protection of wildlife on private lands, i.e., those outside the normal control of the State. The level of protection is the same as for a Nature Reserve. In Sanctuaries, habitat protection and human activities are allowed to occur simultaneously and people are allowed to live in Sanctuaries. No permission from the Department of Wildlife Conservation is required to enter these lands.

MASL has budgeted the following for electric fences within the two projects:

(a) Moragahakanda – 165 km.; capital cost of Rs 61.5 million, maintenance cost of Rs 15 million; and

(b) Kalu Ganga – 500 km., capital cost Rs 232 million, maintenance cost of Rs 50 million.

This amount of fencing is a huge undertaking, particularly its maintenance. (Elephants will very quickly destroy fences once their electric protection fails.) It is envisaged that the MASL will contract the Department of Wildlife Conservation to maintain the fences using a so-called 'revolving fund' (trust fund). About Rs 65 million amount of capital will be invested with the expectation that the interest will be sufficient to fund the maintenance of the fences, which will require some 22 laborers, tractors and grass-cutting machines. The Department of Wildlife Conservation is currently funding research on the optimization of electric fence design.

It is recommended that a guarantee that adequate funding will be available for both the construction and maintenance of these fences should also be seen as a condition for proceeding with the project.

The development of MADP will inundate a considerable area of elephant habitat and it has also encroached on a small portion of the Minneriya-Giritale Nature Reserve at its southern tip where the Naula-Elahera road diversion has been constructed. These reductions in elephant habitat and potential obstructions to movement could also have an influence on the wider elephant population. The MASL has therefore agreed to compensate for these losses by funding a variety of elephant-related conservation measures to be implemented by the Department of Wildlife Conservation. These include the construction and maintenance of electric fences as mentioned above, the establishment of CBOs for fence maintenance, a number of measures for the improvement of habitats and their conservation, and the encouragement of ecotourism. The Rs 148 million cost of this total package has been agreed in a Memorandum of Understanding (MoU) between the MASL and the Department of Wildlife Conservation, which will be signed shortly (expected in June 2010). The signing of this MoU is highly recommended to ensure the implementation of the wildlife management programs by relevant organizations.

2) Minimum Downstream Flow

In any proposed dam project, the minimum flow (= environmental flow or compensation flow) to be maintained in the river downstream of the dam is always an important consideration. However, the case of the Moragahakanda Dam is very unusual. The Amban River is already a highly controlled river, being intercepted by the Bowatenna Dam upstream of Moragahakanda, and by the Elahera Anicut, some 2 km downstream of the proposed dam. The Elahera Anicut has historically diverted much of the river flow for irrigation purposes.

There are two types of stream found in Sri Lanka. The first category, the perennial one, is called river while the second, which has seasonal flows, is called oya. The rivers are visible in the wet zone of Sri Lanka while oyas are visible in the dry zone. The Mahaweli is the only river, which starts from central hill in the wet zone and flows towards the northern dry zone carrying the largest flow volume into the sea. The Amban River is a tributary of the Mahaweli River and starts from the wet zone and flows to the border of the dry zone through the project area. The Amban River has significant amount of inflows into the river through its entire river course, even during the Yala season mainly due to its location in the intermediate zone. Historically, the inflows into this river had been diverted at two locations, namely, Elahera and Angamedilla, to ancient reservoirs located away from the river but within the same river basin. There were tens of thousands of paddy lands fed by these reservoir systems. As a result, the inflow to the river is further enriched with drainage flows from the nearby irrigation systems and seepage water from the main supply canals. The availability of water in the river would contribute towards maintaining more than sufficient river flow required for the well-being of the ecosystem including basic needs of the inhabitants.

The Mahaweli diversion into the Amban River basin since the mid-70s has done tremendous improvement to the water availability in this system until now. This is mainly through increased water usage within the system throughout the year resulting to improved river flows even below the Elahera and Angamedilla Anicuts. The proposed MADP would further improve this situation mainly during the Yala season. Qualitatively, this system would benefit tremendously from this project including river flows below Elahera and Angamedilla over and above the historic figures. However, finding a quantitative minimum value for the environmental flow downstream of Elahera is also a requirement of this project, and the quantitative value was calculated by considering the above-mentioned unusual features of the Amban River.

One can define the Minimum Environmental Flow as the larger of either the observed minimum monthly flow or 10% of the long-term average of minimum monthly flow, which is required for maintaining the livelihood of all the inhabitants in and around the area. Accordingly, assuming both Bowatenna Reservoir and Elahera Anicut are nonexistent, the corresponding flow will be 3.6 million cubic meter (MCM) per month which is approximately 1.4 m^3/s (see Section F.13 of Appendix F for the Elahera River flow) out of 2.25 (=10% of 22.5 June flow) and 3.6 minimum flow over 60 years of records. Therefore, it is suggested that 3.6 MCM per month or approximately 1.4 m^3/s as the minimum environmental flow be maintained.

However, in the short section between the Elahera Anicut and the above-mentioned confluence, it is difficult to establish the minimum environmental flow because the Elahera Anicut was originally constructed more than one thousand years ago. Since then, this short stretch has been in a quite different condition for a long time. The environmental flow for this section needs to be established based on the results of the MASL’s future monitoring of the river flow, river water volume and complaints from the downstream users or neighboring users.

Finally, as for the section between the proposed dam and Elahera Anicut, it is also difficult to establish a practical quantitative environmental flow. This section is always inundated because the backwater from the Ehahera Anicut reaches this dam site. If the depth of water is deep enough, the environmental flow is practically unnecessary.

3) Public Consultation Records

Since the EIA regulation of Sri Lanka does not require the public consultation for EIA, the public consultation meetings with affected local residents were not organized for MADP in the past as the JBIC Guidelines require. However, some forms of public consultation were conducted for the Project, and some environmental issues were also continuously discussed in the public consultations for the RIP (see Table 8.3.4). The public consultations record is summarized in the following table.

Table 8.4.3 Summary of Public Consultation for EIA

No.	Date	Venue	No. and Type of Participants	Topics	Main Comments from Major Stakeholders/ MASL's Responses
1	5 July 2001-11 Sept. 2000	Via the newspaper advertisement	General public (Respondents: Environmental Foundation Ltd., Green Movement of Sri Lanka; National Lands and Reform Campaign and the residents	Call for comments on the EIA report	✓ Request for a proper mitigation of blasting; ✓ Request for a proper removal of tree cover; ✓ Obstruction of mitigatory routes of elephants; ✓ Human-elephant conflict; ✓ Impact on fauna and biodiversity; ✓ Resettlement and impact on livelihood; ✓ Security issues in the resettlement site; ✓ Request for adequate compensation ✓ Responded by the MASL on 20 June 2001 before EIA approval.
2	6 Dec. 2007	Development Centre, Girandurukotte	(1) 125 participants (2) District Secretaries, AGA's, wildlife officers, forest officers, other relevant officers of Mahaweli	Workshop on EIA report finalization	✓ All participants agreed with the suggestions of EIA
3	May 2010	Colombo	3 government officials, 3 environmental NGOs, and 3 academicians	Interviews and suggestions on the proposed wildlife management program	✓ The interviewee considered that the proposed programs were sufficient.

Source of data: MASL

8.5 Summary of the Supplemental Survey for the EIA and RIP Reports (Sub-contracted Work)

8.5.1 Summary of the TOR

The supplemental survey for the existing EIA and draft RIP reports was conducted by the JICA Survey Team as a sub-contracted work. The work consists of (1) translation of the relevant documents, (2) interviews with stakeholders on resettlement, (3) preparation of the resettlement brochure, (4) interviews with wildlife management experts in Sri Lanka, and (5) preparation of the updated EMP and EMoP. The work was completed in May/June 2010.

Table 8.5.1 Brief TOR of the Supplemental Survey

No.	Task	TOR
1	Translation of relevant documents in Sinhala into English	One report on the public consultation, one report on the consent letter collection and the MoU were translated from Sinhalese into English.
2	Hearings/interviews with stakeholders on resettlement including potential resettlers	Targeting 5 local governmental officers, 5 community leaders, 30 potentially displaced persons and 5 NGOs, Community-Based Organizations (CBOs) or self-help organizations.
3	Preparation of the resettlement brochure	A draft prepared by the MASL was translated into English and Tamil. 2,000 copies will be printed (1,850 in Sinhala, 50 in Tamil and 100 in English).
4	Hearings/interview with wildlife management experts in Sri Lanka	Targeting 3 environmental NGOs, 3 academicians and 3 governmental organizations.
5	Preparation of updated EMP and EMoP	To be updated to meet the requirements of JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002) (e.g., responsible org., monitored parameters, monitored locations, methodology, timeframe, frequency and budget).

Prepared by the JICA Survey Team

8.5.2 Outputs of the Supplemental Survey

The supplemental work commenced from early February 2010 and was competed in June 2010.

1) Translation of Relevant Documents in Sinhala into English

Three documents listed below were translated and attached in Section F.27, F.28 and F.15 of Appendix F respectively.

- The report on the consent letter collection organized on 30 June 2009;
- The report on the public consultation records; and
- The MoU between the Department of Irrigation and the MASL on the downstream water use.

2) Hearings/Interviews with Stakeholders on Resettlement including Potential Resettlers

The hearings/interviews on resettlement and public consultation were conducted with 5 local governmental officers, 6 community leaders, 5 CBOs and 32 potentially displaced persons between 5 and 8 May 2010. 13 out of 16 stakeholders responded that the provided public consultation was sufficient. Additionally, 30 out of 32 potentially displaced responded that they have received a copy of the entitlement package document, and 28 out of 32 answered that the information available was sufficient, even though 4 expressed it was unsatisfactory because of no information provision on the exact date of moving to the resettlement site, unsatisfactory valuation results, unreliability of the information and lack of proper awareness.

In conclusion, there are 4 major suggestions which were prepared based on the interview survey:

- Involvement of more local stakeholders such as Pradesiya Sabhas, NGOs, CBOs and religious leaders in the resettlement process;
- Undertaking of special public consultation meetings focusing on the entitlement packages, social infrastructure in the resettlement site, schedule, and the grievance redress mechanism;
- Setting up of a community information center of MADP, which is a one-stop center where any local resident can obtain the necessary information on the resettlement such as the RIP report, EIA-related reports, current status of the project activities and resettlement and the access to the grievance redress system.

The report is attached in Section F.29 of Appendix F.

3) Preparation of the Resettlement Brochure

Two thousand one hundred and fifty copies of the resettlement brochure will be prepared by June/July 2010 (2,000 copies in Sinhala, 50 copies in Tamil and 100 copies in English). The brochure was prepared to inform stakeholders and the families to be displaced on the compensation and resettlement policy in order to improve their awareness on the resettlement. The contents of the brochure are as shown below. The draft in English is attached in Section F.30 of Appendix F.

- Project brief;
- Present status of the project (progress of the partially started construction work);
- Scale of the resettlement and land acquisition;
- Compensation policy including the entitlement matrix;
- Explanations of the relevant regulations and policy;
- Preparation of the resettlement sites;
- Grievance and redress system;
- Overall schedule; and
- Contact persons and further information disclosure.

4) Interviews with Wildlife Management Experts in Sri Lanka

Stakeholder interviews on the subject of wildlife management mitigation measures were undertaken in early May 2010. Nine selected wildlife management experts from the government, NGOs and academic organizations were consulted on the MASL’s planned wildlife management plan.

The report of the interviews is attached as F.17 of Appendix F, which both summarizes the results and provides the raw questionnaire data. The questionnaire was designed to elicit the respondents’ concerns about wildlife conservation within the development and operation of the MADP, and their degree of satisfaction with the wildlife management program that has been prepared to mitigate the potential impacts of the Project upon wildlife. The main planks of that program are the creation of new protected areas including an elephant corridor, and the provision of electric fencing to corral the movement of elephants and avoid human-elephant conflicts. (An MoU has been developed between the MASL and Department of Wildlife Conservation to ensure the implementation of these mitigation measures as part of an integrated package of conservation work which addresses the wider potential impacts of the Project on wildlife, particularly elephants.)

From the responses received, it can be concluded that the respondents in all three groups of experts confirm that the project planning has included sufficient actions to address potential impacts of the Project on wildlife, and has taken adequate steps to avoid human-wildlife conflict that may arise during the construction and operation of the Project.

5) Updated Environmental Management Plan (EMP)

The EMP was updated based upon the existing MASL Environmental Mitigation Plan, review of EIA-related documents of the MADP, interviews with relevant stakeholders, and the results of the site visits of the Survey Team and the ELM Consultants (Pvt) Ltd.

The major changes made were as follows:

(a) Addition of mitigation measures relating to construction activities;
(b) Addition of standards to be met by mitigation measures;
(c) Quantification of mitigation measures that were previously only qualitative, where appropriate; and
(d) Revision of environmental management costs.

Details are described in Section F.18 of Appendix F.

6) Updated Environmental Monitoring Plan (EMoP)

The EMoP was updated based upon the existing MASL Environmental Monitoring Plan, review of EIA-related documents of the MADP, interviews with relevant stakeholders, and the results of the site visits of the Survey Team and EML Consultants (Pvt) Ltd.

The major changes made were as follows:

(a) Addition of monitoring related to construction activities;
(b) Addition of monitoring of environmental quality (e.g., water quality, noise and vibration, air quality, etc.);

(c) Addition of environmental quality standards to be addressed within monitoring; and

(d) Revision of monitoring costs.

Details are described in Section F.19 of Appendix F.

8.6 Recommendations on EIA and RIP

There are seven recommendations in the short-run and three in the long-run especially for the implementation of EIA and RIP.

8.6.1 Recommendations for the Short Term

1) EIA Documentation

Since the 1998 TEAMS EIA for the MADP was conducted in 1989, it was not initially adequate to serve as the EIA for the 2010 project by itself. However, the combination of subsequent Environmental Clearance conditions and the additional environmental and social studies conducted (particularly the Biodiversity Assessment, the Watershed Management Plan and the RIP) together with the improved EMP and EMoP (both prepared as part of the present study) form an adequate level of documentation to safeguard environmental and social interests. Therefore, it is recommended that all these documents should be formally adopted as an addendum to the original EIA report and evidence that the MASL has complied with the conditions imposed in the original Environmental Clearance and its two extensions. This could be done when the Environmental Clearance is again extended, and it is recommended that the MASL should mention this in the application for approval extension that will be made on 25 August 2010.

The conditions and documents referred to above, if implemented, will provide a very considerable degree of mitigation when the Project goes ahead. Not only will adverse environmental effects be minimized but also opportunity will be taken to enhance the environmental benefits of the Project. Recent discussions with IUCN Sri Lanka indicates that while there was initially environmental opposition to MADP, the various additional studies and documents have given local environmental interests adequate assurance that the Project will be properly managed. Indeed, IUCN sees this project as an opportunity to improve conservation while developing a project that is in the country’s interests.

2) Inclusion of the Cost and Schedule of the Mitigation Measures for the Archaeological Remains

Although the overall mitigatory actions for the impact on the archaeological remains were already included in the EMP and EMoP, they need to be reviewed and updated in accordance with the cost estimate and schedule to be provided by the Department of Archaeology in the near future. Especially, the cost and schedule need to be incorporated in the overall project cost and schedule so that it would not cause any delay in the project implementation.

3) Further Consent Letter Collection

The consent letters from the rest of affected people, which is 1% or six more households, need to be collected as early as possible before the JICA's loan appraisal mission which is expected in September 2010 at the earliest.

4) Inclusion of the Additional Potential Resettlers

The newly identified affected people in the transmission alignment (24 landowners) and in System D1 (nine households affected by the branch canal) need to be fully included in the RIP report in terms of the scale of the resettlement and land acquisition, the resettlement site plan, and the budget before its submission to JICA in July 2010

5) Compensation Policy at Full Replacement Cost

As previously mentioned, the compensation policy should be equivalent to the international standards of the replacement cost consisting of the market value and the transaction costs and without any depreciation for the asset. Since there is a discrepancy between the NIRP and Land Acquisition Regulations of 2009, namely, the transaction cost for the land, it was suggested to modify the compensation policy in the RIP to be at full replacement cost (i.e. the market value and transaction cost) in accordance with the NIRP and WB's OP 4.12. More specifically, it was suggested to consider to include the option of "3.10 All other expenses to the owner due to the acquisition" or "3.12 When an owner of a house or of an investment property is displaced, additional 10% payment based on market value" under Section 3 of Land Acquisition Regulations of 2009 to supplement the current gap.

It was agreed among the MASL, JICA Survey Team and JICA Mission members in June 2010 that the MASL will provide (1) the compensation for land at the market value and any other compensation for applicable land transaction costs and (2) the enough livelihood assistance so that the resettlers won't be worse off due to the losses of access to irrigation water, access to agriculture land and employment.

These agreed compensation and assistance need to be included in the final RIP report.

6) Preparation of the Resettlement Monitoring Form

The monitoring form on resettlement needs to be prepared by MASL based on the monitoring form on resettlement included in the updated EMoP (Appendix F 19) and included in the final RIP report before the loan appraisal of JICA. The monitored items shall include the progress of land acquisition and compensation payment and changes in livelihood of the resettlers and host communities.

7) Organization of the Public Consultation Meetings

As discussed between relevant directors of the MASL and the Survey Team on 10 May 2010, the public consultation meeting focusing on the entitlement packages, social infrastructure in the resettlement site, schedule, and the grievance redress mechanism needs to be organized as early as the draft RIP is finalized (expected in July 2010). The details of the suggested public consultation meeting are shown in the following Table 8.6.1. After the public consultation, necessary documents identified in the following table need to be compiled and submitted to the JICA (see Appendix F 31 for the sample agenda and sample formats for the summary of the public consultation and the participants list).

Table 8.6.1 Proposed Arrangement for Public Consultation Meeting on Resettlement

No.	Item	Description of the Necessary Arrangement
1	Purpose	– To explain the compensation and resettlement policy including the entitlement matrix, grievance redress system, contact information of the person in charge within the MASL, schedule, and monitoring plan to the PAPs such as resettlers, landowners, formal/informal occupiers and relevant stakeholders. – To discuss above-mentioned subjects and further recommendations. – Comments & suggestions from meeting participants
2	Venue	– Venue must be accessible to any interested participant, especially considering the access of the vulnerables.
3	Language	– Use of local language. – Provide assistance in Tamil language if necessary.
4	Proposed Agenda	– Introduction – Project components – Expected environmental and social impacts under the EIA and supplementary studies – Planned environmental mitigation measures (Updated SEMP and SEMoP) – Scale of the involuntary resettlement – Resettlement and compensation policy, including the entitlement matrix – Limited option for the acquired land: monetary compensation for the land to be acquired – Future schedule of resettlement – Detailed social infrastructure preparation in each resettlement site (System D1 and F) – Limited availability of irrigation water and possible compensation if irrigation water is not available. – Grievance redress mechanisms – Proposed monitoring plan, including responsible organization(s) – Information disclosure, including the proposal of the community information center – Contact information of project proponent
5	Records	Following documents need to be included in the final RIP report: – Notice of the meeting; – Minutes of meeting; – Agenda; – Any presentation handouts; – List of participants including participants' social groups (e.g., occupation, number of male and female participants); and – Photos of the meetings

Prepared by the JICA Survey Team

8) Resettlement Schedule

The detailed resettlement schedule by phase needs to be prepared in accordance with the progress of other relevant projects, namely, the Kalu Ganga development project for availability of irrigation water in System F and the Medirigiriya Water Supply Scheme for availability of drinking water in System D1. The schedule is currently reviewed by the MASL and will be included in the RIP report. The updated resettlement schedule needs to be regularly disclosed to the affected people, preferably via local government officials/community leaders or at the community information center.

9) Distribution of the Resettlement Brochure

As discussed in the meeting between relevant directors of the MASL and the Survey Team on 10 May 2010, it is suggested that the MASL will deliver one copy of the resettlement brochure to each affected household from June 2010.

8.6.2 Recommendations for the Long Term (During Implementation)

1) Protected Areas and Electric Fencing

As discussed, since the wildlife management program is the biggest and most important component of the EMP, the implementation structure needs to be secured. First, it is recommended that the gazetting of the new protected areas should be done within a stated timetable. Secondly, adequate funding should be available for both the construction and maintenance of these fences. Thirdly, since the program requires collaboration with the Department of Wildlife Conservation, the MoU on the program implementation between the MASL and the department needs to be signed in June 2010 as planned.

2) Minimum Downstream Flow

As previously discussed, the maintenance flow of 3.6 MCM/month, which is approximately 1.4 m^3/s, needs to be secured for the section after the confluence of the rivers downstream of the Elahera Anicut during operation. However, since there was no quantitative target of the maintenance flow in the past and it was coordinated among stakeholders upon the demand, the monitoring and adjustment of the minimum downstream flow is highly suggested as proposed in the EMoP. As for the rest of the sections between the dam and Elahera Anicut, and Elahera Anicut and the confluence, the environmental flow needs to be determined based on the MASL's future monitoring results of the discharged water from the dam and Elahera Anicut, water levels and river flow.

3) Implementation of Resettlement

It is suggested to secure enough manpower to implement the resettlement since this Project involves a large-scale resettlement and resettlement site development which need to be coordinated with the Kalu Ganga development project and other relevant governmental organizations. Therefore, it is important to secure enough financial sources for the personnel structure proposed in the RIP to implement the detailed action plan for resettlement which is currently prepared by the MASL.

Additionally, the establishment of community information centers and continuous public awareness activities by an NGO specializing in social development, CBOs and/or local leaders are suggested as proposed in the interview survey report so that affected persons are able to understand the progress of the Project and consult any concerns with the project proponents.

Moreover, adequate monitoring data management and supervision system shall be established by the Monitoring Unit with assistance from relevant units of MASL in the future detailed design stage. It is recommended to establish such system within the consultancy service.

8.7 Preparation of JBIC Environment Checklists

The JBIC Environment Checklists for Dams & Reservoirs, Other Electric Generation, Irrigation and Power Transmission have been updated incorporating the outputs of the sub-contracted work (see Section F.5 of Appendix F). These are repetitive to some degree, but they provide details of all the likely environmental effects of the Project and the mitigation measures that have been devised to avoid or minimize adverse environmental impacts.

CHAPTER 9 RECOMMENDATIONS

9.1 General

The Survey Team has carried out the preparatory survey in collaboration with the MASL since January to June 2010. Based on the survey results, the Survey Team recommends the following items:

9.2 Additional Investigations to be done during Detailed Design

1) Additional Geological Investigations

- The Survey Team proposed an additional geological investigation along the dam axis and reservoir area, and it is going to be carried out by the MASL before the detailed design stage.
- During the detailed design another additional geological investigation is necessary to obtain the geotechnical information on the foundation of powerhouse, stilling basin, etc, after the layout of main structures are fixed

2) Construction Materials

- Field and laboratory tests on quantity and quality of embankment materials and concrete aggregates from the riverbed, existing borrow area, and the proposed quarry site are necessary.
- Availability of good quality concrete materials, such as cement, fly ash, admixtures, water etc. in Sri Lankan local market shall be investigated.
- The river water from the Amban River will be used for concrete mixing and grouting works, and the quality of the water must be confirmed satisfactory through water quality tests.

9.3 Hydraulic Model Test for Design of Spillway and Water Channel

A series of hydraulic model test is required to be conducted during the detailed design to determine the following design:

- Shape of spillway training walls and chute
- Width and Depth of the stilling basin
- Layout of water channel
- Protection for the existing bridge and

9.4 Water Balance Simulation

1) Factors Used in the Simulation Model

A series of water balance simulation has been carried out in this Survey in collaboration with the MASL. In this simulation, some factors that make the simulation model more accurate and realistic are used. Those factors are not derived theoretically, but determined based on observations of river and canal flows. It is therefore recommended that those factors be verified in the detailed design stage to ensure the water balance simulation results.

One of those factors is flow-rata factors, which are applied to all inflow points of the simulation model to adjust the inflow quantities. The flow-rata factors are decided through calibrations that are carried out at all inflow points once in several years by comparing the theoretical inflow and measured out flow. In particular, the accuracy of the measurement of out flow at the inflow points should be confirmed by checking the devices and methods of the measurement. Other factors, such as system efficiencies, return flow factors, etc. are also recommended to be verified in the detailed design stage.

2) Water Balance Simulation for Future Water Use

The water balance planning in this Survey was prepared based only on the planned Moragahakanda Reservoir and present water demand. However, the plan of water supply to Vanni (northern areas of Sri Lanka) as well as North Central Province from the Moragahakanda Reservoir and other Mahaweli projects (including the Kalu Ganga Reservoir) through a planned North Central canal is announced in the “Mahinda Cintana 2010”.

It is recommended that a water balance simulation be carried out incorporating the future developments on Mahaweli system and future water demand in the detailed design stage, if the above idea of future water supply is developed to a formulation stage by then.

9.5 Agriculture

1) Saving Irrigation Water

The Agriculture Department, MASL and ID are requested to promote spreading the cropping pattern with short-term varieties of paddy among farmers, so as to save water for further extent of irrigation area, future increase of demand of domestic and industrial water in the Project area, or other purposes.

2) Detailed Planning of Soft Components

It is reminded that detailed planning on agricultural extension services, and establishment and strengthening of FOs to be included in the Project components, is to be made in the consulting services for the smooth and successful implementation, prior to its implementation, as described in this Report.

9.6 Project Cost

The MASL and ID are requested to finalize the design and cost estimate of irrigation and social infrastructures at Kaudulla Left Bank extension area and Kaku Ganga area as much as possible, so as to make more accurate cost estimate for a loan arrangement, by the time of expected Appraisal of the Project.

9.7 O&M of Hydropower Station

The Survey Team proposes the same procedure of O&M of the Hydropower Station of the Project as the current practice taken between the MASL and CEB. Meanwhile, some alternative schemes are also proposed as the future options as described in Chapter 5.

It is recommended that the MASL have a discussion with the CEB on O&M of the Hydropower Station as early as possible.

9.8 Recommendations for the EIA

1) EIA Documentation

As previously explained in Chapter 8, since the original EIA was prepared in 1998, several EIA-related documents were prepared continuously to fulfil the conditions of the EIA approval. Therefore, it is recommended that all these documents should be formally adopted as addenda to the original EIA report, and evidence that the MASL has complied with the conditions imposed in the original Environmental Clearance and its two extensions. This could be done when the Environmental Clearance is again extended, and it is recommended that the MASL should mention this in the application for approval extension that will be made on 25 August 2010.

2) Inclusion of the Cost and Schedule of the Mitigation Measures for the Archaeological Remains

In early June 2010, the MASL has requested the Department of Archaeology to provide the cost estimate and the schedule of the detailed study and the preservation work identified in the Archaeological Impact Assessment (AIA) report prepared by the Department of Archaeology in 2009. Since the information is not received by the MASL and the work is expected relatively large, the cost estimate shall be included in the EMP and EMoP and the schedule needs to be incorporated in the overall project implementation schedule.

9.9 Recommendations for the RIP

1) Further Consent Letter Collection

The consent letters from the rest of affected people, which is 1% or six more households, need to be further collected as much as possible before the JICA's loan appraisal mission.

2) Inclusion of the Additional Potential Resettlers

The newly identified affected people in the transmission alignment (24 landowners) and in System D1 (nine households affected by the branch canal) need to be fully included in the RIP report in terms of the scale of the resettlement and land acquisition, the resettlement site plan, and the budget before its submission to JICA in July 2010

3) Compensation Policy at Full Replacement Cost

As previously mentioned in Chapter 8, the compensation policy needs to be equivalent to the international standards of the replacement cost consisting of the market value and the transaction costs and without any depreciation for the asset. As agreed among the MASL, JICA Survey Team and JICA Mission members in June 2010, the MASL will provide (1) the compensation for land at the market value and any other compensation for applicable land transaction costs and (2) the enough livelihood assistance so that the resettlers won't be worse off. The agreed compensation and assistance need to be included in the final RIP report and to be provided in a timely manner when implementing land acquisition and resettlement.

4) Preparation of the Resettlement Monitoring Form

The monitoring form on resettlement needs to be prepared by MASL based on the monitoring form on resettlement included in the updated EMoP (Appendix F 19) and included in the final RIP report before the loan appraisal of JICA. The monitored items shall include the progress of land acquisition and compensation payment and changes in livelihood of the resettlers and host communities. Moreover, adequate monitoring data management and supervision system shall be established by the Monitoring Unit with assistance from relevant units of MASL in the future detailed design stage. It is recommended to establish such system within the consultancy service.

5) Organisation of the Public Consultation Meetings

As discussed between the MASL and the Survey Team, the public consultation meetings explaining on the entitlement packages, the social infrastructure in the resettlement site, the schedule, and the grievance redress mechanism needs to be organised at the village level as early as the draft RIP is finalised (expected in early July 2010). It is also suggested to explain the environmental and social impacts of the Project and proposed major mitigation measures (i.e. major items in the EMP and EMoP) during the same public consultation meetings. After the public consultation, necessary documents identified in Table 8.6.1 shall be to be compiled in the final RIP report and to be submitted to the JICA (see Appendix F 31 for the sample agenda and sample formats for the summary of the public consultation and the participants list).

6) Resettlement Schedule

The detailed resettlement schedule by phase needs to be prepared in accordance with the progress of other relevant projects, namely the Kalu Ganga development project for availability of irrigation water in System F and the Medirigiriya Water Supply Scheme for availability of drinking water in System D1. The schedule is currently reviewed by the MASL and will be included in the RIP report. The updated resettlement schedule needs to be regularly disclosed to the affected people, preferably via local government officials/community leaders or at the community information centre.

7) Distribution of the Resettlement Brochure

As discussed between the MASL and the Survey Team, it is suggested that one copy of the resettlement brochure will be delivered to each affected household by the MASL in early July 2010.

Attachments

Attachment-1 Annual Change of Cultivated Areas and Cropping Intensities (1999/2000-2008/09) (1/3)

Cultivated area in System H
(Kalawewa RB, LB, YE, Dambulu Oya and Kandalama scheme)
Current irrigable area (ha) = 32,100

Unit: ha

Year	Irrigable area	Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000	32,100	31,206	539	31,745	9,073	5,548	14,621	144%
2000/01	32,100	30,220	1,636	31,856	10,709	9,010	19,719	161%
2001/02	32,100	30,517	767	31,284	10,808	5,658	16,466	149%
2002/03	32,100	31,095	750	31,845	11,964	9,662	21,626	167%
2003/04	32,100	30,717	1,333	32,050	4,153	6,960	11,113	134%
2004/05	32,100	30,679	1,383	32,062	12,001	17,892	29,893	193%
2005/06	32,100	30,375	1,701	32,076	18,354	12,002	30,356	194%
2006/07	32,100	29,854	2,157	32,011	14,292	15,493	29,785	193%
2007/08	32,100	28,826	2,720	31,546	22,250	8,419	30,669	194%
2008/09	32,100	29,427	2,303	31,730	8,805	7,667	16,472	150%
Average (10-year)		30,292	1,529	31,821	12,241	9,832	22,073	
CI % (10-year)		**94%**	**5%**	**99%**	**38%**	**31%**	**69%**	**168%**

Source of data: MASL and Irrigation Dept.

Cultivated area in System I/H
(Nachchaduwa, Nuwarawewa and Tisawewa scheme)
Current irrigable area (ha) = 4,907

Unit: ha

Year	Irrigable area	Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000	4,112	3,876	0	3,876	3,876	0	3,876	189%
2000/01	4,112	3,897	0	3,897	3,107	0	3,107	170%
2001/02	4,112	3,511	0	3,511	439	231	670	102%
2002/03	4,907	4,362	0	4,362	4,005	176	4,181	174%
2003/04	4,907	4,169	40	4,209	101	0	101	88%
2004/05	4,907	4,366	0	4,366	2,711	1,629	4,340	177%
2005/06	4,907	4,305	61	4,366	3,561	246	3,807	167%
2006/07	4,907	4,616	206	4,822	2,856	635	3,491	169%
2007/08	4,907	4,628	278	4,906	4,001	888	4,889	200%
2008/09	4,907	4,366	0	4,366	2,458	262	2,720	144%
Average (10-year)		4,210	58	4,268	2,711	406	3,117	
CI % (10-year)		**90%**	**1%**	**91%**	**58%**	**9%**	**67%**	**158%**

Source of data: MASL and Irrigation Dept.

Cultivated area in System M/H
(Huruluwewa scheme)
Current irrigable area (ha) = 4,210

Unit: ha

Year	Irrigable area	Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000	4,210	4,048	0	4,048	2,226	0	2,226	149%
2000/01	4,210	4,210	0	4,210	4,008	0	4,008	195%
2001/02	4,210	4,210	0	4,210	0	723	723	117%
2002/03	4,210	4,210	0	4,210	3,547	663	4,210	200%
2003/04	4,210	4,210	0	4,210	0	0	0	100%
2004/05	4,210	4,210	0	4,210	1,032	541	1,573	137%
2005/06	4,210	4,210	0	4,210	765	992	1,757	142%
2006/07	4,210	4,210	0	4,210	757	971	1,728	141%
2007/08	4,210	4,210	0	4,210	4,040	170	4,210	200%
2008/09	4,210	4,048	161	4,209	1,078	619	1,697	140%
Average (10-year)		4,178	16	4,194	1,745	468	2,213	
CI % (10-year)		**99%**	**0%**	**99%**	**41%**	**12%**	**53%**	**152%**

Source of data: MASL and Irrigation Dept.

Attachment-1 Annual Change of Cultivated Areas and Cropping Intensities (1999/2000-2008/09) (2/3)

Cultivated area in KHFC Scheme
(Kandalama-Huruluwewa Feeder Canal Scheme)
Current irrigable area (ha) = 2,250

Unit: ha

Year	Irrigable area	Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000								
2000/01								
2001/02								
2002/03	2,250	1,477	773	2,250	700	1,310	2,010	189%
2003/04	2,250	2,249	0	2,249	317	340	657	129%
2004/05	2,250	2,250	0	2,250	572	872	1,444	164%
2005/06	2,250	2,200	0	2,200	1,044	1,048	2,092	191%
2006/07	2,250	2,025	225	2,250	450	1,800	2,250	200%
2007/08	2,250	2,000	250	2,250	1,538	234	1,772	179%
2008/09	2,250	2,030	220	2,250	389	610	999	144%
Average (10-year)		2,033	210	2,243	716	888	1,604	
CI % (10-year)		**90%**	**10%**	**100%**	**32%**	**39%**	**71%**	**171%**

Source of data: MASL and Irrigation Dept.

Cultivated area in System G
(Elahera scheme)
Current irrigable area (ha) = 5,750

Unit: ha

Year	Irrigable area	Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000	5,750	5,400	0	5,400	4,168	1,343	5,511	190%
2000/01	5,750	4,232	336	4,568	5,465	0	5,465	174%
2001/02	5,750	5,122	206	5,328	3,627	518	4,145	165%
2002/03	5,750	5,130	114	5,244	4,533	447	4,980	178%
2003/04	5,750	5,465	0	5,465	2,302	787	3,089	149%
2004/05	5,750	5,548	202	5,750	5,465	202	5,667	199%
2005/06	5,750	5,548	202	5,750	4,858	708	5,566	197%
2006/07	5,750	5,117	462	5,579	4,118	537	4,655	178%
2007/08	5,750	5,107	643	5,750	4,912	363	5,275	192%
2008/09	5,750	5,473	251	5,724	3,556	453	4,009	169%
Average (10-year)		5,214	242	5,456	4,300	536	4,836	
CI % (10-year)		**91%**	**4%**	**95%**	**75%**	**9%**	**84%**	**179%**

Source of data: MASL and Irrigation Dept.

Cultivated area in System D1
(Minneriya, Giritale, Kaudulla and Kantale Scheme)
Current irrigable area (ha) = 26,520

Unit: ha

Year	Irrigable area	Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000	25,154	22,948	0	22,948	23,063	0	23,063	183%
2000/01	25,810	23,895	0	23,895	25,022	0	25,022	190%
2001/02	25,810	24,991	0	24,991	19,944	60	20,004	174%
2002/03	25,810	25,064	0	25,064	25,679	0	25,679	197%
2003/04	25,810	25,023	0	25,023	8,788	0	8,788	131%
2004/05	25,810	25,023	0	25,023	25,810	0	25,810	197%
2005/06	26,520	26,518	0	26,518	26,518	0	26,518	200%
2006/07	26,520	26,518	0	26,518	24,602	546	25,148	195%
2007/08	26,520	25,862	0	25,862	25,836	25	25,861	195%
2008/09	26,520	25,862	0	25,862	20,633	2	20,635	175%
Average (10-year)		25,170	0	25,170	22,589	63	22,652	
CI % (10-year)		**97%**	**0%**	**97%**	**87%**	**0%**	**87%**	**184%**

Source: MASL and Irrigation Dept.

Attachment-1 Annual Change of Cultivated Areas and Cropping Intensities (1999/2000-2008/09) (3/3)

Cultivated area in System D2
(Parakrama Samudraya Scheme)
Current irrigable area (ha) = 10,121

Unit: ha

Year	Irrigable area	Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000	10,121	10,121	0	10,121	10,121	0	10,121	200%
2000/01	10,121	10,121	0	10,121	10,121	0	10,121	200%
2001/02	10,121	10,121	0	10,121	10,121	0	10,121	200%
2002/03	10,121	10,121	0	10,121	10,121	0	10,121	200%
2003/04	10,121	10,121	0	10,121	10,121	0	10,121	200%
2004/05	10,121	10,121	0	10,121	10,121	0	10,121	200%
2005/06	10,121	10,121	0	10,121	10,121	0	10,121	200%
2006/07	10,121	10,121	0	10,121	10,121	0	10,121	200%
2007/08	10,121	10,121	0	10,121	10,121	0	10,121	200%
2008/09	10,121	10,121	0	10,121	10,121	0	10,121	200%
Average (10-year)		10,121	0	10,121	10,121	0	10,121	
CI % (10-year)		**100%**	**0%**	**100%**	**100%**	**0%**	**100%**	**200%**

Source of data: MASL and Irrigation Dept.

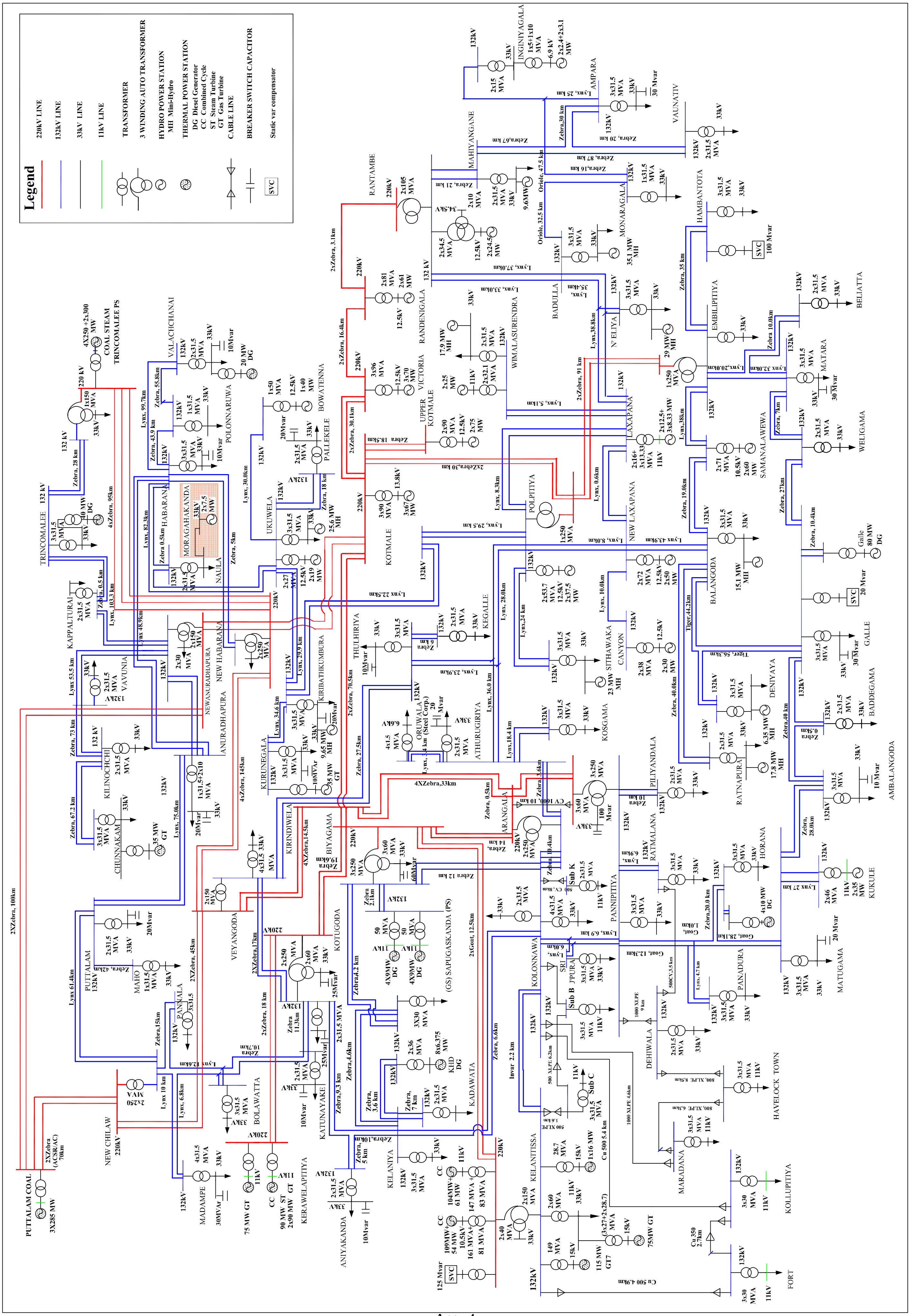
Cultivated area in Total
(System H, I/H, M/H, KHFC, G, D1and D2)
Irrigable Area (ha) = 85,858

Unit: ha

Year		Maha season Paddy	Maha season OFC	Maha season Total	Yala season Paddy	Yala season OFC	Yala season Total	Crop Intensity
1999/2000	81,447	77,599	539	78,138	52,527	6,891	59,418	169%
2000/01	82,103	76,575	1,972	78,547	58,432	9,010	67,442	178%
2001/02	82,103	78,472	973	79,445	44,939	7,190	52,129	160%
2002/03	85,148	81,459	1,637	83,096	60,549	12,258	72,807	183%
2003/04	85,148	81,954	1,373	83,327	25,782	8,087	33,869	138%
2004/05	85,148	82,197	1,585	83,782	57,712	21,136	78,848	191%
2005/06	85,858	83,277	1,964	85,241	65,221	14,996	80,217	193%
2006/07	85,858	82,461	3,050	85,511	57,196	19,982	77,178	189%
2007/08	85,858	80,754	3,891	84,645	72,698	10,099	82,797	195%
2008/09	85,858	81,327	2,935	84,262	47,040	9,613	56,653	164%
Average (10-year)		81,218	2,055	83,273	54,423	12,193	66,616	
CI % (10-year)		**95%**	**3%**	**98%**	**64%**	**14%**	**78%**	**176%**

Source of data: MASL and Irrigation Dept.

Attachmet-2 CEB Power System Diagram year 2016



(to ADB)

Sub Project 13- Construction of Naula 132/33 kV grid substation

13.1 Scope

13.1.1 Naula GS (1x31.5 MVA, 2x132 kV S/B TL bay, 1x132kV S/B Transformer bay, 1x33kV Transformer bay, 4x33 kV feeder bays).

13.1.2 Construction of single in-out connection from Ukuwela-Habarana 132 kV transmission line (2cct, 0.5 km, Zebra).

13.2 Objectives

13.2.1 To cater the growing demand for electricity in Naula area by providing quality and reliable supplies and thereby relieves the loading on existing Ukuwela Grid Substation.

13.2.2 To reduce distribution losses

13.2.3 To connect the proposed Naula Grid Substation to the national grid

13.3 Justification of the sub-project

Naula is located in the Central Province that is primarily based on agro and plantation economy. Agricultural based industries such as paddy processing mills, vegetable and food processing industries located around this area. Naula area has also a potential for development of mineral based industries. An industrial zone has been proposed in Naula area.

The electrification level of the area is about 66% and at present electricity demand is around 26GWh. Presently this area is supplied by Ukuwela and Habarana substations.

Table 13.3.1 :Forecast loading on nearby substations without Naula GS.

Grid Substation	Capacity (MVA)		Forecast Loading / (MW)								
	Present	Propo	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ukuwela	2x31.5	3x31.5	43.8	46.6	50.5	55.6	60.6	66.1	72.4	79.3	86.9
Habarana	2x31.5	3x31.5	50.5	53.7	49.2	52.4	57.0	61.9	67.4	73.6	80.3

As per above forecast loads, the loading of Ukuwela and Habarana substations exceeds 120% under outage of one transformer by year 2013 and 2014 respectively, even after their augmentations. Further Ukuwela substation will be overloaded by year 2015.

Dambulla area is presently fed through a 25km long 33kV feeder from Habarana substation and Naula is fed through a 30km long 33kV feeder from Ukuwela substation. Due to long distribution lines, the voltage profile at both Naula and Dambulla are very poor and also cause high power losses.

- This grid substation is required to cater the load development that is likely to be concentrated in this area.
- It will also provide adequate and quality supply of electricity to the proposed Naula and Dambulla areas
- The 33kV voltage profile of Naula and Dambulla area can be improved after constructing this substation.

In order to meet the growing electricity demand in Naula area and thereby to relieve loading of Ukuwela and Habarana Grid Substations, it is proposed to construct a new grid substation at Naula with single 31.5 MVA transformer and four 33 kV feeders in the year 2010. Load forecast with the proposed new substation at Naula is given below.

Table 13.3.2 :Forecast loading on nearby substations with Naula GS

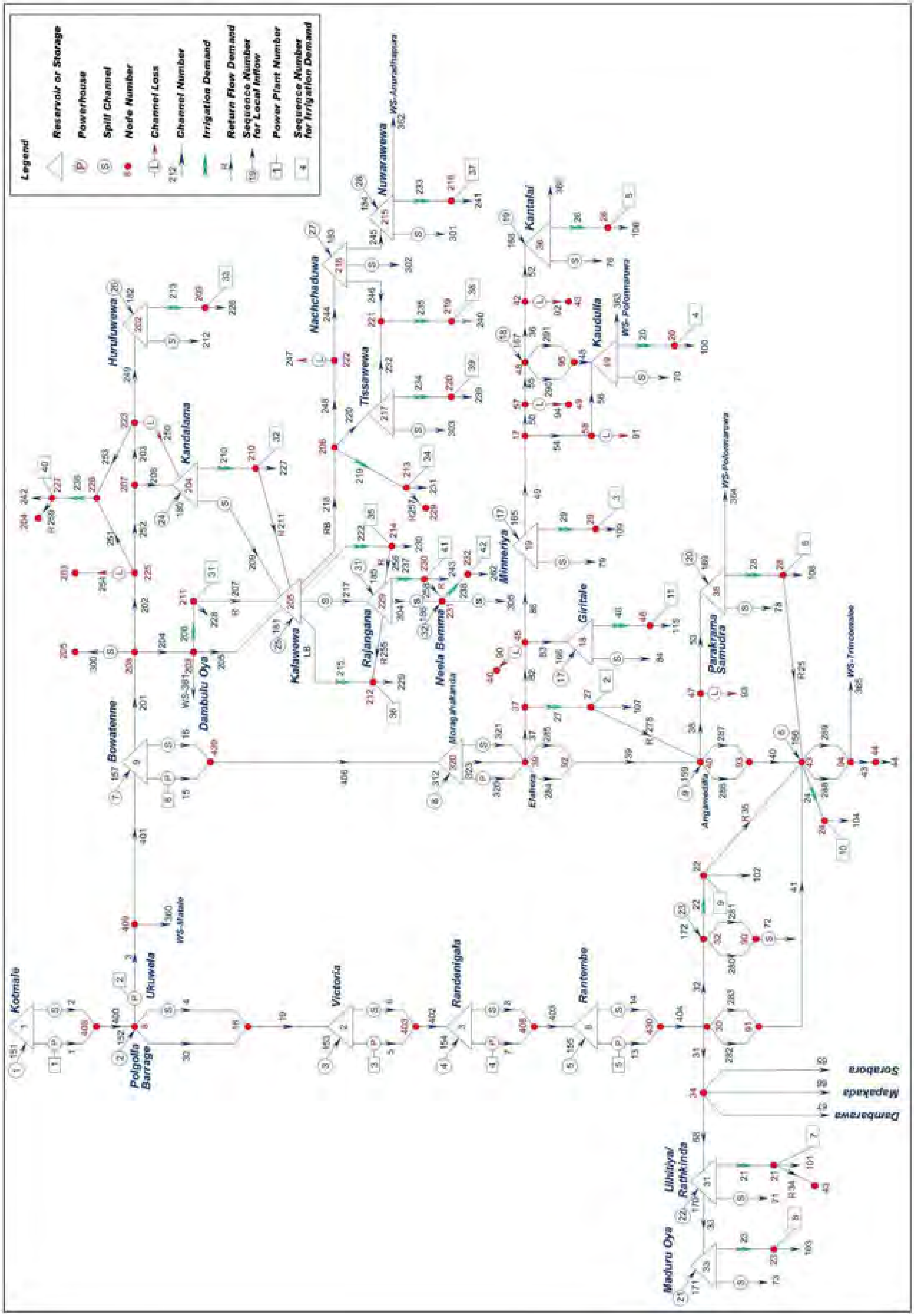
Grid Substation	Capacity (MVA)		Forecast Loading / (MW)								
	Present	Propo	2007	2008	2009	2010	2011	2012	2013	2014	2015
Ukuwela	2x31.5	3x31.5	43.8	46.6	50.5	49.6	54.1	59	64.6	70.7	77.5
Habarana	2x31.5	3x31.5	50.5	53.7	49.2	49.4	53.7	58.3	63.5	69.3	75.6
Naula		1x31.5				9.0	9.8	10.7	11.7	12.9	14.1

If Naula grid substation is constructed as proposed the loading on Ukuwela grid substation can be reduced form 102% to 91% in year 2015. Further it will ensure the load security criterion for both Ukuwela and Habarana grid substations.

Attachment-4 Cultivated Areas and Cropping Intensities in the Project Area

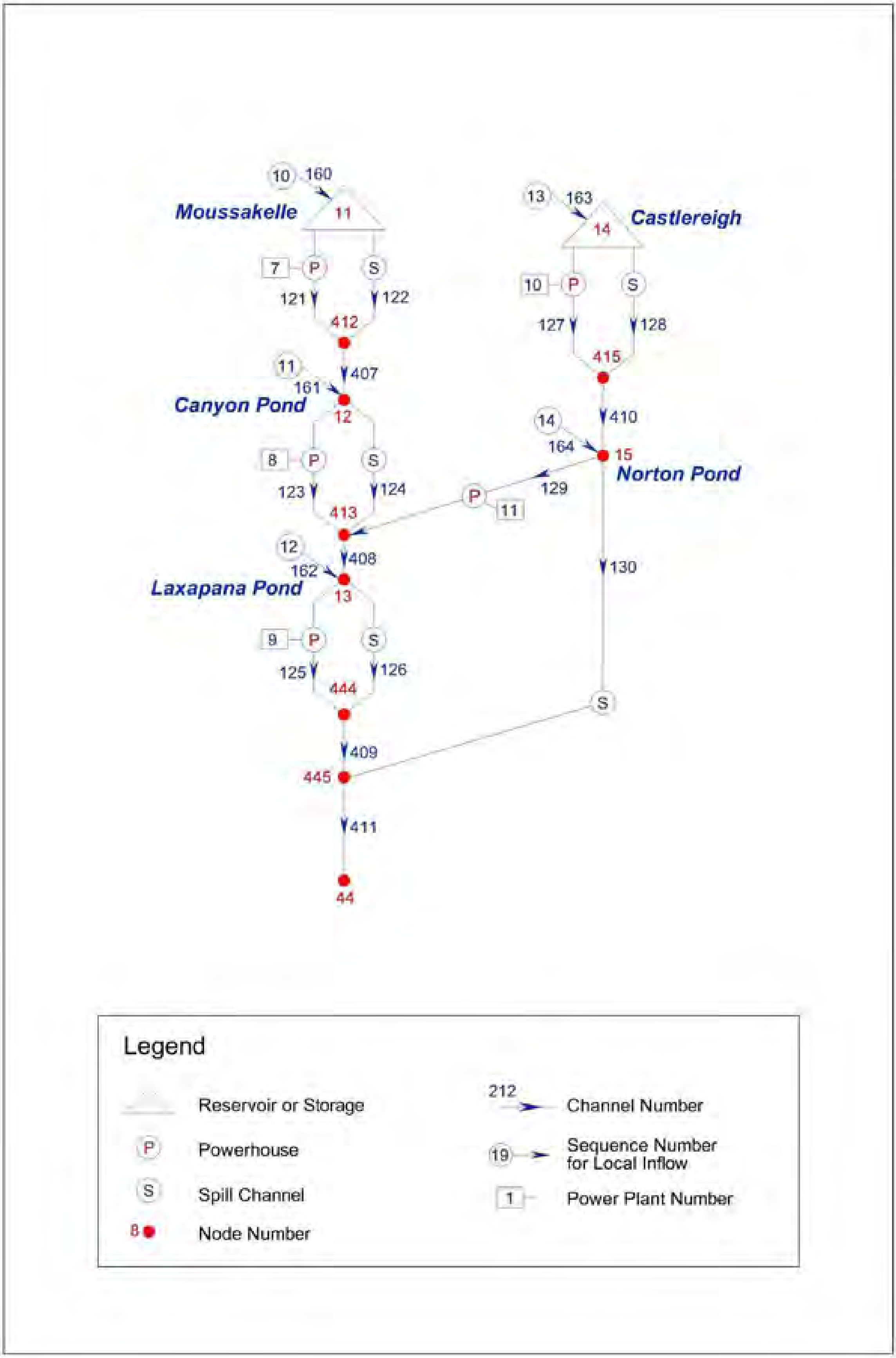
Irrigation System	Irrigable area (ha) 1/	Cultivated Area (ha) 2/							Cropping Intensity (%)						
		Maha season			Yala season			Total	Maha season			Yala season			Total
		Paddy	OFC	Sub-total	Paddy	OFC	Sub-total		Paddy	OFC	Sub-total	Paddy	OFC	Sub-total	
System H															
Kalawewa RB	14,000	13,185	747	13,932	4,868	4,414	9,282	23,214	94%	6%	100%	35%	31%	66%	166%
Kalawewa LB	6,660	6,148	397	6,545	2,547	2,159	4,706	11,251	92%	6%	98%	38%	33%	71%	169%
Kalawewa YE	4,720	4,571	124	4,695	2,338	991	3,329	8,024	97%	2%	99%	50%	21%	71%	170%
Dambulu Oya	2,240	2,181	51	2,232	839	877	1,716	3,948	97%	2%	99%	37%	40%	77%	176%
Kandalama	4,480	4,207	210	4,417	1,649	1,391	3,040	7,457	94%	4%	98%	37%	31%	68%	166%
Sub-Total	**32,100**	**30,292**	**1,529**	**31,821**	**12,241**	**9,832**	**22,073**	**53,894**	**94%**	**5%**	**99%**	**38%**	**31%**	**69%**	**168%**
System I/H															
Nachchaduwa	3,335	2,793	50	2,843	1,633	350	1,983	4,826	90%	2%	92%	53%	11%	64%	156%
Nuwarawewa	1,052	998	8	1,006	788	38	826	1,832	95%	1%	96%	75%	3%	78%	174%
Tisawewa	520	419	0	419	290	18	308	727	81%	0%	81%	56%	3%	59%	140%
Sub-Total	**4,907**	**4,210**	**58**	**4,268**	**2,711**	**406**	**3,117**	**7,385**	**90%**	**1%**	**91%**	**58%**	**9%**	**67%**	**158%**
System M/H															
Huruluwewa	4,210	4,178	16	4,194	1,745	468	2,213	6,407	99%	0%	99%	41%	12%	53%	152%
Sub-Total	**4,210**	**4,178**	**16**	**4,194**	**1,745**	**468**	**2,213**	**6,407**	**99%**	**0%**	**99%**	**41%**	**12%**	**53%**	**152%**
System KHFC 3/															
KH-Feeder canal	2,250	2,033	210	2,243	716	888	1,604	3,847	90%	10%	100%	32%	39%	71%	171%
Sub-Total	**2,250**	**2,033**	**210**	**2,243**	**716**	**888**	**1,604**	**3,847**	**90%**	**10%**	**100%**	**32%**	**39%**	**71%**	**171%**
System G															
Elahera	5,750	5,214	242	5,456	4,300	536	4,836	10,292	91%	4%	95%	75%	9%	84%	179%
Sub-Total	**5,750**	**5,214**	**242**	**5,456**	**4,300**	**536**	**4,836**	**10,292**	**91%**	**4%**	**95%**	**75%**	**9%**	**84%**	**179%**
System D1															
Minneriya	9,099	9,071	0	9,071	8,653	4	8,657	17,728	100%	0%	100%	95%	0%	95%	195%
Giritale	3,076	3,072	0	3,072	2,794	2	2,796	5,868	100%	0%	100%	91%	0%	91%	191%
Kaudulla	5,465	5,312	0	5,312	4,151	57	4,208	9,520	97%	0%	97%	76%	1%	77%	174%
Kantale	8,880	7,715	0	7,715	6,991	0	6,991	14,706	92%	0%	92%	83%	0%	83%	175%
Sub-Total	**26,520**	**25,170**	**0**	**25,170**	**22,589**	**63**	**22,652**	**47,822**	**97%**	**0%**	**97%**	**87%**	**0%**	**87%**	**184%**
System D2															
Parakrama Samudra	10,121	10,121	0	10,121	10,121	0	10,121	20,242	100%	0%	100%	100%	0%	100%	200%
Sub-Total	**10,121**	**10,121**	**0**	**10,121**	**10,121**	**0**	**10,121**	**20,242**	**100%**	**0%**	**100%**	**100%**	**0%**	**100%**	**200%**
Total	**85,858**	**81,218**	**2,055**	**83,273**	**54,423**	**12,193**	**66,616**	**149,889**	**95%**	**3%**	**98%**	**64%**	**14%**	**78%**	**176%**

Source of data: MASL and Irrigation Dept.
Notes: 1/ Irrigable area in 2008/09
2/ Cultivated area of 10-year average (1999/2000 Maha-2009 Yala)
3/ KHFC: Kandalama-Huruluwewa Feeder Canal



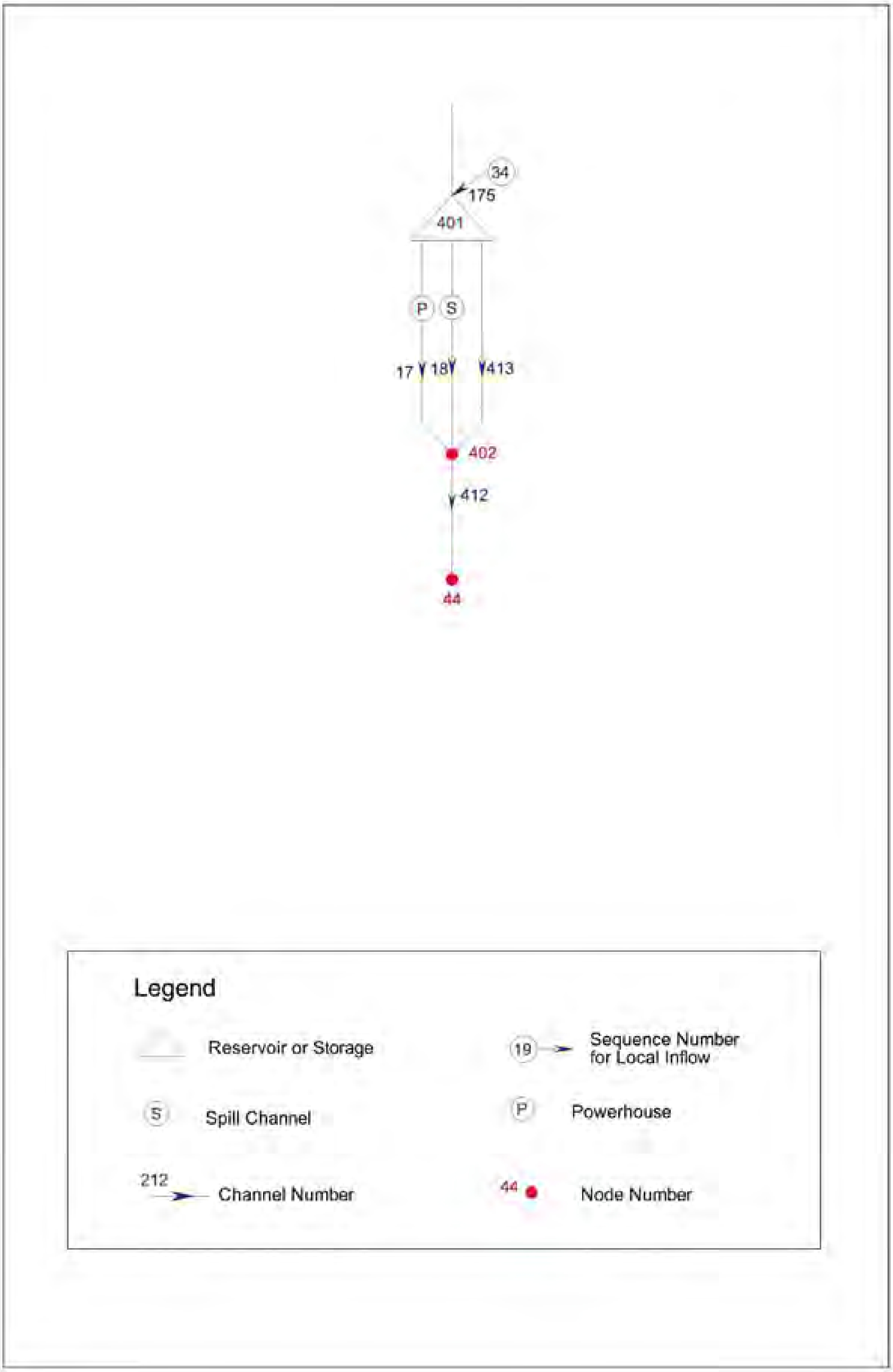
Source of data: MASL

Attachment-5 (1) Schematic Diagram of Mahaweli River Basin



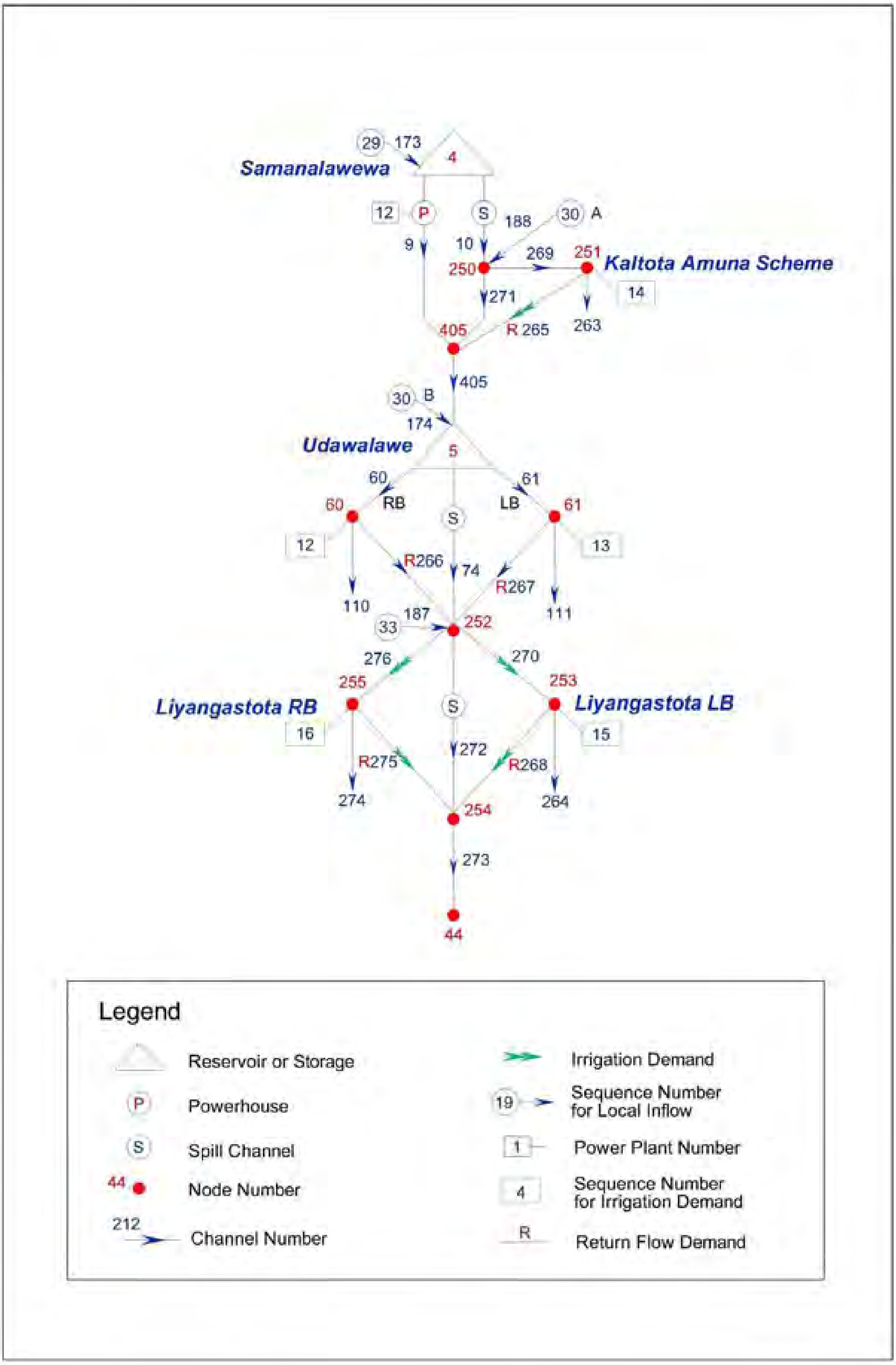
Source of data: MASL

Attachment-5 (2) Schematic Diagram of Kelani River Basin



Source of data: MASL

Attachment-5 (3) Schematic Diagram of Kalu River Basin



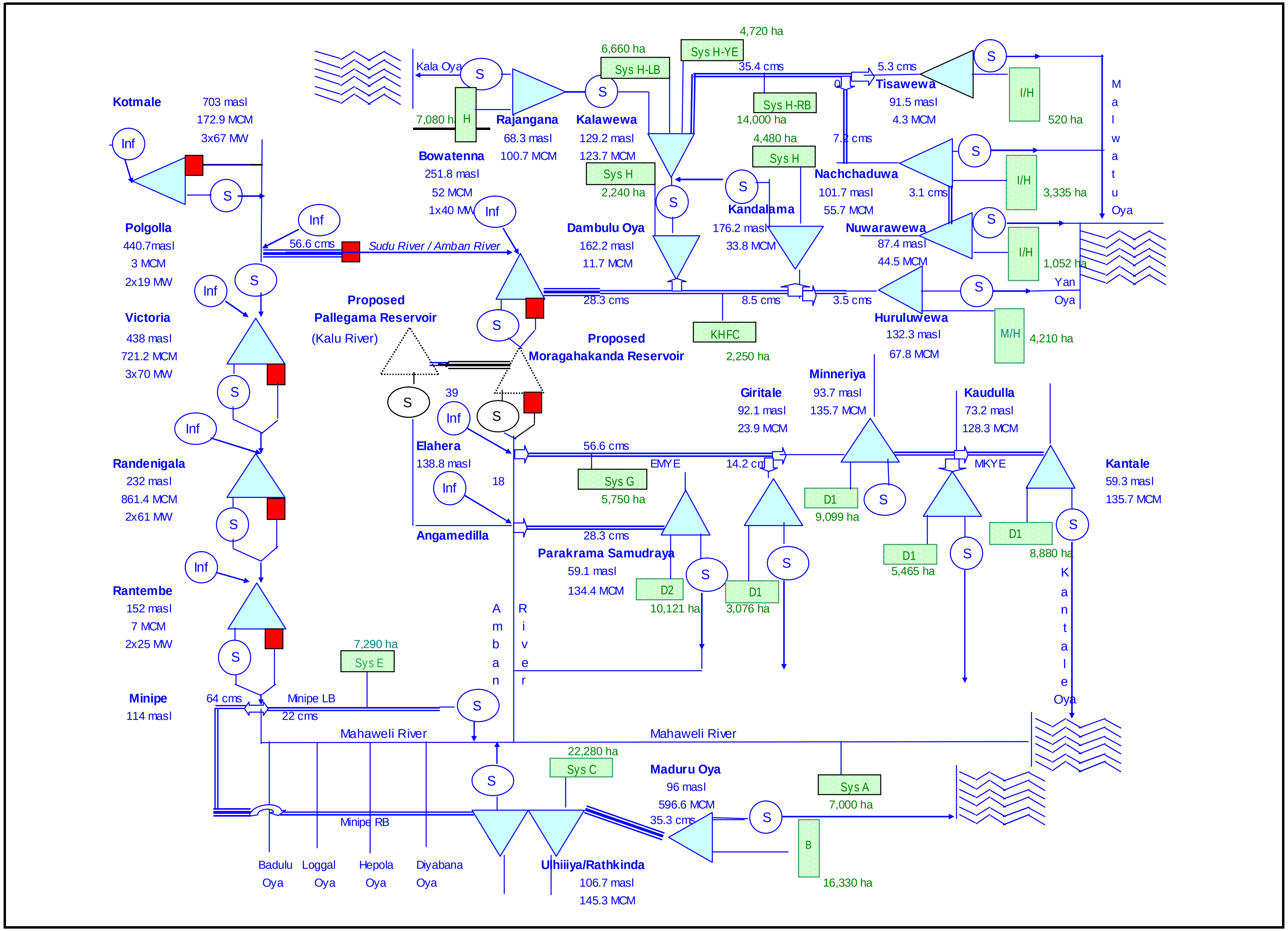
Source of data: MASL

Attachment-5 (4) Schematic Diagram of Walawe River Basin

Attachment-6 Flow-rata Factors of Inflow Series

Inflow Series	Control Point	Basin	Catchment Area (km^2)	Flow-rata Factor	
				2005/06	2008/09
Q01	Kotmale	Kotmale Oya	562	1	1.02
Q02	Polgolla	Mahaweli River	730	1	1.18
Q03	Victoria	Mahaweli River	599	1	0.82
Q04	Randenigala	Mahaweli River	439	1	1.03
Q05	Rantembe	Mahaweli River	788	0.45	0.53
Q06	Manampitiya	Mahaweli River	4,300	1	1
Q07	Bowatenna	Amban River	520	0.7	0.62
Q08	Elahera	Amban River	254	1.34	1
Q09	Angamedilla	Amban River	590	0.81	0.8
Q10	Moussakele	Maskeli Oya	122	1	1
Q11	Canyon	Maskeli Oya	22	1	0.78
Q12	Laxapana	Maskeli Oya	20	2.1	1.43
Q13	Castlereigh	Kehelgamu Oya	114	1	1.04
Q14	Norton	Kehelgamu Oya	17	1	1.04
Q16	Giritale	Amban River	25	1	1
Q17	Minneriya	Amban River	242	1	1
Q18	Kaudulla	Amban River	333	1	1
Q19	Kantale	Kantale Oya	227	1	1
Q20	Parakrama Samudra	Amban River	73	1	1
Q21	Maduru Oya	Maduru Oya	453	1	1
Q22	Ulhitiya/Rathkinda	Ulhitiya Oya	282	1	1
Q23	Minipe L/B	Mahaweli River	183	1	1
Q24	Kandalama	Kala Oya	133	1.5	1.5
Q25	Kalawewa	Kala Oya	677	3	3
Q26	Huruluwewa	Yan Oya	200	1	1
Q27	Nachchaduwa	Malwathu Oya	611	1	1
Q28	Nuwarawewa	Malwathu Oya	83	1	1
Q29	Samanalawewa	Walawe River	353	0.88	0.85
Q30	Udawalawe	Walawe River	802	1.5	1.32
Q31	Rajangana	Kala Oya	751	1	1
Q32	Kala Oya Seaoutfall	Kala Oya	1,265	1	1
Q33	Liyangastota	Walawe River	1,140	1	1
Q34	Kukule	Kalu River	334	1	1

Source of data: MASL



Source of data: MASL

Attachment-7 System Characteristics of Mahaweli System

Attachment-8 Cropping Intensities and Water Duties in Water Balance Simulation

Diversion from Amban River	Irrigation System	Irrigation Scheme	Irrigable Area without Project (ha)	Without Project (Year 2011-2016)					Irrigable Area with Project (ha)	With Project (Year 2017-2021)					With Project (Year 2022-2040)				
				Cropping Intensity			Water Duty (ha/mcm)			Cropping Intensity			Water Duty (ha/MCM)		Cropping Intensity			Water Duty (ha/MCM)	
				Maha	Yala	Annual	Maha	Yala		Maha	Yala	Annual	Maha	Yala	Maha	Yala	Annual	Maha	Yala
Bowatenna	H	Kalawewa RB	14,000	100%	66%	166%	77	70	14,000	100%	80%	180%	82	81	100%	80%	180%	95	83
		Kalawewa LB	6,660	98%	71%	169%	87	82	6,660	100%	80%	180%	95	86	100%	80%	180%	110	88
		Kalawewa YE	4,720	99%	71%	170%	111	91	4,720	100%	80%	180%	115	89	100%	80%	180%	135	93
		Dambulu Oya	2,240	99%	77%	176%	111	93	2,240	100%	80%	180%	115	96	100%	80%	180%	135	100
		Kandalama	4,480	98%	68%	166%	103	89	4,480	100%	80%	180%	110	95	100%	80%	180%	129	98
		Sub Total	32,100	99%	69%	168%	88	79	32,100	100%	80%	180%	94	86	100%	80%	180%	109	88
	I/H	Nachchaduwa	3,335	92%	64%	156%	104	58	3,335	100%	80%	180%	99	55	100%	80%	180%	118	56
		Nuwarawewa	1,052	96%	78%	174%	119	72	1,052	100%	80%	180%	122	77	100%	80%	180%	140	79
		Tisawewa	520	81%	59%	140%	77	81	520	100%	80%	180%	80	80	100%	80%	180%	95	83
		Sub Total	4,907	91%	67%	158%	103	63	4,907	100%	80%	180%	101	61	100%	80%	180%	119	62
	M/H	Huruluwewa	4,210	99%	53%	152%	139	77	4,210	100%	80%	180%	140	81	100%	80%	180%	165	83
	KHFC	KH-Feeder Canal	2,250	100%	71%	171%	41	27	2,250	100%	80%	180%	46	31	100%	80%	180%	53	32
Elahera	G	Elahera	5,750	95%	84%	179%	61	51	5,750	100%	100%	200%	65	55	100%	100%	200%	76	57
	D1	Minneriya	9,099	100%	95%	195%	131	93	9,099	100%	100%	200%	135	100	100%	100%	200%	159	104
		Giritale	3,076	100%	91%	191%	101	57	3,076	100%	100%	200%	106	65	100%	100%	200%	125	67
		Kaudulla	5,465	97%	77%	174%	133	74	6,885	100%	100%	200%	135	77	100%	100%	200%	149	75
		Kantale	8,880	92%	83%	175%	172	96	8,880	100%	100%	200%	161	96	100%	100%	200%	179	93
		Sub Total	26,520	97%	87%	184%	137	84	27,940	100%	100%	200%	138	87	100%	100%	200%	157	87
Angamedilla	D2	Parakrama Samudra	10,121	100%	100%	200%	84	66	10,121	100%	100%	200%	86	72	100%	100%	200%	101	73
		Grand Total	85,858	98%	78%	176%	95	70	87,278	100%	90%	190%	99	76	100%	90%	190%	115	78
Incremental Area (ha)										Maha	Yala	Total			Maha	Yala	Total		
H										280	3,608	3,888			280	3,608	3,888		
I/H										639	808	1,447			639	808	1,447		
M/H										16	1,155	1,171			16	1,155	1,171		
KHFC										7	196	203			7	196	203		
G										294	914	1,208			294	914	1,208		
D1										2,770	5,287	8,057			2,770	5,287	8,057		
D2										0	0	0			0	0	0		
Total										4,006	11,968	15,974			4,006	11,968	15,974		

Prepared by the JICA Survey Team

Attachment-9 (1) Cropping Pattern and System Efficiency in Water Balance Simulation (Case-A_Without Project: 2011-2016)

Crop Type	System H						System I/H			
	Kalawewa RB	Kalawewa LB	Kalawewa YE	Dambulu Oya	Kandalama	Sub-Total	Nachchaduwa	Nuwarawewa	Tissawewa	Sub-Total
Irrigable Area (ha)	14,000	6,660	4,720	2,240	4,480	32,100	3,335	1,052	520	4,907
Maha										
Paddy (135 days) LHG	1,858	873	1,174	446	883	5,234	931	333	140	1,404
Paddy (105 days) LHG	3,715	1,745	2,347	893	1,767	10,467	1,862	665	279	2,806
Paddy (135 days) RBE	2,537	1,177	350	281	519	4,864				-
Paddy (105 days) RBE	5,075	2,353	700	561	1,038	9,727				-
OFC	747	397	124	51	210	1,529	50	8		58
Maha total (ha)	13,932	6,545	4,695	2,232	4,417	31,821	2,843	1,006	419	4,268
Yala										
Paddy (105 days) LHG	2,475	1,255	1,559	559	1,099	6,947	1,089	263	193	1,545
Paddy (90 days) LHG	1,238	628	779	280	550	3,475	544	525	97	1,166
Paddy (105 days) RBE	770	443				1,213				-
Paddy (90 days) RBE	385	221				606				-
OFC	4,414	2,159	991	877	1,391	9,832	350	38	18	406
Yala total (ha)	9,282	4,706	3,329	1,716	3,040	22,073	1,983	826	308	3,117
Annual Total (ha)	23,214	11,251	8,024	3,948	7,457	53,894	4,826	1,832	727	7,385
Start water issue - Maha	15-Oct	15-Oct	15-Oct	1-Oct	1-Oct	1-Oct	1-Nov	1-Nov	1-Nov	1-Nov
Start water issue - Yala	15-Apr	1-May	1-May	1-May	1-May	15-Apr	15-May	15-May	15-May	15-May
System Efficiency *1 - Maha	0.61	0.70	0.83	0.79	0.71	-	0.72	0.89	0.57	-
System Efficiency *1 - Yala	0.67	0.83	0.90	0.90	0.87	-	0.54	0.75	0.82	-

Crop Type	System M/H	KHFC	System G	System D1					System D2	Total
	Huruluwewa	KHF canal	Elahera	Minneriya	Giritale	Kaudulla	Kantale	Sub-Total	Parakrama Samudra	
Irrigable Area (ha)	4,210	2,250	5,750	9,099	3,076	5,465	8,880	26,520	10,121	85,858
Maha										
Paddy (135 days) LHG	1,392	299		3,024	1,024	1,771	2,572	8,391	3,374	20,094
Paddy (105 days) LHG	2,786	598		6,047	2,048	3,541	5,143	16,779	6,747	40,183
Paddy (135 days) RBE		379	1,738					-		6,981
Paddy (105 days) RBE		757	3,476					-		13,960
OFC	16	210	242					-		2,055
Maha total (ha)	4,194	2,243	5,456	9,071	3,072	5,312	7,715	25,170	10,121	83,273
Yala										
Paddy (105 days) LHG	1,163	428		5,769	1,863	1,384	2,330	11,346	6,747	28,176
Paddy (90 days) LHG	582	214		2,884	931	2,767	4,661	11,243	3,374	20,054
Paddy (105 days) RBE		49	2,865					-		4,127
Paddy (90 days) RBE		25	1,435					-		2,066
OFC	468	888	536	4	2	57		63		12,193
Yala total (ha)	2,213	1,604	4,836	8,657	2,796	4,208	6,991	22,652	10,121	66,616
Annual Total (ha)	6,407	3,847	10,292	17,728	5,868	9,520	14,706	47,822	20,242	149,889
Start water issue - Maha	1-Nov	1-Nov	15-Oct	15-Oct	15-Oct	1-Nov	1-Nov	15-Oct	15-Oct	1-Oct
Start water issue - Yala	15-May	15-May	1-May	15-Apr	1-May	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr
System Efficiency *1 - Maha	0.99	0.30	0.55	0.68	0.55	0.78	0.95	-	0.45	-
System Efficiency *1 - Yala	0.76	0.26	0.65	0.90	0.53	0.65	0.80	-	0.61	-

Prepared by the JICA Survey Team

Note: *1: The above System Efficiency used in the water balance simulation, which the MASL introduced and uses for their routine planning, is a composed factor including main and branch canals efficiency, distributary canal efficiency, field canal efficiency, field application efficiency, and also re-use of irrigation water within the relevant irrigation system/scheme.

Attachment-9 (2) Cropping Pattern and System Efficiency in Water Balance Simulation (Case-B_With Project: 2017-2021)

Crop Type	System H						System I/H			
	Kalawewa RB	Kalawewa LB	Kalawewa YE	Dambulu Oya	Kandalama	Sub-Total	Nachchaduwa	Nuwarawewa	Tissawewa	Sub-Total
Irrigable Area (ha)	14,000	6,660	4,720	2,240	4,480	32,100	3,335	1,052	520	4,907
Maha										
Paddy (135 days) LHG	1,867	888	1,180	448	896	5,279	1,112	351	173	1,636
Paddy (105 days) LHG	3,733	1,776	2,360	896	1,792	10,557	2,223	701	347	3,271
Paddy (135 days) RBE	2,550	1,189	350	282	552	4,923				-
Paddy (105 days) RBE	5,100	2,377	700	564	1,105	9,846				-
OFC	750	430	130	50	135	1,495				-
Maha total (ha)	14,000	6,660	4,720	2,240	4,480	32,100	3,335	1,052	520	4,907
Yala										
Paddy (105 days) LHG	2,987	1,421	1,857	608	1,463	8,335	1,779	281	277	2,337
Paddy (90 days) LHG	1,493	710	929	304	731	4,168	889	561	139	1,589
Paddy (105 days) RBE	1,537	691				2,228				-
Paddy (90 days) RBE	768	346				1,114				-
OFC	4,415	2,160	990	880	1,390	9,835				-
Yala total (ha)	11,200	5,328	3,776	1,792	3,584	25,680	2,668	842	416	3,926
Annual Total (ha)	25,200	11,988	8,496	4,032	8,064	57,780	6,003	1,894	936	8,833
Start water issue - Maha	1-Oct	1-Oct	15-Oct	1-Oct	1-Oct	1-Oct	1-Nov	1-Nov	1-Nov	1-Nov
Start water issue - Yala	15-Apr	15-Apr	1-May	15-Apr	15-Apr	15-Apr	1-May	1-May	1-May	1-May
System Efficiency [*1] - Maha	0.60	0.70	0.86	0.81	0.77	-	0.75	0.91	0.60	-
System Efficiency [*1] - Yala	0.76	0.86	0.90	0.90	0.91	-	0.57	0.79	0.84	-

Crop Type	System M/H	KHFC	System G	System D1					System D2	Total
	Huruluwewa	KHF canal	Elahera	Minneriya	Giritale	Kaudulla	Kantale	Sub-Total	Parakrama Samudra	
Irrigable Area (ha)	4,210	2,250	5,750	9,099	3,076	6,885	8,880	27,940	10,121	87,278
Maha										
Paddy (135 days) LHG	1,403	300		3,033	1,025	2,103	2,960	9,121	3,374	21,113
Paddy (105 days) LHG	2,807	600		6,066	2,051	4,206	5,920	18,243	6,747	42,226
Paddy (135 days) RBE		390	1,842					-		7,155
Paddy (105 days) RBE		780	3,683					-		14,309
OFC		180	225			576		576		2,476
Maha total (ha)	4,210	2,250	5,750	9,099	3,076	6,885	8,880	27,940	10,121	87,278
Yala										
Paddy (105 days) LHG	2,245	480		6,066	2,051	2,103	2,960	13,180	6,747	33,324
Paddy (90 days) LHG	1,123	240		3,033	1,025	4,206	5,920	14,185	3,374	24,678
Paddy (105 days) RBE		127	3,477					-		5,831
Paddy (90 days) RBE		63	1,738					-		2,916
OFC		890	535			576		576		11,836
Yala total (ha)	3,368	1,800	5,750	9,099	3,076	6,885	8,880	27,940	10,121	78,585
Annual Total (ha)	7,578	4,050	11,500	18,198	6,152	13,771	17,760	55,881	20,242	165,863
Start water issue - Maha	1-Nov	1-Nov	15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	15-Oct	1-Oct
Start water issue - Yala	1-May	1-May	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr
System Efficiency [*1] - Maha	0.99	0.34	0.54	0.74	0.58	0.72	0.88	-	0.46	-
System Efficiency [*1] - Yala	0.83	0.30	0.69	0.92	0.60	0.66	0.83	-	0.65	-

Prepared by the JICA Survey Team

Note: *1: The above System Efficiency used in the water balance simulation, which the MASL introduced and uses for their routine planning, is a composed factor including main and branch canals efficiency, distributary canal efficiency, field canal efficiency, field application efficiency, and also re-use of irrigation water within the relevant irrigation system/scheme.

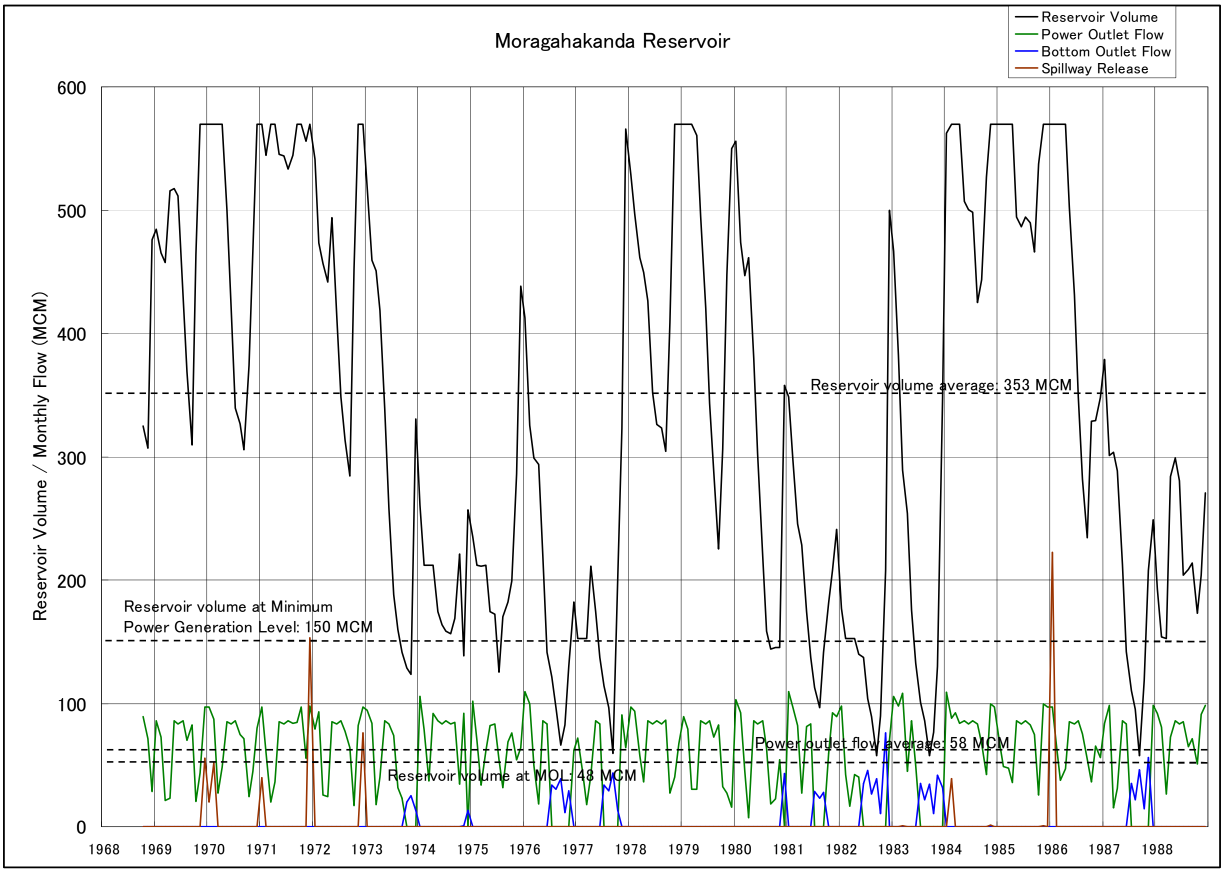
Attachment-9 (3) Cropping Pattern and System Efficiency in Water Balance Simulation (Case-C_With Project: 2022-2040)

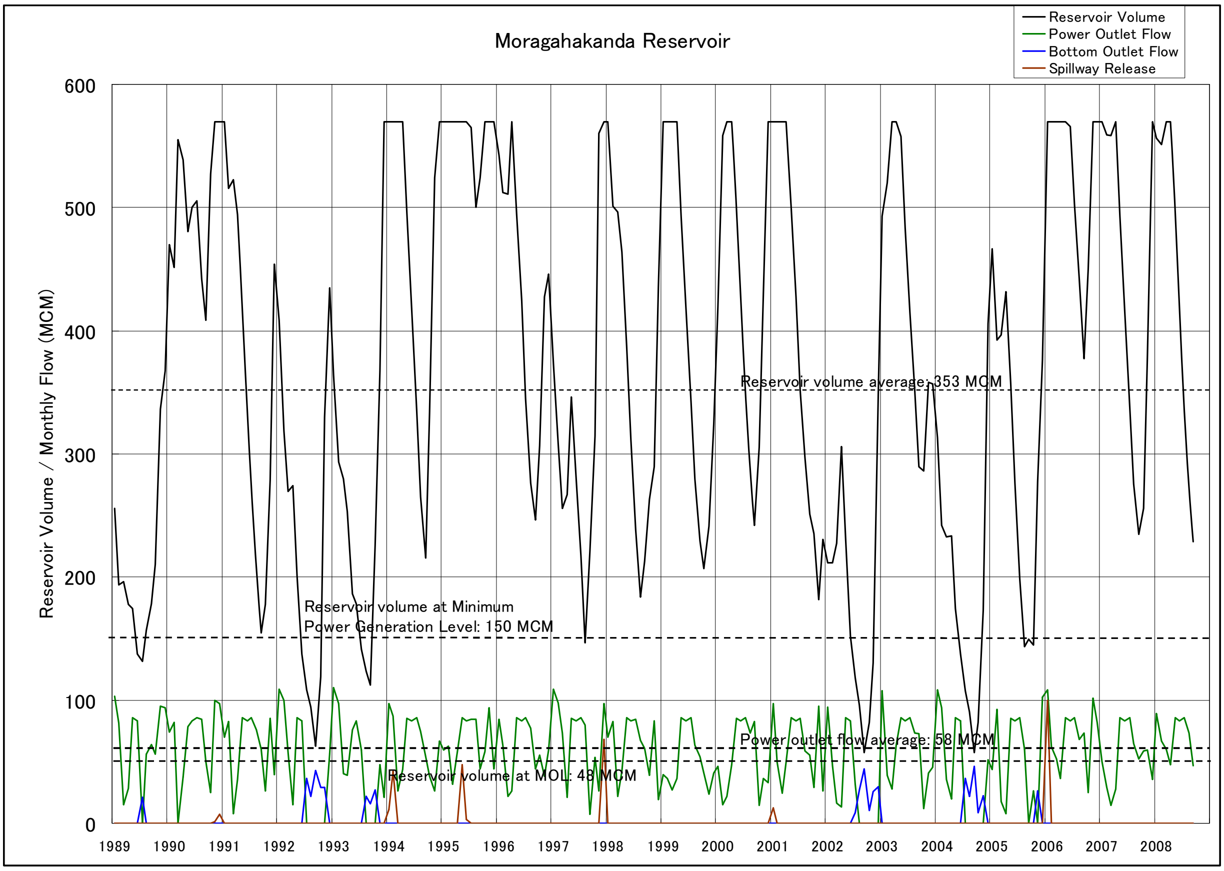
Crop Type	System H						System I/H			
	Kalawewa RB	Kalawewa LB	Kalawewa YE	Dambulu Oya	Kandalama	Sub-Total	Nachchaduwa	Nuwarawewa	Tissawewa	Sub-Total
Irrigable Area (ha)	14,000	6,660	4,720	2,240	4,480	32,100	3,335	1,052	520	4,907
Maha										
Paddy (105 days) LHG	3,733	1,776	2,360	896	1,792	10,557	2,223	701	347	3,271
Paddy (90 days) LHG	1,867	888	1,180	448	896	5,279	1,112	351	173	1,636
Paddy (105 days) RBE	5,100	2,377	700	564	1,105	9,846				-
Paddy (90 days) RBE	2,550	1,189	350	282	552	4,923				-
OFC	750	430	130	50	135	1,495				-
Maha total (ha)	14,000	6,660	4,720	2,240	4,480	32,100	3,335	1,052	520	4,907
Yala										
Paddy (105 days) LHG	2,240	1,066	1,393	456	1,097	6,252	1,334	421	208	1,963
Paddy (90 days) LHG	2,240	1,066	1,393	456	1,097	6,252	1,334	421	208	1,963
Paddy (105 days) RBE	1,153	518				1,671				-
Paddy (90 days) RBE	1,153	518				1,671				-
OFC	4,415	2,160	990	880	1,390	9,835				-
Yala total (ha)	11,200	5,328	3,776	1,792	3,584	25,680	2,668	842	416	3,926
Annual Total (ha)	25,200	11,988	8,496	4,032	8,064	57,780	6,003	1,894	936	8,833
Start water issue - Maha	1-Oct	1-Oct	15-Oct	1-Oct	1-Oct	1-Oct	1-Nov	1-Nov	1-Nov	1-Nov
Start water issue - Yala	15-Apr	15-Apr	1-May	15-Apr	15-Apr	15-Apr	1-May	1-May	1-May	1-May
System Efficiency *1 - Maha	0.60	0.69	0.86	0.81	0.77	-	0.76	0.90	0.61	-
System Efficiency *1 - Yala	0.76	0.85	0.90	0.90	0.90	-	0.57	0.79	0.84	-

Crop Type	System M/H	KHFC	System G	System D1					System D2	Total
	Huruluwewa	KHF canal	Elahera	Minneriya	Giritale	Kaudulla	Kantale	Sub-Total	Parakrama Samudra	
Irrigable Area (ha)	4,210	2,250	5,750	9,099	3,076	6,885	8,880	27,940	10,121	87,278
Maha										
Paddy (105 days) LHG	2,807	600		6,066	2,051	4,206	5,920	18,243	6,747	42,226
Paddy (90 days) LHG	1,403	300		3,033	1,025	2,103	2,960	9,121	3,374	21,113
Paddy (105 days) RBE		780	3,683					-		14,309
Paddy (90 days) RBE		390	1,842					-		7,155
OFC		180	225			576		576		2,476
Maha total (ha)	4,210	2,250	5,750	9,099	3,076	6,885	8,880	27,940	10,121	87,278
Yala										
Paddy (105 days) LHG	1,684	360		4,550	1,538	3,155	4,440	13,682	5,061	29,001
Paddy (90 days) LHG	1,684	360		4,550	1,538	3,155	4,440	13,682	5,061	29,001
Paddy (105 days) RBE		95	2,608					-		4,373
Paddy (90 days) RBE		95	2,608					-		4,373
OFC		890	535			576		576		11,836
Yala total (ha)	3,368	1,800	5,750	9,099	3,076	6,885	8,880	27,940	10,121	78,585
Annual Total (ha)	7,578	4,050	11,500	18,198	6,152	13,771	17,760	55,881	20,242	165,863
Start water issue - Maha	1-Nov	1-Nov	15-Oct	15-Oct	15-Oct	1-Nov	1-Nov	15-Oct	15-Oct	1-Oct
Start water issue - Yala	1-May	1-May	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr	15-Apr
System Efficiency *1 - Maha	0.99	0.34	0.54	0.74	0.58	0.72	0.88	-	0.46	-
System Efficiency *1 - Yala	0.83	0.31	0.69	0.92	0.60	0.66	0.83	-	0.65	-

Prepared by the JICA Survey Team

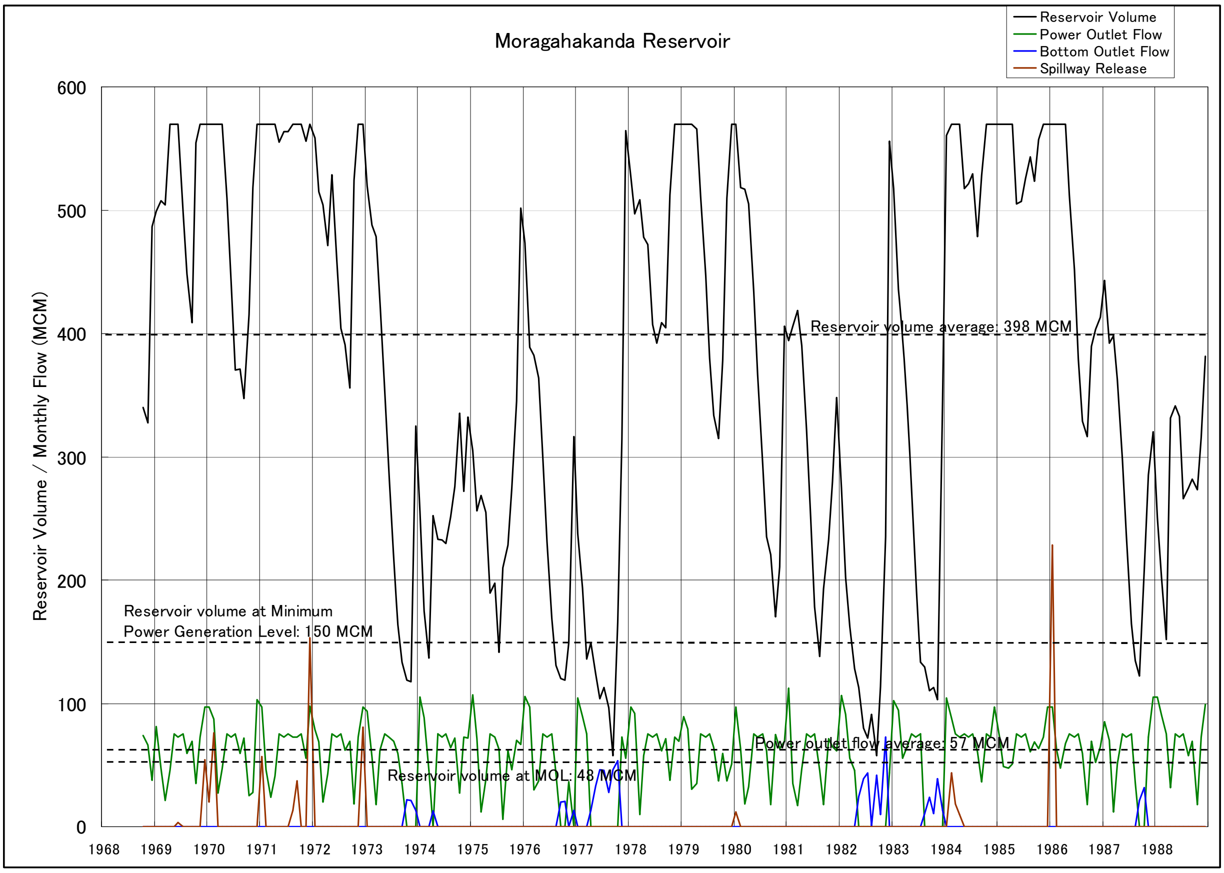
Note: *1: The above System Efficiency used in the water balance simulation, which the MASL introduced and uses for their routine planning, is a composed factor including main and branch canals efficiency, distributary canal efficiency, field canal efficiency, field application efficiency, and also re-use of irrigation water within the relevant irrigation system/scheme.

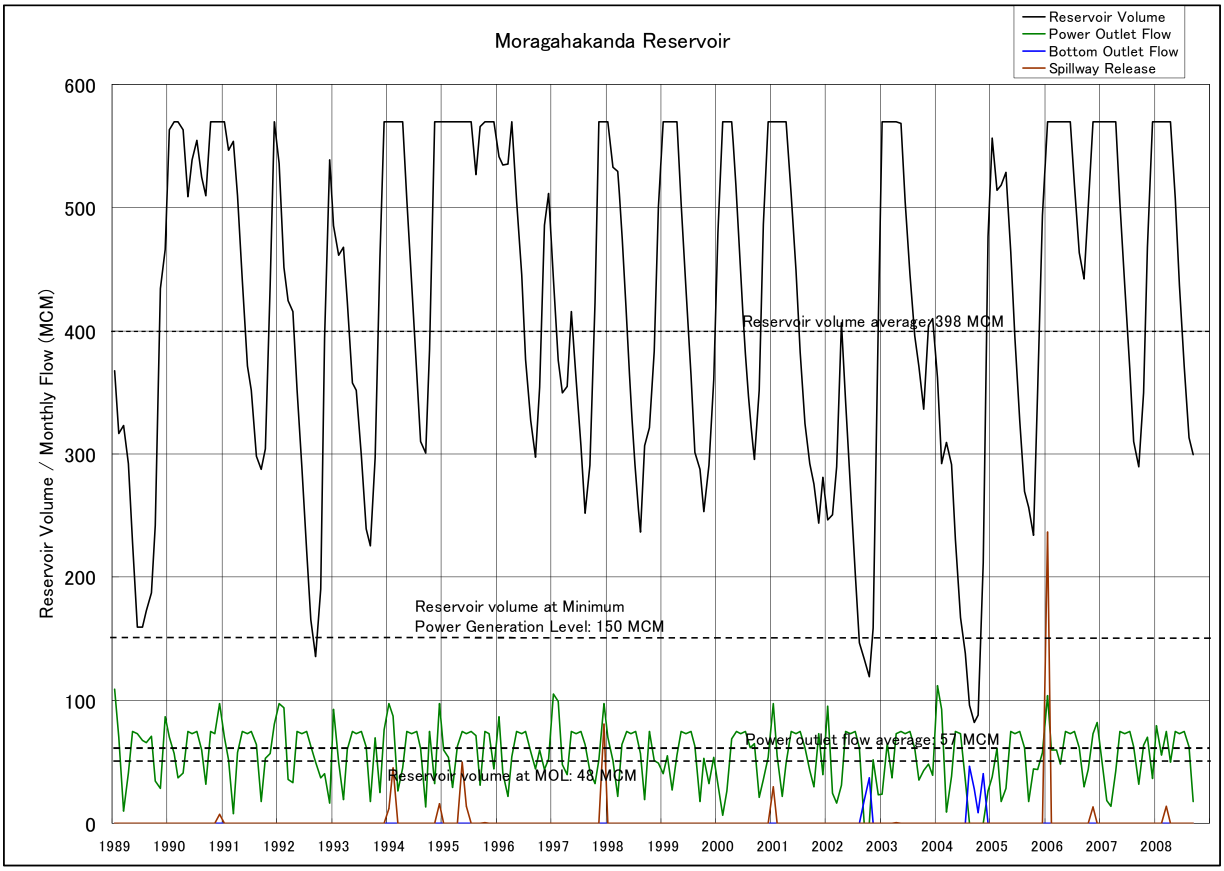




Prepared by the JICA Survey Team

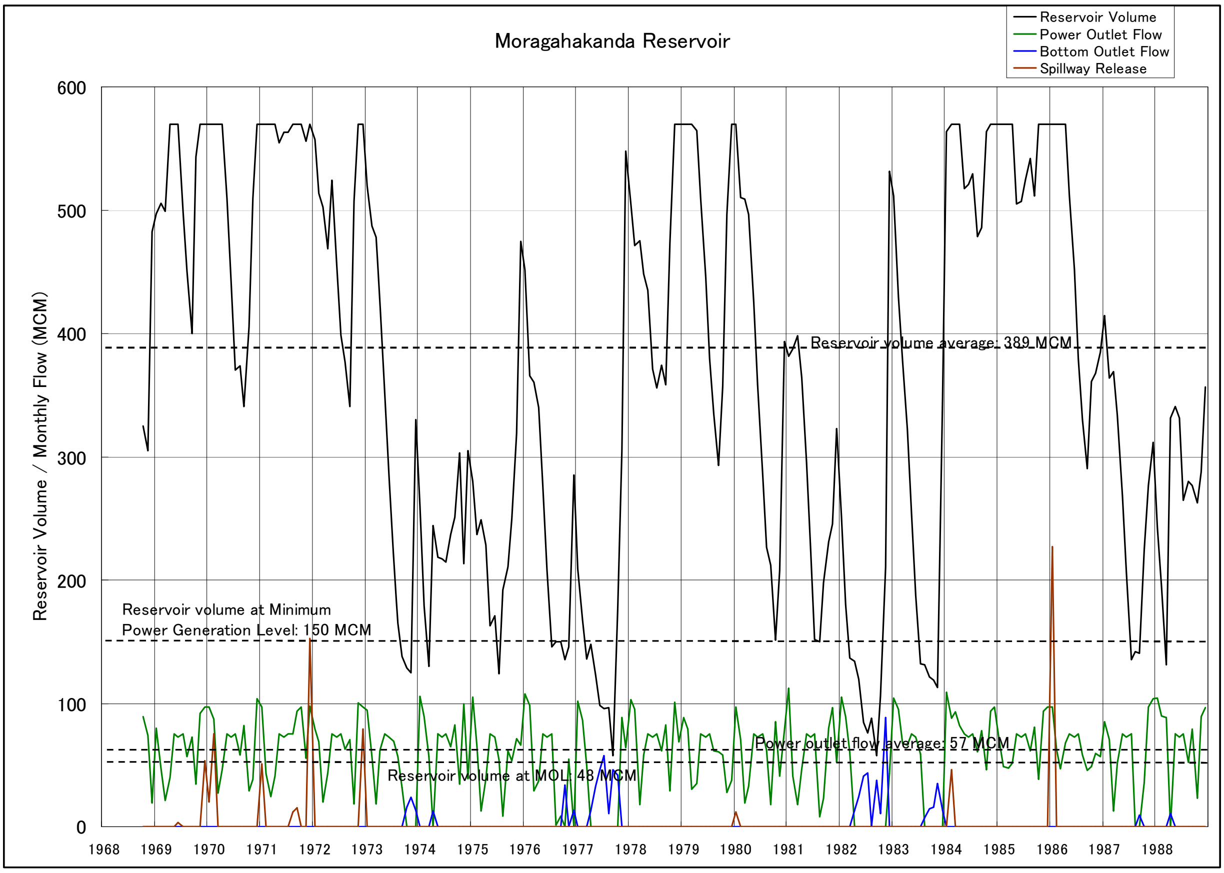
Attachment-10 (1) Simulated Monthly Reservoir Volume, Power Outlet Flow, Bottom Outlet Flow and Spillway Release of Moragahakanda Reservoir (Case-B_With Project: 2017)

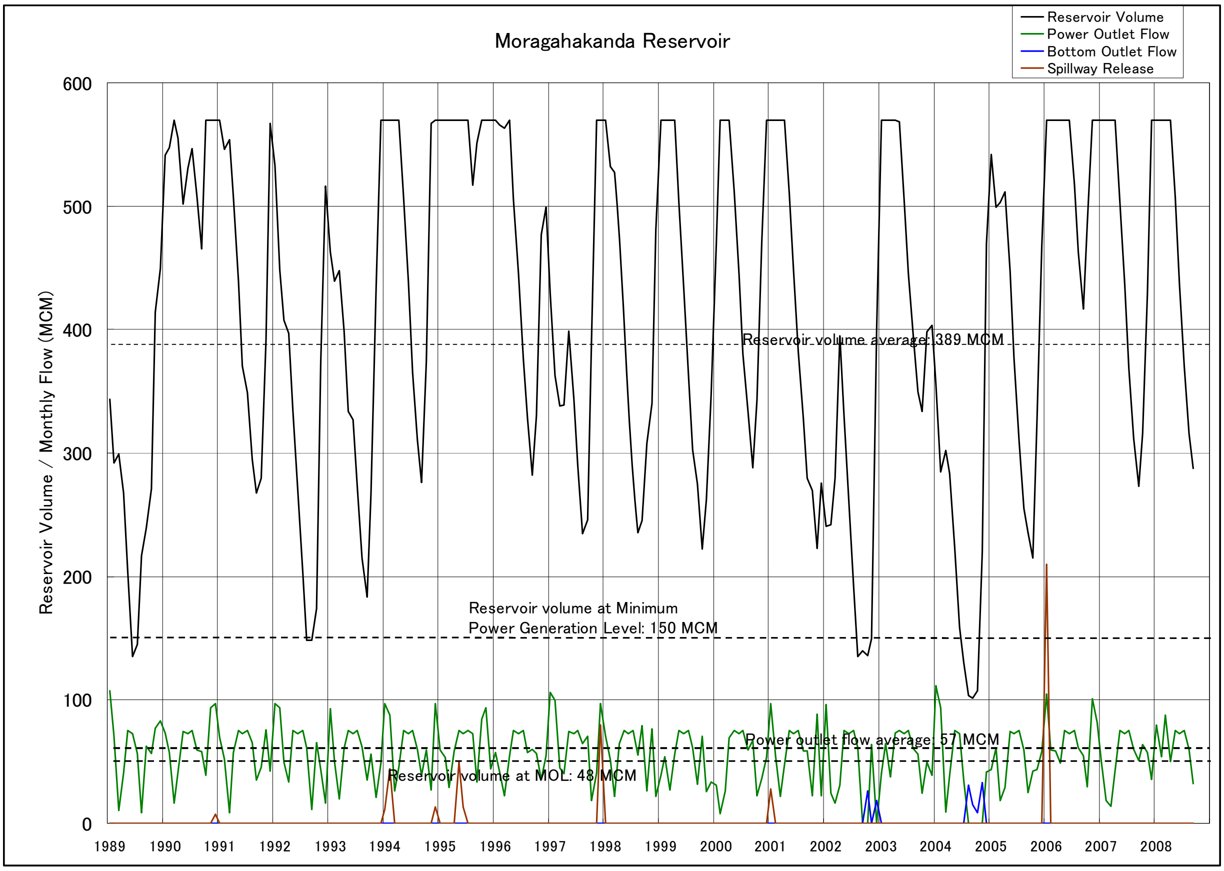




Prepared by the JICA Survey Team

Attachment-10 (2) Simulated Monthly Reservoir Volume, Power Outlet Flow, Bottom Outlet Flow and Spillway Release of Moragahakanda Reservoir (Case-C_With Project: 2022)





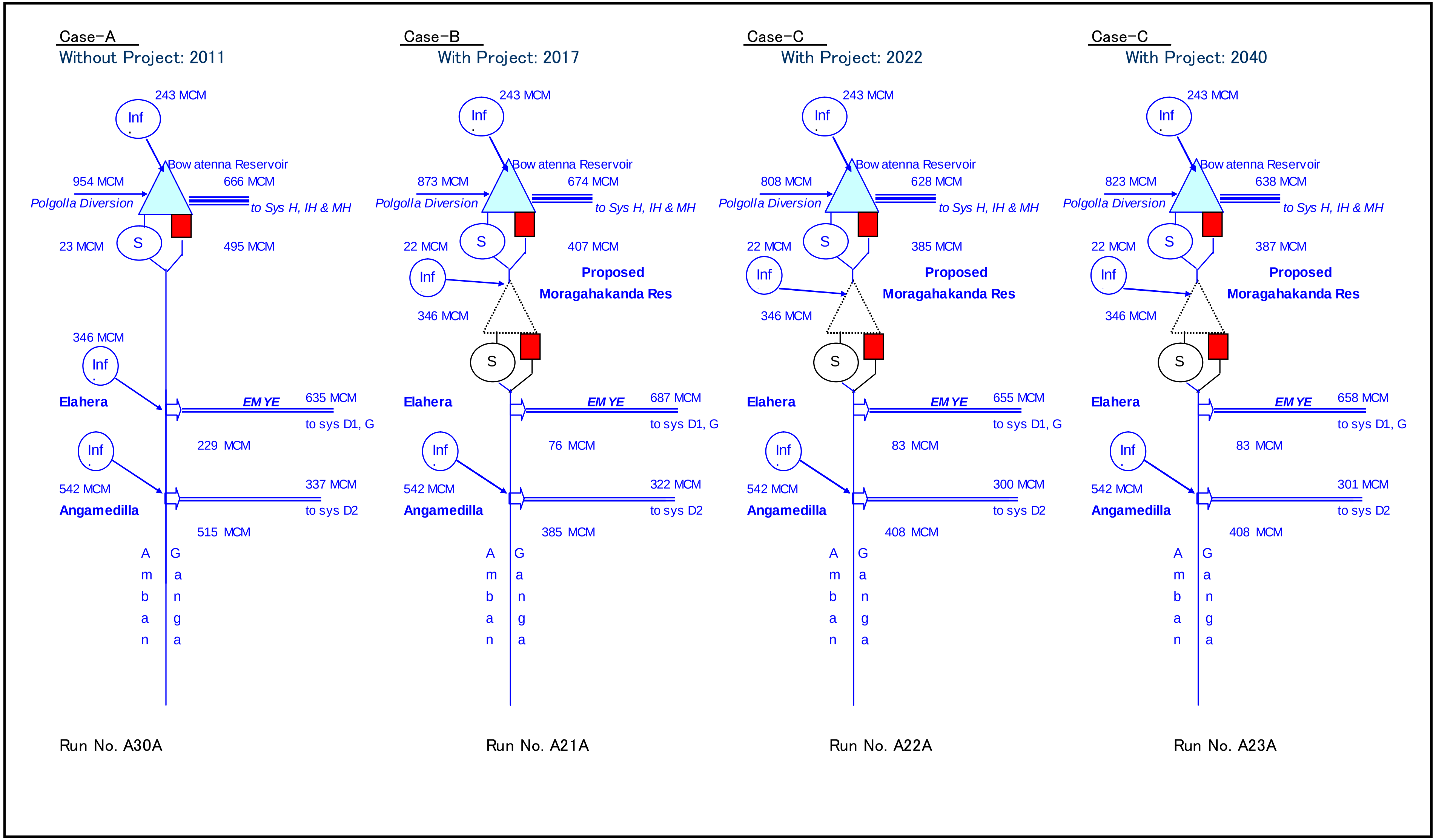
Prepared by the JICA Survey Team

Attachment-10 (3) Simulated Monthly Reservoir Volume, Power Outlet Flow, Bottom Outlet Flow and Spillway Release of Moragahakanda Reservoir (Case-C_With Project: 2040)

Attachment-11 Cropping Intensities, Water Issues and Water Duties of Each Simulation Case

Diversion from Amban River	Irrigation System	Irrigable Area (ha)		Cropping Intensity						Water Issue (MCM)								Average Annual Water Duty (ha/MCM)			
				Without Project			With Project			Maha				Yala							
		Without Project	With Project							Without Project	With Project			Without Project	With Project			Without Project	With Project		
				Maha	Yala	Annual	Maha	Yala	Annual	2011	2017	2022	2040	2011	2017	2022	2040	2011	2017	2022	2040
Bowatenna	H	32,100	32,100	99%	69%	168%	100%	80%	180%	363	343	294	294	279	299	292	290	84	90	99	99
	I/H	4,907	4,907	91%	67%	158%	100%	80%	180%	44	49	41	41	52	65	63	63	81	77	85	85
	M/H	4,210	4,210	99%	53%	152%	100%	80%	180%	30	30	25	25	29	42	41	41	108	105	115	115
	KHFC	2,250	2,250	100%	71%	171%	100%	80%	180%	55	49	42	42	60	59	56	56	33	38	41	41
Elahera	G	5,750	5,750	95%	84%	179%	100%	100%	200%	89	88	76	76	94	105	101	101	56	60	65	65
	D1	26,520	27,940	97%	87%	184%	100%	100%	200%	188	203	178	178	275	319	320	320	105	107	112	112
Angamedilla	D2	10,121	10,121	100%	100%	200%	100%	100%	200%	120	118	101	101	152	141	138	138	74	78	85	85
Grand Total		85,858	87,278	98%	78%	176%	100%	90%	190%	889	880	757	757	941	1,030	1,011	1,009	83	87	94	94

Prepared by the JICA Survey Team



Prepared by the JICA Survey Team

Attachment-12 Average Annual Water Balance in Amban River

Attachment-13 Abstract of "Technical Requirement for Interconnection of Generation Resources" by CEB

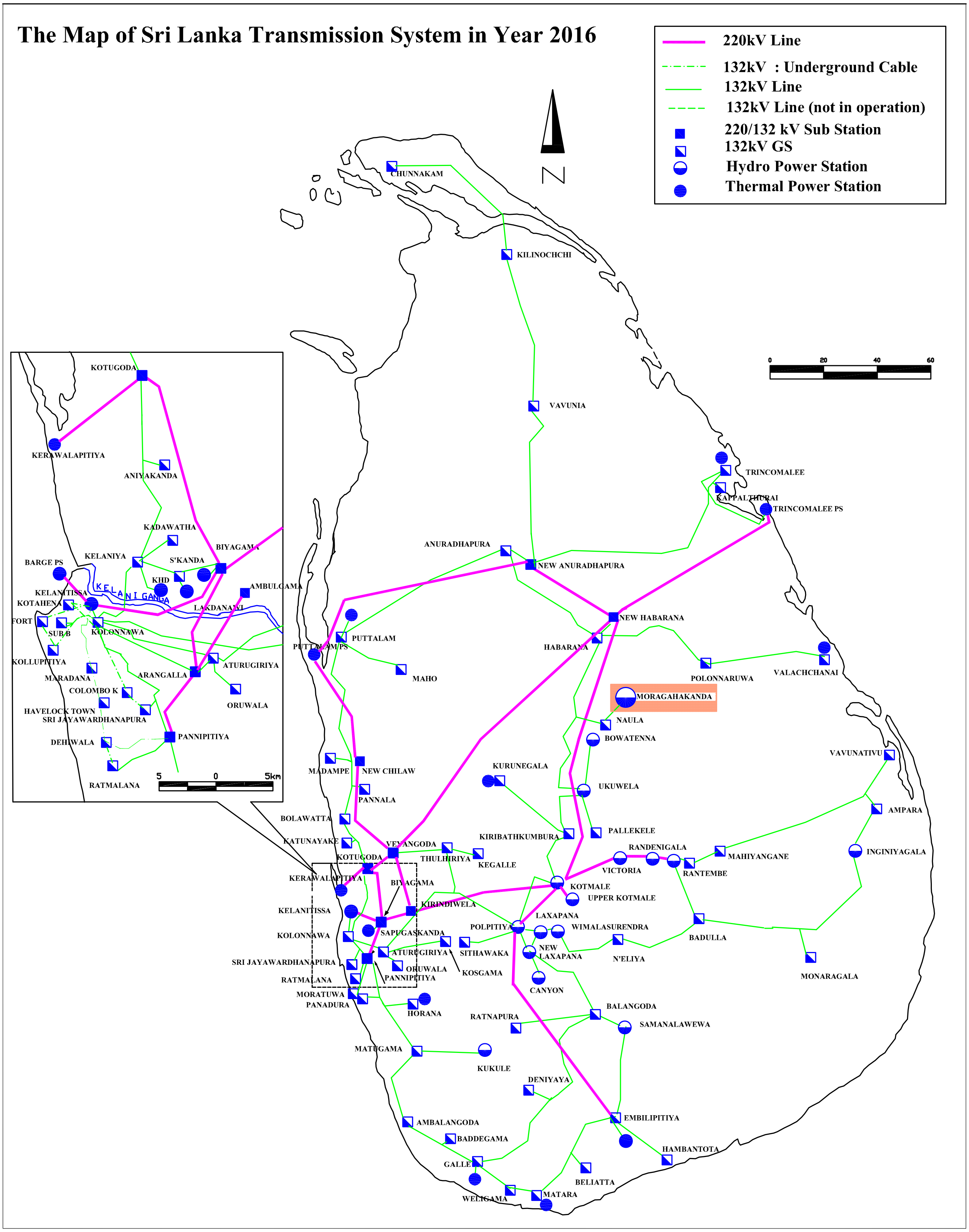
<table>
<tr><td colspan="2">Section</td><td>Requirements</td></tr>
<tr><td>1</td><td>Introduction</td><td>1) Applied for above 33kV level
2) Applied for new, expanded, restarted, modified projects
3) Purpose: For safe operation, integrity, reliability of CEB transmission network
4) Study and analysis without ownership
5) CEB reviews issues such as short-circuit, transient voltage, reactive power requirements, stability, harmonics, safety, operations, maintenance Prudent Electric Utility Practices</td></tr>
<tr><td>2</td><td>Scope</td><td>Applied for all new or expanded Generation Projects.
a) Applicable Codes, Standards, Criteria and Regulations:
listed Section 11
b) Environmental Consideration: National Environmental Act(NEA), EIA study
c) Safety, protection and Reliability
d) Special Generator Distribution Studies: due to high speed reclosing and single-pole/three pole switching
e) Interconnection Studies: Estimated for execution</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Studies & Information</td><td>d) Studies: transmission system capability, transient stability, voltage stability, losses, voltage regulation, harmonics, voltage flicker, electromagnetic transients, machine dynamics, ferroresonance, metering requirements, protective relaying, substation grounding, fault duties</td></tr>
<tr><td>3.1 Initial Request to CEB for Interconnection
3.2 Request for CEB to conduct System Impact and Facility Requirement Study (Detailed Interconnection Study):
Information required for Detailed study:
A. Technical Description of the Project, including
1) Electrical Single line Diagram, type of generation, proposed nameplate ratings, site location map, site plan, transmission routing, description
Of the proposed connection to the CEB network
2)All available generator and transformer data
3)Validated models and data for power flow and dynamic simulation. (details to referred to "Guideline")</td></tr>
<tr><td>4</td><td>System Parameter</td><td>4.1 Planning Criteria:
a) Voltage at the live bars of CEB network: 33kV:±0%(normal operation): ±0%(single contingency condition)
b) System frequency: 50Hz±1%
4.2 Present CEB Network
System Frequency: 50Hz±4%(normal), -6% to +5% up to 3 seconds</td></tr>
<tr><td>5</td><td>General Requirements</td><td>5.2 a) Point of interconnection: a 33kV bus bar of a 132kV/33kV grid substation
b) For Generation Projects less than 100MW, a firm connection is required or not is to be determined by Transmission Division of CEB.
c) iii) CEB uses single-pole protective relaying on some 33kV lines.
iv) The Generation Project is expected to supply up to maximum available reactive capability.
5.3 Earthing of Electricity Networks and Generators: Single point earthing.
b) A at 33kV level: to be designed in consultation with CEB.</td></tr>
</table>

		The generator transformer must be impedance earthed:(250A) 5.6 Insulation Coordination: High voltage side of a generator transformer is not earthed. 5.9 Isolating, Synchronizing and Blackstarting a) Isolation: The project shall not energize a de-energized CEB line. b) Synchronization: Automatic synchronization shall be supervised by a synchronizing check relay. d) Blackstarts: Blackstart capability is needed in some conditions.
6	Performance Requirements	6.2 Switchgear: a)IEC56 High voltage alternating current circuit breaker. b) Circuit Breaker Operating Times at 33kV class: Rated interrupting time 3-4cycles, Automatic recluse time:50(1st shot)&250(second shot) 6.3Generators, Step-Up and Auxiliary Transformers: 1) IEC-34 Rotating electrical machine. 2) Generator excessive voltage excursion: not in excess of 10% of nominal voltage. 3) Short circuit ratio of generating unit: not less than 0.5 4) Capable of supplying rated power output(MW) at any point between 0.8 lagging and 0.95 leading power factor. 5) Continuously maintaining constant active power output for system frequency changes within the range 50.5 to 49.5Hz. Within the range of 49.5 to 47 Hz, not more than 5% at 47Hz. 6) The active power output under steady state conditions: not affected by the voltage changes. 7) The reactive power output under steady conditions: fully available within 5% at all voltage level. 8) Design of generating plant: to be capable of operation below. 47.5-52Hz: Continuous operation 47-47.5Hz: At least 20seconds operation 9) Transformer reactance and tap settings to be coordinated with CEB to optimize the reactive power capability 6.4 Excitation Equipment and Voltage Control 1) All synchronous generator: Automatic voltage control mode 2) The excitation system nominal response: to be 2.0 or higher 3) Terminal voltage overshoot: not exceeding 10% for an open circuit 4) Voltage regulator : Power System Stabilizer(PSS) and overexcitation limiter to be included. The adjustment of AVR setpoint to meet CEB voltage schedule. 6.5 Governor Speed and Frequency Control: Droop characteristic within the range of 2% to 10%. Regularly set at 4%.
7	Protection Requirements	7.1 CEB makes the final determination as to the protective devices and identifies modification and/or additions required by the Project. 7.2 Protection Criteria: Internal fault, external fault, abnormal conditions c) A digital fault recorder to be supplied. 7.3 Protective relays: Refer to List of Protection Relay
8	System Operation Requirements	8.1 Telemetry Requirements: continuous telemetering of kW, kWh, Net project output, 8.2 SCADA Requirements: 1) Control and status indicators of power circuit breakers and isolators. 2) Indication: Real and reactive power flows, voltage levels, AVR operating point, % loading, parameter limits, major protection function.

9	Telecommunication Requirements	9.1 Telecommunications facilities: all or any of Microwave systems, Fiber-optic system, Wireline facilities. 9.2 Voice Communications: A terminal for Party Line Telephone system, Telephone system, A public telephone and a fax, A dedicated voice communication, Equipment for transmission and receipt of e-mails, 9.3 Data Communications: SCADA, Revenue Metering System 9.4 Telecommunications for Control & Protection: Redundant system for CEB Transmission Network, maximum permissible throughput operating times, equipment compatibility
10	Definitions	To be referred
11	References	To be referred

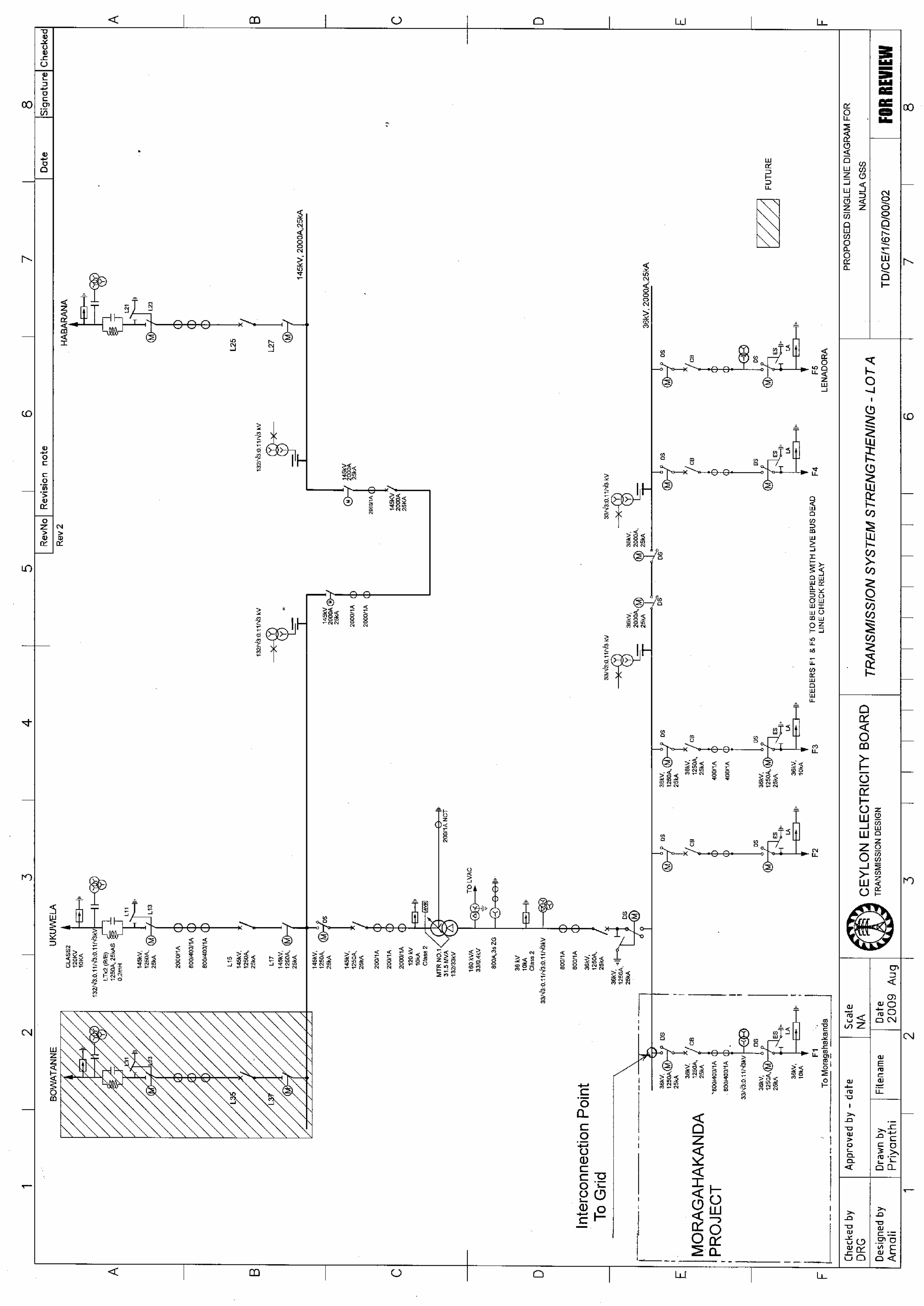
Source of data: CEB

Attachmet-14 Power System Map year 2016



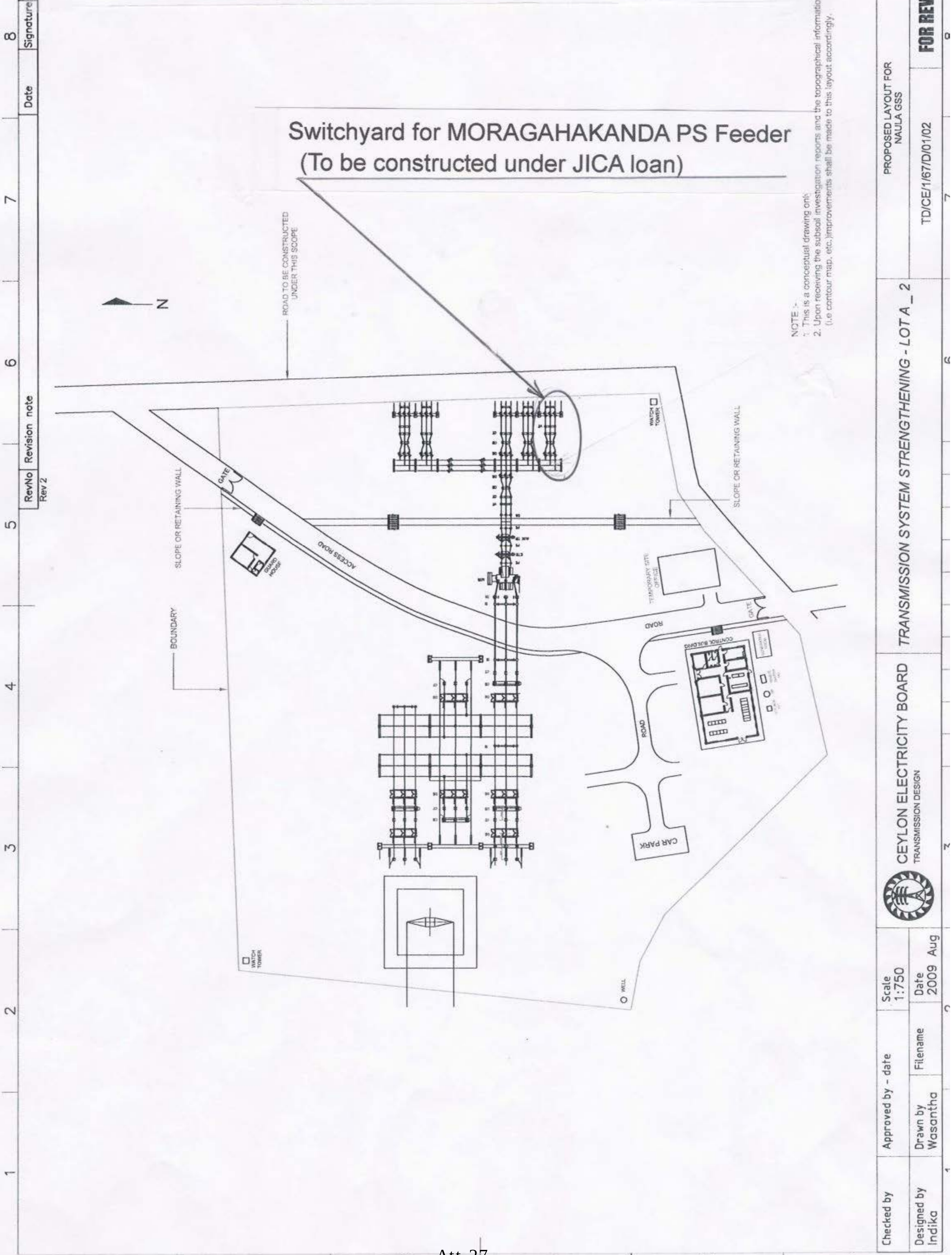
Source: CEB

Attachment-15 Proposed Single Line Diagram of NAULA Grid Substation

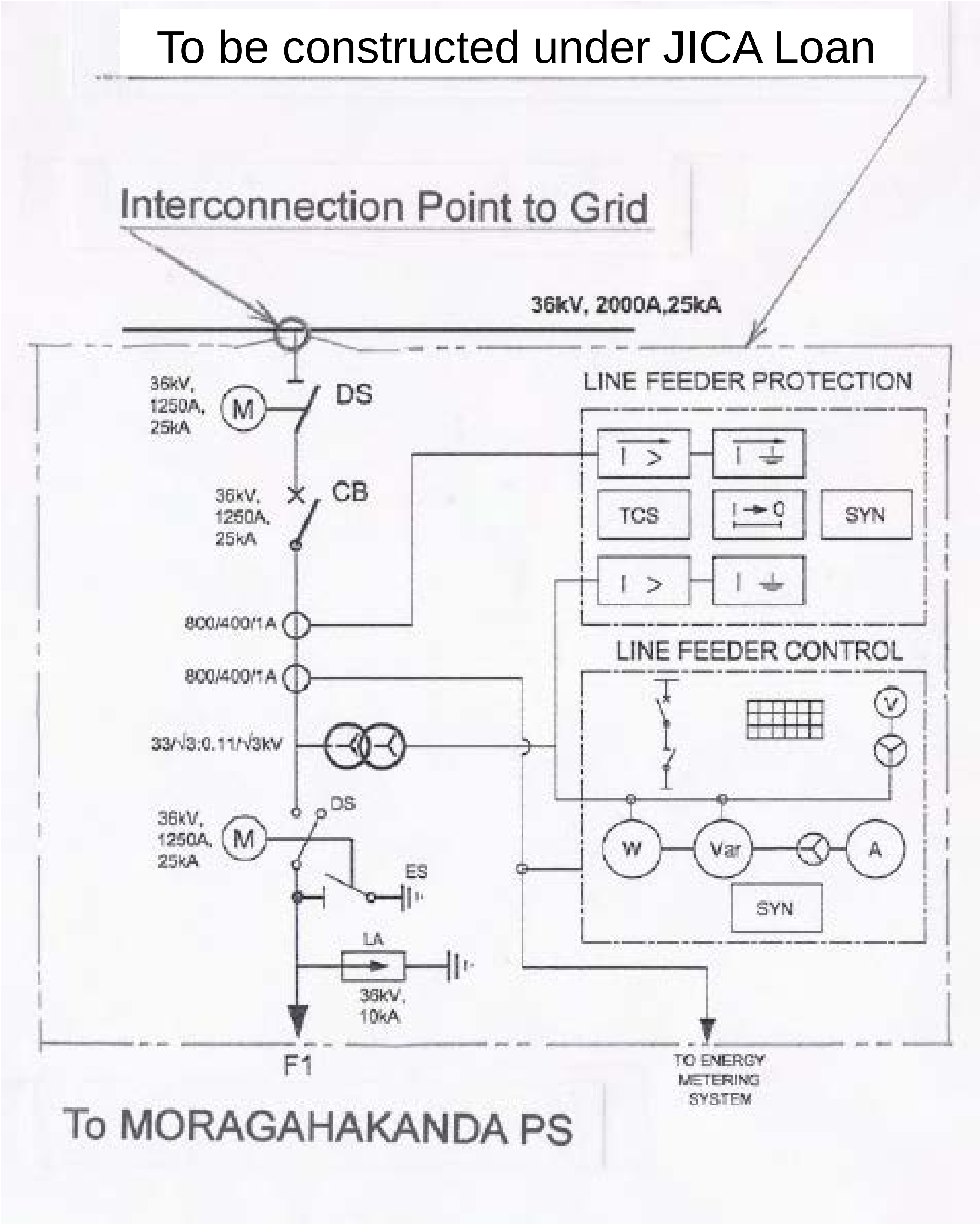


Attachment-16 **CEB NAULA GSS:**

Switchyard for Feeder for MORAGAHAKANDA PS



Attachment-17 CEB NAURA GSS: Single Line Diagram of Feeder for MORAGAHAKANDA PS

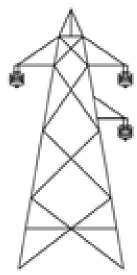


Prepared by the JICA Survey Team based on data from the CEB

Attachment-18 Comparison and Requirements of 33kV Transmission Line

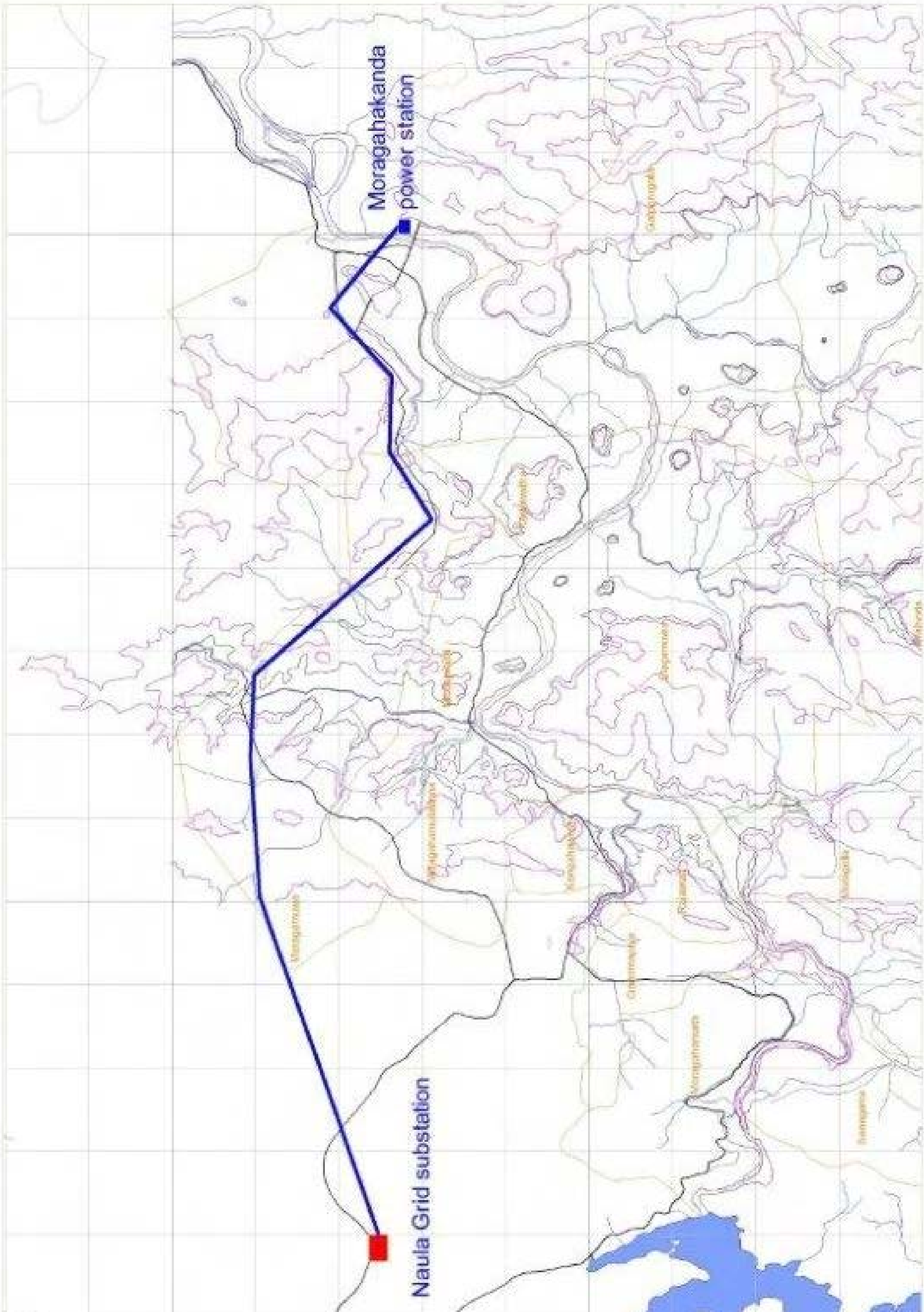
Main Specifications and Requirements	• **Capacity:**17.6MVA(15MW,cos ϕ =0.85), 308A • **Voltage:**33kV, 3 phase • **No. of Line:** 1 • **Connection:** Moragakahanda Power Station to CEB Naula Grid Substation • **Conductor:**Lynx:185mm2, Allowable current(daytime)=345A • **Design Criteria:** Wind pressure 970N/sq.m, Min. temperature 7℃、Maximum temperature 75℃, Thunderday per day:62-80/year. ROW:15m each side

Comparison of Transmission Line Options

Type	**Steel Tower**	**11m Concrete Pole**
Span	200 - 300 meters	40 - 50 meters
Route	Exact path not decided. Most economical design will be made once detail design work begins. Approximate length of line is 15 km and number of towers will be 60.	Along new road constructed by MASL. Approximate length will be 20 km.
Advantages	• smaller environmental impact due to lesser amount of trees being cut • shorter length leading to smaller line impedance • no need for way leaves clearance	• Faster Construction • No special expertise or equipment required during construction • lesser design cost
Disadvantages	• Line needs to be specially designed for particular path • Longer construction period and design time including survey	• Can be damaged due to road accidents • Risk of damage due to landslides • Require way leaves clearance every six months
Reliability	Very high reliability according to CEB engineers	Low reliability according to CEB engineers
Maintainability	Maintenance is difficult due to jungle and repair time is long. But maintenance is required very rarely	Maintenance is easy and require very little time. But faults are common if frequent line maintenance is not performed
Cost (Standard cost of CEB)	about 10 million rupees per km total estimated cost is 150 million rupees	about 2.4 million rupees per km total estimated cost is 48 million rupees
Sample Picture		
Evaluation	Recommended	----------------------

Prepared by the JICA Survey Team

Attachment-19 Route of 33 kV Transmission line



Prepared by the JICA Survey Team based on data from the CEB

Attachment -20　Salient Features of Moragahakanda Dam and Power Staion

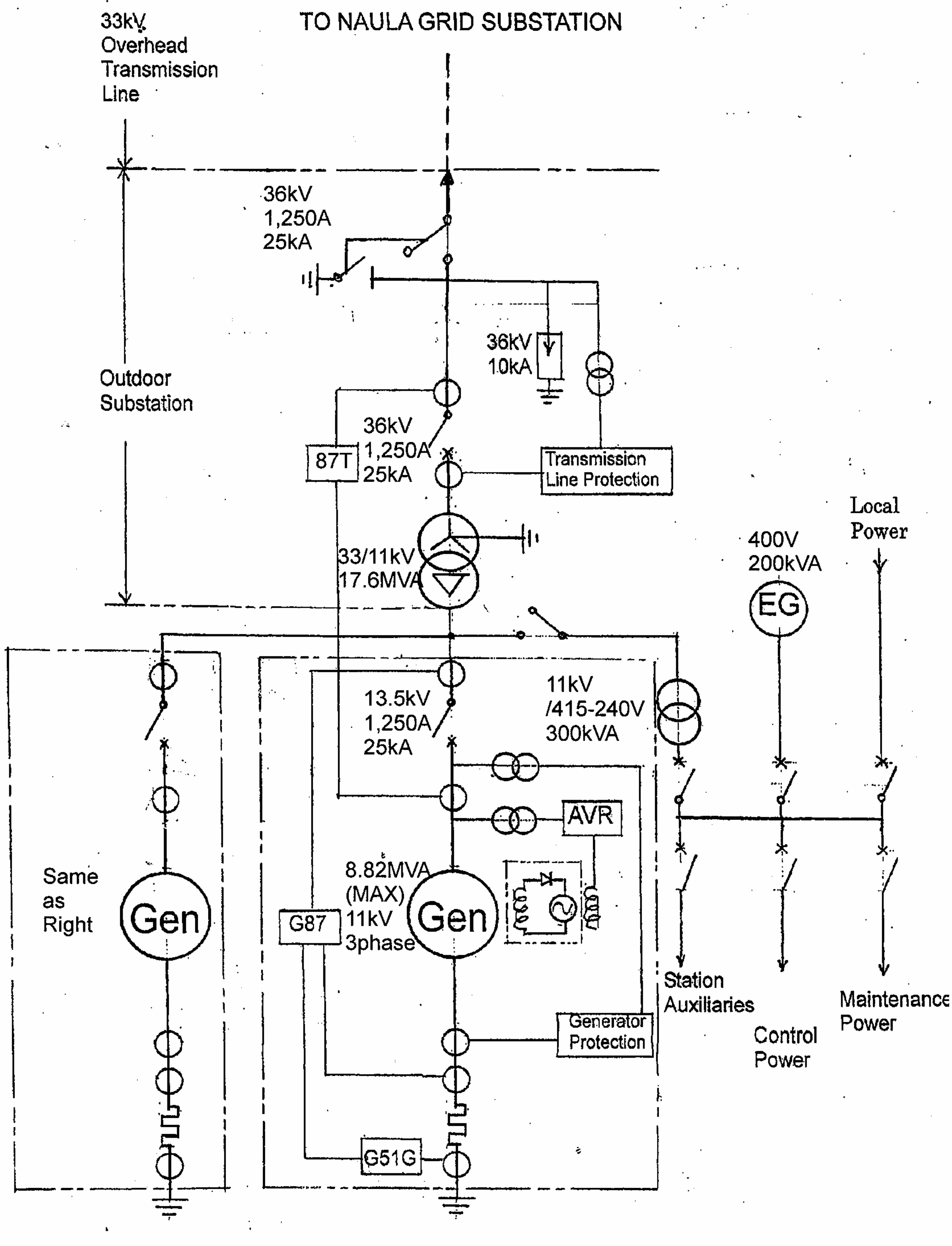
	Descriptions	Unit	Present Study (2010)	Previous FS (2001)
1	River and Hydrology at Dam Site			
	Name of River	-	Amban Ganga	Amban Ganga
	Catcment Area	km^2	768	768
	Mean Annual Flow (self catchment)	m^3/s	24.6	24.6 (Year 1949-98)
	Recorded max. flood	m^3/s	1,605	1,605 (in 1978)
	Dam Design Flood (p=1/1,000)	m^3/s	3,797	3,797
	Safety Check Flood (p=1/10,000)	m^3/s	4,749	4,749
2	Reservoir			
	Maximum Flood Level	m asl	185.59	185.59
	Full Supply Level (FSL)	m asl	185.00	185.00
	Minimum Operation Level (MOL)	m asl	155.00	155.00
	Minimum Level for Generation	m asl	165.00	165.00
	Area at FSL	km^2	29.5	29.5
	Volume at FSL	MCM	569.9	569.9
	Volume at MOL	MCM	48.6	48.6
	Active Storage	MCM	521.3	521.3
3	Main Dam			
	Type	-	Rockfill dam	RCC dam
	Crest Elevation	m asl	188.5	187.0 (or 188.0)
	Crest Length	m	465	463
	Maximum Height	m	61	65
	Dam Volume	m^3	1,380,000	368,000
	Upstream Slope	-	1:1.8 (v:h)	1:0.1 (v:h)
	Downstream Slope	-	1:1.7 (v:h)	1:0.75 (v:h)
4	Saddle Dam No. 1			
	Type		RCC dam	Rockfill dam
	Crest Elevation	m asl	187.5	188.0
	Crest Length	m	365	361
	Maximum Height	m	51.5	42
	Dam Volume	m^3	171,000	674,000
	Upstream Slope	-	Vertical	1:1.5 (v:h)
	Downstream Slope	-	1:0.8 (v:h)	1:1.5 (v:h)
5	Saddle Dam No. 2 (presently under construction)			
	Type	-	Earthfill dam	Earthfill dam
	Crest Elevation	m asl	188.5	188.0
	Crest Length	m	374	374
	Maximum Height	m	21.5	21
6	Spillway			
	Type	-	Gated weir with chute and stilling basin	Gated weir with chute and stilling basin
	Design outflow	m^3/s	3,797	3,778
	Weir crest elevation	m asl	174.0	174.0
	Number of bays	-	5	5
	Width of one bay	m	9.7	9.5
	Width of pier	m	2.5	2.5
	Type of gate	-	Radial gate	Radial gate
	Width of chute and stilling basin	m	58.5	57.5
	Stilling basin floor elevation	m asl	137.0	124.0
	Stilling basin wall top elevation	m asl	155.0	147.0
	Stilling basin length	m	87.0	83.5

	Descriptions	Unit	Present Study (2010)	Previous FS (2001)
7	Bottom Outlet			
	Type	-	Pipe conduit with jet-flow gate	Pipe conduit with roller gate
	Number of bottom outlets	-	2	2
	Gate center elevation	m asl	142.5	138.0
	Size of gate (clear opening)	m	Diameter 1.6	1.80 x 2.00
	Discharge capacity at MOL	m^3/s	50	90
8	River Diversion Conduits			
	Type		Horizontal holes (D-shape) in dam	Horizontal holes in dam
	Number of bottom outlets		6	-
	Sill elevation	m asl	138.0 & 139.5	135.0
	Section size of conduit	m	5 x 5	5 x 5
9	Intake & Penstock			
	Type	-	Bellmouth with horizontal penstock	Bellmouth with inclined penstock
	Number of intakes		2	1
	Diameter of penstock pipe	m	2.5	3.91
10	Powerhouse			
	Type	-	Reinforced concrete building at dam toe	Reinforced concrete building at dam toe
	Number of generating units		2	1
	Installed capacity	MW	7.5 x 2 = 15	20
	Building size (W x L)	m	22.5 x 42.0	17.66 x 30.98
	Rated head	m	40.0	40.0
	Maximum net head	m	46.0	46.0
	Maximum discharge per unit	m^3/s	21	50
	Spiral casing center level	m asl	135.0	133.9
	Rated speed	rpm	375	230.8
	Power factor	-	0.85	0.86
	Frequency	Hz	50	50
	Rated generator capacity	MVA	8.0 x 2 = 16.0	20.9
	Annual energy production	GWh	66.3	45.0
	Tailbay end sill level	m asl	137.0	137.0
	Normal tailwater level (full opera'n)	m asl	138.0	138.5
	Maximum tailwater level	m asl	145.2	145.5
11	Transmission Line			
	Capacity	MVA	17.6	22.9
	Voltage	kV	33	132
	Length	km	15	41.8
	Number of circuit	-	1	1
	Conductor size	mm^2	185	240
	Number of towers	-	60	167

Attachment-21

SCHEMATIC DIAGRAM OF MORAGAHAKANDA POWER STATION

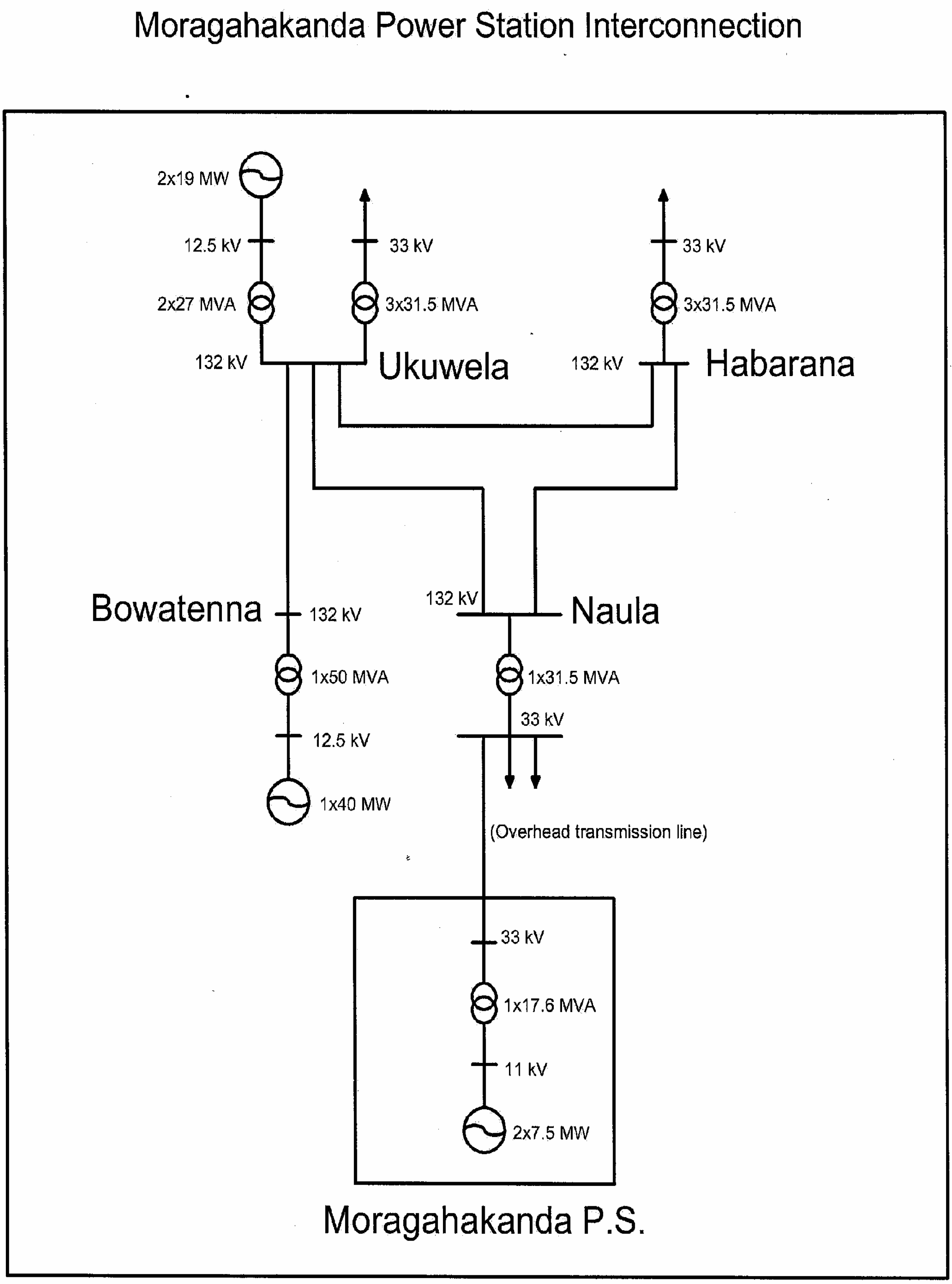
(2x7.5MW Scheme)



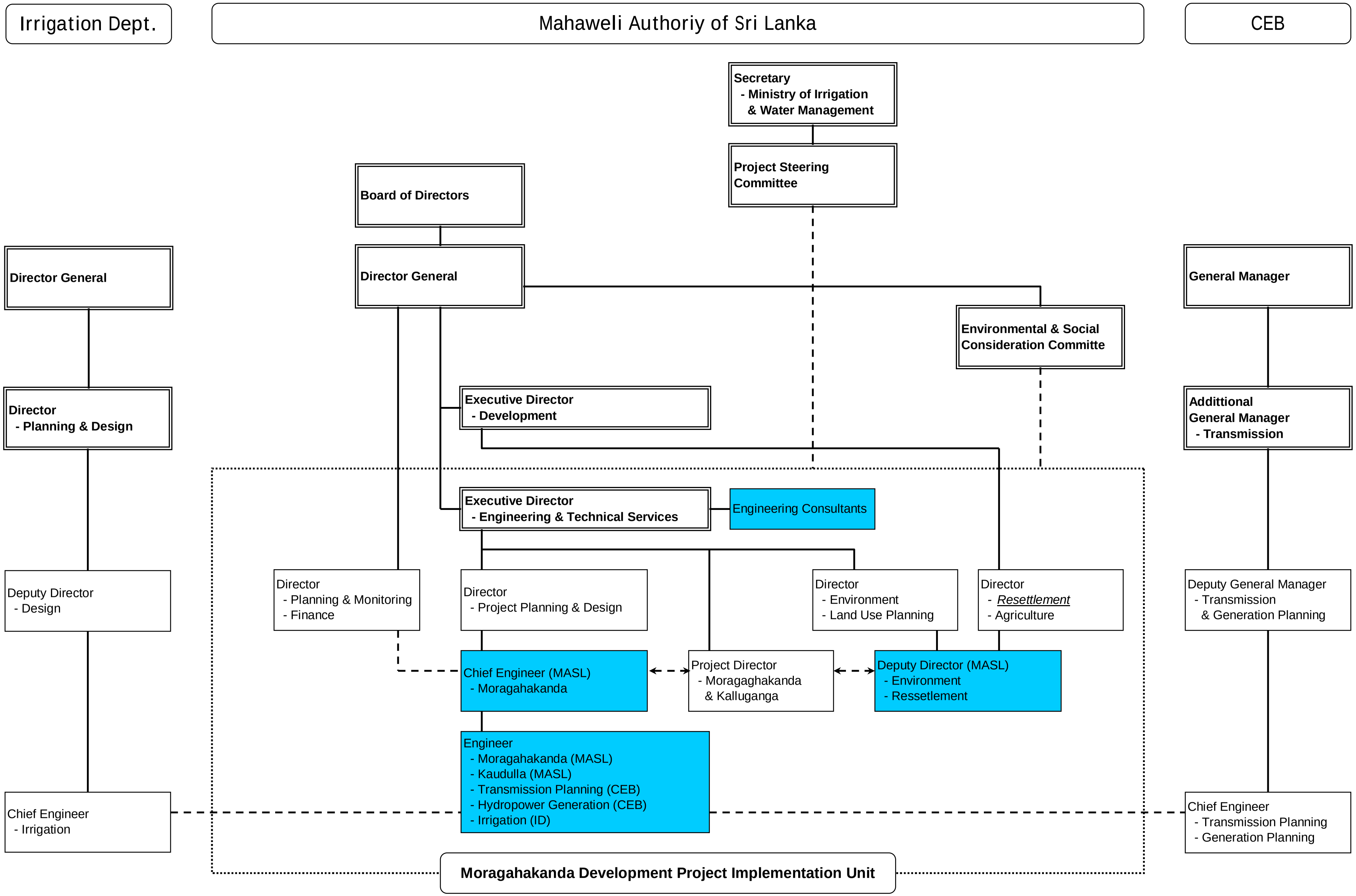
Attachment-22 List of Electrical Equipment (2x7.5MW)

No		Equipment Name	Specification	unit	Q'ty
		<Power Geneartion including Mechanical>			
1	Synchronous Generator		Vertical type, indoor, air cooled Speed 500rpm (12pole) 11kV, 3phase, pf=0.85 lagging Ratedcapacity:11.8MVA,10MW Brushless excitation (Weight:70.2ton)		2
2	Auxiliary Equipment for Generator				2
	1)	Exciter	Rotating, brushless type		
	2)	Excitation control panel with AVR			
	3)	Oil lubrication system	(common with turbine)		
	4)	Oil lifter with hudraulic unit	(common with turbine)		
3	Step-up transformer		Outdoor installed, ONAN 11kV/33kV, 23.5MVA		1
4	11kV Switchgear		Main circuit breaker, 13.5kV, 1,250A,25kA Switchgears for auxiliary equipment PT,CT,DS		2
5	33kV switchgear(at PS side)		Outdoor, steel structured, aluminum busbar		1
	1)	Circuit breaker	36kV, 1,250A, 25kA		
	2)	Disconnecting switch	36kV, 1,250A, 25kA		
	3)	Lightning arrester			
	4)	Isolator with earthing switch			
	5)	Tranmision line protection relays with PT,CT			
6	Generator control panel		Operation & supervising board with mimic bar Automatic synchronizer panel		2
7	Telemetry & Telecommunication		SCADA,, Party line		1
8	Station Auxiliary Equipment				
	1)	Station transformer	Indoor installed, mold insulation 11kv/415-240V, 300kVA		1
	2)	Emergency generator	Diesel oil driven, outdoor package type 200kVA, 400V, 3 phase With exciter, switch, control board		1
	3)	Control source	DC and AC control source		1
	4)	Station Service Control Center			1
	5)	Wiring Material		lot	1
		<33kV Transmission Line>			
9	33kV Transmission line		Steel tower, total: about 15km		
	1)	Conductor for overheadline	single circuit, Lynx(ACSR, 185mm2)	km	15
	2)	Cable for PS inside	XLPE cable	km	0.6
	3)	supporting material	Steel tower, insulator, stay etc	No.	60
		<33kV Switchyard>			
10	33kV Switchgear(at Naula)		Outdoor, steel structured, aluminum busbar		1
	1)	Circuit breaker	36kV, 1,250A, 25kA		
	2)	Disconnecting switch	36kV, 1,250A, 25kA		
	3)	Lightning arrester			
	4)	Isolator with earthing switch			

Attachment-23



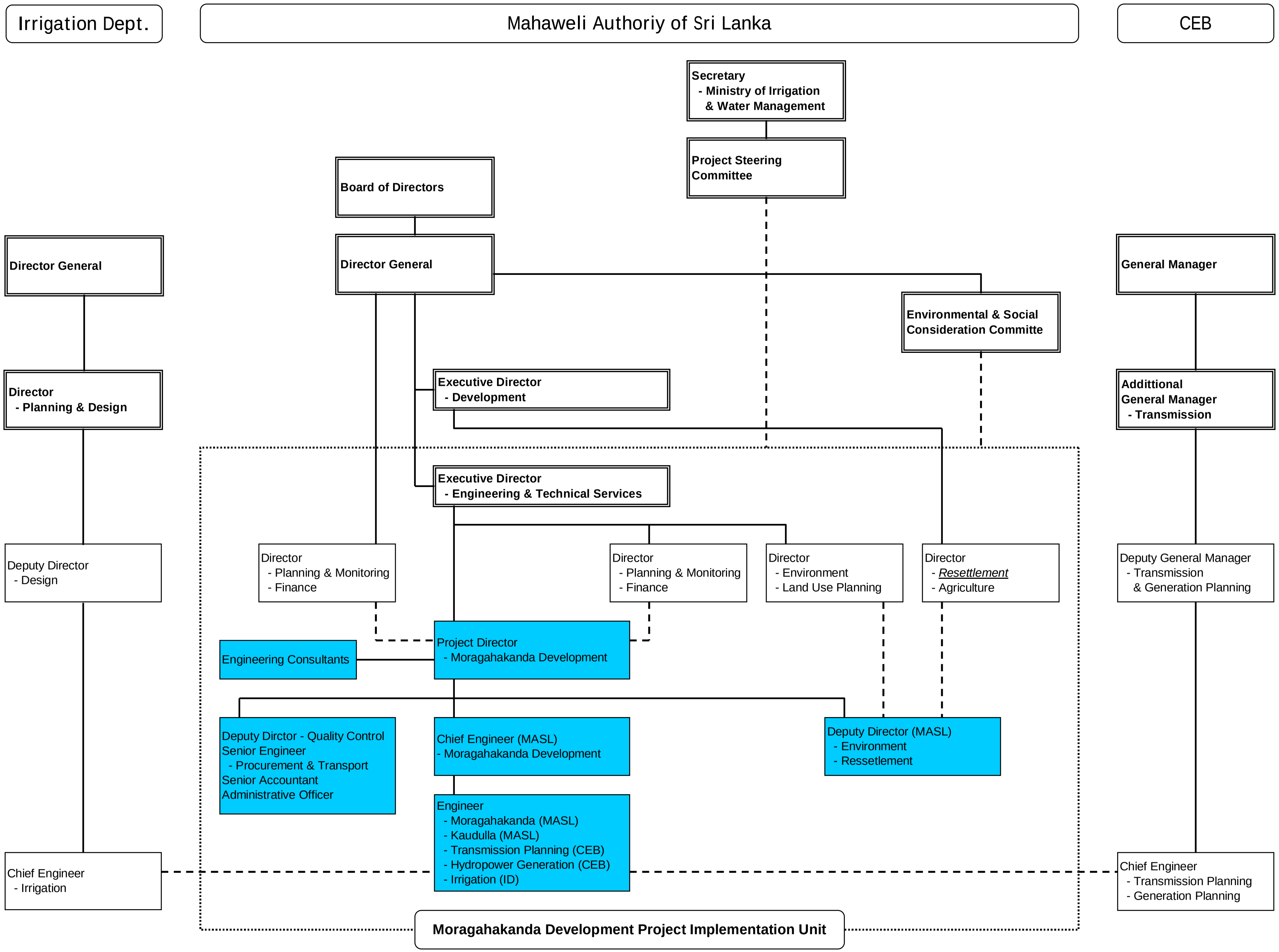
Attachment-24 Proposed Project Implementation Unit Organization Structure (Design and Tender Stage)



Prepared by the JICA Survey Team

Note: Shaded position is newly proposed position

Attachment-25 Proposed Project Implementation Unit Organization Structure (Construction Stage)



Prepared by the JICA Survey Team

Note: Shaded position is newly proposed position

Attachment-26 Safety and Quality Control System Checklist

Items to Confirm	Items to be Confirmed	Confirmation Result
(1)Laws and various standards related to safety and quality control	The existence or nonexistence of laws and various standards related to safety and quality control, as well as the names of those laws and contents of related provisions (1) Names of laws (2) Contents of related provisions	(1) Factories Ordinance No. 45 of 1942 (2) The provisions warrant the safety and health of workers and workplace.
	The existence or nonexistence of safety and quality control manuals at the executing agency (1) Names (2) Contents (examples of items to be described) • Is the method of patrolling of sites (frequency of such patrols, etc.) indicated as reference? • Is the frequency with which consultants and contractors are consulted indicated as reference? • Are the rules and regulations (or manuals) governing safety and quality control included?	(1) Safety at the construction stage will be the responsibility of the contractor as per the conditions of contract and is expected to provide the safety manual. Safety at O&M is the responsibility of the HAO&M of MASL and safety manual for this purpose is available with them. Quality control during construction is based on the general and technical specifications for the work which forms part of the contract documents and the quality control aspects during O&M will be based on the O&M manual prepared by the consultant at the end of the construction work. (2) The issues related will be covered in these manuals.
(2) Mandates of departments in the executing agency in charge of safety and quality	Identification of the safety and quality control department and number of staff members	At construction stage: • No of total staff members at the executing agency: to be determined by the executing agency (the contractor) to be selected by bidding process. • Name of the safety and quality control department: to be provided by the executing agency, which will be the

control and the services		contractor selected for the work. • No of staff members in the department : to be determined by the contractor (executing agency) At the O&M stage: • No. of total staff members at the executing agency (MASL): 4600 persons • Name of the safety and quality control department: Headworks Administration, Operation and Maintenance Unit (HAO&MU) • No. of staff members in the department above: 450 persons
	Details of the mandates of the department in charge of safety and quality control (1) State of implementation of site patrols (2) Availability of accident statistics related to all projects under jurisdiction of the executing agency (Attach accident data for the past 3 years) (3) Guidance and instructions for consultants and contractors (4) Documents on the mandates of the department in charge safety and quality control (Attach the document) (5) Others (Describe specifically)	Not applicable
	State of implementation of training for staff in charge of safety and quality control (Reference) • Training in the safety and quality management system • Training in matters related to laws • Training in developing awareness of the dangers of	Not applicable

	accidents • Training in the role of safety and quality control in the executing agency • Training in construction method and method of safety and quality control • Training in method of collecting accident statistics and their effective utilization • Training in accident prevention techniques • Others	
	Information concerning past accidents in construction etc. (1) Has the information concerning past accidents been accumulated? In addition, ascertain what the policy is for accumulating accident information (eg.: recording information on only accidents resulting in death in accordance with the organizational rules). (2) Components and contents of accident information (Reference) • No. of accidents • Situation in which accidents occur • Scale of accident (amount, number of casualties, existence or nonexistence of third-party injuries) • Emergency response • Cause of accident • Future prevention method • Others(Describe specifically)	Not applicable
(3)Assignment plan for staff in charge of safety control related to the Japanese ODA loan project	Assignment plan for staff in charge of safety control related to the Japanese ODA loan project (1) No. of staff members in charge of safety control	The contractor who will be selected for the project, as the executing for the construction work has to provide the required details. Safety and quality control during O&M will be by the HAO&M unit of MASL, and the details have been provided under item (2)

(4)Competence and experience of staff in charge of safety and quality ocntrol	Projects in which the staff handled safety and quality control (1) Projects handled (2) Names of positions the staff held or their status therein (3) Details of the service performed	Safety and quality control during construction will be handled by the contractor to be selected. HAO&M unit of MASL which is expected to handle the O&M including safety and quality control of the project has been handling all completed projects under the Mahaweli Development Scheme. It has a strong organisational base to handle it led by a senior engineer as its Director with senior engineers in charge at every project office with a total number of 450 in the workforce covering the safety and quality control of the completed projects.
(5)System of confirming safety and quality control in the executing agency	Method of confirming safety and quality control in the executing agency (1) Regular consultative meetings with construction managers and contractors (2) Site patrol (3) Others(Describe specifically)	For O&M, HAO& M follows the procedures given in the safety manual. There are routine procedures involving daily, weekly, monthly and annual safety checks based on the level of safety requirement. Training programmes are arranged with the Industrial Safety Unit of the Department of Labour as required and on the job training is given internally for the new recruits by the units headed by the Engineers in Charge of each project.
(6)Confirmation related to theframework for responding to accidents	Specific method of sharing information within the executing agency when an accident occurs *Briefly describe the framework for sharing for sharing information when an accident occurs. Attach a phone calling tree, relevant regulations etc. as needed. (1) The manual for responding to an accident (2) Is the department to contact in the case of an accident described in the manual?	For construction work, the contractor has to include the details such as forms of accident reporting, emergency contact phone numbers including phone calling tree according to the priority order etc. For the O&M ,the HAO&M of MASL which is responsible for the
	Method of keeping staff members in the executing agency informed about the framework for responding to an accident • Implementation status of holding a briefing session to inform all staff members about the manual and its contents.	The safety and quality control manual is kept in the EIC's office for reference. HAO&M Unit conducts seminar engaging experts industrial safety on the procedures to be adopted regarding safety at site including accidents. In case of accidents both internal and police inquiries are

	• Submission of an accident report and holding of investigative commissions	arranged and appropriate action is taken and recorded.
(7)Method adopted by the executing agency to confirm training programs in safety and quality control provided by contractors for workers	Method of confirmation adopted by the executing agency • Method of confirmation of preliminary training (in-house education, qualification process) • Method of confirmation of the training schedule during construction (safety conventions, consultative meetings to discuss safety, post accident response conference etc.)	• Method of confirmation of preliminary training: -Certificates regarding skill training -testing to confirm the skills before recruitment • Method of confirmation of training schedule during construction -contractor will prepare schedules of training, meetings and other related actions in this respect and to the satisfaction of the Department of Labour.
(8)Others	Public agencies with jurisdiction over safety issues (in Japan, the Ministry of Health, Labour and Welfare) • Names of the public agencies • Demarcation between those public agencies and the executing agency regarding safety • Existence or non-existence of an official certification system governing specialist labour (heavy-construction-equipment operator etc.) • On-site inspections of construction sites, guidance etc.	• Name of the public agency with jurisdiction over safety issues: Department of Labour under Ministry of Labour relations and Manpower, authorized by the Factories Ordinance. • Department of Labour in its capacity as the agency with jurisdiction over all national agencies over safety issues, is authorized to inspect the safety system and take appropriate action against the executing agencies. • An official certification system is governing specialist labour is available through a licensing process requiring appropriate training and satisfying the examiner to obtain the licence. • On site inspections are carried out by the Department of Labour as authorized by the Factories Ordinance