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THE ACCELERATED MAHAVELI DEVELOPMENT PROGRAMME

With Compliments from
The Author

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THE ACCELERATED MAHAWELI DEVELOPMENT PROGRAMME

by

Ratna S. Cooke

PREVIOUS STUDIES

Engineering Studies for the diversion of the Mahaweli Ganga were done by the United States Operation Mission (as USAID was then called) with Ceylon Government counterparts mainly from the Irrigation Department during 1958-62 on a request by the Government of Ceylon, on the orders of Hon. C. P. de Silva, Minister Agri. and Lands. A joint-report was issued (by U.S.O.M. and I.D.) in 1962 on the "Feasibility of Development, Mahaweli Ganga Transbasin Diversion Scheme". A diversion of the Mahaweli at Primrose Hill near Kandy was proposed, with appurtenant works, which benefitted 325,000 acres of land in the North Central Province with irrigation facilities and provided generation of 1,500 million Kilowatt hours of hydropower energy with an installed capacity of 260 Megawatts. The estimated cost of the scheme was Rs. 1.279 million. The primary benefits derived from this project was estimated at Rs. 171.6 million per annum. (Rs. 80 million from Irrigation and Rs. 91.6 million from power).

When this project proposal was taken up in Parliament in 1963, it was decided to make a request to the United Nations to do an independent study of the Mahaweli Ganga land and water resources and make its own recommendations, for the overall development of the Mahaweli Ganga resources (including its basin development). It was argued that such a diversion of the Mahaweli in its upper reaches may be detrimental to future projects lower down in the Mahaweli Ganga basin, such as Victoria and Randenigala.

During the same period, The Hunting Survey Corporation of Canada prepared an inventory of the land and water resources of the Mahaweli Ganga and adjacent areas (in co-operation with the Survey Department of Ceylon) under Colombo Plan assistance. This report based on aerial photography, contains valuable data on the land and water resources of the Mahaweli basin, for the evaluation of their potential for development. By airphoto interpretation and ground survey geological mapping was done and also mapping of land form and soils, land use and forest cover. It also contains basic data for hydrological studies of the Mahaweli basin and a 'plan for irrigation and power development'.

In response to the Ceylon Government's request, the United Nations undertook a 'Survey of the land and water resources of the Mahaweli Ganga' with a team of UNDP FAO specialists, engaged on these studies from 1964 to 1968, with Ceylon Government Counterparts—of which I was the Co-Manager.

A final report was issued in three volumes by the by the FAO in 1969 with a Master Plan for development of the Mahaweli resources, supported by reports on seventeen subjects, namely: Dam Design, Irrigation Engineering, Soil Science, Hydrometeorology, Geology and Geophyscial Surveys, Agronomy, Hydropower, Rural Sociology, Land Use, Water Management, Agricultural Economics, Agricultural Development and Extension, Marketing and Credit, Forestry, Land Settlement, Topographical and Aerial Surveys.

The **UNDP Master Plan** envisages agricultural development with irrigation facilities of 900,000 acres of land and the generation of 2,037 million kilowatt hours of hydropower energy, with an installed capacity of 507 megawatts. The capital cost (estimated in 1968) was Rs. 5,583 million, excluding cost of activities resulting directly for the project, but having their own justification, estimated at Rs. 1,120 million. In view of the large magnitude of the Investment involved, the Master Plan was divided into three phases, for stepwise implementation over a period of 30 years. Further studies on the three projects recommended in phase I were carried out in some detail in the second part of the UNDP Study.

To develop the natural yield of the Mahaweli Ganga 14 reservoirs are proposed, 4 on the Mahaweli, 10 on its tributaries. Twelve of these are multi-purpose units for the development of irrigation and hydropower, and the other two are only for irrigation. The Projects in the Master Plan are interconnected, but can be done independently of each other in a period of 4 to 6 years each. These reservoirs will regulate 4.75 million acre-feet annually from the Mahaweli and its tributaries. This is far in excess of the irrigation needs of the Mahaweli basin (recommended in Phase I), Therefore a transbasin diversion of the Mahaweli to the Maduru Oya basin (including 0.26 million ac.ft. from its own basin) with a reservoir on Maduru Oya and another on Badulla Oya, with small Power Stations, are recommended in Phase II. After meeting the irrigation demand in Phases I and II, the surplus water is recommended for diversion to the North Central parts of the island in Phase III to develop 324,000 acres of land. These lands are located in six of the major river basins in that region. Seven service reservoirs are proposed, in addition to 18 major irrigation tanks in that region, to store and regulate the diverted waters, in addition to 0.7 million ac.ft. of run-off from their own catchments.

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Best Available Document

The conveyance of the diverted flow from the Mahaweli Ganga to the propose service reservoirs and existing major tanks in the diversion areas is effected by 4 transbasin canals (i.e. tunnels from Polgolla diversion and Bowatenne with transbasin canal to Kala Oya basin, a Left Bank Canal from below Randenigala, a Right Bank Canal from Minipe up to Ratkinda with tunnel to Maduru Oya basin and a North Central Province Canal from below Moragahakande to the North Central parts of the island).

The regulated flow will provide irrigation facilities to 900,000 acres of land, of which 246,000 acres are presently cultivated existing lands, which will receive additional water for continuous cultivation throughout the year. The other 654,000 acres are new lands, presently in jungle.

The lands to be benefited are grouped under 14 irrigation systems designated 'A' to 'M'. Land Use Surveys indicate that more than 50% of the land proposed for development is suitable for cultivation of a variety of high value crops other than rice. The engineering proposals of development envisaged in the UNDP Master Plan are contained in Volume I of the UNDP/FAO Report. More detailed studies of the three projects recommended in Phase I are contained in Volume II and recommendations for Organisation and Management are contained in Volume III.

Implementation of Project I (Polgolla Diversion)

This part has been dealt with extensively in the quarterly journal of the Institution of Engineers (S.L.)'s Journal, Vol. 2, No. 4 of December 1974, with articles on different aspects of Project I; such as Designs, Construction of dam, tunnel, Ukuwela Power House, Bowatenna Complex and model studies.

The Accelerated Mahaweli Programme

When the present Government took office in July 1977, it was decided to accelerate the pace of development of the Mahaweli Development Programme, and do as much of the UNDP Master Plan as possible in the next 5 to 6 years. A Task Force, consisting of leaders in various aspects of development, was set up by H.E. the President (then P.M.) to recommend ways and means of accomplishing the accelerated programme.

It was decided to expedite the completion of irrigation facilities to the new lands in System 'H' under Kalawewa in Project I (Polgolla Diversion) and take up the following multi-purpose projects for implementation in the next five to six years :

Victoria Multipurpose Reservoir Project
Kotmale Multipurpose Reservoir Project
Maduru Oya Multipurpose Reservoir Project
Randenigala Multipurpose Reservoir Project
and Moragahakande Multipurpose Reservoir Project

and the development of new irrigation systems under these projects, mainly Systems C,B,D and G. Details are given under "Downstream Development".

This programme is really the essence of the "UNDP Master Plan" Projects.

This decision was taken with a view to providing solutions to three of the major problems facing the country in 1977, namely, acute unemployment, draw of foreign exchange for agricultural imports and shortage of power. The annual draw on foreign exchange resources on food imports was over Rs. 6,000 million which will be substantially reduced by the production under the new lands brought under irrigation, in extent about 300,000 acres (120,000 ha.).

This will create employment during construction activities and thereafter for agricultural production, for nearly a million people.

The import liberalisation policies after 1977 and development of new industries led to a sudden upsurge in the rate of growth of power demand, which rose to an average of 12% after 1978. The present shortage in power requirements will be met when these projects are commissioned.

The 1st three hydropower projects in the accelerated programme will more than double the existing hydropower development capacity of 420 MW and firm energy production of 1750 GWH annually (including Polgolla, Bowatenna and Canyon).

VICTORIA PROJECT

The Victoria Project stands out as unique in many respects. It is the highest structure and the first arch dam to be built in the island. It has a fully automatic hydraulically controlled system for the spillway gates to open when the water level rises during floods, without having to depend on the power supply, which is so uncertain especially during times of heavy rain. Concrete for dam construction is conveyed to the site in 6 cubic metre buckets on two aerial cableways (called Blondins) of 20 ton capacity spanning 820 metres, from fixed towers on the left bank to moving carriages on the right bank, which by travelling over a track 360 metres long, enables the 'Blondins' to virtually cover every part of the dam. The average concreting rate per 'Blondin' is about 60m³ per hour on the left bank to 90 m³ per hour on the right bank.

Dam Parameters

The double curvature arch concrete dam is 122 metres high and has a maximum thickness of only 25 metres at the base. This type of dam was selected as the most economic solution at this site.

Peak flood inflows of 9510m³/s have been allowed for in the design of the spillway with 8 radial gates 12.5 m x 6.5 m.

Two low level outlets (4.1 m. dia. and 350 m. apart) will enable the reservoir to be drawn down and to pass

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silt which may accumulate upstream of the dam. A branch pipe (300 mm. dia.) from each of these outlets will provide riparian users downstream with compensation water. A concrete lined stilling basin, extending 110 metres downstream of the dam (with the floor 3m. thick) will dissipate the energy from the overspill jet and the discharge jets from the two low level compensation water outlets.

To reduce seepage from under the dam, a grout curtain is being formed from the lowest gallery in the dam, by injecting grout under pressure through inclined holes in the river bed of 120 m. max. length reducing gradually to 30 m. at the abutments.

Construction

The dam is constructed in a series of 15 m. wide vertical blocks cast in 2 m. vertical lifts. In order to control temperature rise in the mass concrete, chilled water is added during mixing and also passed through 25 mm. dia. pipes cast in the dam. Construction joints between blocks are pressure grouted from the galleries to provide the necessary bond between the blocks to act as an arch dam.

Diversion of the river in the first stage of construction is through the Right Bank of the river. In Stage 2, the river will be diverted through two temporary openings in the Right Bank of the dam. In the final stages the river flow through the temporary right bank openings will be stemmed for reservoir impounding to commence and river flows can thereafter be passed only through the dam outlets or the power station.

Delays were encountered in the early stages of construction due to unforeseen geological conditions discovered in dam block 4 and the downstream apron area.

Power Tunnel

For the first phase of power development a single tunnel (6.2 m. dia. and 5.8 km. long) is being constructed to convey a maximum flow of 140 m^3/sec.

The tunnel intake is on the Right Bank of the river, 150 m. upstream of the dam with a sloping trash rack slab to enable a rake, controlled by a gantry above, to be lowered to clean the screens at the intake (to protect the valves and turbines). Twin intakes are being constructed including the second intake together with a short length of the second tunnel to be constructed in future, to double the capacity of the power station to generate secondary energy.

The tunnel will be lined with concrete 500 mm. thick and its final length of 420 metres will be steel lined leading to the penstock (830 m. long) also steel lined.

A Surge Chamber is being constructed 544 m. from the downstream tunnel portal to accommodate variations in discharge when the turbines are suddenly shut down, or take on load. Its finished diameter is 21 m. and has a maximum depth of 157 m. from the top to the tunnel invert.

Construction of the tunnel is being done from 4 faces—(i.e. intake, outlet and from an intermediate adit 2,275 m. from the intake) adopting improved blasting techniques.

The surge chamber and the two shafts for the intake gates are being constructed by the raise-bore method, which involves first drilling a 250 mm. dia. pilot hole vertically downwards towards the tunnel below. This hole is then enlarged to 2 m. dia. by a raise-bore working upwards from the tunnel and final excavation to the required diameter is carried out by normal methods from top downwards, the excavated material being removed via the 2 metre shaft through the tunnel.

Concrete linings of the surge chamber and gate shafts will be slip-formed

The Power Station is a reinforced concrete structure situated on the Right Bank about 5 km. downstream of the dam. Excavation for the second stage power house (to double the capacity later) is being done now.

The first stage structure will be 82 m. long 27 m. wide with a maximum height of 37 m. above foundation. This machine hall will have two 75 ton overhead electric travelling cranes.

It will house three Francis Turbines designed for a head of 190 m., with a speed of 333 r.p.m., generating at 12.5 KV (primary voltage), with a rated output of 70 MW (with a .85 power factor) to be housed at 13 m. centres. The primary voltage will be stepped up to 220 KV and connected to a substation at Kotmale.

The Switchyard 125 m. long and 86 m. wide is connected to the Power Station cable basement by a concrete cable tunnel.

Erection of the first turbine is programmed to start in July 1984 followed by generation at the end of 1984. followed by the remaining two machines at 3 month intervals—for commissioning by July, October 1984 and January 1985.

The active storage of the Victoria Reservoir is 698 million cubic metres (565 T.A.F.) and will generate 780 GWH of useful energy per year.—The irrigation potential under this project is 45,000 ha. (112,000 acres)—which will be in System 'C' on the Right Bank of the Mahaweli below Minipe and augment 'B' under Maduru Oya.

Costs

	Rs. Mil.
Dam	2338
Tunnel	939
Power Station	259
Hydraulic Equipment	613
Physical Contingencies	512
Bonus on Civil Contract	60
Electro-mechanical Contracts	871
Cables	63
Transmission Lines	102
Consultancy	432
Digane Township	104
Work by Other Agencies	328
Overall Contingencies and Parity Changes	835
	7456

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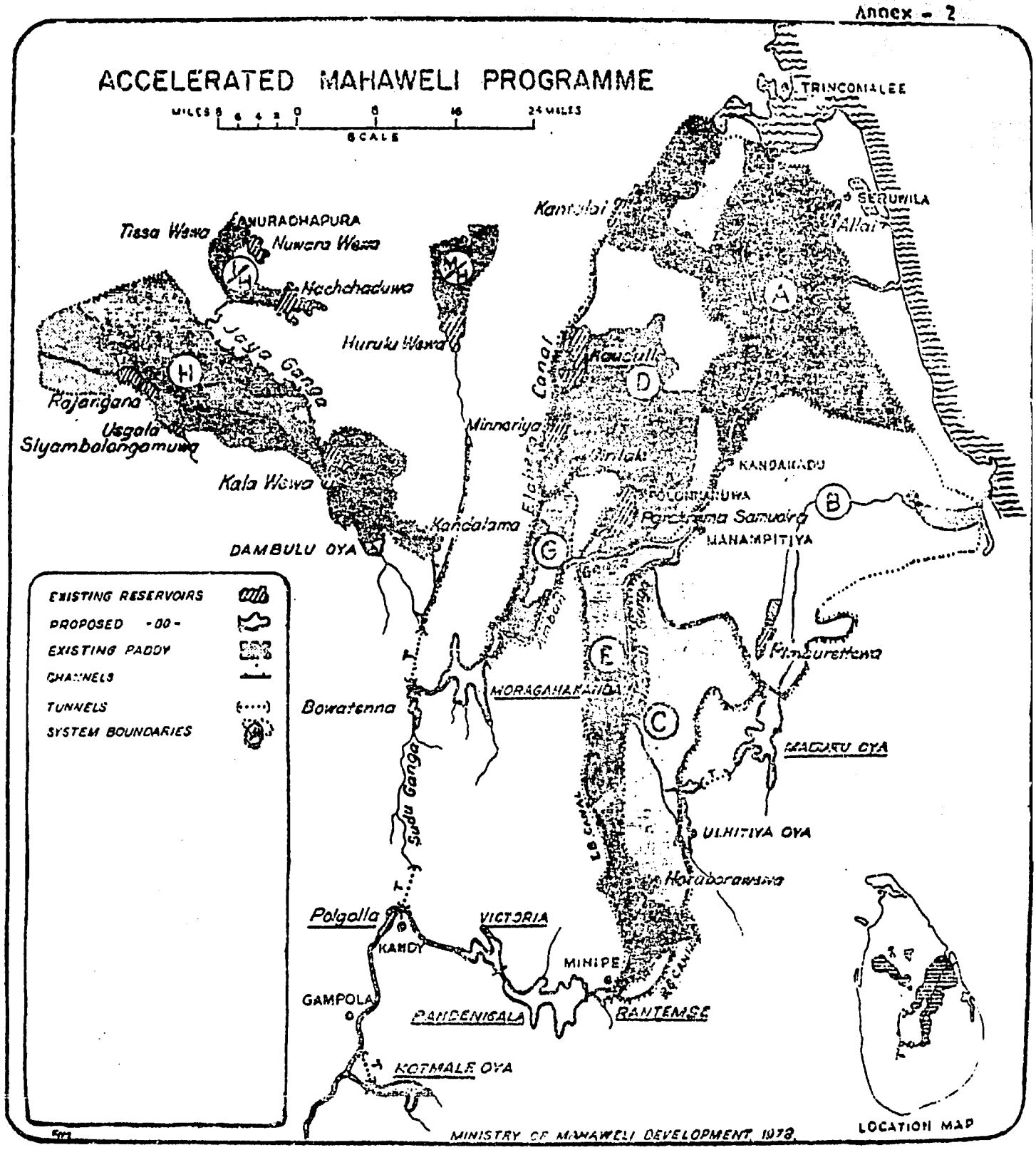
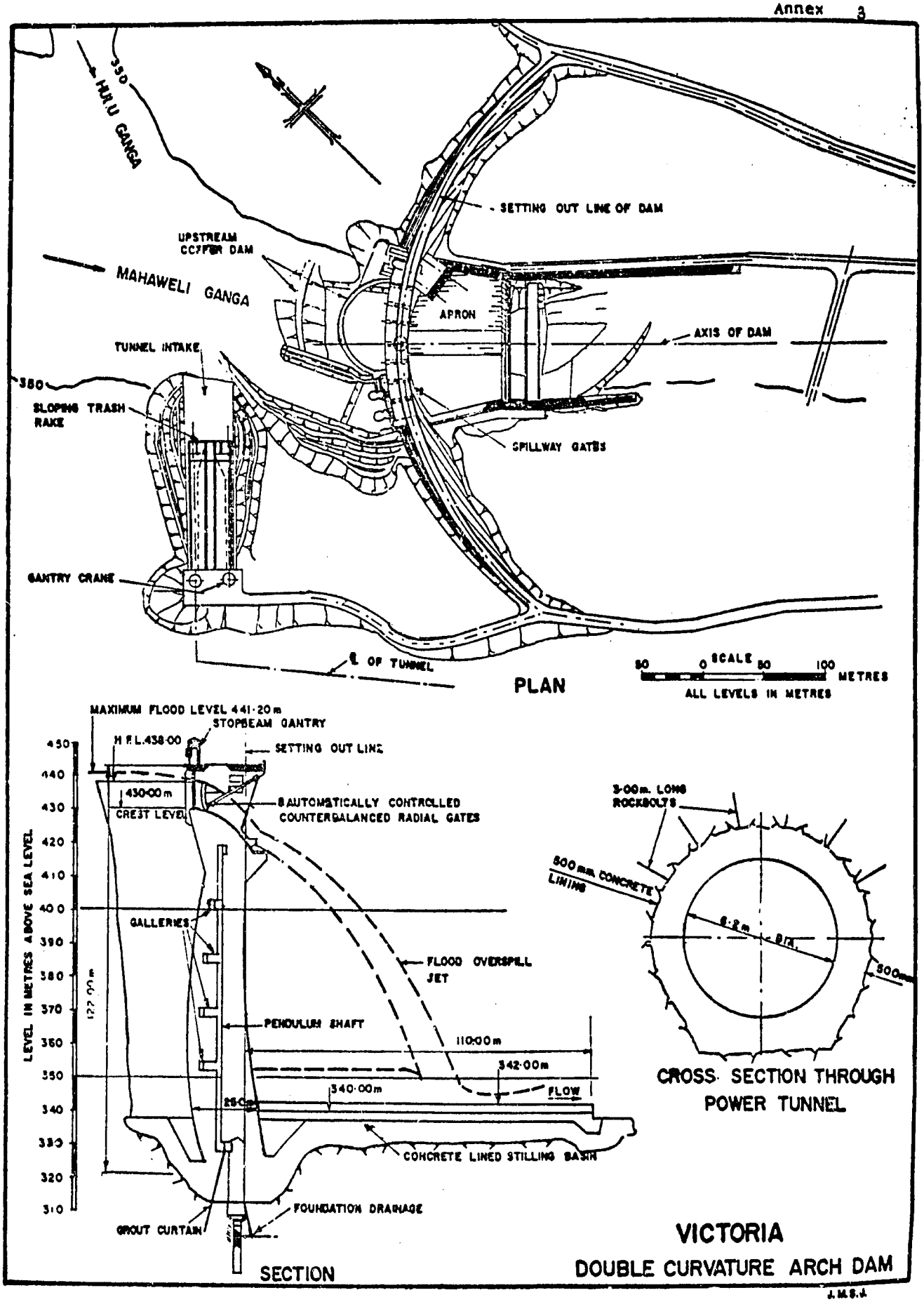
Annex - 2


ACCELERATED MAHAWELI PROGRAMME
MILES 8 6 4 2 0 8 16 24 MILES
SCALE
TRINCOMALEE
SERUWILA
Allai
Kantalai
ANURADHAPURA
Tissa Wewa
Nuwara Wewa
Nachchaduwa
Jaya Ganga
Huruku Wewa
Kaudulla
Minneriya
Elahera Canal
Rajangana
Usgala
Siyambalangamuwa
Kala Wewa
Kandalama
DAMBULU OYA
KANDAKADU
POLONNARUWA
Parakrama Samudra
MANAMPITIYA
Mahaweli Ganga
MORAGAHAKANDA
Bowatenna
Sudu Ganga
MADURU OYA
ULHITIYA OYA
Polgolla
VICTORIA
KANDY
MINIPE
GAMPOLA
PANDENIGALA
RANTEMBE
KOTMALE OYA
EXISTING RESERVOIRS
PROPOSED -00-
EXISTING PADDY
CHANNELS
TUNNELS
SYSTEM BOUNDARIES
MINISTRY OF MAHAWELI DEVELOPMENT, 1978.
LOCATION MAP


HULU GANGA
390
SETTING OUT LINE OF DAM
UPSTREAM COFFER DAM
MAHAWELI GANGA
APRON
AXIS OF DAM
TUNNEL INTAKE
380
SLOPING TRASH RAKE
SPILLWAY GATES
GANTRY CRANE
℄ OF TUNNEL
PLAN
SCALE
50 0 50 100 METRES
ALL LEVELS IN METRES
MAXIMUM FLOOD LEVEL 441·20 m
STOPBEAM GANTRY
H.F.L.438·00
SETTING OUT LINE
430·00 m
CREST LEVEL
AUTOMATICALLY CONTROLLED COUNTERBALANCED RADIAL GATES
LEVEL IN METRES ABOVE SEA LEVEL
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
GALLERIES
FLOOD OVERSPILL JET
PENDULUM SHAFT
110·00 m
342·00 m
340·00 m
FLOW
CONCRETE LINED STILLING BASIN
FOUNDATION DRAINAGE
GROUT CURTAIN
SECTION
3·00 m. LONG ROCKBOLTS
500 mm. CONCRETE LINING
6·2 m
500 mm
CROSS SECTION THROUGH POWER TUNNEL
VICTORIA
DOUBLE CURVATURE ARCH DAM
J.M.S.J.

The construction work on the dam and tunnel has been awarded to Messrs. Balfour Beatty—Nut'all Co., of U.K. (Dam. Rs. 1.468 million, Tunnel, Rs. 645 million). The Power House building contract is by Messrs. Costain of U.K. for Rs. 251 million.

Other contracts have been awarded for hydraulic equipment, turbines, generators, transformers, switchgear, miscellaneous plants, cables, cranes and transmission lines.

Donor Country

This project is being financed by Great Britain with an outright grant of £100 million.

U.K —has also provided technical assistance grants totalling £4.75 million: viz. for feasibility studies (£1 m), geological investigations (£1.5 m), drilling and laboratory testing equipment (£0.45 m), Bailey bridges (£.7 m) and construction equipment (£1.1 m).

A further sum of £20 million has been arranged on credit from U.K. for the purchase of electro-mechanical equipment for this project.

Resettlement of those Displaced

The reservoir bed area covers an extent of about 9,000 acres in the Dumbara Valley, consisting of about 105 villages. The total number of families affected is estimated to be around 4,950 with a population of about 25,000 people. A little less than half (2,200) of them opt to be resettled in the Kandy district, for which purpose some estates are being acquired. The other 2,750 families will be resettled in the Mahaweli development areas. This resettlement programme is now in progress.

Teldeniya is one of the major towns that will be inundated under Victoria. Plans have been made for the civic amenities that were available at Teldeniya to be replaced in a number of new townships to be created in the area.

A new township with all civic amenities has been created at Digane with about 200 houses for the contractors' and consultants' personnel working on the Victoria dam. Digane will be one of the towns that will absorb some of those displaced under the reservoir.

Other towns, which are likely to expand and absorb people so displaced are Kundasale, Udispattu, Udawela and Adikarigama. The families who wish to remain close to their original habitat will be resettled in a number of new villages to be set up in estates, to be taken over by the Mahaweli Authority, such as Pallekelle, Haragama, Ahaspokuna, Kolongahawatte. Those who exercised the option to receive alternate lands in the downstream areas are being provided with lands in Girandurukotte area in System 'C'.

Parts of main roads on the left and right banks of the Mahaweli Ganga and Huluganga will be submerged e.g. from Tennekumbura to Teldeniya and Hanguranketa and from Teldeniya to Udispattu and Madugoda (a total length of about 30 km.). These roads are being retraced and reconstructed on higher ground along with power transmission and telecommunication lines.

KOTMALE PROJECT

Feasibility studies were carried out by the Water and Power Development Consultancy Services (WAPCOS) under Technical Assistance from India from 1973 to 1976.

This is mainly a hydropower project, in the upper reaches of the Mahaweli on the Kotmale Oya between Pussellawa and Ulapane. This will be a rockfill dam (the second of this type in the island) 87 metres high and 600 metres long along its crest, in the first stage, holding a reservoir of 174×10^6 cu. metres (141,400 ac.ft.) capacity, with an underground power station, for the first time in Sri Lanka.

Sir William Halcrow & Partners in association with Messrs. Kennedy & Donkin of UK and C.E.C.B. (Sri Lanka) were appointed to provide consultancy services for this project and Construction work was awarded to Messrs. Skanska Cementgjuteriet of Sweden in 1979.

The initial contract for civil works, completed last year, included :

(a) the Contractors' and Engineers' camps, comprising 250 houses and buildings for office and civic amenities;
(b) two diversion tunnels 9.2 m. in diameter;
(c) access roads;
(d) access tunnel to the underground machine chamber;
and
(e) investigations for quarry.

This was followed by an underground works contract for :—

(a) 6½ km. of low pressure power tunnel (6.2 m. finished dia.);
(b) high pressure shaft connecting the low pressure tunnel to the machines (The diameter being 5.3 m. at top reducing progressively to 2.4 m. at inlet to turbine);
(c) intake gate shaft;
(d) upstream surge shaft having a depth of 160 m. and a dia. of 15 m;
and
(e) vent shaft;
(f) underground machine chamber (70 m. long x 18 m. wide and 347 m. high);
(g) tail race tunnel;
and
(h) outfall structure.

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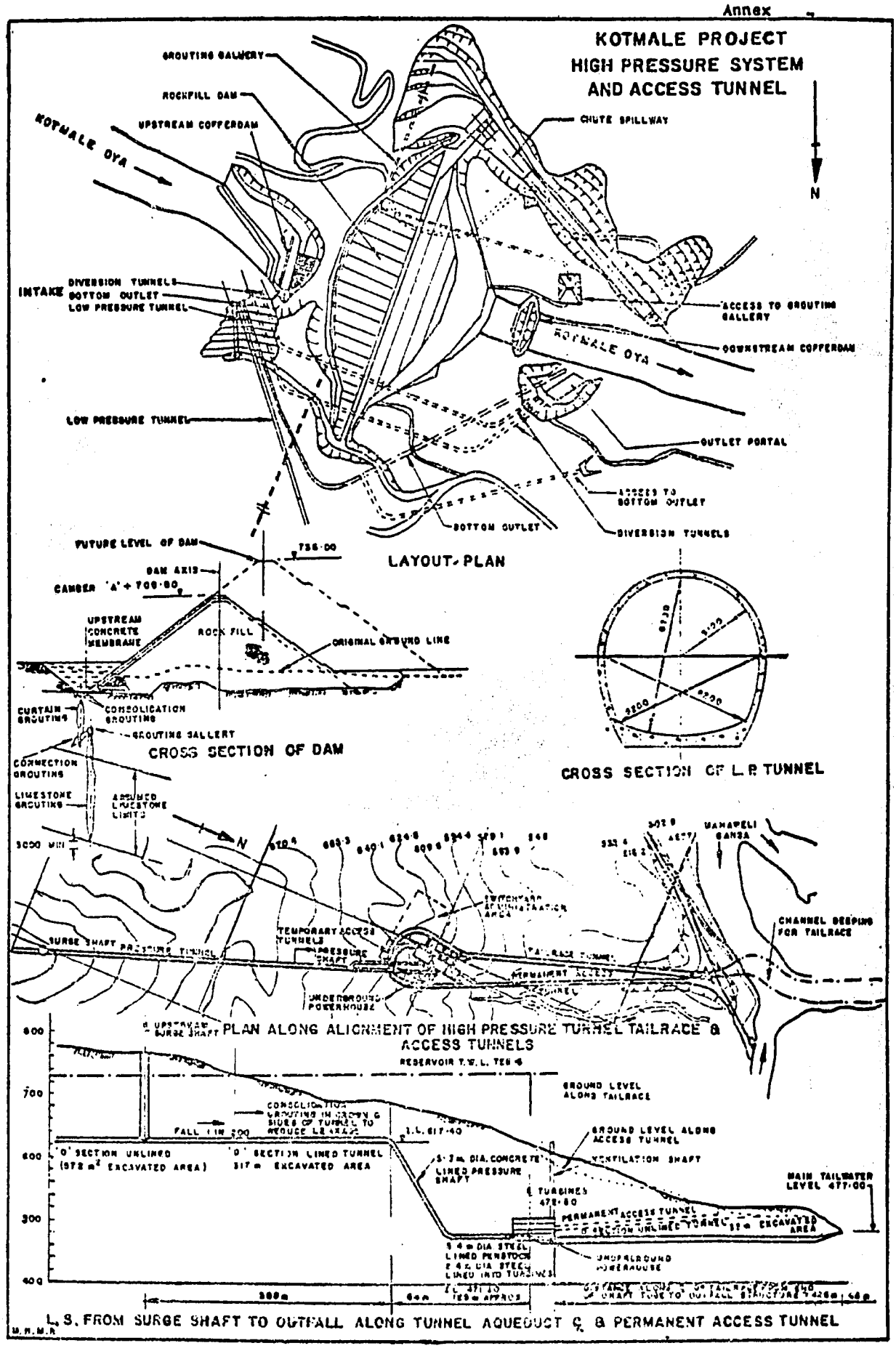
KOTMALE PROJECT
HIGH PRESSURE SYSTEM
AND ACCESS TUNNEL
N
GROUTING GALLERY
ROCKFILL DAM
UPSTREAM COFFERDAM
KOTMALE OYA
CHUTE SPILLWAY
INTAKE
DIVERSION TUNNELS
BOTTOM OUTLET
LOW PRESSURE TUNNEL
ACCESS TO GROUTING GALLERY
DOWNSTREAM COFFERDAM
KOTMALE OYA
LOW PRESSURE TUNNEL
OUTLET PORTAL
ACCESS TO BOTTOM OUTLET
BOTTOM OUTLET
DIVERSION TUNNELS
LAYOUT PLAN
FUTURE LEVEL OF DAM
DAM AXIS
CANGER 'A' + 709·80
UPSTREAM CONCRETE MEMBRANE
ROCK FILL
ORIGINAL GROUND LINE
CURTAIN GROUTING
CONSOLIDATION GROUTING
GROUTING GALLERY
CROSS SECTION OF DAM
CROSS SECTION OF L.P. TUNNEL
CONNECTION GROUTING
LIMESTONE GROUTING
ASSUMED LIMESTONE LIMITS
MAHAPELI GANGA
CHANNEL DEEPING FOR TAILRACE
SURGE SHAFT
PRESSURE TUNNEL
TEMPORARY ACCESS TUNNELS
PRESSURE SHAFT
UNDERGROUND POWERHOUSE
PERMANENT ACCESS TUNNEL
PLAN ALONG ALIGNMENT OF HIGH PRESSURE TUNNEL TAILRACE & ACCESS TUNNELS
RESERVOIR T.W.L. 765·6
GROUND LEVEL ALONG TAILRACE
CONSOLIDATION GROUTING IN CROWN & SIDES OF TUNNEL TO REDUCE L.P. LEAKAGE
FALL 1 IN 200
I.L. 617·40
GROUND LEVEL ALONG ACCESS TUNNEL
'D' SECTION UNLINED (572 m² EXCAVATED AREA)
'D' SECTION LINED TUNNEL 317 m² EXCAVATED AREA
5·7 m DIA. CONCRETE LINED PRESSURE SHAFT
VENTILATION SHAFT
MAIN TAILWATER LEVEL 477·00
TURBINES 472·80
PERMANENT ACCESS TUNNEL
UNDERGROUND POWERHOUSE
L.S. FROM SURGE SHAFT TO OUTFALL ALONG TUNNEL AQUEDUCT & PERMANENT ACCESS TUNNEL

The raise boring technique (which can excavate to a max. dia. of 2.5 m.) to a great extent was used in the excavation of the intake gate shaft, upstream surge shaft and the cable and vent shaft. Enlarging the bore to the required diameter is by conventional drill and blast methods. These works are now nearing completion.

Dam Construction

The contract for the construction of the rockfill dam, costing Rs. 2,850 million, has been awarded in October 1981 and is now in progress. This was not awarded earlier due to adverse geological features in the dam area, with potential problems such as landslides, leakage of water, sliding of the dam and piping around the foundations. A panel of international experts was appointed by the Mahaweli Authority in 1979 to examine and report on these problems. They recommended certain modifications which have now been incorporated in the design. This resulted in the dam axis being shifted 200 m. downstream of its former location and additional precautionary measures being adopted, namely, the provision of a large underground draw-off and an underground grouting gallery for grouting the limestone seam to seal off leaks.

As costs of construction were meanwhile escalating, the headworks had to be modified to be kept within Rs. 6,000 million (at June 1979 estimated rates).

The modified 87 m. high rockfill dam will have an upstream membrane with a minimum thickness of 300 mm. This first stage height of the dam, will have provision in the design to enable it to be raised to final height of 116 m. at a later date, at which height the reservoir capacity will become 408 x 10^6 cu. metres (331,000 ac.ft.).

A chute spillway located on the left bank consists of 3 Nos. 14 m. x 15 m. radial gates capable of discharging the design-flood of 5,550 cumecs. On raising the dam to its final height, this will be converted to an orifice-type spillway.

The modified project will enable the generation of 460 GWH of firm energy, with two units (Francis Turbines) 67 MW each operating under a head of 226 m. with provision to install a third unit on raising the dam to its final height. The contract for the supply of electro-mechanical equipment for the Power Station plant has been awarded to Messrs. ASEA.

According to the present programme this project is expected to be completed in March 1985, while the first hydropower unit under it is expected to be tested and commissioned in December, 1984.

The Mahaweli Authority has agreed to pay a bonus of Rs. 10 million per week as an incentive to the contractor for earlier completion, up to a maximum of Rs. 160 million.

Donor Country

This project is being financed with an import-support grant from Swedish Aid and Swedish Kroner 307 million have been used up from 1979 to 1982. A total sum of Swedish Kroner 1,395 million (including the SK 307 M. used up) earmarked by Swedish Government will be released yearly from 1982/83 up to 1987, which is about 55% of the cost of the project.

In addition to the power benefits under Kotmale, the regulated releases from this reservoir will firm up the irrigation and power benefits under Polgolla and Bowatenna.

The Kotmale Reservoir area will also reduce the occurrence of floods in the low lying areas around Gampola.

General

In addition to the access roads already constructed for use during construction, the roads from Pussellawa to Ulapane on the Right Bank and from Nawalapitiya to Sangilipalama on the Left Bank, are getting submerged and being deviated. Three bridges have to be built, one across Kotmale Oya at Sangilipalama, another across the Mahaweli at Ulapane and the third across the Atabage Oya.

The total number of families displaced under the reservoir are 3,050 which contains about 15,000 persons. About 1,750 have agreed to take up alternative irrigable allotments in System "H" under Kalawewa and most of them have been resettled there. The other 1300 families opted to remain close to their habitat.

A total of about 2,600 acres have been acquired for resettlement purposes, in estates like Rothschild, Tispane etc.

Costs

	Estimated Contract Price June, 1979		*Absolute Contract Price including price variation*
	(Rupees Million)		
1. Work done by government agencies .. (for surveys, rehabilitation, communications, establishment and consultants)		500 ..	800
2. *Civil works—*			
Initial works ..	681		
Underground works ..	1214		
Reservoir ..	2187		
		4082 ..	6122
3. *Hydraulic equipment—*			
Tunnel steel linings ..	46		
Tunnel gates, etc. ..	56		
Spillway gates ..	90		
Bottom outlet ..	75		
		267 ..	438
4. *Generating Plant—*			
Power Station ..	292		
Sub-station ..	152		
		444 ..	739
5. Physical contingencies ..		321 ..	481
Total ..		5614	8580

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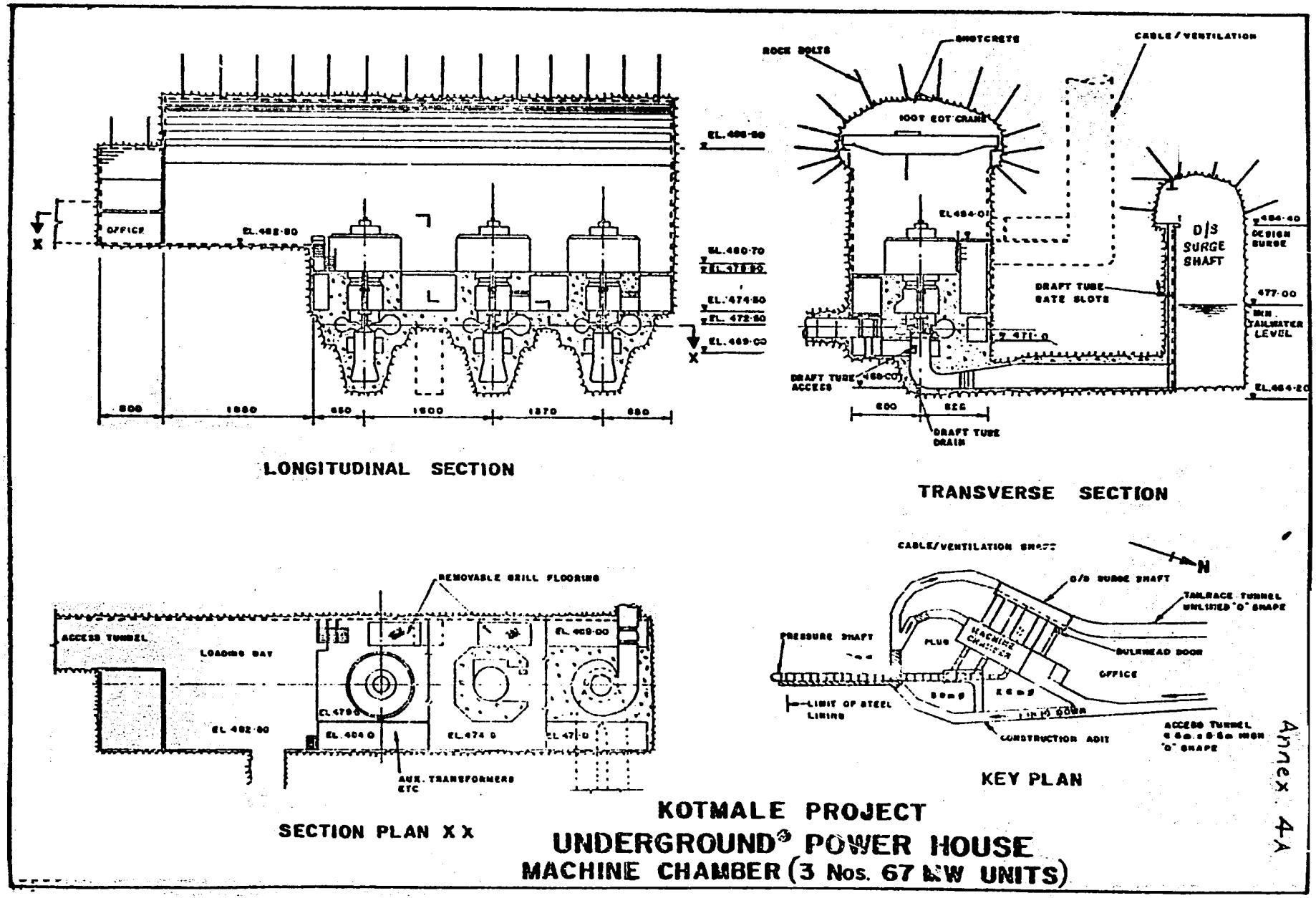
OFFICE
EL. 482·80
EL. 480·70
EL. 474·50
EL. 472·50
EL. 469·00
1500
1370
ROCK BOLTS
SHOTCRETE
CABLE / VENTILATION
100T EOT CRANE
EL. 484·01
D/S SURGE SHAFT
DESIGN SURGE
DRAFT TUBE GATE SLOTS
477·00
MIN. TAILWATER LEVEL
DRAFT TUBE ACCESS
DRAFT TUBE DRAIN
EL. 464·20
REMOVABLE GRILL FLOORING
ACCESS TUNNEL
LOADING BAY
EL. 482·80
EL. 469·00
EL. 474·0
AUX. TRANSFORMERS ETC
CABLE/VENTILATION SHAFT
N
D/S SURGE SHAFT
TAILRACE TUNNEL UNLINED 'O' SHAPE
PRESSURE SHAFT
PLUG
MACHINE CHAMBER
BULKHEAD DOOR
OFFICE
LIMIT OF STEEL LINING
CONSTRUCTION ADIT
ACCESS TUNNEL
LONGITUDINAL SECTION
TRANSVERSE SECTION
SECTION PLAN X X
KEY PLAN
KOTMALE PROJECT
UNDERGROUND POWER HOUSE
MACHINE CHAMBER (3 Nos. 67 MW UNITS)

Annex 4A

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MADURU OYA RESERVOIR

A rockfill dam was selected as the most economical type of dam suitable for this site, after considering other alternatives such as a concrete gravity (next best) and an earthfill dam. This is the first rockfill dam to be constructed in Sri Lanka.

The water resources of the Mahaweli Ganga being more than sufficient to develop all the lands in the Mahaweli Basin, transbasin diversion of the Mahaweli waters was recommended and the nearest adjacent basin proposed was that of Maduru Oya, on the eastern side of the Mahaweli. The site selected for the proposed dam is at the same site where an ancient earthen dam had been constructed, which is now in a breached condition.

Dam

The dam is situated 40 Km. south of Manampitiya and has a maximum height of 41 metres with a crest elevation 101 metres above M.S.L. and length along the crest 1,090 metres. The upstream face will have a slope of 1.8 horizontal to 1.0 vertical, while the downstream has a slope of 1.5 horizontal to 1.0 vertical.

The storage of Maduru Oya Reservoir is 596×10^6 cu.m. (483,730 ac.ft.) of which the dead storage is about 15%.

Spillway

A 150 metre wide chute free-flow spillway, excavated in rock with a free-overflow concrete ogee section about 1/2 m. high is provided on the Left Bank of the dam, capable of discharging 1.610 cumecs (56,480 cusecs) with a flood lift of 1.9 m.

Sluices

The Right Bank sluice (4.0 m.dia.) will have a capacity of 32.5 cumecs (1,150 cusecs) and the Left Bank sluice (4.5 m.dia.) a capacity of 56.2 cumecs (1,985 cusecs). There is provision for one Kaplan turbine unit of about 2.5 MW capacity under the Right Bank sluice and 2 Kaplan units of 2. 5 MW each under the Left Bank sluice—under a rated head of 13 metres. These turbines will be installed later, for which purpose provision will be made under each of these sluices.

Increasing the Storage

It has been proposed to raise the dam by 2 metres and increase the storage of Maduru Oya Reservoir by 20% (i.e. to 710×10^6 cu.m.) and this is to be done now on the same contract with only about 1½% additional quantities. The spillway is to be raised by 2 metres by the provision of gates, to get the additional head.

There are two saddle dams, one on the Left Bank 520m. and 20 m. high. will be of earth fill and rockfill. The saddle dam on the Right Bank will be of earth fill 60m. long and 12 m. high.

Link Tunnel

The Catchment area of Maduru Oya Reservoir is only 453 sq.km. (175 sq.mi.) yielding about 260,000 ac.ft. annually from its own catchment. It will be augmented by 680,000 ac.ft. per year from Victoria Reservoir through the Minipe Right Bank Canal and *Link Tunnel* from Ratkinda Reservoir.

The link tunnel is 5.6 km. long (3.5 mi.) with a diameter of 4.7 m. (14.7 ft.) in the unlined sections, 4.2 m. in the concrete lined sections and 4.4 m. in shotcreted sections with a capacity of 34 m^3/sec. The inlet channel leading to the tunnel from Ratkinda is 920 m. long and 6 m. wide and the outlet channel is 140 m. (460 ft.) long.

Donor Country

The project is financed with a long term soft loan from Canada of C $ 76 million, free of interest, to be repaid in 30 years, and a Technical Assistance Grant of C $ 7 million to cover the cost of engineering consultancy services required for the project.

Contractors

The dam contract was awarded to "FAFJ", i.e Messrs Foundation-Atlas-Fitzpatrick-Janin Co. of Canada at the end of 1979 to be completed in 3 years and the work is progressing satisfactorily.

Consultants

The consultants are Messrs. Crippen International of Canada—working in association with CECB of Sri Lanka.

Irrigable Command

The lands in System 'B' commanded by this reservoir are 46,750 ha. (115,500 ac.) of new lands and 3,750 ha. (9,263 ac.) of existing lands which are described under "Downstream Development".

Ancient Bisokotuwa

While excavating for the outlet canal from the Maduru Oya Right Bank Sluice, the old Bisokotuwa was discovered inside the ancient embankment. It is built out of brickwork and has two conduits almost in the same alignment as the new sluice.

In order to preserve this ancient structure, the new sluice channel is being deviated and taken through a tunnel, without disturbing the old Bisokotuwa.

Access Roads

The narrow access road from Manampitiya to Pimburettewa (about 22 k.m) has been realigned with about 50 new structures and widened to 10 m. It has been extended to Maduru Oya headworks (19 km.) with about 38 structures. A road 10 km. long joining the ends of the tunnel, also has been constructed with about

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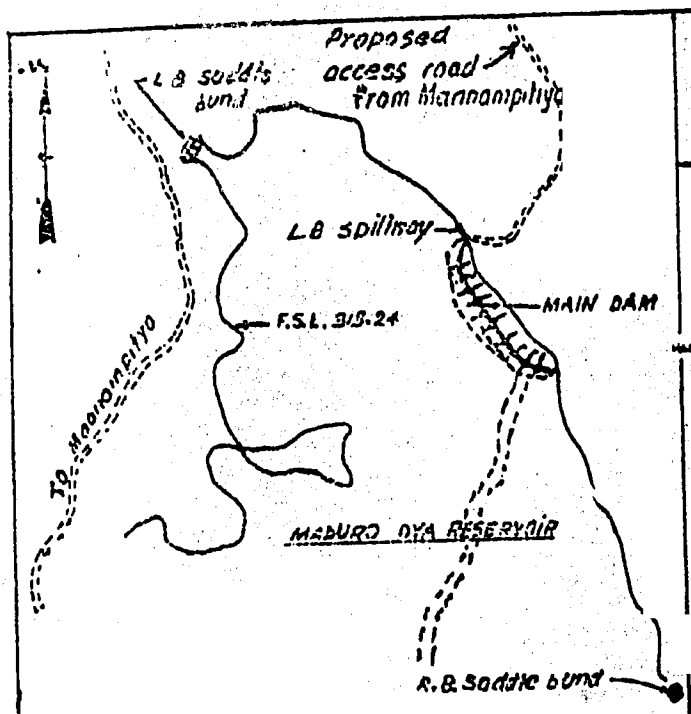
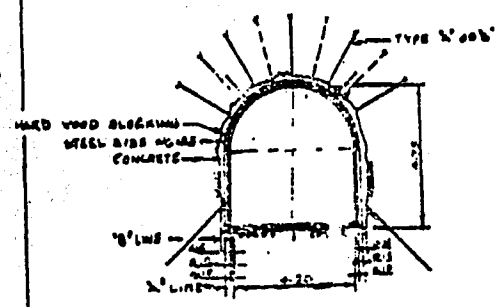
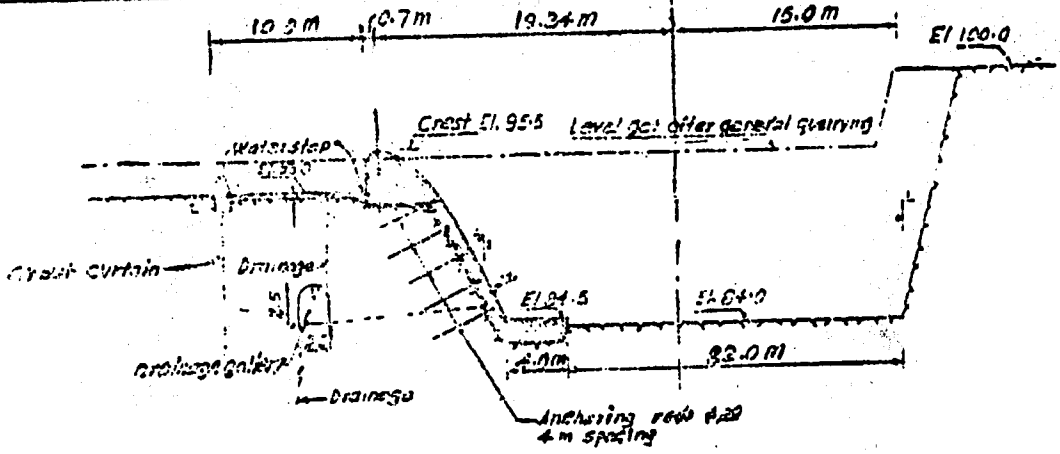
MADURU OYA HEADWORKS



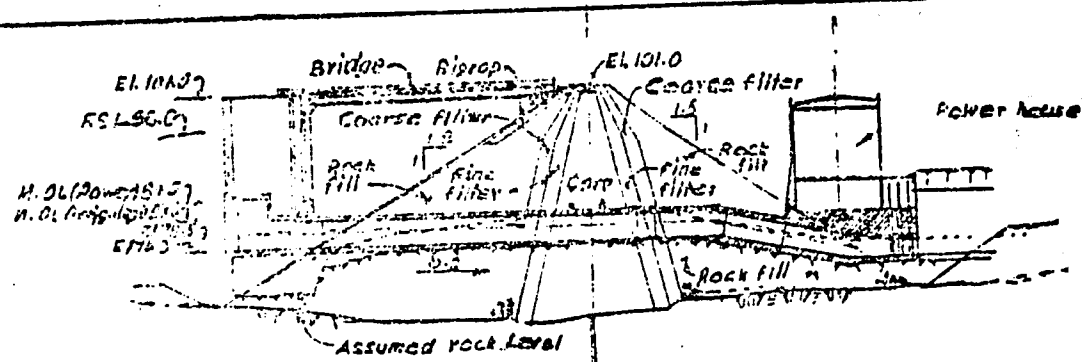
LAYOUT PLAN



CROSS SECTION OF TUNNEL
(Link from Ratkinda)



SPILLWAY SECTION



R.B. SLUICE

21 structures—which connects System 'C' (from Ratkinda) to System 'B' (Maduru Oya Headworks).

Supplies

The required power supply for construction and domestic purposes have been provided to Maduru Oya headworks by the CEB, from Polonnaruwa.

Water Supply for the construction staff has been provided after filtration from Pimburettewa.

The Ceylon Petroleum Corporation has constructed a special refuelling station at Welikanda to cater for this project—with a storage capacity of 250,000 litres (50,000 gallons) diesolene and 22,500 litres (50,000 gallons) petrol.

Camps

All the buildings for the contractors, consultants and CECB staff, housing, shopping, schooling and recreational facilities, have been completed in System B area and Polonnaruwa. Almost all the staff are now resident at Maduru Oya and all the required facilities are provided, including a swimming pool, circuit bungalow and well equipped quarters for expatriate staff.

Costs

	Rupees Million		
	Local	*Foreign*	*Total*
1. Estimated final cost of dam, spillway and associated structures ..	235	951	1186
2. Link tunnel	54	234	288
3. Hydromechanical Equipment and other costs including escalation			526
Headworks Total (say) ..			2000
Infrastructure (roads, buildings, power supply, communications etc.)			150
Approx. Overall Costs ..			2150

RANDENIGALA PROJECT

This Complex consists of two dams at Randenigala and Rantembe. The construction of Randenigala dam has been recently awarded on tender. It is a rockfill structure 94.0 m. high and 485 m. long (3.7 MCM in volume), with a vertical impervious core in the centre, and a slightly curved longitudinal axis, convex upstream.

It has a spillway 60.1 m. wide with 3 Taintor gates 15.26 m. x 16.70 m. wide with a downstream chute 48 m. wide and 231.8 m. long capable of discharging a flood discharge of 8,085 m^3/sec. (i.e. 285,300 cu.ft/sec.). During construction, the river will be diverted through two diversion tunnels each 9.6 m. in diameter, and lengths 404 m. and 464 m. One of these diversion tunnels will be plugged after construction and the other will serve as a bottom (or Irrigation) outlet.

A penstock 5.8 m. dia. and 330 m. long bifurcating to 2 of 3.5 m. dia. (Capacity 2 x 90m^3/sec.) will lead from the intake through the body of the dam to the Power House to energise 2 Francis Turbines with an installed capacity of 61 MW each working under a gross head of 80 m.—to produce 525 GWH of energy (average) annually, the firm energy being 366 GWH annually.

The contractors are expected to mobilise at site by November 1982 and work on the diversion tunnels will commence in March 1983. This will be followed by the excavation of the core trench and construction of the coffer dam. The coffer dam which will be incorporated in the main dam eventually, is at elevation 191 m. MSL with a top width of 5 m. designed for a 100 year flood. This coffer dam of 43 m.ht. is higher than the Maduru Oya dam. The width of the main dam is 295 m. at the toe level 148 m. MSL. Work will proceed next on the grouting gallery and grouting will take place for about 12 months.

Embankment rockfill and the core fill will commence with grouting work. The dam is expected to be completed at the end of 1985.

Spillway construction will commence in 1983 and completed 4 months prior to the completion of the dam

The reservoir capacity is 860 million m^3 at F.S.L of 232 m. above MSL with a flood lift of 4.2 m.

The Power Control building and switchyard will come up at the Rantembe site.

RANTEMBE

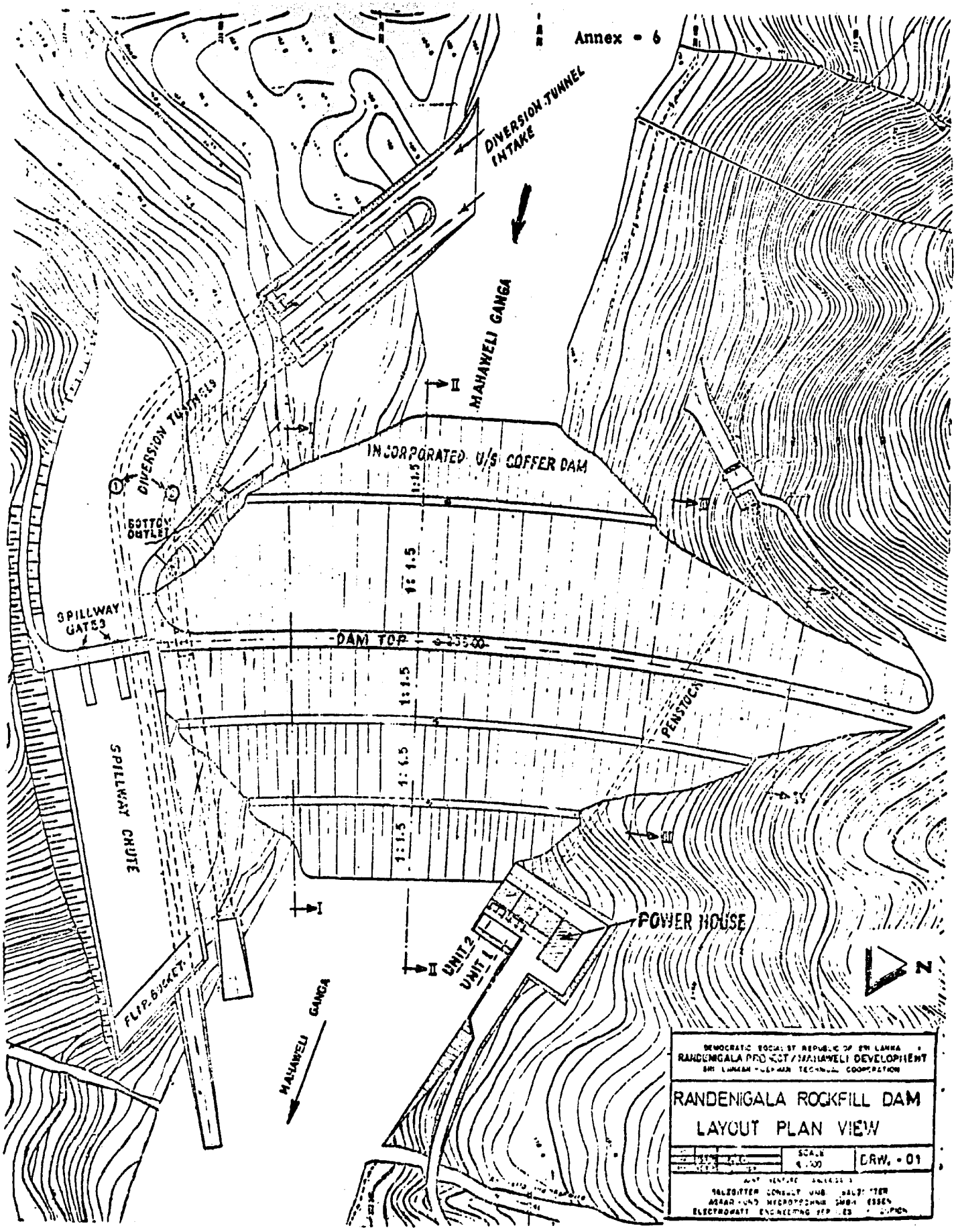
Rantembe Dam will be taken up later about 3 km. downstream of Randenigala, below the confluence of the Uma Oya with the Mahaweli Ganga. It will be a concrete gravity dam 41. 5 m. high with a crest length of 420 m. (Total volume of concrete being 215,000 cubic metres).

The Spillway will have 4 Taintor Gates 16.21 m. x 16.0 m. with 4 chutes 16 m. wide and 50 m. long—capable of a maximum discharge of 10,235 m^3/sec.

There will be 2 bottom (Irrigation) outlets provided with Taintor gates each capable of a maximum discharge of 200 m^3/sec.

Steel Penstocks of dia. 4.2 m. with a rated discharge of 90 m^3/sec lead to the power station equipped with 2 Francis Turbines with an installed capacity of 24.5 MW each working under a gross head of 33.5 m. This will produce 158 GWH of firm energy annually (average 251 GWH).

Annex - 6


DIVERSION TUNNEL INTAKE
MAHAWELI GANGA
DIVERSION TUNNELS
INCORPORATED U/S COFFER DAM
BOTTOM OUTLET
SPILLWAY GATES
DAM TOP
PENSTOCK
SPILLWAY CHUTE
POWER HOUSE
UNIT 2
UNIT 1
FLIP BUCKET
MAHAWELI GANGA
N
DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA
RANDENIGALA PROJECT / MAHAWELI DEVELOPMENT
RANDENIGALA ROCKFILL DAM
LAYOUT PLAN VIEW
DRW. - 01

Donor Country

The Federal Republic of Germany has provided financial assistance for this project of DM 400 million on easy terms. This was considered enough for the Headworks of Randenigala and Rantembe Projects, but due to price escalation this will be sufficient only for Randenigala at present costs. Rantembe will therefore be taken up later. F.R.G. had also provided a Technical Assistance Grant of DM 6.6 million for Consultancy.

The Consultants for these projects are a Joint Venture consisting of Saltzgitter Consult GmbH (Saltzgitter), Electrowatt Engineering Services Ltd. (Zurich) and Agrar and Hydrotechnik GmbH (Essen).

Irrigation Benefits

The area to be brought under irrigation by further regulation of Mahaweli flows at Randenigala (and Rantembe) is as yet unspecified. Systems B, C, etc. (about 75,000 ha. in extent) are provided with water releases from Victoria. The UNDP Master Plan proposed a transbasin diversion of the surplus waters, after Randenigala is constructed, to the N.C.P. through a transbasin canal from below Moragahakande. Subsequent feasibility studies by the "Randenigala Joint Venture Consultants" (led by Saltzgitter Consult GmbH) have made a comparative study of transbasin diversion of the surplus waters from the Mahaweli to the North Western Dry Zone, North Central Region, the South Eastern Dry Zone and to System 'A'.

Moragahakande Reservoir on the Ambanganga has not been taken up for construction, because studies by NEDECO Consultants, who conducted a feasibility review of the Accelerated Programme have shown that this reservoir is not needed to meet the irrigation and power requirements under the accelerated programme. It may be required later, for transbasin diversion to the N.C.P. areas.

DOWNSTREAM DEVELOPMENT

The irrigable areas benefited under the reservoirs in the Accelerated Mahaweli Programme are shown in the key diagram (Annex 2). They consist of :—

System		*Existing ac.*	*New ac.*
H	In Kala Oya basin, with Polgolla Diversion, augmented by Kotmale	71,000	60,000
G	Under Elahera, with Polgolla Diversion, augmented by Kotmale	5,000	8,000
D	In Ambanganga basin under Minneri, Polonnaruwa etc., with Polgolla Diversion	73,000	26,000*
M	Under Huruluwewa, with Polgolla Diversion	8,000	—
E	Under Minipe Left Bank ..	15,000	—
C	Under Minipe Right Bank from Victoria	9,000	70,000
B	Under Augmented by Victoria, Maduru Oya	9,300	110,000
A	In the Mahaweli Deltaic area ..	14,000	60,000**
	Total (approx.) ..	194,200	334,000

Future Areas of Development

Feasibility Studies have been carried out, by a team of Consultants called "Joint Venture Randenigala" (Messrs. Saltzgitter Consult, Agrar & Electrowatt) financed by the World Bank, on alternative future areas of development, with the excess water resources from the Mahaweli especially after Randenigala Reservoir is constructed.

*to be considered after Moragahakande.

**to be finalised after feasibility studies.

Of the three alternative areas studied, they recommend the development of 40,000 ha. in the South Eastern Dry Zone as the optimal economic solution, yielding benefits of Rs. 120 million per year at a discounting rate of 10%.

SYSTEM 'C'

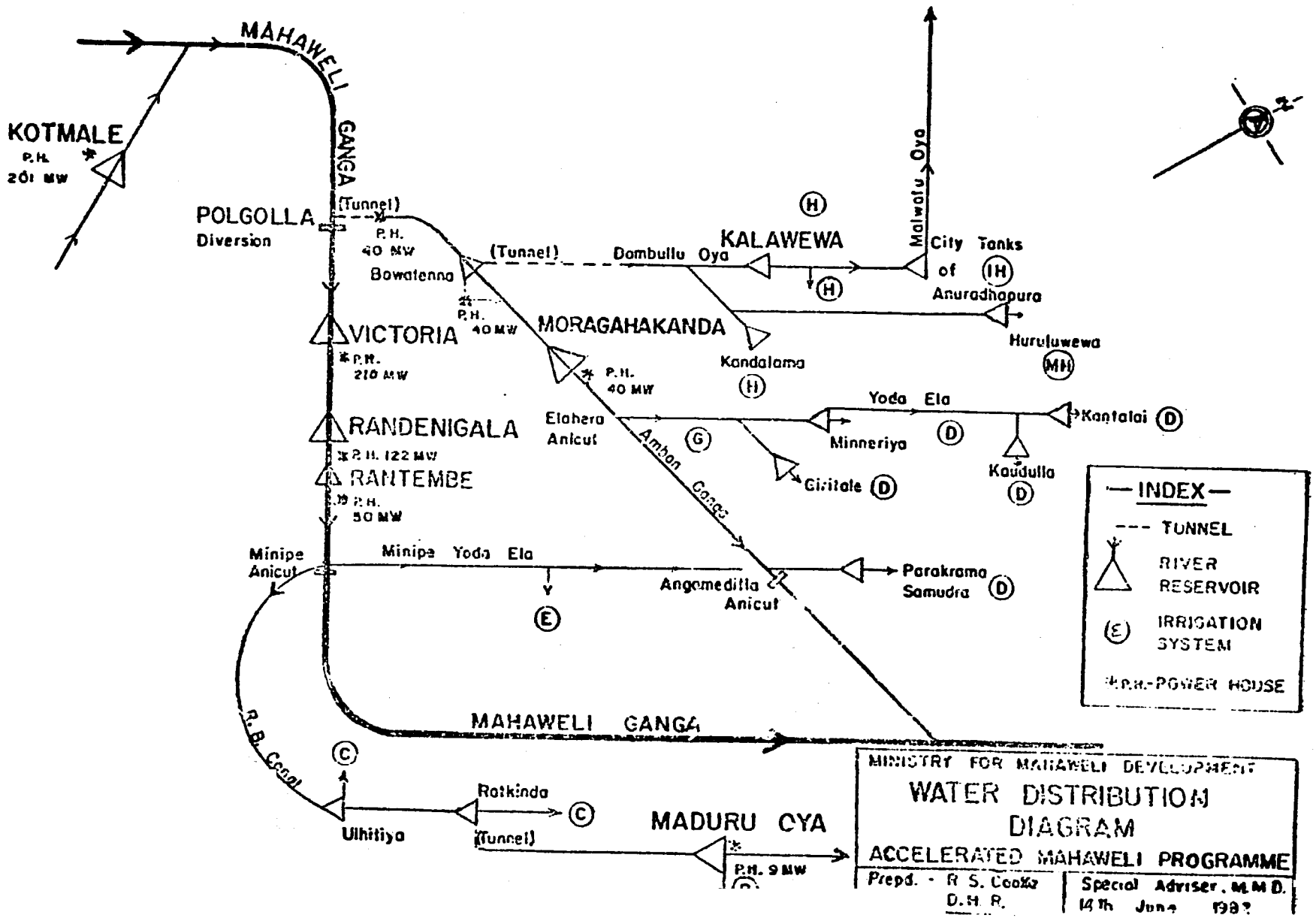
This requires the Construction of an Anicut at Minipe, Right Bank Transbasin Canal and reservoirs at Ulhitiya and Ratkinda.

Minipe Anicut

A new anicut across the Mahaweli Ganga is being constructed at a site about 150 m. downstream of the ancient anicut, which had been restored to feed the existing Minipe Yoda Ela (Left Bank Canal) which irrigates System 'E' 15,200 acres (6,330 ha.).

The crest level of the new anicut will be 114 m. above MSL. It is a concrete structure 200 m. long with an average height of 5 m. (maximum height about 9 m. in the deepest section).

This anicut will head up water for issues to the Left Bank Canal and the new Right Bank Transbasin Canal, through a new Head Sluice.


MAHAWELI GANGA
KOTMALE
P.H.
201 MW
POLGOLLA
Diversion
(Tunnel)
P.H.
40 MW
Bowatenna
P.H.
40 MW
VICTORIA
P.H.
210 MW
RANDENIGALA
P.H. 122 MW
RANTEMBE
P.H.
50 MW
Minipe
Anicut
Minipe Yoda Ela
E
R.B. Canal
C
Ulhitiya
Ratkinda
(Tunnel)
C
MADURU OYA
P.H. 9 MW
MAHAWELI GANGA
(Tunnel)
Dombullu Oya
KALAWEWA
H
H
Malwatu Oya
City of Anuradhapura
Tanks
IH
Huruluwewa
MH
MORAGAHAKANDA
P.H.
40 MW
Kandalama
H
Elahera
Anicut
G
Ambon Ganga
Yoda Ela
Minneriya
D
Giritale
D
Kantalai
D
Kaudulla
D
Angomeditta
Anicut
Parakrama
Samudra
D
INDEX
TUNNEL
RIVER
RESERVOIR
IRRIGATION
SYSTEM
P.H.-POWER HOUSE
MINISTRY FOR MAHAWELI DEVELOPMENT
WATER DISTRIBUTION
DIAGRAM
ACCELERATED MAHAWELI PROGRAMME
Prepd. - R. S. Cooke
D.H.R.
Special Adviser, M.M.D.
14th June 1982

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R.B. Transbasin Canal

The Right Bank Canal will be concrete-lined and have a conveyance capacity of 63.7 m³/sec (2,250 cusecs). It is 30.8 km. long with a water depth of 3.45 m. and a gradient of 200 mm/km.

The Right Bank transbasin canal crosses four large tributaries of the Mahaweli Ganga, namely Badullu Oya, Loggal Oya, Heppola Oya, and Diyabana Oya.

At Badullu Oya there will be an aqueduct (7 m. x 5 m.) from 3.24 km. to 3.8 km. with a capacity of 64 m³/sec. which will be carried on 7 piers (maximum height 23 m.) at 20.1 m. spans. This will be followed by a tunnel 208 m. long with a dia. of 5.8 m., concrete lined, horse-shoe section.

The Loggal Oya level crossing from 5.15 km. to 7.75 km. consists of an earthen embankment 2.20 km. long with a maximum height of 29.6 m. It will have a labyrinth weir 175 m. long, with crest level 111.70 m/MSL designed to discharge a 200-year flood of 1,800 m³/sec. with 5 drawdown gates 1.8 m. wide x 1.2 m. high with sill at level 104.9 m/MSL.

The Heppola Oya level crossing between 9.2 km. to 13.95 km., has an earthen embankment 1.14 km. long and maximum height 19.6 m. It will also have a labyrinth weir designed to discharge a 200-year flood of 100 m³/sec. and 2 drawdown gates 1.8 m. x 1.2 m. at level 104.6 m/MSL.

The Diyabana Oya level crossing from 25.4 km. to 26 km.—will have an earthen embankment 0.6 km. long with a maximum height of 7 m. It will also have a labyrinth weir designed to discharge a 200-year flood of 160 m³/sec.

On the Minipe Right Bank Canal there are 3 irrigation outlets to feed existing reservoirs at Mapakade, Dambarawa and Sorabora, with a peak demand of 3 m³/sec.

There are also 25 drainage crossings, 6 road bridges and 2 irrigation overcrossings (aqueducts) across this Right Bank canal.

Ulhitiya and Ratkinda Reservoirs

At 30.8 km. the Right Bank Canal enters the Ulhitiya Oya, which is impounded lower down with an earthen embankment at 110m/M.S.L., 4.76 km. long and maximum height 25.6 m.

There is another reservoir across Ratkinda Oya formed by an earthen embankment 1.2 km. long with a maximum height of 24.7 m. with the same bund top level.

This is linked to the Ulhitiya Oya by a link canal—the combined reservoir capacity is 146 MCM with one concrete spillway 76 m. long with 7 radial gates 10 m. x 4.5 m. on the Right Bank of Ulhitiya reservoir.

System 'C' New Lands

The new lands in System 'C' are in sparsely populated areas, now almost entirely in jungle, with hardly any access roads or existing villages. The nearest town is Mahiyangana, in Zone 1 which contains three existing irrigation schemes under Dambarawa, Mapakade and Sorabora—ancient reservoirs restored about 50 years ago—irrigate about 3,550 ha. (9,000 acres) of wetland rice. The only recent irrigation scheme in that area is at Nagadeepa, which is above the command of the Right Bank Canal, but about a quarter of the lands under it falls within Zone 1.

System 'C' is divided in 6 Zones, of which Zones 2 to 6 contain the new lands. The gross extent of new lands is about 52,500 ha. of which the turn-out command area is about 28,500 ha.

New townships are coming up at Giranduru Kotte in Zone 2, and Dehiatta-Kandiya in Zone 4.

Zones 3 to 6 will be under the Right Bank Main Canal No. 2 extending 17.5 km. beyond Ratkinda Reservoir with 5 Branch Canals (the longest of which is 29.3 km.) and 4.7 km. of minor branch canals, totalling 59 km. in length. The new irrigated holdings to be provided in System 'C' are about 23,000 ha. nett.

In Zone 2, there will be about 5,050 ha. under Ulhitiya Reservoir Left Bank Main Canal No. 1 (11 m³/sec) 10.9 km. long, 3 Branch Canals, 120 km. of D'Canals, and 360 km. Field Canals, 3 villages and 10 hamlets.

In Zone 3, there will be about 2,700 ha. with 71 km. of D'Canals and 212 km. Field Canals, 2 villages and 9 hamlets

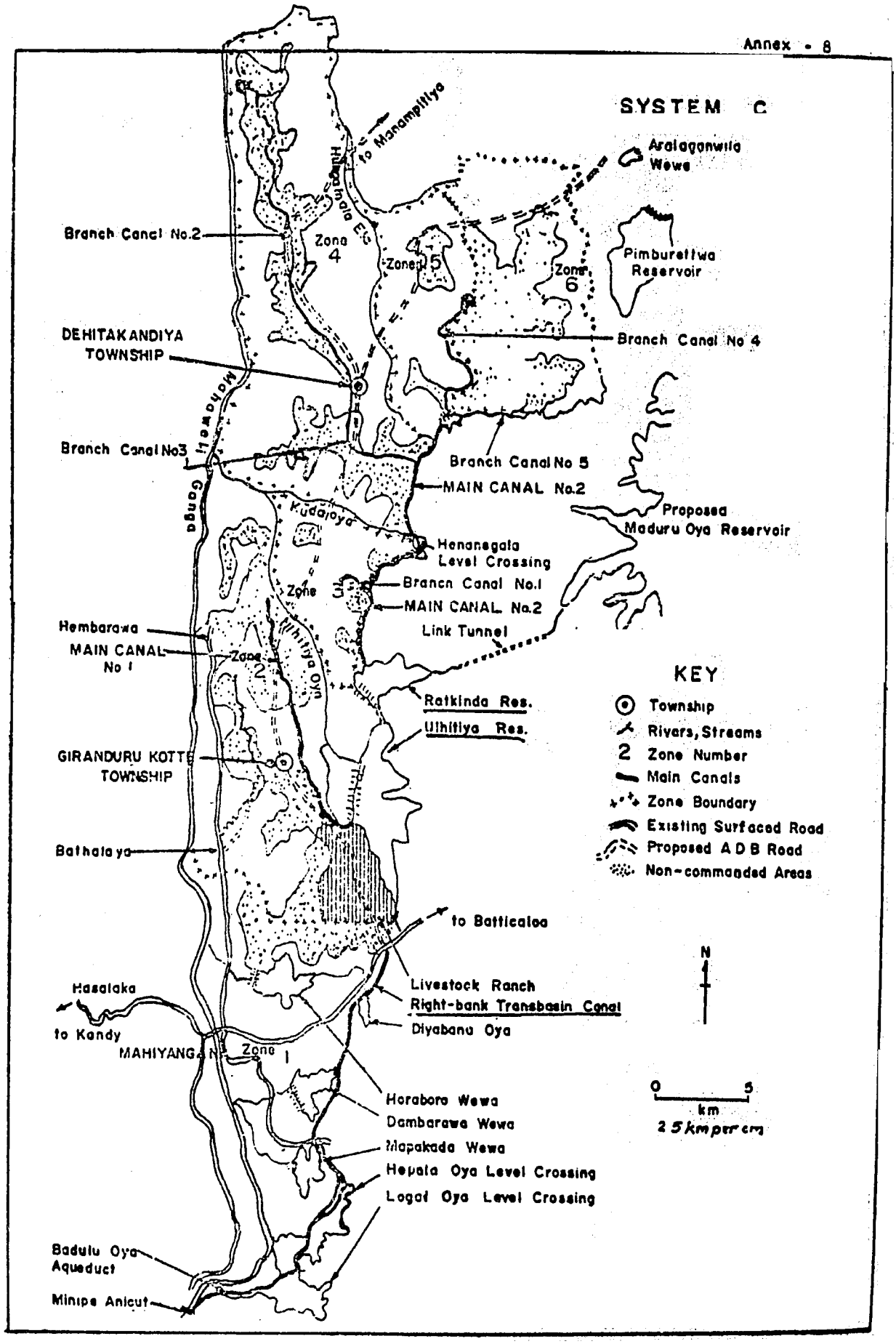
In Zone 4, there will be about 10,000 ha. with 200 km. of D'Canals, and 760 km Field Canals, 8 villages and 31 hamlets.

In Zone 5, there will be about 2,600 ha. with 49 km of D'Canals, and 189 km Field Canals, 2 villages and 9 hamlets.

In Zone 6, there will be about 2,500 ha. with 60 km. of D'Canals, and 200 km. Field Canals, 8 villages and 9 hamlets.

These new lands are to be settled with farm families on irrigable lots of 1 ha. per family and highland 0.2 ha. for house lots. In Zone 2 some 5,000 ha in extent are taken up as a pilot phase for development around Giranduru-Kotte.

There were only a few existing roads in System 'C', such as a minor road from Mahiyangana to Hembarawa of which only the first six miles up to Alutharama were metalled and tarred. A new system of roads will link the Townships at Mahiyangana to Giranduru-Kotte and Dehi-ata-Kandiya to villages in System 'C' and extended to System 'B'.


SYSTEM C
Araliaganwila Wewa
Pimburettwa Reservoir
Branch Canal No.2
Zone 4
Zone 5
Zone 6
Branch Canal No 4
DEHITAKANDIYA TOWNSHIP
Mahaweli Ganga
Branch Canal No3
Branch Canal No 5
MAIN CANAL No.2
Proposed Maduru Oya Reservoir
Kudaloya
Henanegala Level Crossing
Branch Canal No.1
MAIN CANAL No.2
Link Tunnel
Hembarawa
MAIN CANAL No 1
Zone 2
Ulhitiya Oya
Ratkinda Res.
Ulhitiya Res.
GIRANDURU KOTTE TOWNSHIP
Bathalaya
to Batticaloa
Hasalaka
to Kandy
MAHIYANGANA
Zone 1
Livestock Ranch
Right-bank Transbasin Canal
Diyabanu Oya
Horabora Wewa
Dambarawa Wewa
Mapakada Wewa
Hepala Oya Level Crossing
Logal Oya Level Crossing
Badulu Oya Aqueduct
Minipe Anicut
KEY
Township
Rivers, Streams
Zone Number
Main Canals
Zone Boundary
Existing Surfaced Road
Proposed A D B Road
Non-commanded Areas
N
0 5
km
2.5 km per cm

Donor Countries

The Right Bank Transbasin Canal from 4.7 km. to 30.8 km. is being financed by the World Bank with a soft loan of $90 million. Funding for Zone 2 of System 'C' is from the European Economic Community in a sum of $22.5 million and the Right Bank main canal from Ratkinda for irrigation systems in Zones 3 to 6 are from Japan and Kuwait of $45 million each.

The general layout of System 'C' is shown in Annex 8.

SYSTEM 'B'

The irrigation of System 'B' will be from Maduru Oya Reservoir augmented by water from Victoria through a LINK Tunnel from Ratkinda Reservoir which has been described earlier.

The gross extent of System 'B' is 130,000 ha. of which the new irrigable area is about 36,950 ha. nett and 8,594 ha. of upland.

The Left Bank Main Canal 57.3 km. long has a conveyance capacity of 56.2 m³/sec. There are Left Bank branch canals for a total 104 km. in length. The left bank area will be taken up in two phases, 1 (a) being up to 23.5 km. of the Main Canal including LB R2 and LB R1 i.e. Zones 1 and 5, which contain 6,763 ha. paddy land and 1,848 ha. upland.

Phase 1(b) will be the balance area under the Left Bank main canal and branches, up to Station 'B' 52.9 km including LB L8 and LB R7 (i.e. Zones 2, 3 and 4A) containing 13,842 ha. of paddy land and 3,344 ha. upland. Beyond this, up the end of Left Bank Main Canal there is a "drop-out" area (phase 1c) containing 3,999 ha. of paddy land and 1,710 ha. upland.

The Right Bank Main Canal 40.7 km. long has a conveyance capacity of 32.5 m³/sec and it has branch canals a total 56 km. in length.

System 'B' Phase 2 will be the entire Right Bank containing 12,339 ha. of paddy land and 1,692 ha. upland.

The contract for the Left Bank Main Canal has been awarded in May 1982 to Messrs. Zackry & Dillingham of USA and the contractors are now mobilising in System 'B' to start work.

Donor Countries

This part of the work is financed with a soft loan of US $ 85 million from U.S. AID for the Left Bank Main and Branch Canals in Phase 1(a) to be followed by Phase 1(b)—to be completed in about 2 years time.

For the infrastructure development of the Left Bank area, final feasibility studies have been completed by the Overseas Project Section of the Department of Agriculture, N.S.W. Australia, from whom financial assistance (of about Austr. $ 15 million) is expected shortly, sufficient for Phase 1 (a) Zones 1 and 5. Financial assistance from Saudi Fund (about Saudi Riyals 85 million) is expected for the balance Left Bank infrastructure.

Further financial assistance is expected from Saudi Fund (Riyals 171 million) and Canada (C $ 50 million) for Maduru Oya Right Bank development.

Townships

The existing villages in this development area are Manampitiya, Welikande, Aralaganvila, Punanai, Trukonamadu and Meyankolla of which two will be selected to be upgraded as future townships to serve System 'B'.

Roads

The Main Highway and Rail-road from Polonnaruwa to Batticaloa passes right across System 'B' through Manampitiya, Welikande and Punanai. A system of new roads are proposed to link the towns and villages on this main road to Aralanganvila, Trukonamadu and Meyankolla and also a new rail-road from Welikande to the north up to System 'A' and to the south into System 'C'.

The Asian Development Bank is financing the construction of the main roads in System 'B' and 'C' (which will be interlinked) with a soft loan of $10 million. A total length of 105 km of new roads will be constructed and 46 km of existing roads will be improved under this programme.

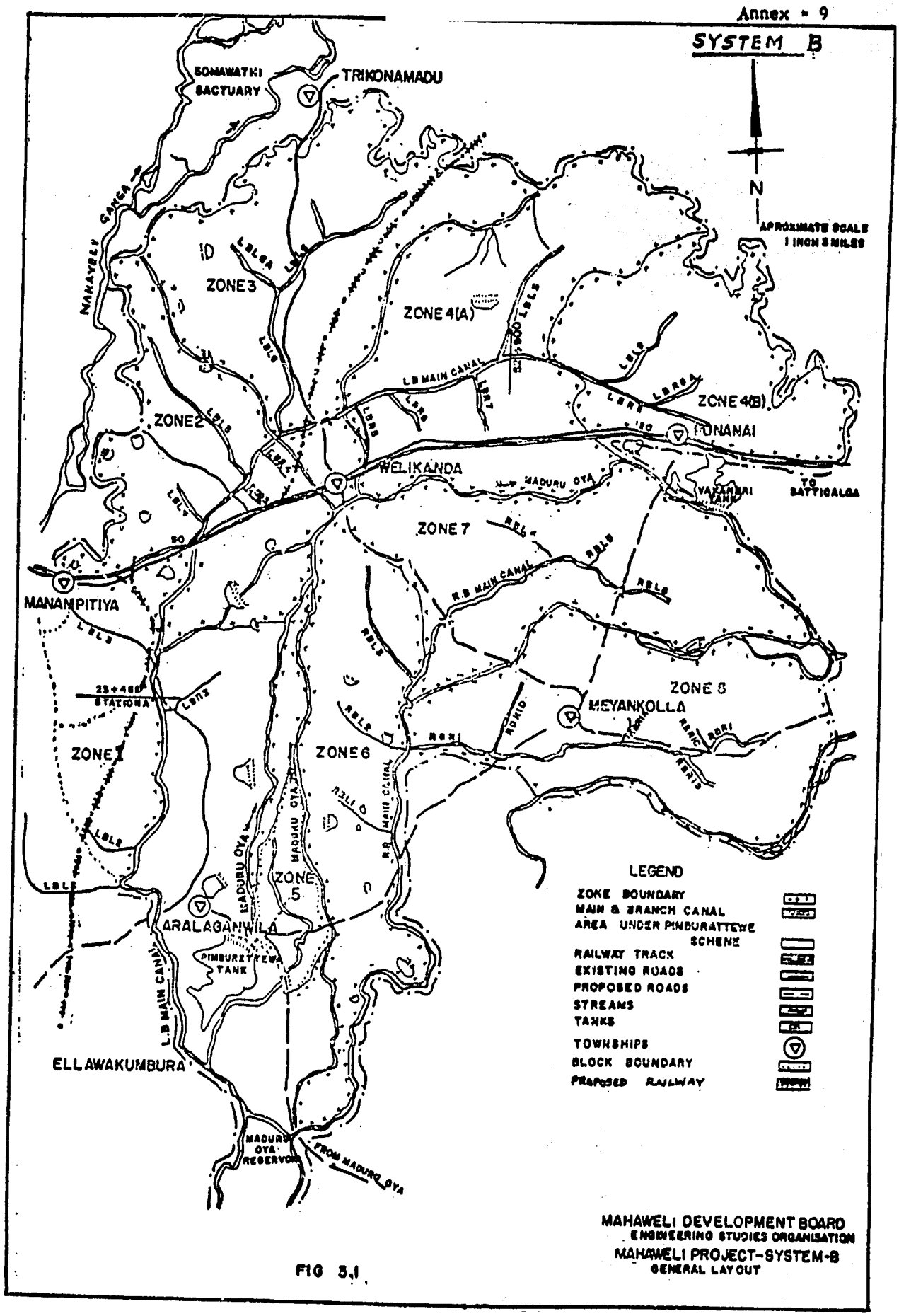
A general layout plan of System 'B' is shown in Annex 9.

Costs

Estimated Costs of Downstream Development

	Rs. Mil.	
System 'C'		
Minipe Anicut	12.14	
RB Transbasin Canal 0 to 3.24 km.	42.84	
Badullu Oya Aqueduct ..	30.30	
Badullu Oya Tunnel	20.34	
RB Transbasin Canal 4.7 to 30.8 km.	537.50	
Ulhitiya Reservoir	78.04	
Ratkinda Reservoir	57.35	
Irrigation Infrastructure Zone 2	348.00	
Irrigation Infrastructure Zones 3 to 6	1232.33	2359
System 'B'		
LB Main and Branch Canals ..	2100.00	
Irrigation Infrastructure Zones 1 to 5 L.B.	1843.00	
RB Main and Branch Canals ..	2150.00	6093
Irrigation Infrastructure for RB Zones—(not yet estimated) ..		
		8452

Total (with RB Irrigation Infrastructure of "B") Rs. 10,000 million (approx.)



MAHAWELI DEVELOPMENT BOARD
ENGINEERING STUDIES ORGANISATION
MAHAWELI PROJECT-SYSTEM-B
GENERAL LAYOUT

FIG 3.1

SYSTEM 'G'

The area on the Left Bank of the Ambanganga below Elahera-Minneriya-Yoda Ela is designated System 'G'. This comprises of 1,825 ha. (4,560 ac.)of irrigated lands according to the specifications. The colonists also have 1.25 ha (3 ac.) of highland each for their house and upland lot. A part of these house lots have since been converted into irrigated land—In addition about 820 ac. of lands have been developed with irrigation facilities under Village Expansion.

There is an extent of 9,220 acres of unalienated lands below the existing area up to the Ambanganga. Most of this area has been encroached on and illicitly cultivated in a haphazard manner. It will be possible to do systematic development of about 7,400 ac.

The present capacity of Elahera-Minneriya-Yoda Ela is 2,000 cusecs, which is a trunk conveyance canal to augment Minneriya, Giritale, Kandulla and Kantalai.

At present there are as many as 42 offtakes taking water to the existing Elahera fields in System 'G', which number is undesirable off a Conveyance Canal. These will be reduced to less than one third that number in the rehabilitated irrigation system for 'G'.

The approximate costs are—

	Rs. Mil.
Land and Water Resources Development	94.0
Buildings for Headquarters	15.0
Demonstration Farm	0.6
Social Infrastructure	21.0
Procurements	30.0
Staff and Operational Costs ..	16.0
Subsidies	6.0
Technical Assistance	22.0
Physical Contingencies	30.3
Total	234.9

The project is financed by a tripartite agreement between the Government of Sri Lanka, European Economic Community and Belgian Government. The FAO is administering the project on behalf of the donor countries.

SYSTEM 'A'

This area is in the Mahaweli Delta which contains about 36 200 ha. (89,400 ac.) of irrigable land. A part of this land is subject to seasonal flooding, another part on the Left Bank is not to be developed being the Somawathiya National Reserve and there is a forest reserve on the Right Bank.

The gross irrigable extent is about 22,500 ha. of which 6,200 ha. are existing developed lands under Allai scheme (5,850 ha.) and neighbouring areas (1 350 ha.).

Feasibility studies on System 'A' have been carried out by the "Joint Venture Randenigala" Consultants (Messrs. Saltzgitter, Agrar, & Electrowatt) and their report of February 1982 is now under consideration.

A diversion structure will be required across the Mahaweli Ganga at Kandekadu, about 25 km. downstream of Manampitiya and two diversion canals for the L.B. and R.B. to Irrigate System A.

The nett irrigable area that can be taken up and settled is about 14,000 ha. (33,600 ac.). The farming will be based on a rice monoculture.

Mr. Ratna S. Cooke, BE(Hons)Madras, FIE(SL), CEng, graduated with First Class Honours in 1944 and joined the Department of Irrigation. He rose progressively to be Deputy Director, Irrigation. From 1970 to 1975 he was General Manager, Mahaweli Development Board and from 1975 to 1978 he was Chairman, Mahaweli Development Board. He is presently Engineering Consultant to F A O and Special Advisor to the Ministry for Mahaweli Development.

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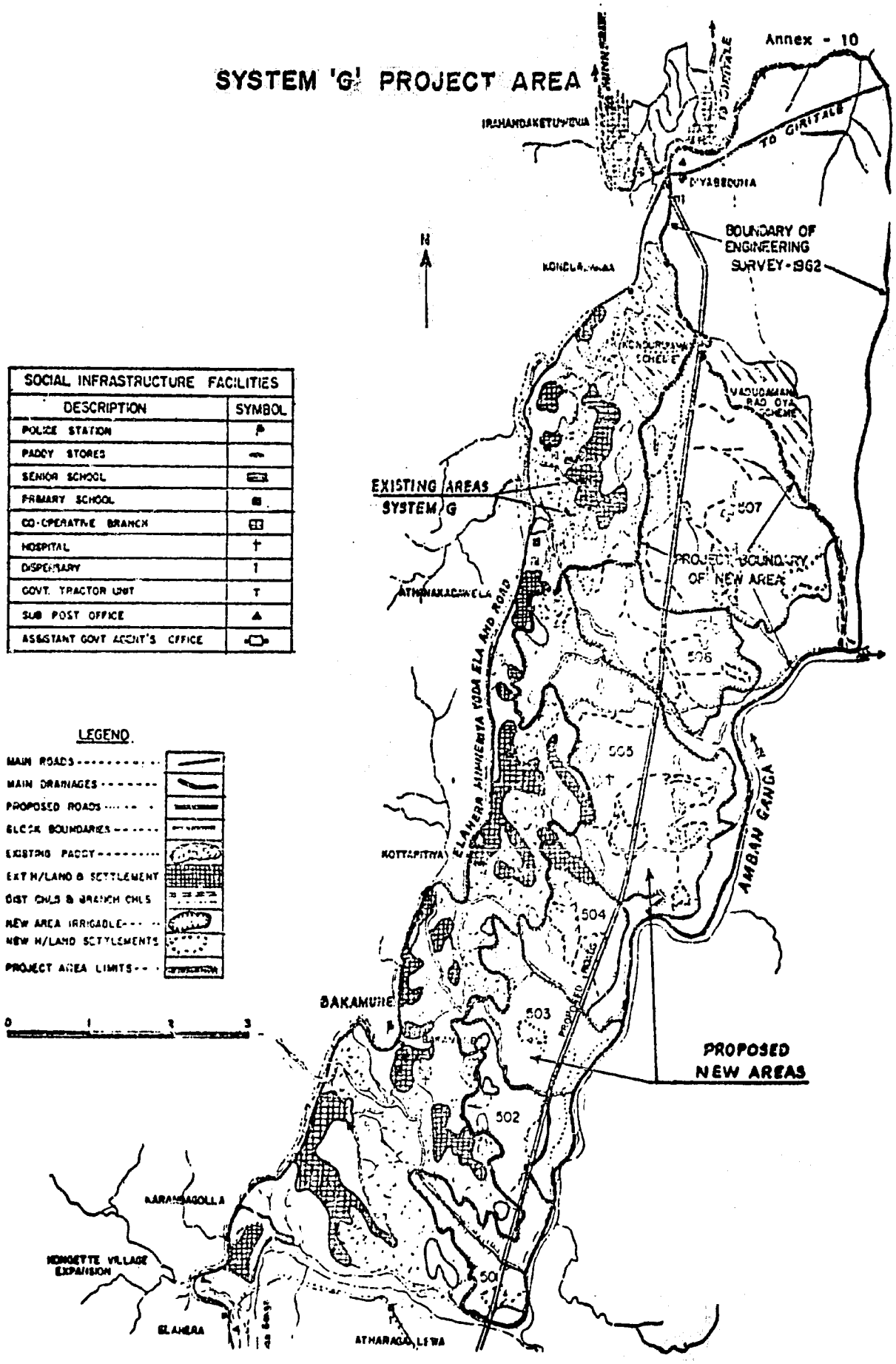
Annex - 10

SYSTEM 'G' PROJECT AREA



SOCIAL INFRASTRUCTURE FACILITIES	
DESCRIPTION	SYMBOL
POLICE STATION	
PADDY STORES	
SENIOR SCHOOL	
PRIMARY SCHOOL	
CO-OPERATIVE BRANCH	
HOSPITAL	
DISPENSARY	
GOVT. TRACTOR UNIT	
SUB POST OFFICE	
ASSISTANT GOVT AGENT'S OFFICE	

LEGEND

- MAIN ROADS
- MAIN DRAINAGES
- PROPOSED ROADS
- BLOCK BOUNDARIES
- EXISTING PADDY
- EXT H/LAND & SETTLEMENT
- DIST CNLS & BRANCH CNLS
- NEW AREA IRRIGABLE
- NEW H/LAND SETTLEMENTS
- PROJECT AREA LIMITS

PARAMETERS OF PROJECTS - MAHAWELI ACCELERATED PROGRAMME

Parameters	Kotmale (Final Stage)	Kotmale (1st Stage)	Victoria	Maduru Oya	Randenigala	Rantembe
Full Supply (MSL)	728 m/MSL	703 m/MSL	438 m/MSL	96 m/MSL	232 m/MSL	152 m/MSL
Crest Elev. (MSL)	735 m/MSL	706.5 m/MSL	443 m/MSL	101 m/MSL	238.0 m/MSL	155 m/MSL
Gross Storage (FSL)	408 Mcum	174 Mcum	730 Mcum	596 Mcum	860 Mcum	21 Mcum
Type of Dam	Rockfill	Rockfill	Concrete Arch	Rockfill	Rockfill	Concrete
Max. ht. above bed	116 m	87 m	118 m/MSL	41 m + 2m	94 m	43.5 m
Length along crest	600 m	600 m	555 m	1080 m	485 m	415 m
				LB Saddle 520m long x 20m.ht. RB Saddle 60m. long x 12m. ht.		
Spillway—Type	Orifice (later)	Chute (now)	Gates in Dam	Free Overflow	Gates	Gates in dam
Length				150 m	62 m Chute	Chute 76 mx100m
No. and size of gates	3 of 14 m x 15 m	3 of 14 m x 15 m	8 of 12.5mx8.0m		3 of 16.7mx15.0m	4 of 16.2 m x 16 m
Discharge at HFL	5,550 cumecs	5,550 cumecs	8,200 cumecs		8,085 cumecs	10,235 cumecs
Tunnel Length	6.5 km (Diversion 2 x 9.2 m dia., .5 km long)	6.5 km	5.4 km —	5.7 km (Link from Ratkinda)	330 m penstock (Diversion 2 x 9 m dia.)	20 m penstock —
Type	Horse Shoe (Lined)	Horse Shoe (Lined)	Circular (Lined)	D-Shape (part-lined)	(1) 470m (2) 380m long	Steel
Diameter	6.2 m	6.2 m	6.2 m	4.7 m x 4.85 m	Steel 5.8 to 3.5 m	4.2 m
Max. Capacity	110 m³/sec	110 m³/sec.	137 m³/sec	34 m³/sec	2 x 90 m³/sec	90 m³/sec
Power House—Type	Underground	70m x 18m x 35m	Concrete 82m x 27m x 37m	Below Sluices	Below dam	Below dam
Installed capacity	3 of 67 MW	2 of 67 MW	3 of 70 MW (Plus 3 x 70 MW, 2nd Stage)	3 of 2.5 MW (later)	2 of 61 MW	2 of 24.5 MW
Type of Turbine	Francis	Francis	Francis	Kaplan	Francis	Francis
Gross Head	251 m	226.5 m	190 m	13 m	80 m	33.5 m
Total Annual Energy	405 GWH (Firm) & 130 GWH secondary	310 GWH (Firm) & 145 GWH secondary	780 GWH	36 GWH	525 GWH (Average) 366 GWH (Firm)	251 GWH (Average) 158 GWH(Firm)
System Irrigated						
New Area	A & Augment H	Augment H	C & Part B	Part 'B'	South East Dry Zone	
Existing Area	10,000 ha.	—	(23,000 ha + 30,000 ha) 10,000 ha	(10,000 ha) 3,750 ha	(40,000 ha)	
Date of Completion (later)		1985	1984	1982/83	1985	
Donor Country		Sweden	U.K.	Canada	F.D.R. Germany	(To be determined)
Approximate Costs Rs. Million		8,580	7,500	2,150		
Downstream Costs			System 'C' = 2,359	'B' = 10,000		

Prepared by - R. S. C. 15. 6. 82

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SPUN CONCRETE - AN APPROPRIATE TECHNOLOGY IN SRI LANKA

by

D. L. O. Mendis

Appropriate Technology

There have been various definitions and discussions of the term Appropriate Technology. In this paper such discussion of the meaning of the term is avoided. Instead, the use of spun concrete technology in Sri Lanka is mentioned, and the potential for further development is discussed so that the appropriateness of this technology is thus described implicitly. However, it is necessary to state at the outset that there is a distinction between process technology and product technology which has to be briefly clarified. Process-technology describes the method or process, including designs and specifications (sometimes called software), and the plant and equipment (sometimes called hardware) used in the manufacture of a product. Product technology describes the materials, labour and capital used in manufacture, and the quality and properties of the resultant product. This is discussed further, below.

Pre-cast Concrete Technology

Pre-cast concrete products have been manufactured for a long time, sometimes as an alternative to in-situ concrete construction, (i.e. as an alternative process technology) and sometimes as an alternative to other products, (i.e. as an alternative product technology).

Pre-cast concrete process technology has an advantage over in-situ concrete technology in the possibility of better quality control which results in a better quality product. Better quality control includes the possibility of steam curing. Better quality is seen in such intrinsic properties as strength and impermeability. It is also seen in longer life (or durability) of the product, as well as in better dimensional accuracy, and better finish. There is also the possibility of reducing waste and achieving overall price competitiveness, especially if economics of scale are possible in production.

Amongst the disadvantages of pre-cast concrete technology may be mentioned the need for handling and transport, which increases the possibility of damage and losses.

Some types of pre-cast concrete process technologies which have been used in Sri Lanka include—

1. Pre-casting using conventional moulds or shutters which are recovered by dismantling to release the pre-cast concrete products for curing; or sometimes steam curing is done with the product still in the mould).
2. Pre-casting using various types of movable shutters for making pre-cast concrete products; of these, machine made sand-crete or line-crete blocks are the best example, where an 'egg-laying' type of machine is used. In this method a long line or bed is necessary along which the machine moves.
3. (*a*) Pre-tensioned pre-stressed concrete for manufacture of lintols, beams, railway sleepers, etc., also using the long-line method.

   (*b*) Post-tensioned pre-stressed concrete production for manufacture of heavy concrete products like bridge beams.
4. Ferro-cement technology which has been given various names in various places. Products of this process technology include geo-desic-domes, water tanks and boats.
5. Spun concrete technology which is used for manufacture of pipes, poles, piles, columns for buildings, water tanks, septic tanks, etc.

Types of pre-cast concrete product technologies known in Sri Lanka include—

Reinforced cement concrete, unreinforced cement concrete, lime-crete and sand-crete, ferro-cement, various fibre-reinforced concretes, and of course pre-stressed concrete.

Process Technology and Product Technology— Progressive Development

Process technology generally develops in the industrial environment of a particular country to suit the stage of development of that country. The design and specifications (software) of a particular process technology will suit the factors of production in that country. On the other hand it is also possible for a process technology to be designed and manufactured in one country to suit the stage of development and factors of production in another country, and the technology transferred as a package. We in Sri Lanka have been at the receiving end of many transfers of technology, a few of which have been tailor made to suit our stage of development and factors of production but many of which have not been so designed. By far the best situation is for indigenous development of a process technology. However, at our present stage of development it is necessary to use some components transferred from abroad for progressive development of indigenous technology. Sometimes the software of a process technology may be imported in the form of designs, drawings and specifications and the hardware assembled locally. Sometimes imported process technology could be modified or adjusted to suit our factors of production allowing for local manufacture of some hardware components.