Final Report

Environmental Impact Assessment of Clay Extraction and Blanketing of Samanalawewa Reservoir for Leakage Mitigation

Submitted to

Ceylon Electricity Board

by

TEAMS

Consultants in Technology, Management & Development Studies

TEAMS (Pvt) Ltd. P. O. Box 262 Colombo, Sri Lanka

July, 1994

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9th Aug.,1994

General Manager
C.E.B., Colombo - 02.

E.I.A. OF Clay Extraction and Blanketing of Samanala Wewa for Leakage Mitigation

Dear Sir,

The final report on the above assignment is submitted herewith in quadruplicate.

Thanking You.

Yours Sincerely,

S.H.C. de Silva
Team Leader

Copy- Project Director,
Samanala H.E.P.

Only 3 copies
1 sent to Ch CCB
1 " Proj Dr
24/8/12

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EXECUTIVE SUMMARY

1. Investigation before Construction

The Samanalawewa Project is located immediately downstream of the confluence of Walawe Ganga and the Belihul Oya. It was first investigated by the Irrigation Department of Sri Lanka in 1957, followed by the investigations of engineers from Canada and USA. These studies were finalized in 1966 by Engineering Consultants Incorporated, (ECI) USA.

In 1973 the project at the same site was further studied by Engineering Studies Organization (ESO) of Mahaweli Development Board with assistance of Snowy Mountains Engineering Corporation (SMEC), Australia.

These studies were reviewed by Central Engineering Consultancy Bureau (CECB), Sri Lanka in 1975, just before Engineers of USSR started their investigations.

From 1975 to 1978, comprehensive investigations were carried out in the same project site and 'Detail Project Reports' for construction were prepared in 1978 by Hydro Institute, USSR and CECB, Sri Lanka.

In 1977, however, the national project priority was shifted from the Samanalawewa Project to Mahaweli Development Projects (well known as the Accelerated Mahaweli Programme), so Samanalawewa project was suspended.

Since then reconnaissance type survey reports and review reports were prepared by various foreign and local engineering firms in different years such as; Reconnaissance Report, Nippon Koei, Japan (1982); Engineering Review and Recommendations - Technical Report by BBCIL, Gibbs & GEC of UK (1984); Review Report, Electrowatt Engineering Services Ltd, Switzerland (1985) ; Technical Report, Central Engineering Consultancy Bureau, Sri Lanka (1985).

Since 1957, although some of these reports suggested additional investigations for the reservoir watertightness to assess the necessity of designing cut-off works, it is recognized that no reports pointed out any doubt on the feasibility of the project but always recommended the immediate construction.

2. Investigations and Cut-off Works During Construction

Based on the investigations and review reports carried out since 1957, the construction of the power station and the pressure tunnel commenced in 1986 whilst additional investigations to improve the detailed design of the dam and appurtenant structures were also commenced in 1986 and the funding for construction was finalised.

3. Dam

The 530 metre long 100 m high rockfill dam has a clay core. A grouting gallery runs the full length of the dam. This was used to provide a conventional grout curtain under the dam. This curtain is of 106 m depth and used split spacing technique of primary, secondary, tertiary and quartenary holes. In addition to this grout curtain, consolidation and blanket grouting were done to reduce seepage. Subsequent tests with ground water level measurements show that the dam fulfils its task of seepage cut off and its stability is as designed. Further investigations followed in 1988 to assess the necessity for cut- off measures on the right bank.

4 Right Bank Cut off Works

In 1989, the Project Consultants [Sir Alexander Gibb and Partners (UK), the Design Engineer, Joint Venture Samanalawewa, the Supervising Engineer, consisting of Nippon Koei Co.Ltd. (Japan), Electrowatt Engineering Services (Switzerland) assisted by Central Engineering Consultancy Bureau (Sri Lanka)] concluded that cut-off measures against the possible right bank leakage would be necessary.

The right bank cut-off works - 1300m long adits and grouting works- were proposed by the Project Consultants, reviewed by four Sri Lankan Experts and executed from Nov. 1990 to March 1992.

This new grout curtain was designed to arrest leakage paths to a depth of 100 m below river bed or 250 m below ground surface along the right bank ridge.

However during construction, the 180 m deep investigation holes drilled below the adit, in sections where the curtain hangs, have shown that fracturing and solutioning continues below the grout curtain ie, 150 m below the river bed. In order to provide a curtain at this depth additional adits would have to be excavated in saturated ground which involves extremely difficult work.

At this stage it was agreed by all parties to adopt an observational approach by filling the reservoir once the grout curtain had been constructed to a depth that could be reached practically and economically using the available equipment.

5. Trial Filling and Major Leakage Incident

The reservoir was partially filled from 2nd June 1991 (maximum El. 405 m), and an attempt to fill the reservoir again commenced in March 1992 after the grouting works were completed.

On 22.10.1992 the ground water level reached a critical level, with reservoir level at approximately 440 m, inducing major leakage through an ancient landslip area on the right bank flank, 300m downstream of the Dam. This washed 20 to 40 thousand cubic metres of overburden within a few hours. However the flow stabilized to 3 cumecs of clear water in half a day by which time the high ground water table on the right bank saddle had fallen by 20m. Since November 1992 the leakage has remained constant between 2 and 3 cumecs whilst the reservoir water level has been maintained at around 430m by discharging water through the power generating plant. It is noted that the leakage volume is also the minimum amount of water needed for the Kaltota irrigation scheme of 833 ha (2060 acres) and additional water is discharged from the irrigation outlet whenever required.

An International Review Panel of Experts (M/s J.B.Cooke, P.Londe, G. Post and A.H.Meritt) examined the scheme in February 1993 and concluded that the dam and reservoir were safe for storage and recommended wet blanketing as the remedy to reduce the leakage.

6 Area of Ingress

The geological data collected and the observed ground water fluctuations indicate that the likely ingress area is limited to within a 1000 m stretch of Walawe river bed upto 1700 m upstream of the dam.

Water samples tested chemically also confirm that the leakage route is confined to a 200 to 300 m section below the grout curtain in the right bank. A seismic reflection (boomer) and echo sounding survey done in March 1993 also indicated that filled hollows were present along a 300 m stretch of the river bed, within the 1000 m stretch identified above.

Thus the area of major ingress has been adequately identified by scientific approaches.

7. The Remedial Measures - Wet Blanketing

As the ingress area is now fairly well identified, wet blanketing is the recommended remedy for the reservoir to continue generating power. With over 50 m height of water, the storage could not be easily emptied for a dry blanket cure.

The material for blanketing has been identified in the former borrow area of Kinchigune and the area could yield the estimated quantities.

The method of deposition has been planned so that the soil from borrow area is transported by barges, a distance of 4 km and dumped in the water by bottom opening hatch, once the barge has been positioned in the target area. Two other possibilities for wet blanketing are, to use a suction dredger, or by dumping material brought by road to the edge of the reservoir and end tipping it from the side. These methods are more expensive and wasteful. The wet blanket approach dumping by barge is environmentally the least disruptive and has been recommended for execution.

The alternatives of dry blanketing or extending grout curtains have been dropped as upto 9% of the countrys national energy demand is met by the Samanalawewa Power Station. At the least there would be a severe lack of power during peak demands if Samanalawewa is not available for power generation.

8. Environment Impact Assessment - EIA

The EIA has examined the proposed method and recommends a monitoring program that should be continued for a period of 20 years at least, so that the reservoir can store water and fulfill its objectives of power generation and providing irrigation to the Kaltota scheme.

The monitoring programme which is already in operation needs to be enhanced and carried out in detail during and after blanketing as the problem confronted is a prototype of a seepage problem for the country in general and detailed monitoring will yield much know how in managing such situation's elsewhere.

The environmental impacts are confined to the period of the wet blanket operation, and limited to the area of the reservoir that has already suffered the initial impact of construction work and habitat disturbance during dam construction.

The EIA has assessed the different scenarios of using the scheme as it is currently being used and draws attention to the possible loss of the power and energy production capacity if the present mode of operation should be continued. The country's need to minimise thermal generation require the designed capacity of the Samanalawewa Project to be realised at the earliest opportunity. This can be achieved by continuing to operate, maintain and monitor the reservoir to the high, standards already set after the remedial works. However, given the history of this project, funding should be provided for maintenance for wet blanket or other desired remedial measures that may be needed in the years to come.

ACRONYMS

Ac.ft.	-	Acre feet
AD	-	Anno Domino
BBICL	-	Balfour Beatty International Construction Limited
BC	-	Before Christ
BOD	-	Biological Oxygen Demand
COD	-	Chemical Oxygen Demand
CEA	-	Central Environmental Authority
CCD	-	Coast Conservation Department
CEB	-	Ceylon Electricity Board
CECB	-	Central Engineering and Consultancy Bureau
CF	-	Conservator of Forests
CHA2	-	Charnockite 2
DA	-	Department of Agriculture
DAS	-	Department of Agrarian Services
EC	-	Electrical Conductivity
El	-	Elevation
EIA	-	Environmental Impact Assessment
EIAR	-	Environmental Impact Assessment Report
ERL	-	Environmental Resources Ltd.
FD	-	Forest Department
FSL	-	Full Supply Level
GW	-	Ground Water
Gwh	-	Giga watt hour
HEP	-	Hydro Electric Project
IEE	-	Initial Environmental Examination
IEER	-	Initial Environmental Examination Report
JVS	-	Joint Venture Samanalawewa
Km	-	Kilo meter
LB-1	-	Left Bank - 1
LUPPD	-	Land Use and Policy Planning division
LLO	-	Low Level outlet

M	-	Meters
MADR	-	Ministry of Agricultural Development and Research
MLIMD	-	Ministry of Lands Irrigation and Mahaweli Development
MPE	-	Ministry of Power and Energy
MLLD	-	Ministry of Lands and Land Development
MCM	-	Million Cubic Meters
MSL	-	Mean Sea Level
MW	-	Mega Watt
NARA	-	National Aquatic Resources Agency
NE	-	North East
NPV	-	Net Present Value
NARESA	-	Natural Resources Energy and Science Authority
PAA	-	Project Approving Agencies
PP	-	Project Proponent
PV	-	Present Value
RB	-	Right Bank
RBS		Right Bank Saddle
ROR	-	Run of the River
S/MLIMD	-	Secretary, Ministry of Lands Irrigation and Mahaweli Development
SHEP	-	Samanala Hydro Electric Project
SLS	-	Sri Lanka Standards
SW	-	South West
Tp	-	Trial pit - 1

GT	-	New Gas Turbine
GTKP	-	Kelani Tissa Gas Turbine
KPST	-	Kelani Tissa Steam Turbine
DSSP	-	Sapugaskanda Diesel
DSLX	-	Sapugaskanda diesel Extension
COL - 1	-	Trincomalee Coal 150 MW
COL - 2	-	Trincomalee Coal 300 MW
GTR	-	Refurbished Gas Turbine

Probability of occurrence condition	1	10% (very wet)
	2	20% (wet)
	3	40% (medium)
	4	20% (dry)
	5	10% (very dry)

1 Introduction

Samanalawewa Hydro Electric Project is located on the south of the central massif of Sri Lanka 105 km east of Colombo and 35 km south of Nuwara Eliya.

The project has a long history having been first investigated by the Irrigation Department in 1957. In March 1958 Tudor Engineering of Washington D.C. published a Reconnaissance Study report on the Seven Virgins Project and Samanalawewa. This was followed by a reconnaissance report by Photographic Survey Corporation Ltd. of Toronto Canada. Then Engineering Consultants Incorporated (ECI) of Denver Colorado carried out a fresh feasibility study in 1966.

Their report concluded that: "the Samanalawewa project is both technically feasible and economically justified" with a recommendation that, "Construction of the Samanalawewa Project should be undertaken at the earliest practicable date".

However the project did not proceed further till 1971 when additional investigations were recommended and carried out in 1973. A report prepared by Engineering Studies Organization of Mahaweli Development Board assisted by an Australian Consultant (Snowy Mountains Engineering Corporation), concluded that, "the project is found to be the most economic of various alternatives considered" with a recommendation that, "the Samanalawewa project should be implemented without further delay".

These studies were further reviewed by the Central Engineering Consultancy Bureau (CECB), Sri Lanka in 1975. Some extracts of the review report are:

- "The Samanalawewa Project has been investigated and studied by several national and foreign Consultancy Organizations and Committees of Specialists. Perhaps no other hydro electric project in Sri Lanka has been investigated and studied to the extent that Samanalawewa Project has been studied".

- "These (unusual surge arrangements) remain the only design aspects, needing further review which will be carried out jointly by the Soviet specialists and the Bureau".

- "The next hydro energy shortage is expected in 1980. It is necessary that Samanalawewa Project be commissioned as early as possible to save considerable foreign exchange on imported fuel. Therefore additional investigations must be limited to the minimum extent necessary for the preparation of the Detail Project Report".

From 1975 to 1978, comprehensive investigations were carried out and in 1978 'Detail Project Reports' for construction were finalized by Consultants of USSR and CECB, Sri Lanka.

It is worth recalling that Volume II of this report at page 58 reads "at the saddle No.1 where bed rocks are deeply weathered, seepage can take place from the reservoir to the ravine at the downstream side. Calculations show that at this reach 1.1 km long, the water losses can amount to 50 litres/sec. The considerable length of seepage paths and correspondingly small exit gradients allow one to think that piping is not expected."

The project was found to be feasible for implementation and construction of the Denagang Oya Bridge and access roads to the sites commenced during this period.

In 1977, however, the national project priority was shifted by the Government from the Samanalawewa Project to the Mahaweli Development Projects, so Samanalawewa project was suspended again.

1.1 Studies from 1982 to 1985

Since then reconnaissance type surveys and review reports have been prepared by various foreign or local engineering firms in different years as follows:-

1982	Reconnaissance Report by Nippon Koei, Japan
1984	Engineering Review and Recommendations,a Technical Report by a Group of consultants, contractors and suppliers, UK.
1985	Review Report by Electrowatt Engineering Services Ltd, Switzerland.
1985	Technical Report by Central Engineering Consultancy Bureau, Sri Lanka.

Although some of these reports suggested additional investigations for the reservoir watertightness, to assess the necessity of designing cut-off works, none of the reports cast any doubt on the feasibility of the project or suggested postponement of construction. For example:- "Power market studies indicate an energy deficit in the CEB system from the year 1991. With all available and proposed generating capacity, Samanalawewa Project is the most economically attractive project to meet this shortage".

It is also noted that the location of Samanalawewa dam has always been proposed at "the site immediately downstream of the confluence of Walawe Ganga and the Belihul Oya" since 1957, with slight modifications of a few tens of metres for optimization by different consultants. No report has proposed any other dam site location.

1.2 Project Parameters

The dam is a rock fill dam, 100 m high and straddles the Walawe river 250 m below its confluence with Belihul Oya. The dam has a crest length of 530 m with a gated chute spillway capacity of 3600 cumecs for the predicted 10,000 year flood. (determined from storm patterns obtained from the Irrigation Department upto 1975)

It is also equipped with a low level outlet which can discharge 75 cumecs at full supply level of elevation 460 m and a power tunnel 5.35 km long 4.5 m diameter which is fully lined, leading to a 120 MW power station at an elevation of 320 m below the dam level, intended to generate 462 Gwh annually. (according to past hydrological data and Kaltota Irrigation requirement) The minimum operating level is elevation 424 m in the reservoir.

The dam has a clay core founded on fresh rock on the left abutment and river bed. On the right abutment the core foundation was more weathered, but of sufficient quality to be a sound foundation for this type of dam. Additional preferential leakage paths were identified from earlier data necessitating the provision of significant cut-off works to render it impermeable.

1.3 Commencement of the Construction

In 1985, the Government of Sri Lanka requested financial assistance from foreign funding countries for construction based on the 'enormous' investigations and review reports carried out by both the local engineering teams and foreign firms since 1957.

When funding was finalised in 1986, construction of the power station and the pressure tunnel commenced, whilst additional investigations were carried out to furnish more data to improve the detailed design of the dam and appurtenant structures. Only slight modifications to the detailed design were made, based on these investigations.

1.4 Investigation and Studies during Construction

Construction of the dam and appurtenant structures commenced in 1987. Additional investigations to assess the necessity for cut-off measures in the right bank commenced in 1988.

These investigations revealed the existence of 2 major possible leakage paths from the area approximately 700 m and 1700 m upstream of dam towards the downstream, whereas the dam foundation and its vicinity was confirmed to be fairly water-tight.

In 1989, construction of adits and grouting works in the right bank to close the possible leakage paths were proposed by the project consultants [The Design Engineer, Sir Alexander GIBB and Partners (UK), the Supervising Engineers consisting of Nippon Koei Co.Ltd (Japan) and Electrowatt Engineering Services (Switzerland) assisted by Central Engineering Consultancy Bureau (Sri Lanka)] and reviewed by the Four Experts of Sri Lanka Engineers.

Although the need for further reservoir bed water tightness studies had been discussed, the problem was only specifically identified during construction.

The grout-curtain was constructed through the right bank saddle to approximately 100 m below the river bed elevation of 380 m (180 m below reservoir full supply level at 460 m elevation). This grouting operation revealed that the ground was unexpectedly pervious to much greater depth than anticipated and it was decided to adopt an observational approach by filling the reservoir once the grout- curtain had been provided to a depth that could be reached practically and economically by the available equipment on site.

.5 <u>Major Leakage Incident</u>

During construction of the grouting works the reservoir was partially filled (up to El. 400 m) to assess the need for a cut off. The requirement was confirmed and only after the completion of the grouting works was an attempt to fill the reservoir, with a controlled trial inpounding, recommended to commence in March 1992.

A major leakage occurred on 22nd October 1992 through the right bank flank, 300 m downstream of the Dam, with 7.5 cumecs of flow washing out surface soil, when reservoir level was raised to El. 439 m. The leakage water was clear on the following day and the leakage volume gradually decreased to 2 - 3 cumecs and stabilized in this range with the reservoir water level at around El 430 m. As is normal in such incidents the LLO was opened to full capacity until the implications of slope failure and leakage had been fully assessed. Unfortunetly opening the LLO, without warning the inhabitants living down stream, and the subsequent stories published in the press, have led the local population to believe that the dam and reservoir are unsafe.

The safety of the dam and the right bank ridge was confirmed by the project consultants and endorsed by an International Review Panel invited by the Government of Sri Lanka in February 1993.

The review panel reported "the stability of the dam could not be affected by many times the maximum credible leakage that might pass through the right abutment ridge with full reservoir level at elevation 460 m. The right abutment perimeter of the reservoir will safely pass any amount of leakage for full reservoir, before any measures are taken to reduce leakage"

1.6 Area of Ingress

The area of major ingress was identified to approximately between 700m and 1700 m upstream of the dam on the Walawe, by the geotechnical investigations and piezometric level monitoring carried out during construction.

After the heavy leakage incident, monitoring of the water chemistry has demonstrated that the area of major ingress can be limited to a length of 700m of the river bed along the Walawe in the said area.

A seismic survey (boomer survey) carried out in the said area, from the reservoir surface in March 1993, has also identified depressions covered with river bed sediments within a 300 m stretch of the river bed in this area as the priority area for blanketing. These depressions in the river bed are well coincident with the inferred location of Fault-1 and the geological unit (CHA-2), into which the largest quantity of grout was injected from the grouting adits.

From the above scientific approach, the area of main ingress has now been adequately identified.

1.7 Remedial Works

Countermeasures have been discussed among all the parties concerned including the International Review Panel. Various proposals were presented during the discussions and finally the panel recommended wet blanket as the most practical and economical solution. All parties acknowledged that the wet blanket would be the best method if the water ingress could be identified.

In small pump storage projects the entire bed is made impervious by an impermeable layer which could be asphalt, concrete or geotextiles. In the case of Samanalawewa with a water spread of 809 ha (2000 Acres) and a bed area of say 1214 ha (3000 Acres) such sealing will be exorbitant in cost.

As tried out in similar ailing projects elsewhere in the world, clay dumping or blanketing became a pragmatic approach.

Clay blanketing if done in the dry could be an economic and reliable remedy for a situation as at Samanalawewa, if the area of leaking valley floor was known before impounding commenced. The risks involved in dry blanketing are well illustrated by the Tarbala experience, where open work gravels' in the valley floor were identified prior to construction. To seal these pervious gravels a dry blanket was constructed to a distance of 1700 m (5,600 ft) upstream of the dam by compacting 60 cm thick layer of clay with four passes of a 10 ton vibrating roller. During impounding problems with the diversion tunnel closure gates resulted in the reservoir being drawn down to remedy the gates. However an inspection of the blanket, revealed sink holes that had almost breached into the open - work gravels. These were filled and compacted in the dry, prior to re-impounding. However, during the next impounding sink holes continued to develop. As it was not feasible to drain a 11,500 MCM reservoir with a dam 146 m (480 feet) high for a second time and also lose 1750 MW of power produced by the 10 No. 175 MW units, wet blanketing was the remedy used thereafter in repairs. The wet blanketing was found very effective in sealing the leakage through sink holes after identifying them by side scan sonar method.

The Samanalawewa Project has been supplying the National Grid with energy of 350 Gwh annually as well as daily peaking power of 120 MW. Therefore remedial works that need emptying the reservoir will be sacrificing this energy, as well as incurring additional costs for coffer dams and river diversions.

If dry blanketing were to be adopted and new ingress areas or sink holes are located after subsequent impounding, drawdown of the reservoir again for dry repair of blanket is not practical. Wet blanketing has still to be resorted to seal the leakages.

Considering technical and economic aspects and the lessons from Tarbela, wet blanketing emerges as the most desirable remedy for arresting seepage at Samanalawewa.

The government has accepted this and the project proponent CEB in terms of the National Environment (Amendment) Act of 1988 sought responses from ten consultancy firms in the island to provide an EIA. Out of the four who responded to the invitation M/S Team Pvt. Ltd. was selected by the CEB for the supply of the EIA which follows.

2 PURPOSE OF THE STUDY AND LEGAL REQUIREMENTS

2.1 Purpose

An EIA focuses on problems, conflicts or natural resource constraints that could influence the viability of a project.

The aim of an EIA is to ensure that potential problems are foreseen and addressed at an early stage in the project's planning and design. Likely predictions and options are made available to decision makers, and therefore the EIA will enhance and augment the project planning by identifying possible impacts, suggesting amelioration methods, monitoring and evaluation procedures.

2.2 Methodology

In order to brief the members of the team of their responsibilities and establish communication links among themselves and with the Client and other parties such as the CEA, the JVS, the Consultant Engineer and the designated experts, a meeting was held on 26th April, 1994 at which the Chairman TEAMS Ltd., the Team Leader, the Project Director of C.E.B, the Geologist of J.V.S. and the members of the study team were present.

The responsibilities of the team members were discussed at length, sources of documented information and persons to be contacted were identified and arrangements were made to collect the documented data and to visit the relevant sites and meet the individuals in order to gather information.

The Samanalawewa site was visited by the team on 01st May 1994, where they spent three days acquainting themselves with the problems at the site. On 2nd May, after an exhaustive briefing by the JVS staff, the team inspected the environs of the reservoir by visiting important sites such as the borrow area, leakage point, Kaltota Amuna, the power house and the deserted settlements at Kinchigune. The suspected area of ingress and the nearby embankments were seen by boat.

Having understood the main issues, the data required and the urgency of the expected deliverables, the team arranged to collect the data from the available documents and the data banks at the CEB, CECB and the Irrigation Department. Among the sources were

* SHEP Environmental Study by CECB
* SHEP Environmental Post Evaluation Study by TEAMS
* SHEP Environmental Studies ERL
* Recommendations for remedial Measures by JVS
* Seismic Reflection Profiling
* Identification of leakage path using water quality monitoring data.
* Minutes of the monthly Review Committee Meetings

* Water monitoring records
* Data bank at the Irrigation Department on Hydrological aspects and rainfall.
* Data bank at CEB on energy costs, supply and projected demand.
* Data bank on water quality monitoring from CECB

Acknowledgement is due to the JVS staff, the settlers at Kinchigune, the farmers at Kaltota, Ms. G.Juleff Project Director and Coordinator Samanalawewa Archaeological Project, the articles in the newspapers by several writers and numerous other individuals and institutions which complied with requests for data.

There were subsequent visits to Samanalawewa on 11th and 12th May and several meetings of consultants in groups and also the individual exchange of ideas. The group meeting held on 17th May was particularly useful in exchanging ideas on new findings that have been thrown up by the studies as they have proceeded. At this meeting it was possible to integrate the observations and conclusions derived by individual consultants and synthesize their conclusions. Thereby it was made possible for the team to prepare the present overview of the Environmental Impact Assessment and recommend the mitigatory measures and monitoring programmes.

Once a sufficient amount of environmental data was collected, matrix analysis was carried out as a rapid environmental assessment technique to quantify the magnitude of environmental impacts with respect to the proposed project activities. Matrix analysis basically incorporates a list of project activities with a checklist of environmental conditions or characteristics that might be affected. Combining checklists as horizontal and vertical axis for the matrix allow the identification of cause effective relationships in the cells of the matrix (either qualitative or quantitative estimates). Quantitative estimates are combined into a weighted scheme leading to a total impact score. At this stage, it is sufficient enough to use a simple interaction matrix which is simply a two dimensional chart showing project activities (on one axis of the matrix) and the checklist of environmental parameters (on the other axis). Those activities which are likely to have an impact on any component of the environment can be identified by placing crosses in the corresponding intersecting cells. This procedure is based on expert judgement. If necessary, expert judgement can be extended to denote the 'magnitude importance' of the impact in each cell by using a grading system (quantified and graded matrix).

Initial environmental examination was carried out to identify different types of aquatic ecosystems and critical aquatic habitat. Preparation of an environmental inventory of this nature is a value-free summary of the existing characteristics of a specific defined location. This was completed without consideration of potential or proposed development activities. A list of environmental characteristics of the proposed project areas to be investigated is given in **Table 2.2 (1)**. The potential

Table 2.2(1)

A MATRIX TABLE WHICH SHOWS THE POTENTIAL IMPACTS OF THE PROJECT ACTIVITIES

Priority value	Impact	Project Activity			
		EB	TB	BD	CR
12	Forest				
13	Wildlife		+	+	+
14	Biodiversity		+	+	+
22	Icthyofauna			+	
4	Soil erosion	+		+	+
5	Soil fertility				+
7	Bank stability	+			
1	Water quality	+	+	+	
6	Water table	+		+	
8	Air quality	+	+		+
15	Diseases	+	+		+
17	Sanitation	+	+	+	+
10	Crop production			+	+
9	Irrigation			+	
16	Flood control	+		+	
18	Resettlement				
3	Archaeological resources	+			
11	Landscape	+	+		+
19	Noise Pollution	+	+	+	+
20	Disaster Probability	+	+	+	+

EB = Extraction of Blanketing material

TB = Transportation of Blanketing material

BD = Barge dumping of Blanketing material

CR = Construction of Roads

environmental impacts of water resources development project of this nature are listed in **Fig.5.1.(2)** (Chapter 5). Information on environmental characteristics of the project sites was collected by retrieving already available information or field investigations. In addition, herbarium comparisons were carried out with respect to floral diversity and vegetation types when necessary.

As envisaged, the team is aware of the need for a detailed study which will further illustrate and amplify the salient observations presented in this report, with additional material which can be obtained during the period provided in the TOR.

2.3 Legal Requirements

Large scale development work often entails construction work which changes the landscape, habitat and ecological parameters. In order to minimise the impacts from such construction or engineering works the Government by its Cabinet decision of November 1983 made it mandatory that all development work of the public and private sector be subjected to an Environment Impact Assessment [EIA] to be in force from 01.01.1984.

By this decision Sri Lanka, a developing country, moved into the vanguard of environment awareness. It is opportune to recall that such legislation entered the statute books in the U.S.A. only in 1970 when it made the E.I.A. a legal requirement for major development work.

Legal provision on Environmental Impact Assessment is provided by the National Environmental (Amendment) Act No. 56 of 1988. The law has been brought into effect by gazette notification dated 24th June 1993.

Under the above law on EIA, TEAMS Pvt. Ltd. has been entrusted with the EIA study of Clay Extraction and Blanketing of Samanalawewa Reservoir for Leakage Mitigation.

The National Environmental (Amendment) Act of 1988 defines "Environmental Impact Assessment Report" as follows:

"environmental impact assessment report" means a written analysis of the predicted environmental consequences of a proposed prescribed project and containing an environmental cost benefit analysis, if such an analysis has been prepared, including a description of the project, and includes a description of the avoidable adverse environmental effects of the proposed prescribed project; a description of alternatives to the activity which might be less harmful to the environment together with the reasons why such alternatives were rejected, and a description of any irreversible or irretrievable commitments of resources required by the proposed prescribed projects".

This clearly states that the legal requirements of an EIA report are to provide:

1. A project description
2. A cost benefit analysis
3. An assessment of the avoidable environmental effects
4. A description of alternatives
5. The criteria for rejecting the alternatives
6. A description of irreversible or irretrievable commitments caused by the project.

The basic steps of an EIA study as given in the Act are as follows. (A detailed account is given in Annex 6)

i In accordance with guidelines issued by the CEA, the Project Proponent (PP) should provide **preliminary information** on the project as requested by the Project Approving Agency (PAA).

ii Based on the **preliminary information** obtained from the PP the PAA decides, in consultation with other agencies likely to be affected by the project, including the CEA, whether an Initial Environmental Examination Report (IEER) or Environmental Impact Assessment Report (EIAR) is required and a TOR for such a report is prepared. The developer is accordingly informed about the required report.

iii The proponent submits the IEER or the EIAR to the PAA.

iv (In respect of an EIAR), the PAA, by notification in the gazette and one national newspaper in English, Sinhala and Tamil, invite the public to make written comments on the report to the PAA within 30 days from the date of the first appearance of the notice.

v The PAA forwards to the PP the comments received from the public for review and response within six days from the date of completion of the period of public inspection.

vi The decision by the PAA as to whether the project can be approved or not is communicated to the PP within 6 days of the receipt of the response of the PP. If the project is not approved, the reason for not approving will be given.

vii If the project is approved, the PAA forwards to the CEA a plan prepared to monitor the project in order to ascertain whether steps required for the mitigation of adverse environmental impacts of the project are followed as specified by the PP.

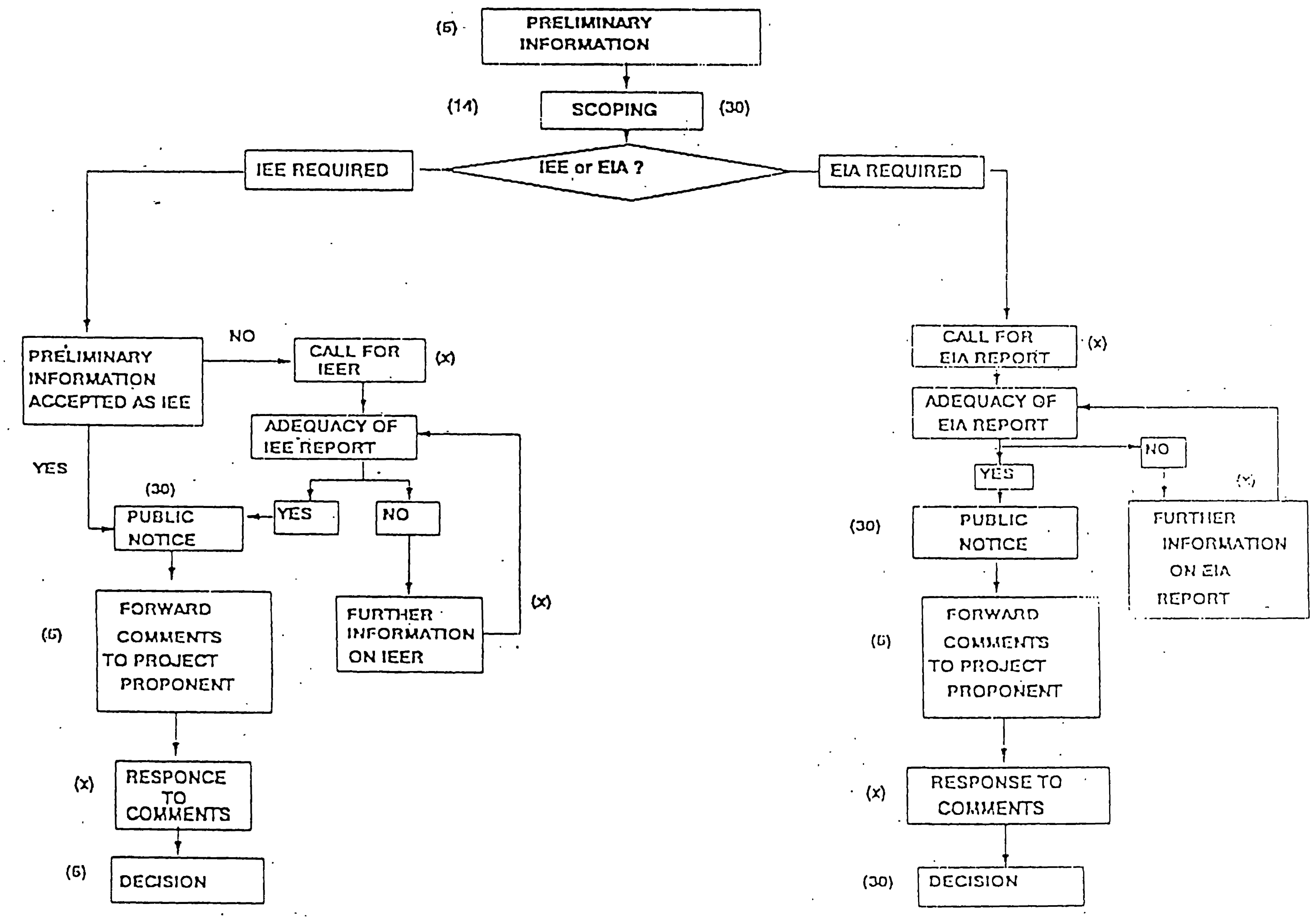
viii The PAA publishes in the gazette and in one national newspaper in English, Sinhala and Tamil the decision to approve the project.

ix If an approved project is abandoned or changed, the PP should inform the PAA and any change in the project is subject to approval by the PAA.

The flow chart in Fig. 2.3 (1) explains the above procedure in diagrammatic form.

The above description does not cover the procedure applicable to IEER and projects coming under the purview of the CCD as they are not applicable to the present study.

Figure 2.3(1) Environmental Impact Assessment Procedure Prescribed by the CEA



NOTE : Figures in brackets indicate the maximum number of days allowed for the activity specified.
Symbol (x) denotes that the period is not fixed because the related activity has to be performed by the project proponent.

3. PROPOSED WET BLANKET AND ALTERNATIVE METHODS FOR LEAKAGE MITIGATION

3.1 Purpose of Project

As stated in the introduction, the requirements for leakage mitigation at Samanalawewa are two fold:

a) for economic reasons
b) to negate the local populations perception that the dam and reservoir are not safe.

The objectives are therefore, to reduce leakage at FSL to those that are economically acceptable (< 2 cumecs). To achieve this economic objective and to allay the public's perceived fears, ground water levels must not rise above EL 430 m lest there could be a further water burst.

3.2 Identifying the Area of Ingress

The likely area of ingress of the seepage has been limited to about a kilometer length of the Walawe river-bed from 700 m to 1700 m upstream of the dam, presently drowned by the reservoir water.

This area falls inside the Matihakka fault zone F_1 and the fault zone F_2 to a lesser extent.

Extensive tests were carried out to pin point the area of ingress some of which are listed below.

i) Divers sent to the reservoir bed as a trial could not locate ingress area in bed of reservoir, indicating general diffusion as opposed to a sink hole. Divers cannot work for a long time at 50 metre depth of water.

ii) Underwater cameras could not register any movement due to the turbidity of the water.

iii) The absence of a vortex, or movement of surface water.

iv) The seepage water and the reservoir water showed differences in electrical conductivity (EC). EC gives a general indication of dissolved ion concentration. A change in EC value suggests a change in ion concentration of the water sample. The EC of the river water is low (30-50 / cm) and the ground water is high (above 300 /cm) the EC of the leakage water has decreased gradually with time indicating that the ground water is being diluted.

(v) Tests for water chemical analysis of samples from observation wells RBS4, RBS6 and RBS10 and the main leakage have shown systematic change in water quality reflecting dilution of the right bank aquifer by the reservoir. This confirms the leakage water traverses the area RBS4, RBS6 and RBS10

(vi) Area B, ie the area to the East of the Matihakka fault zone F1 is hydrologically interconnected, but with preferential flow zones.

The fact that ground water levels in area B fell or rose with river water levels confirms the interconnections throughout, but the hydro chemistry data has identified the preferential zones.

vii) The main ingress area can be identified as the area to the west of GW 15 towards adit G covering a river length of 700 m on the Walawe based, on geological, hydro-logical and water chemical analysis data.

3.3 Clay Blanket to Reduce Seepage in Samanalawewa

JVS the consultants of CEB comprising Nippon Koei and Electrowatt assisted by C.E.C.B. and Sir Alexander Gibbs & Partners and the Panel Commission of M/S Barry Cook, Meritt, Londe and Post have all recommended wet blanketing as the most appropriate mode of reducing the heavy leakage.

3.4 Remedial Measures Available

The avenues open to remedy the loss of storage water, which have been assessed are:

i Empty the reservoir and plug the reservoir bed near fault zone F1, called Matihakka fault. This could be carried out by clay blanket about 1/2 to 1 metre in thickness and compacted to seal. This will mean stopping power generation for one year or more, in addition to the cost of reopening the diversion tunnels and other attendant costs.

ii Restarting grouting along the 1315 m tunnel to depths of more than 250 m or until an impervious layer is detected. Another tunnel may have to be constructed in pervious rock, 100 m below the existing tunnel. Enormous volumes of ground water will flow into the tunnel, while excavating and from grouting holes while grouting. This will become a laborious and costly exercise if tunnelling and grouting is done with reservoir levels at 430m to generate power.

iii Providing a drainage to control ground water levels in the right bank. This would mean driving a drainage tunnel into the feeble rock, construction of which will require emptying the reservoir. This proposal will ultimately increase the leakage which will result in a intolerable loss to the CEB, while not achieving the aim of the remedial measures.

iv As the present "leakage" or burst is on a fold in the Matihakka fault with clear water exiting, it is a pragmatic approach to use the natural leak through the fold in the fault as the drainage outlet. See **plate I Annex I**

v Using the reservoir as a run of the river (ROR) project maintaining the water level at 430 m and continuing to generate power with a storage of 80 MCM, instead of the designed 254 MCM. The reduced storage will reduce the energy that can be generated as only 20 MCM of live storage will be available above the minimum operating level of 424 m. This does not meet the primary objective of the remedial measures.

vi Seal the ingress area and reduce leakage without emptying the reservoir, which is currently generating about 9% of the country's peak power by "wet blanketing". In this approach a well graded, gravelly, sandy silt is dumped on the ingress area. There are three methods of carrying out such sealing. They are :

(a) Side dumping from above water level, using dump trucks.
(b) Dumping by bottom opening barges.
(c) Sealing by cutter suction dredger, which can suck in the material brought to the reservoirs edge by trucks, pumping it to the target area and allowing the material to settle on the bed.

The three methods are best illustrated by figures 1,2 & 3 in the **Appendix** 3.4

The consultants retained by the CEB as well as the independent team of renowned consultants whose services were obtained by the Sri Lanka Government have opted for wet blanketing using the second method of barge dumping.

vii <u>No Remedial Action Alternative</u>

The condition of the project since the major leakage of 22.10.92 is to control the reservoir level to El.430 m by discharging the inflows through the 2 turbines and generate power in the process. The seepage is allowed to flow into the Walawe and from there to be picked up by the 2 anicuts at Uggal Kaltota to irrigate 834 ha (2060 acres).

This is a very pragmatic approach if the hill side on the Right Bank of the dam is guaranteed by its stability and there are no major storms in the catchment. In case of a storm the lake water level will rise above 430m and higher. The operation of 2 turbines will not be sufficient to prevent reservoir levels rising even up to full supply level. Such a situation would be precarious if a further burst occured with ground water levels rising in Area B to the east of the Matihakka fault. Such a burst could take place at any location downstream of the dam if the ground water levels were to rise above El 430 for a protracted period of time. Further bursts could increase the leakage volume to such a level that reliable power generation cannot be continued, although safety of the dam has been firmly confirmed in such a case. Hence the "No Project Scenario" should be avoided and remedial action taken without delay to guarantee the continuity of power generation and to allay the publics' perception of danger.

4. THE EXISTING ENVIRONMENT

4.1 Introduction

The creation of the Samanala Wewa has had the following environmental consequences:

Clearing of virgin jungle, removal of the ancient village of Kinchigune, from reservoir area and exposure of the catchment to denudation for the construction of camps, access roads and borrow areas.

Such concentrated activity always promotes illicit felling of forests in the vicinity and gemming in fragile zones of the montane topography.

Into this adjusted environment is now the threat of further disruption by the proposed "Clay Extraction and Wet Blanket Project" for remedying the leakage. The purpose of this study is to assess such possible disruptions and recommend mitigatory measures.

The proposed borrow area of Kinchigune located in LB-1 about 2.1 km west of the dam site, on the left bank of the Belihul Oya. It is a gently sloping area between El 430 - 440 meters, which is some 30-40 m below the designed Full Supply Level (FSL). Soil characteristics of the proposed extraction area in Kinchigune is similar to that of the reservoir bed and the earth fillings of the dam.

The pattern of the water movement at the proposed clay dumping area with respect to discharge, directions and internal currents were not available. It was noticed that fishing in the reservoir is possible. However no records were found to show that the reservoir had been stocked with exotic fish species.

There is no significant natural vegetation to be protected in the borrow area. This area however will be submerged for significantly long periods of time over the years once the reservoir level is raised. There is evidence of a reforestation programs undertaken by the Forest Department in the high ground between GW 13 & GW 15 under the project area to safe guard this environment but the work appears to be taking place at a slow pace.

The fauna of the area contains varied wildlife including leopards (Panthers Pardus), small mammals, birds, reptiles and amphibians. Although a quantitative analysis is not possible at this stage, there is evidence that the existing habitat of terrestrial fauna has been improved due to natural growth of vegetation around the immediate catchment.

There is no definite land use pattern in the borrow area, which is a part of Kinchigune. Most of remaining lands are derelect home gardens with coconut and other native species, which is now becoming natural forestry with small scrub jungle conditions.

4.2 Climate

The project area spans three different agro-climatic zones defined by mean annual rainfall viz: the Wet Zone, Intermediate Zone and the Dry Zone. The upper catchment of the reservoir lies in the wet zone, while the reservoir is located in the intermediate zone. The transition from the intermediate to the dry zone occurs roughly along the Kapugala Kaltota escarpment. The greater part of the catchment area however lies in the wet region.

4.3 Geology

The area under study includes specifically the potential borrow areas for clay extraction, the leakage area and in general the regional aspects that have a bearing on the proposed wet blanketing project.

4.3.1 Main Geomorphological Feature

Fig. 4.3 (1) indicates the general position of the entire Samanalawewa with respect to its regional geology. The general geology and structure is taken from the unpublished data of the then Geological Survey Department (now the Geological Survey and Bureau of Mines). The perimeter of the approximate Full Supply Level of the reservoir is shown against the relief features. It is to be noted that the reservoir is in a relatively flat area, which is generally referred to as the "Kaltota or Balangoda plateau". It is flanked on the north by the main scarp limiting the Peak Wilderness - Horton Plains above which the Walawe head waters and its major tributaries-the Denagama Oya, Belihul Oya and Kiriketi Oya originate. On the south there is a sharp drop of slightly over 457 m (1500') over the Kaltota scarp into the valley of Katupath Oya. Another important relief feature is the narrow passage of the valley below the dam site in the down stream direction to Ratkinda. Here it opens out into the wide valley of the Kaltota settlements of the Right and Left bank schemes of Uggal Kaltota **(Fig. 4.3.(1))**

4.3.2 Hydrologically Susceptible Area

The position of relief depressions or of accumulation points which are possible obscure sink holes or other internal drainage areas have been interpreted from aerial photo analysis and are also indicated in **Fig.4.3 (1).** It is to be noted that these features are not confined to one rock type. Further the northern limb of the limestone band of the Balangoda synform which should be exposed in general parallel to the Belihul Oya branch of the reservoir, is likely to outcrop in the region of the areas of saddle 1 and 2, but is obscured. The existence of thin and thick limestone bands and lenses and the incorporation of limestone material in the rock assemblage (rock units CHA1, CAL and CHA2) of the right bank abutment has been observed:

(i) as exposures down stream of the dam on the hill slope in the area subject to land slides, seepages;

(ii) the present leak area and in the borings. (All such units are hydrologically susceptible to deterioration.)

4.3.3 Hydro Thermal Activity

Hydro thermal activity replacing some of the calcareous parts with less soluble secondary material (dolomitic cement - according to JVS reports) is observed in the area designated as "Area B" **(See Fig.4.3 (2)** at the end of the appendices). In contrast, in area A the calcareous component in the rocks remain largely intact and solution action has been confined to the ground surface areas of exposure and to the upper boundaries of rock units.

4.3.4 Critical Rock Band Affecting Leak

It has also been noted that rock band designated CHA 2 in area B **(See Fig.4.3 (2))** which originally contained thick limestone material that has been removed, is exposed in the Walawe river-bed in the region west of adit "G" and observation well GW 15.

The approximate demarcation of Area A from Area B (the problematic area) is on the north west side of fault 1. **(See Fig.4.3 (2)).**

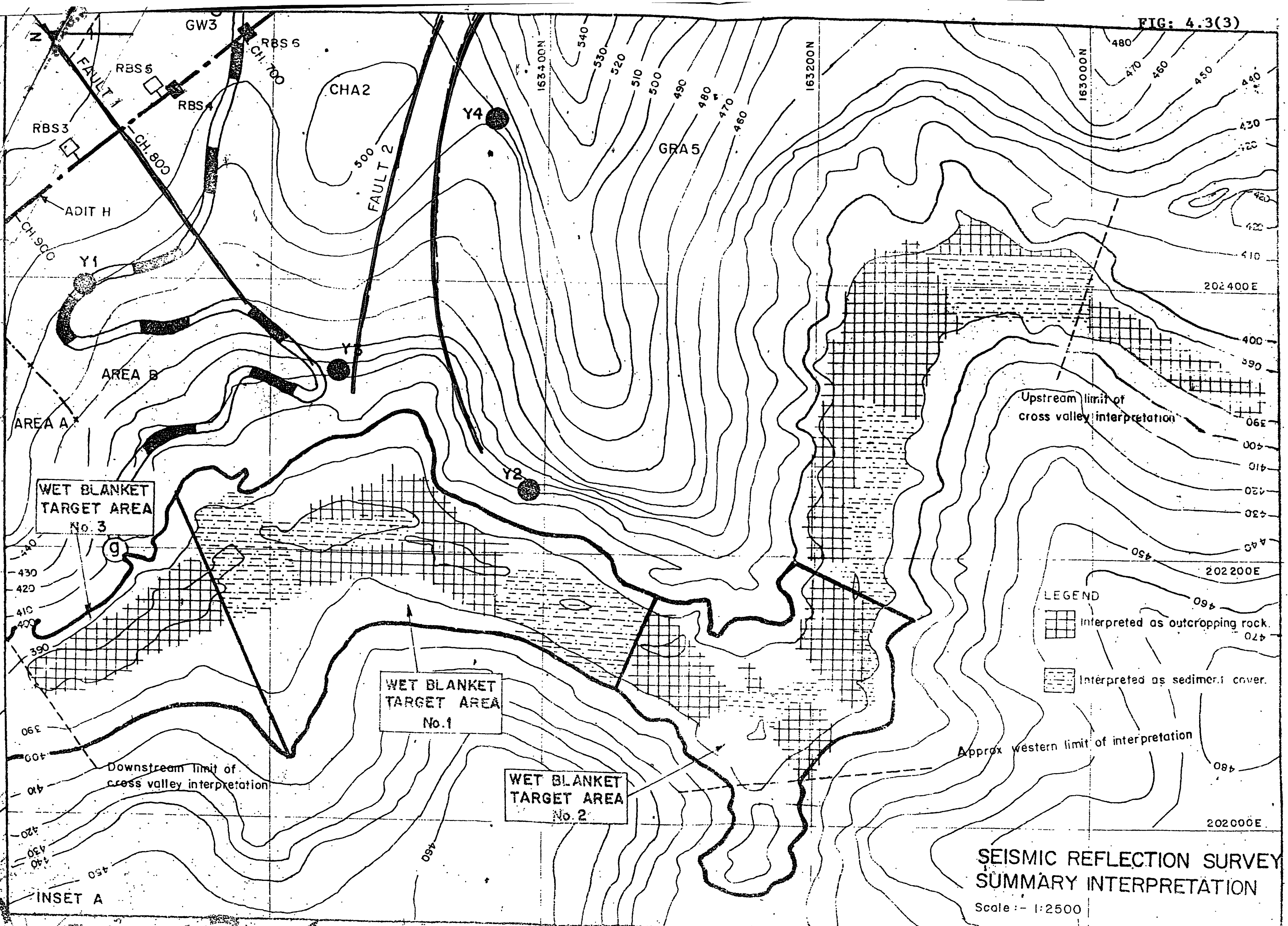
4.3.5 Likely Ingress Area

The likely ingress area from these observations and from the results of the chemical analyses of reservoir water, as compared with waters of the bore holes and at leakage exit, reasonably delimits the possible leakage area as between adit G - and GW 15 and is estimated as being confined to an approximately 700 m stretch of the Walawe river bed.Enlarged plan of ingress area is shown in Fig 4.3 (3).

4.3.6 Slope Conditions

Several earlier earth slips are indicated in and around the perimeter of the reservoir. These have been mapped on a photo base and are subject to further field confirmation. Some are of appreciable size and because of the possibilities of recurrence which is a common phenomenon in land slide prone areas, a better appraisal of such mass movement activities in the neighbourhood in general (eg. Killakandura area) and around the perimeter of the reservoir would be advantageous.

FIG: 4.3(3)



SEISMIC REFLECTION SURVEY
SUMMARY INTERPRETATION

Scale :- 1:2500

4.3.7 Impacts on Slopes and Ameliorative Measures

A full scale analysis of steep, medium and low gradient slopes with identification of any slope deteriorating factors would be advantageous in formulating a slope stability, rehabilitation and catchment conservation programme. It can be designed as a long term programme. Open slopes without cover and disturbed slopes due to illicit gemming were noted earlier within the boundary of the reservoir.

4.4 Soils

The proposed area for extracting materials for wet blanketing is the existing borrow area at Kinchigune used for borrowing materials for the dam core.

4.4.1 Stratigraphy of the Area:

The investigations carried out in this area have revealed that this area consists of:

(i) The upper layer which is formed with secondary deposits probably of slope wash origin, chiefly consisting of sandy clay or silt brown or reddish brown in colour.

(ii) The lower layer of terrace deposits chiefly consisting of sandy soils with large amount of boulders. Underlying this is a layer of weathered rock.

4.4.2 Materials for Wet Blanketing:

Fig 4.4.2 (1) illustrates the proposed area to be utilized for borrowing material for wet blanketing which lies between E1 430m., the present operating level of the reservoir and E1 460., the FSL of the reservoir. The extent of this area is about 25 hectares. The trial pits located in this area are TP1K, TP2K and TP3K the logs of which are given in **Fig 4.4.2 (2)** to **Fig.4.4.2 (4)**. **Table 4.4 (1)** illustrates the Gradation, the Atterberg Limits and the Classification of the material available for the blanket. **Fig.4.4.2 (5)** shows the Grain Size Accumulation Curve (LB-1).

4.4.3 Specifications for Blanket Material:

The typical grading required for the blanket material is given in **Fig.4.4.3 (1)**. The material shall be well graded, gravelly, sandy silt/silty sand and not be so cohesive as to form lumps.

4.4.4 Availability of Material:

By analysing the available field investigation and laboratory test results obtained from trial pits it could be stated that the layer to a depth of about 1m. is not suitable for blanket material as the material in this layer contains highly plastic clay. According to the specifications stipulated for blanket material, the thickness of material at each trial pit location available for this purpose is as follows.

FIG. 4·4 2(1)

KEY DIAGRAM

TOPOGRAPHICAL SURVEY OF BORROW AREA - KINCHIGUNE

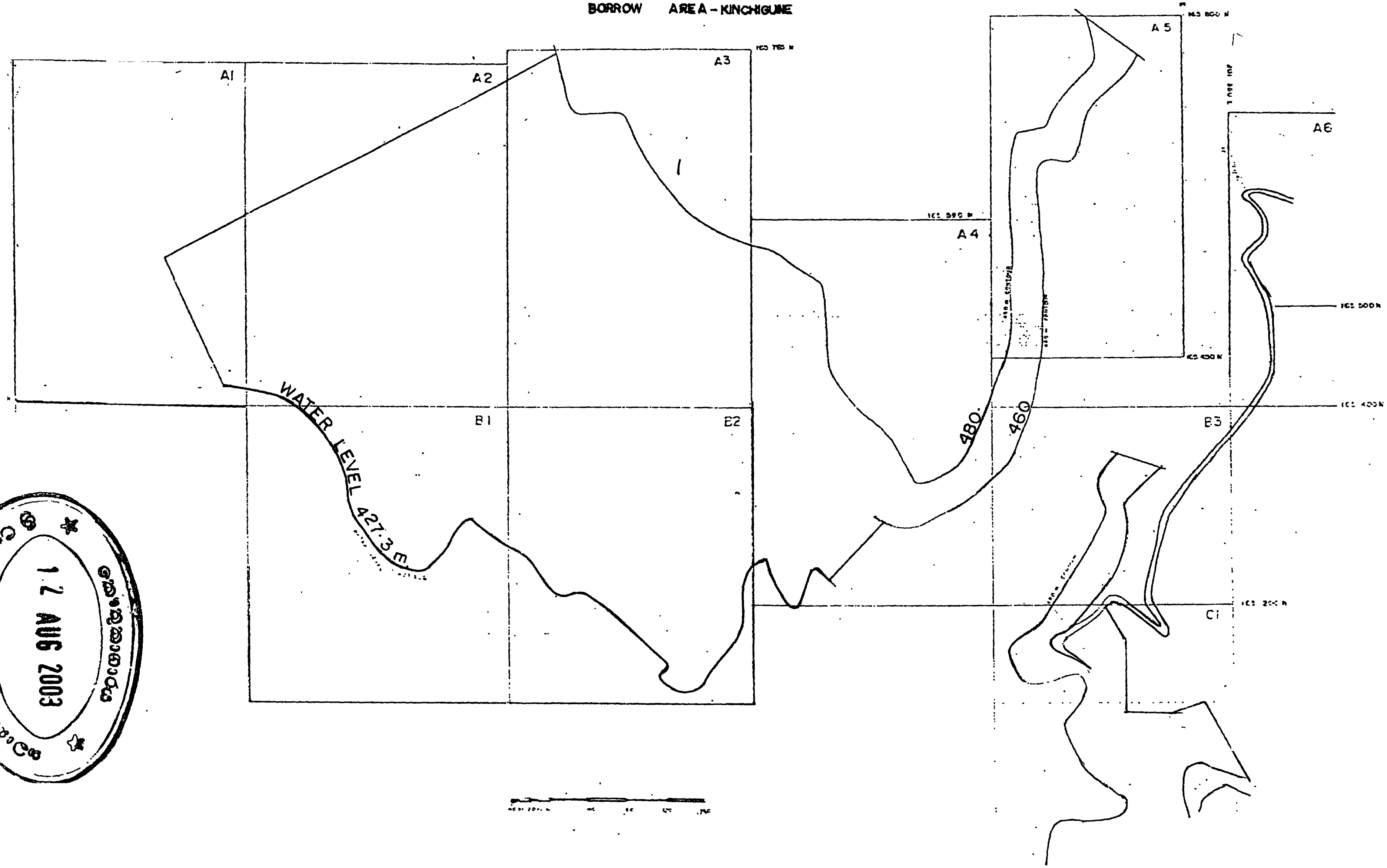


FIG. 4.4 2(2) SOIL PROFILE

NAME OF SURVEY & LOCALITY: LB-1 (Kinchigune) DATE Aug. 01, 1986

HOLE NO. TP-1K SURVEYED BY

GROUND ELEVATION m GROUND-WATER LEVEL m

DEPTH	ELEV. (Top of stratum) (m)	THICKNESS OF STRATUM	LOG	CLASSIFICATION	COLOR	DESCRIPTION	DIAMETER OF HOLE
0.1		0.1		Paddy	grey	·Paddy clay	
0.6		0.5		Clay	yellow brown	·Very wet	
2.1		1.5		Clay SC SM	reddish brown	·containing quartz particles, very wet, ·containing gravel (gneiss) max dia. 10cm (1.1 - 1.3m deep) ·containing gravel & boulder (gneiss), dia. 5cm - 20cm (1.6 - 1.8m deep)	
2.7		0.6		Silty sand	grey & brown	·Silty sand (weathered gneiss) ·rather wet ·containing brown clay sporadically	
3.0		0.3			grey	·weathered gneiss	

(Depth scale mark: 1.0 beside Clay/SC stratum)

FIG. 4.4 2(3) SOIL PROFILE

NAME OF SURVEY & LOCALITY: LB-1(Kinchigune) DATE Aug. 06, 1986

HOLE NO. TP-2K SURVEYED BY

GROUND ELEVATION m GROUND-WATER LEVEL m

DEPTH	ELEV. (Top of stratum) (m)	THICKNESS OF STRATUM	LOG	CLASSIFICATION	COLOR	DESCRIPTION	DIAMETER OF HOLE
0.75		0.75		sandy clay	light brown	·drier than Wo by around 2%	
1.0		0.25		CL	brown	·containing sand & ·medium hard	
1.9		0.9		clay	reddish brown	·rather soft ·slightly wetter than Wo	
4.0		2.1		gravelly clay SC	reddish brown	·generally wet (Wo+2 - 3%) ·containing weathered gneiss gravel of 2cm - 10cm (2.5 - 2.7m deep) ·containing limestone boulder of 20 - 30cm sporadically (2.8 - 3m deep)	
6.4		2.4		gravelly clay SC	reddish brown	·containing weathered gneiss gravel, limestone gravel etc. ·clay is wet (Wo+2 - 4%)	

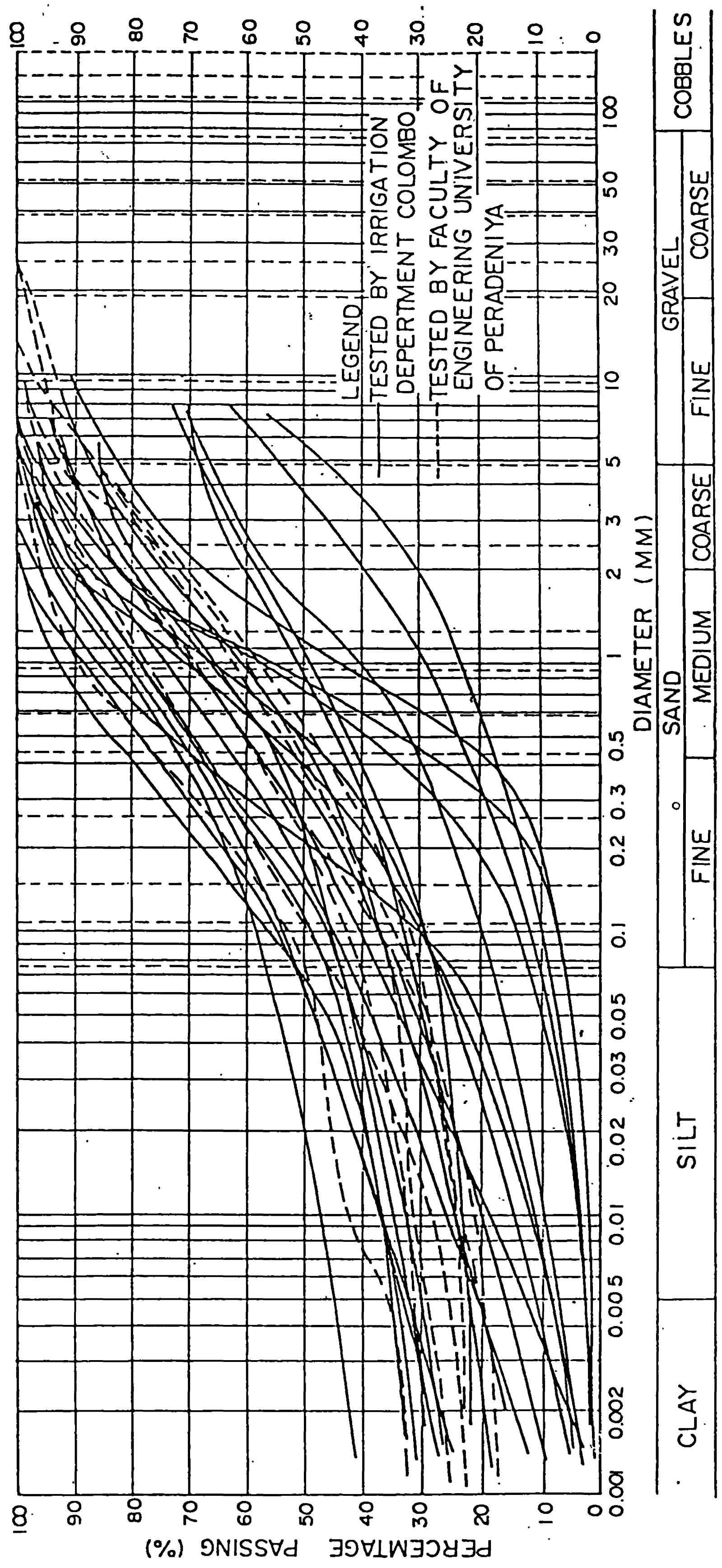
FIG. 4.4 2(4) SOIL PROFILE

NAME OF SURVEY & LOCALITY: LB-1 (Kinchigune) DATE Aug. 4, 1986

HOLE NO. TP-3K SURVEYED BY

GROUND ELEVATION m GROUND-WATER LEVEL m

DEPTH	ELEV. (Top of stratum) (m)	THICKNESS OF STRATUM	LOG	CLASSIFICATION AND DESCRIPTION OF MATERIAL: CLASSIFICATION	COLOR	DESCRIPTION	DIAMETER OF HOLE
0.2		0.2		organic clay	light brown	·containing small amount of organic material	
0.5		0.3		sandy silt	brown		
1.2		0.7		sandy clay CH	brown	·containing sand (quartz) and gravel	
1.8		0.6		sandy clay SC	reddish brown	·sand content relatively small ·moisture close to Wo	
2.6		0.8		gravelly clay	reddish brown	·moisture close to Wo	
3.1		0.5		SM	greyish brown	·highly weathered gneiss ·low plastic ·hard at the bottom past	

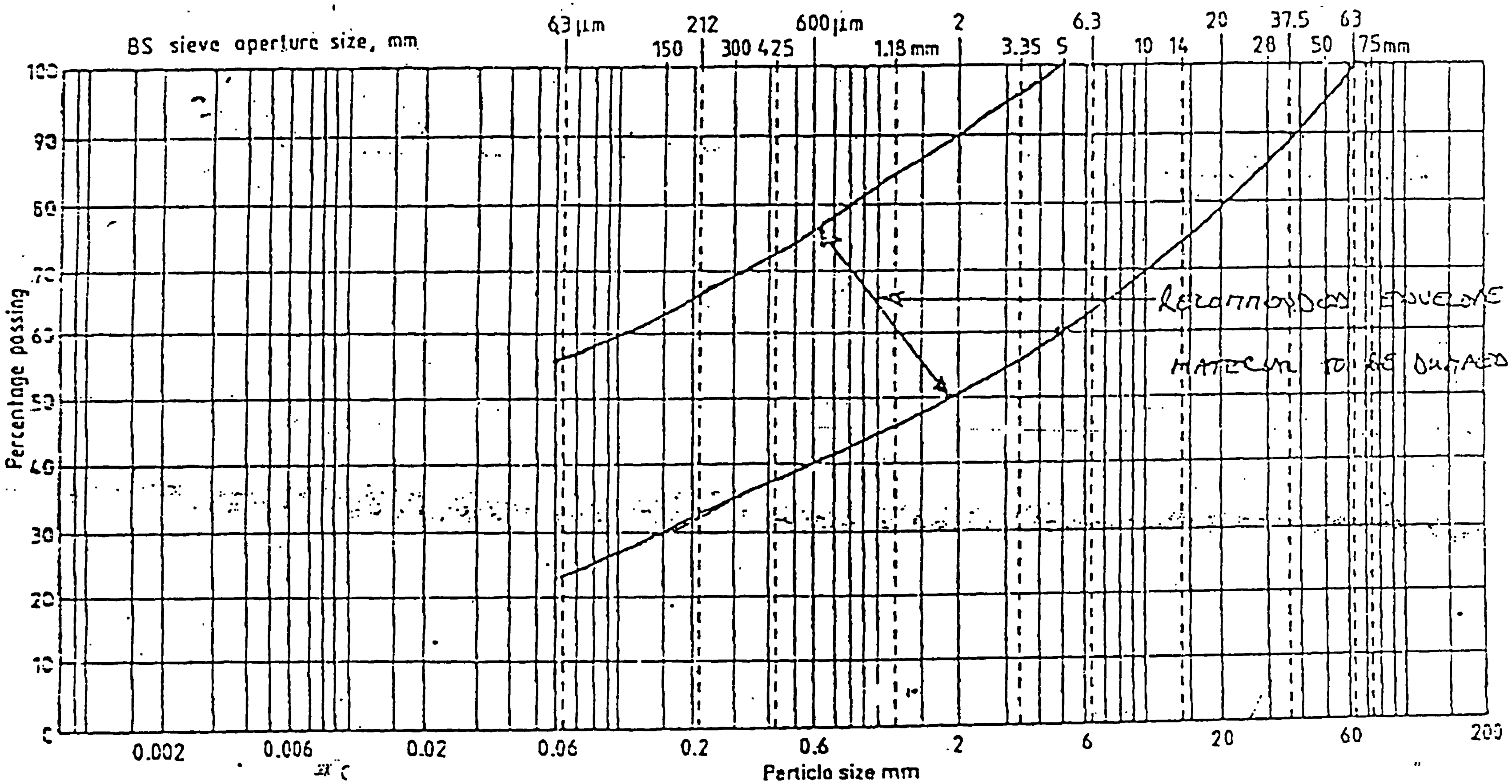


SAMANALAWEWA HYDROELECTRIC PROJECT GEOTECHNICAL INVESTIGATION 1986-1987	Fig. 9
GRAIN SIZE ACCUMULATION CURVE (LB-1)	

FIG. 4·4·3(1)

Particle size distribution chart

Location	Soil description	Job ref.	82870 C	Sample no.	SPEC
SAMPINMALUENA – WET DUMPING	Well graded gravelly sandy silt/silty sand.	Borehole/Pit no.	SPEC	Depth	N/A – m
Test method	BS 1377 : Part 2 : 1990 : 9.2/9.3/9.4/9.5/9.7 *			Date	5/7/93



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES	BOULDERS
	SILT			SAND			GRAVEL				

* Delete as appropriate

Operator	Checked	Approved

TABLE 4.4 (1) - SUMMARY OF LABORATORY TESTS

Trial Pit No.	Sample depth	Gradation				Consistency			Classification
		Gravel 4.76-75mm	Sand 0.074-4.76mm	Silt 0.005-0.074mm	Clay 0.005 mm	LL %	PL %	PI%	
TP1K	1	8	48	16	28	51.31	23.6	27.7	SC
	2	1	72	20	7	-	-	NP	SM
TP2K	1	0	48	24	28	41.7	20.5	21.2	CL
	2	32	37	12	19	55.3	25.0	30.3	SC
	2.75	2	71	23	4	-	-	NP	SM
	3.00	8	57	10	25	52.5	26.3	26.2	SC
	4.00	14	55	12	19	46.3	22.0	24.3	SC
	5.00	14	55	13	18	45.1	25.0	20.1	SC
	6.00	2	53	21	24	48.5	25.6	22.9	SC
	6.5	4	54	28	14	-	-	NP	SM
TP3K	1	1	42	15	42	59.3	30.0	29.8	CH
	2	5	61	12	22	46.3	25.5	20.8	SC
	3	3	59	33	5	-	-	NP	SM

TABLE 4.4 (2) - SUMMARY OF SURVEY - KINCHIGUNE

Drawing No.	Total Vol. between 430 - 460 m (m^3)	Availability (%) (estimated)	Material Available (m^3)
A 1	64,297	25	16,074
A 2	635,284	10	63,528
A 3	968,510	60	581,106
A 4	1,020,690	80	816,552
A 5	0		
B 1	83,454	40	33,381
B 2	366,241	20	73,248
TOTAL	3,138,476	-	1,583,890

Note : Availability of suitable material was estimated by persons who were in charge of estimation of core material at Kinchigune during the dam construction.

TP1K...... 1.70m.
TP2K...... 5.50m.
TP3K...... 1.90m.

Based on the above, the average thickness of available material is about 3.00 m..

However, by considering the variation in topography and the presence of the sloping weathered rock layer which limits the depth of borrow, the maximum average depth to which the material could be extracted should be assessed as 2.50m.

The extent between El 430M. and El 460m is about 25 Hectares. Therefore the total quantity of material available is 625,000 m^3

According to the specifications the blanket material should be well graded gravelly sandy silt/silty sand free of cobbles. On inspection, it was observed that this area contained about 15% to 20% boulders and cobbles. Thus allowing for boulders and cobbles the material available for blanket is about 500,000 m^3. The tentative requirement of material for the blanket is about 500,000 m^3.

JVS asserts that the percentage of coarse sand and gravel in the material for clay core of the dam is smaller than that of material used for wet blanket. With the higher percentage of coarse sand now permissible, Kinchigune can supply 1.58 millions cubic meters between elevation 430m and 460 m. See **Table 4.4 (2)** and **Fig.4.4.(4).** Further material could be made available by lowering the reservoir level to the minimum operating level of El 424 m, when material could be excavated and piled for use at the barge loading site.

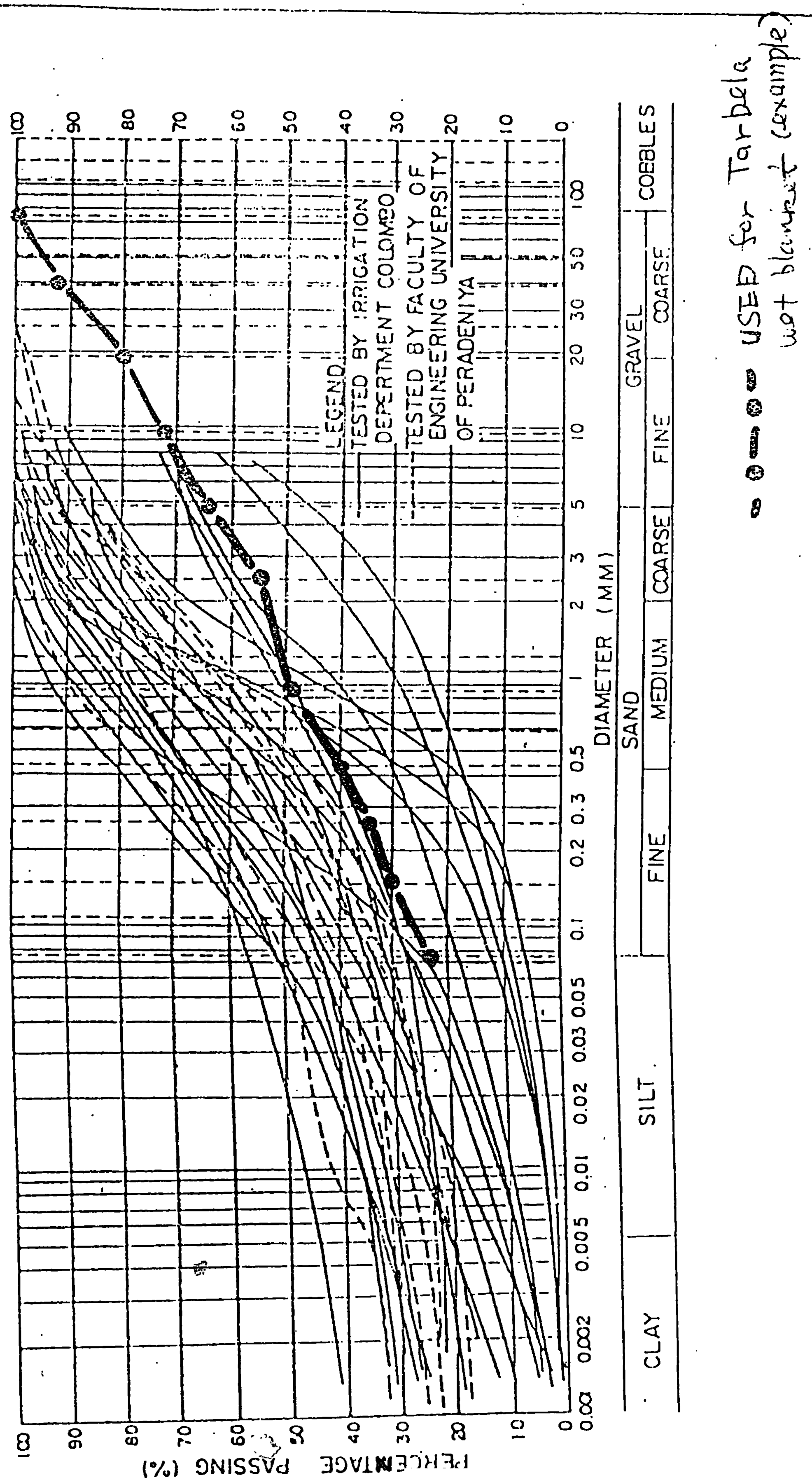
In the event of material being still insufficient for wet blanketing at the aforesaid borrow area, further quantities are available at the Pilipota borrow area in close proximity to and across the Belihul Oya. Russian investigators had estimated up to 0.4 MCM of material being available there.

4.4.5 Conclusion

From the above analysis the available material for the blanket within the proposed area is sufficient. The alternate site on the Right Bank of Walawe and upstream of the dam is not recommended because :

- it may change the geological characteristics of the leakage area;
- it will lead to higher erosion and the eco system will be adversely affected;
- removal of the existing forest will affect the environment;
- removal of the overburden will change the pore pressures in this vulnerable area.

In Kinchigune area the topography above E1 460m. is steeper (about 35%) than the existing proposed area below FSL. Thus, in exploiting this area for borrowing material extreme care should be exercised to prevent any erosion and landslides.



SAMANALAWEWA HYDROELECTRIC PROJECT
GEOTECHNICAL INVESTIGATION 1986-1987

Fig. 9

GRAIN SIZE ACCUMULATION CURVE

4.5 Reservoir

4.5.1 Hydrology

Since the wet blanket operation entails a period of over one year to implement, it has been thought prudent to re-examine the basin characteristics and future floods. This is an area of crucial importance since the operating level is now fixed at 430 m instead of the designed full supply level of 460 m.

During the period of wet blanketing which can extend from one to two years, the reservoir could face a storm that will bring the run-off to near bund top level and the safety of the reservoir would be at risk. Although the dam is safe in such an event the present spill capacity has to be increased and a new spill way constructed with sill level at El 430m. This has been analysed as it is very critical for the safety even during wet blanket process.

i) **Flood discharges through the spillway:**

There are 3 radial gates 11 m. wide and 14 m. high to discharge floods over the Samanalawewa dam and the design discharge capacity of the spillway is 3600 cumecs (126,000 cusecs). It is proposed to maintain the water level of the reservoir between 424 and 430 m and operate the power house without any interruption to the power generation during the wet blanketing. This treatment might take well over 18 months and it is therefore intended to simulate the reservoir water levels during one complete water year which includes both N.E. and S.W. monsoons. During this operation, all three gates will be kept fully open. The sill level of the radial gates are at 446.7 m, which is 22.7 m above the minimum operating level.

The selection of a flood for the simulation was done by going through the historical records. According to the available stream flow records, though gauging of Walawe Ganga at the dam site commenced during 1950, the highest flood had been estimated in May 1940. According to the records, the magnitude of this flood was estimated as 2264 cumecs (80,000 cusecs).

There are many gaps in the data base, though continuous monitoring commenced in the period of 1950 to 1960 and therefore design flood peak for the simulation cannot be obtained directly from the frequency analysis of flood peaks. As continuous rainfall data in the Samanalawewa area is available for a considerably long period, it is proposed to select a critical rainstorm by studying the past rainfall records and then estimate the river flow due to that storm.

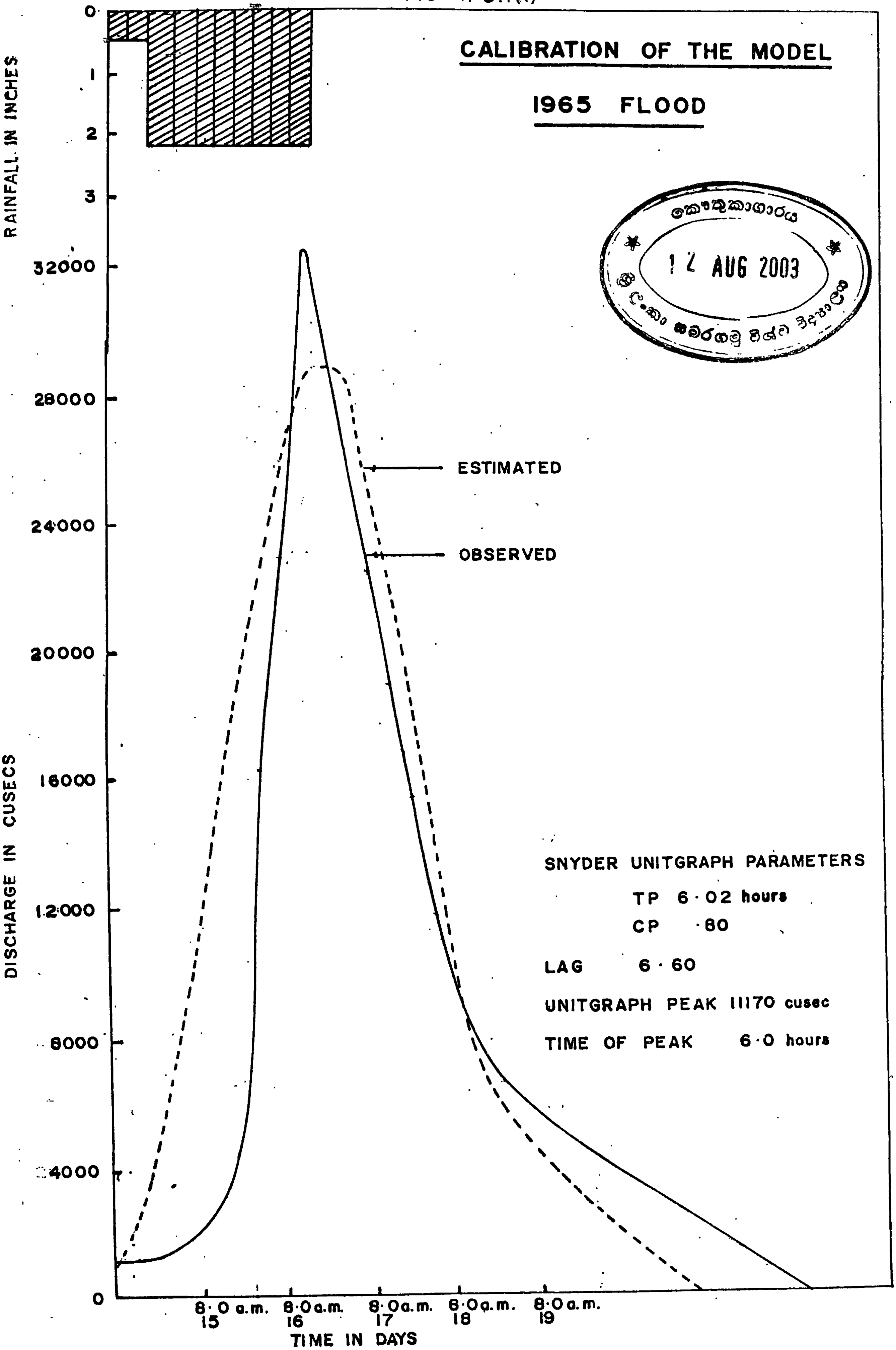
According to rainfall information, the worst flood had occurred in May 1940 and weighted daily rainfall from the 15th to the 20th of this month in Samanalawewa catchment was 1125 mm (45.0 inches) with a maximum of 375 mm (15.0 inches) during 24 hours. (ECI - May 1966).

According to the records available, this flood was recorded by the Irrigation Department as 2264 cumecs (80,000 cusecs) as previously mentioned, but as there was no continuous river gauging at that time, this has to be considered as an estimation rather than an observation. Therefore this estimated flood hydrograph is not used, as better methods are now available for such estimation.

For simulation of the reservoir levels during the 1940 flood, firstly the Samanalawewa catchment without the reservoir has to be simulated. For this purpose, the Samanalawewa catchment has to be calibrated by an application of a hydrological model using some observed flood hydrographs and corresponding rainstorms. For this purpose HEC 1 model developed by the U.S. Army Corps of Engineers, USA, is used with observed flood hydrographs in 1986, 1976 and 1965 for calibration. Calibration during the 1965 flood was more acceptable than the other years. **Fig.4.5.1 (1)** shows the model calibration using the 1965 flood. The hydrograph from the model was fitted to the observed one by adjusting the two parameters of the model. These parameters are based on the Snyder synthetic unit hydrograph and one is the time to peak Tp and other is Cp. From the model calibration, Tp is estimated as 6.02 hours and Cp is estimated as 0.80. **Fig.4.5.1 (1)** shows the model calibration. This optimized value of Tp was further verified by estimating the time of concentration of the catchment from the catchment topography. It was found that the results obtained from the mathematical optimization is realistic. Detail computation of time of concentration is given in the **Appendix 4.5.1 (1).**

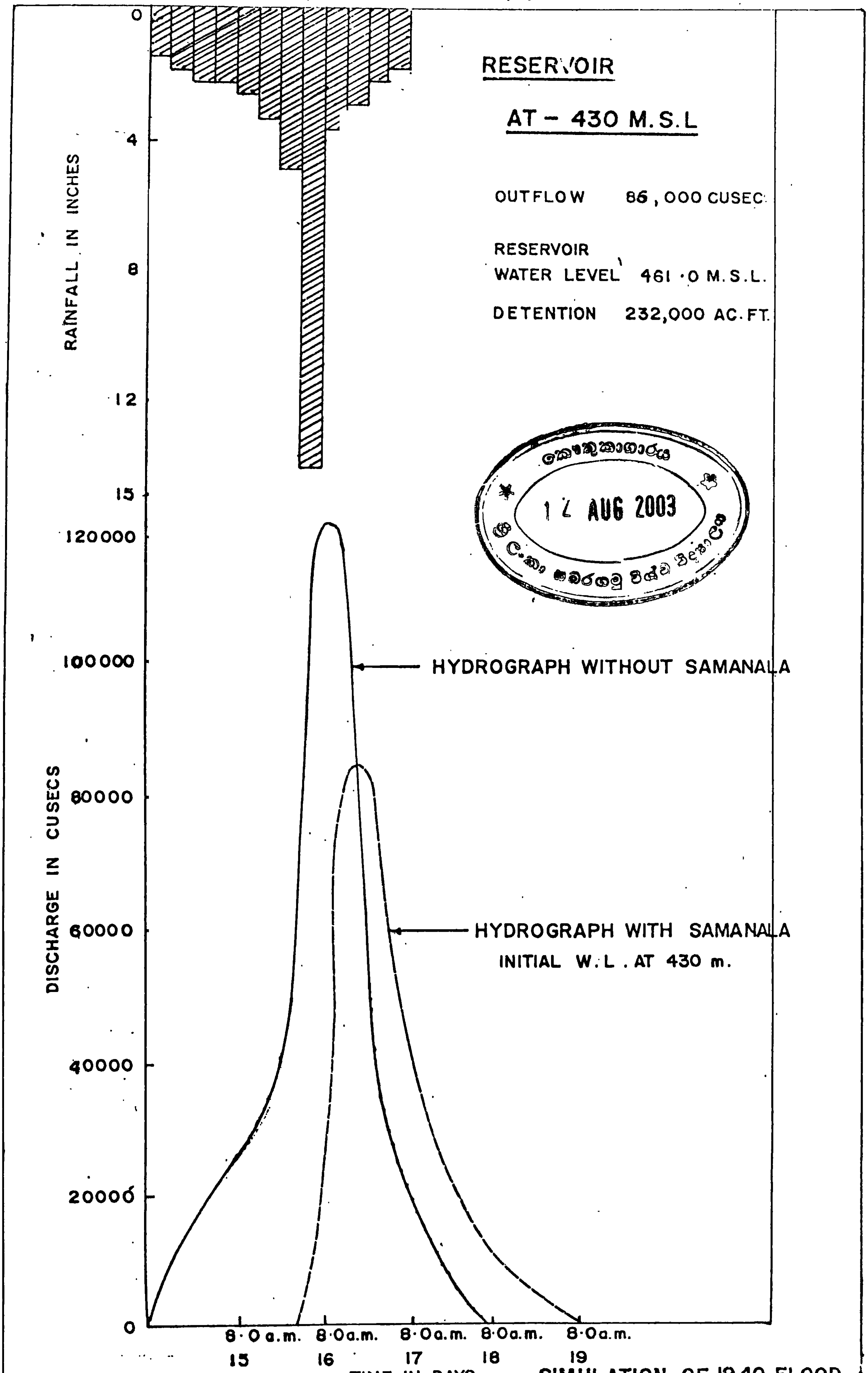
Then the calibrated model was used to simulate the 1940 rainstorm to obtain the resulting flood hydrograph. **Fig.4.5.1 (2)** shows this simulation and it is noted that the flood peak estimated from this model is 3420 cumecs (120,833 cusecs) against the originally estimated peak flow of 2264 cumecs (80,000 cusecs) by the Irrigation Department. This inflow hydrograph is now routed through Samanalawewa, when the water level is at 430 m. The result of this is also shown in **Fig.4.5.1** (2) From the above it is clear that the routed hydrograph will have a peak of 2405 cumecs (85,000 cusecs) and this will correspond to a water level of 461.0 m which is 1.0 m above the full supply level of the reservoir. This is also shown in **Fig.**4.5.1 (2). **Fig.4.5.1 (3)** shows the area capacity curves used for flood routing through the reservoir. **Fig.4.5.1** (4) shows the reservoir simulation, if the reservoir is kept empty at the time of arrival of the 1940 flood. This shows that the reservoir will rise to a level of 458 m only.From this it is clear that in the event of an extreme flood the initial reservoir level will not be significant as the detention capacity of the reservoir is small at lower levels.

FIG - 4·5 (1)



CALIBRATION OF THE MODEL
1965 FLOOD
RAINFALL IN INCHES
0
1
2
3
32000
28000
24000
20000
16000
12000
8000
4000
0
DISCHARGE IN CUSECS
ESTIMATED
OBSERVED
SNYDER UNITGRAPH PARAMETERS
TP 6·02 hours
CP ·80
LAG 6·60
UNITGRAPH PEAK 11170 cusec
TIME OF PEAK 6·0 hours
8·0 a.m. 15
8·0 a.m. 16
8·0 a.m. 17
8·0 a.m. 18
8·0 a.m. 19
TIME IN DAYS

FIG - 4·5·1(2)



SIMULATION OF 1940 FLOOD

FIG - 4·5·1(3)

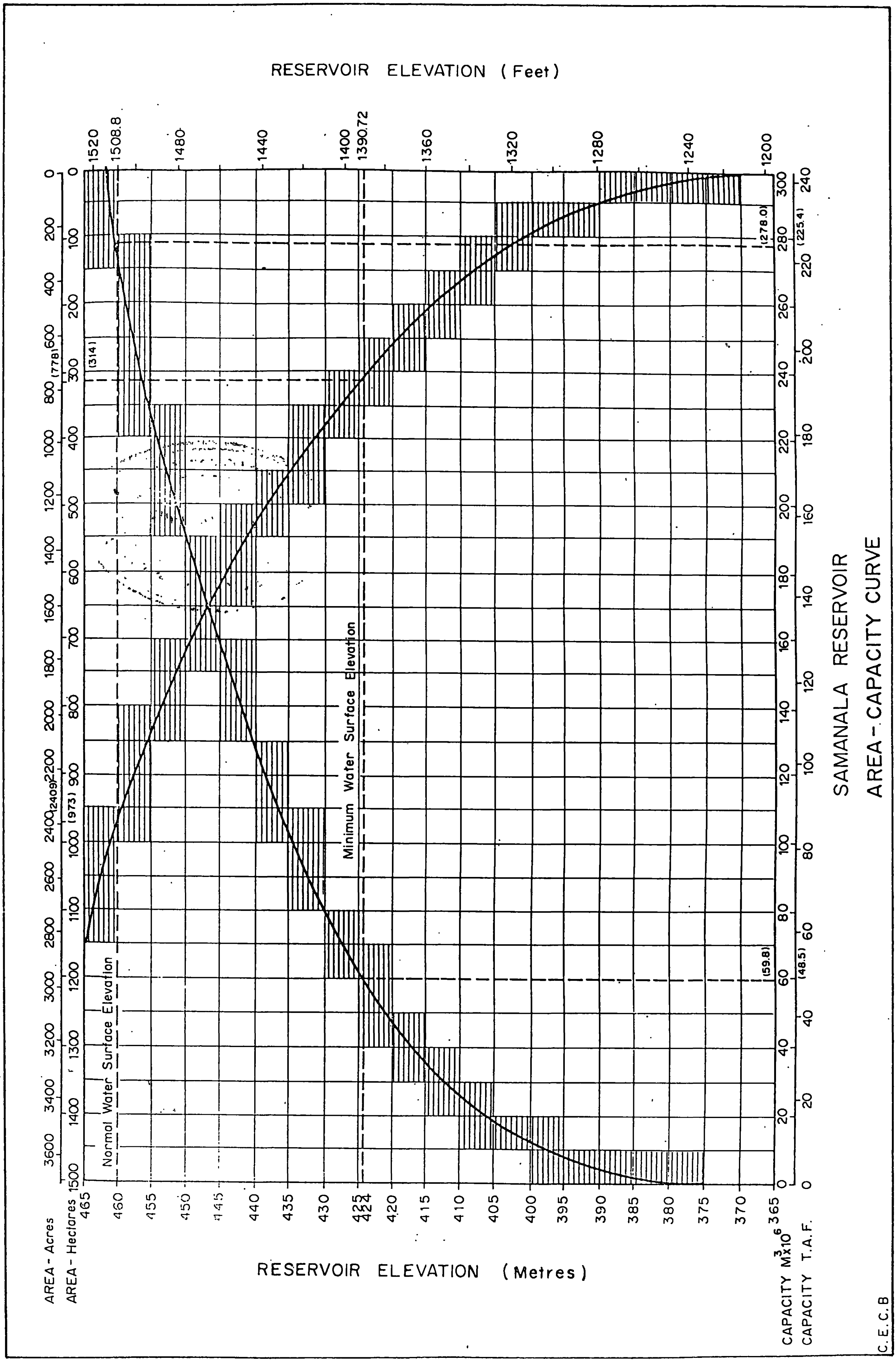
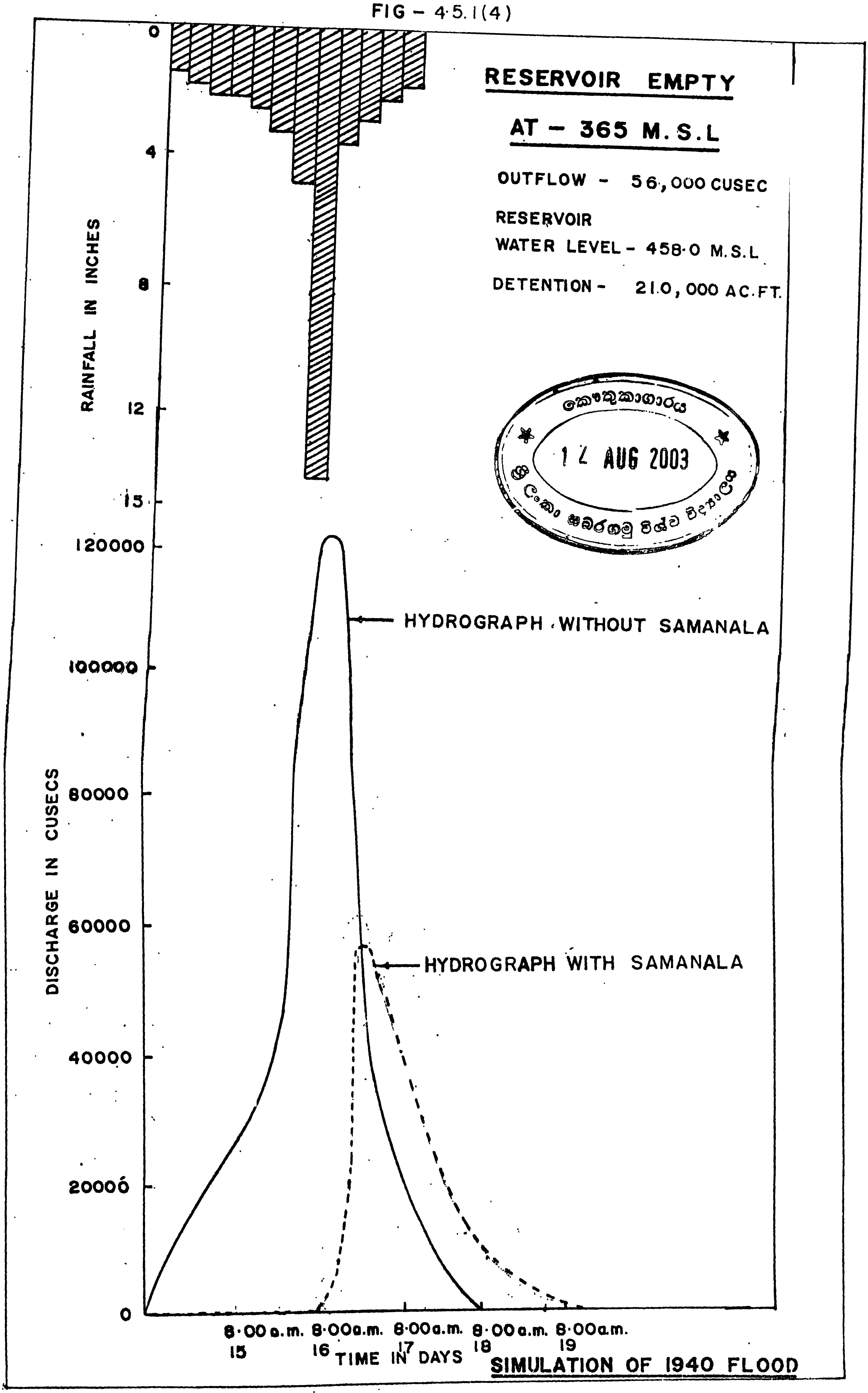

SAMANALA RESERVOIR
AREA - CAPACITY CURVE
RESERVOIR ELEVATION (Feet)
RESERVOIR ELEVATION (Metres)
AREA - Acres
AREA - Hectares
CAPACITY M³x10⁶
CAPACITY T.A.F.
Normal Water Surface Elevation
Minimum Water Surface Elevation
1508.8
1390.72
(778)
(314)
(2409)
(973)
(278.0)
(225.4)
(59.8)
(48.5)
C.E.C.B

FIG – 4.5.1(4)


RESERVOIR EMPTY
AT – 365 M.S.L
OUTFLOW – 56,000 CUSEC
RESERVOIR
WATER LEVEL – 458·0 M.S.L
DETENTION – 210,000 AC.FT.
RAINFALL IN INCHES
0
4
8
12
15
DISCHARGE IN CUSECS
120000
100000
80000
60000
40000
20000
0
HYDROGRAPH WITHOUT SAMANALA
HYDROGRAPH WITH SAMANALA
8·00 a.m. 15
8·00 a.m. 16
8·00 a.m. 17
8·00 a.m. 18
8·00 a.m. 19
TIME IN DAYS
SIMULATION OF 1940 FLOOD
14 AUG 2003

After estimation of the probable flood level due to such an extreme event, the next important thing is to find out the probability of occurrence of a flood of such magnitude during the next 2 years. It is assumed that wet blanketing would take about 2 years. For this purpose, it is necessary to assign a return period to the 1940 flood. Therefore the annual maximum flood peaks observed at Samanala dam site from 1958 were examined and found that the records are not consistent and that there are many gaps. Therefore 17 flood peaks were analyzed with extreme value distribution type 1 (Gumbel) by fitting a straight line for the empirical distribution. The better methods of estimation of distribution parameters are not worth in this situation due to inconsistencies in the data base. From this analysis, it was estimated that a 3396 cumecs (120,000 cusec) flood will have an approximate return period of 700 years. The details of the analysis are given in the **Appendix 4.5.1 (2).**

Then the probability of this flood occurring during the next 2 years was estimated by the Poisson distribution and it was found that probability is 0.002. This shows that though the impact of such an extreme event is unimaginable, the occurrence is a very rare probability. This computation is given in the **Appendix 4.5.1 (3).**

In the light of above it is reasonable to simulate the reservoir for a flood of 50 or 100 year return period.Therefore simulation was done for a rain storm of 28 inches spread over 5 days.Storm of above distribution can be regarded as a flood of 100 year return period.Simulation shows a flood detention of 246 MCM (200,000 ac.ft) and resulting water level would be El 457 m., which is 3 meters below the full supply level.

ii) **Diversion requirement for dry blanketing:**

In case of dry blanketing, the quantity of material required for treatment as well as the haul distance will be considerably reduced. In addition, the slow transport mechanism over water will be eliminated during dry, blanketing as road transport is quicker. Therefore by assuming a 3 month operation period for dry blanketing, the diversion capacity required for a tunnel has to be estimated by analyzing the long term monthly flows of Walawe Ganga. It was found that the flows in the river were lowest during the months of June, July and August. Observations from 1960 to 1988 show that during June to August the maximum flow was 269 cumecs (9415 cusecs) and the minimum flow was 1.2 cumecs (41 cusecs). Normally for diversion of low flows during such a construction, the flow corresponding to a 10 year return period is the most appropriate. **Appendix 4.5.1 (4)** shows the frequency analysis of low flows during June to August and flow corresponding to a 10 year return period was estimated as 241 cumecs (8500 cusecs) during this dry period.

The diversion capacity of the tunnel already constructed during the construction of Samanalawewa has the capacity of 1500 cumecs (52,500 cusecs) and therefore it is quite adequate for this purpose. However it would be necessary to remove the concrete plugs of this diversion tunnel for dry blanketing. Since the constructed diversion tunnels are located downstream of the ingress area, a new diversion tunnel would have to be constructed to divert Walawe river because the capacity of the Power Tunnel is not sufficient for diverting the flood even during dry periods. The location of the tunnel intake would have to be sited far upstream of the ingress area to allow for the possible extension of the dry blanket.

See **Fig.5.1 (1)** which illustrates the above requirements.

The technical feasibility of a new diversion tunnel, removal of the concrete plug and construction of 2 coffer dams requires investigation. Costs of such an operation will be prohibitive, besides loss of generating capacity to the national grid during the period of construction which may even exceed five years, apart from the time required for dry blanketing.

i) Sedimentation of the dead storage of the reservoir:

The proposal is to excavate 500,000 cu. m. of blanketing material between the full supply level contour (460 m) and the minimum operating level (424 m) in the reservoir bed. As the excavation is below the full supply level, siltation of the reservoir due to excavated material will be compensated by the increased reservoir capacity due to excavation.

However, one has to note that most of the excavated material will be placed in the area reserved for dead storage in the reservoir which is below the 424 m level. Therefore, it will reduce the dead storage volume which is meant to store sedimentation from the Samanalawewa catchment due to natural soil erosion. However the dead storage of the reservoir is high due to its configuration. Sediment studies carried out by the Irrigation Department in 1985 showed that sedimentation due to natural process was 238 cu. m./sq. km./ year., which is 81367 cu.m. per year for the whole catchment. Therefore the sedimentation resulting from the wet blanketing is similar to the accumulated sediment load during 6 years of operation. However, Samanalawewa has a large dead storage of 60 MCM (48,500 Ac.ft.) and therefore the effect of siltation is negligible.

4.5.2 Water Quality

i) Preliminary Observations

The shoreline of the reservoir is steep and continuous shoreline erosion is prominent throughout the reservoir mainly due to geo-morphological instability. (See **Plate 2 Annex 1**) The present status of the Samanala reservoir and the on-going engineering activities were observed. The dam-reservoir monitoring programme with special reference to the water quality of the reservoir and its inflows, leakage out-fall and bore holes were carefully examined.

A progressive decrease in electrical conductivity at the leakage out-fall over time was noticed.

The reservoir shows a sharp decline in thermocline at the first 10 m depth from the surface. According to the thermal properties and the circulation of the water column, Samanalawewa reservoir may be classified as an oligomictic reservoir where the temperature is well above 4^0 C with rare circulation unlike in temperate reservoirs where thermal stratification may occur throughout the year. However, the epilimnetic water temperature may vary due to the prevailing local weather and the climatic conditions.

Below 10 m, the temperature gradient was significantly low, forming a sharp thermocline. There may be daily density changes in the upper 10 - 15 m strata even during calm days but such changes in the epilimnion may not cause any disturbances. However, release of water from the deeper layers for power generation and irrigation may result in periodic mixing of oxygenated surface layers with the deeper layers which is favourable.

The vertical distribution pattern of dissolved oxygen in the Samanalawewa reservoir is a clinograde curve. However, there is no evidence of anoxic conditions in the bottom layers during the day time. High oxygen concentration in the euphotic zone indicates high photosynthetic activity of planktonic algae. A marked oxygen depletion has been observed below 10 m where mixing of surface waters with the deep layers is limited.

Lower pH values in the bottom water indicates decomposition processes associated with the accumulated phytomass, resulting from inundation of existing vegetation during the construction period.

The other physical and chemical characteristics reported for the reservoir water do not show a significant deviation from a deeper highland reservoir in Sri Lanka (eg. Kotmale, Victoria).

The ionic composition and the concentration of the groundwater and leakage water show significant variabilities indicating the geological heterogeneity of the area.

There was a dense growth of attached filamentous algae (epilithic) at the leakage out-fall. The density of the algal growth decreases progressively downstream and no such algal mat is observed after the confluence of the leakage out-fall and the Walawe proper about 350 m downstream of the dam.

In addition to algal growth at the leakage out-fall, a peculiar odour was smelt and the fast-flowing water was sky blue in colour.

The water released from the irrigation valve was murky in colour indicating a high concentration of suspended solids in the water at the depth from which it is released.

In contrast, a difference in water turbidity was observed at the confluence of the leakage and the Walawe river. The bottom substrata of the Walawe river downstream of the dam consists mainly of boulders.

Generally, the shoreline of the reservoir is steep and prominent shoreline erosion was noticed throughout the reservoir indicating geo-morphological instability.

The above information and anticipated engineering activities during the process of clay dumping will be coupled to assess the impact of clay dumping on aquatic life in the Samanala reservoir and the downstream of the Walawe river using the matrix analysis technique.

ii) Values of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

The expected changes are in the BOD & COD values, which are negative impacts. BOD of the reservoir water may rise slightly on dumping clay in the water due to decomposition of benthic deposits, dead algae and biomass.

The COD values may also increase due to decay of vegetation.

If the dumping material contains high nutrient levels, then it could promote eutrophication and algal blooms. Total inorganic nitrogen levels of more than 1 mg/l is not desirable in reservoirs.

iii) **Temperature differences**

Temperature differences between the bottom of the reservoir and dumping material would cause water currents, affect micro organisms and hence disturb the ecological balance.

iv) **Contaminants**

Clay may introduce toxic contaminants such as pesticide residues, other agro chemicals or metals (arsenic,chromium etc), which deteriorate the quality of water.

v) **Types of material in clay:**

Preferential dissolving of particular component of the soil could cause the parameters of water to rise above the limits prescribed for potable water.

vi) **Suspended Matter**

Dumping of clay material may cause a sharp increase in suspended matter, which could spread through out the reservoir and finally reach the intake with adverse effects on the turbines. Sampling studies undertaken in the reservoir, main leakage, and various piezometric holes for water quality monitoring, show that the water quality in the area including reservoir water, is satisfactory in terms of physico-chemical parameters.

Results of BOD,COD, nitrogen and phosphorous analysis carried out with samples collected over the surface of the reservoir (El 427.6 m) near the leakage zone are illustrated in the **Fig 4.5.2 (1-6)**. Careful study of these results shows that at present the parameters are within tolerable limits.

However it is very important to monitor closely any changes in composition of water due to the clay blanketing operations, since the water downstream is used for human consumption and irrigation purposes, and to assist in avoiding other adverse effects in the environment.

4.5.3 Aquatic Life

Only 19 species of riverine fish have been reported in the project area as important aquatic organisms. Of these 19 species, only 5 have been identified as endemic and they are listed as threatened species. However, it is important to take the other aquatic organisms also into consideration, since they play a significant role in the overall eco-system processes. Aquatic organisms inhabiting these eco-systems can be broadly divided into organisms that are adapted to running waters (lotic) and to

Fig 4.5.2.(1) Samanalawewa Hydroelectric Project Reservoir Surface Samples.
B.O.D Values.vs Time

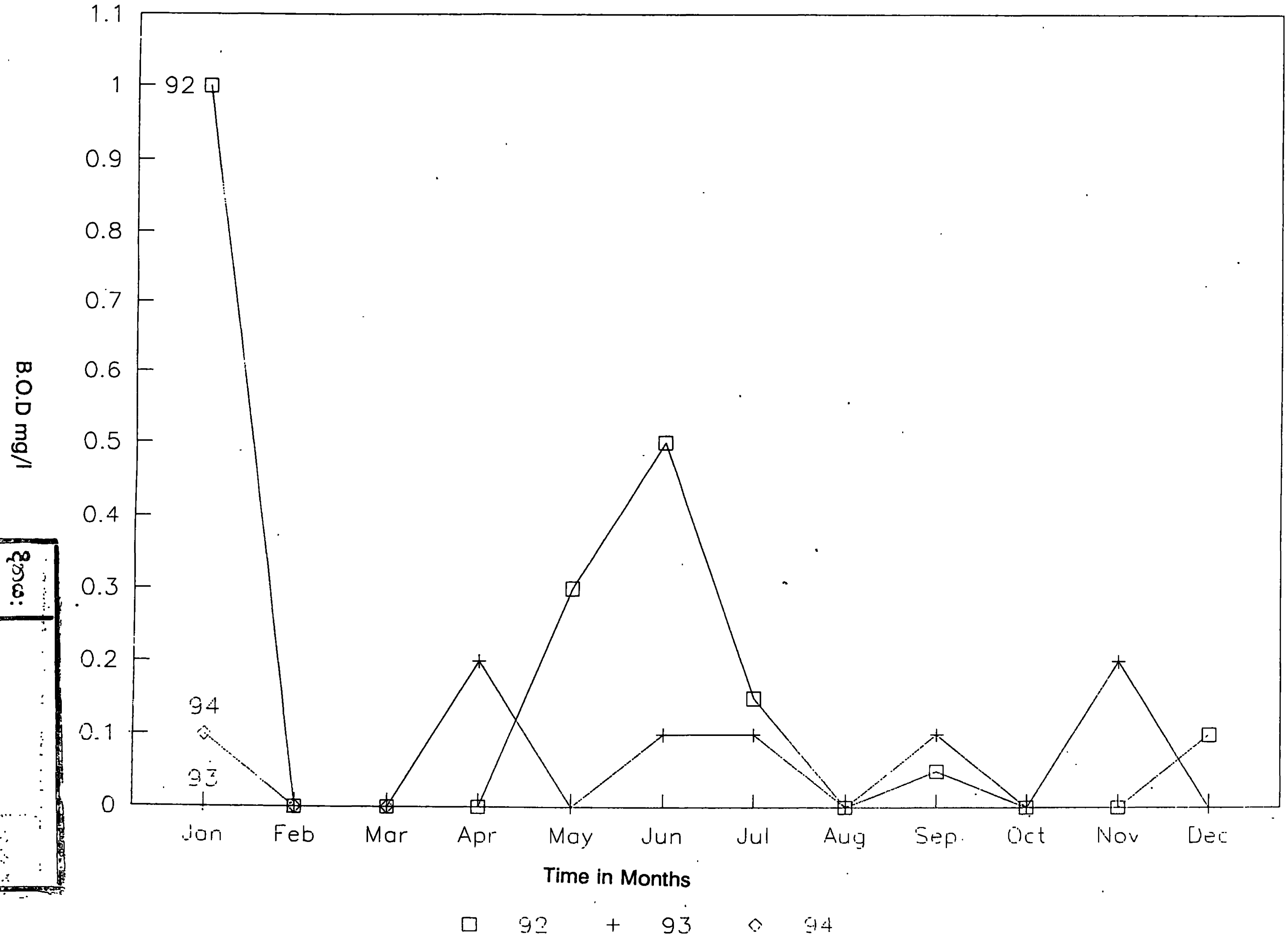


Fig 4.5.2.(2) Samanalawewa Hydroelectric Project Reservoir Surface Samples.
C.O.D Values.vs Time

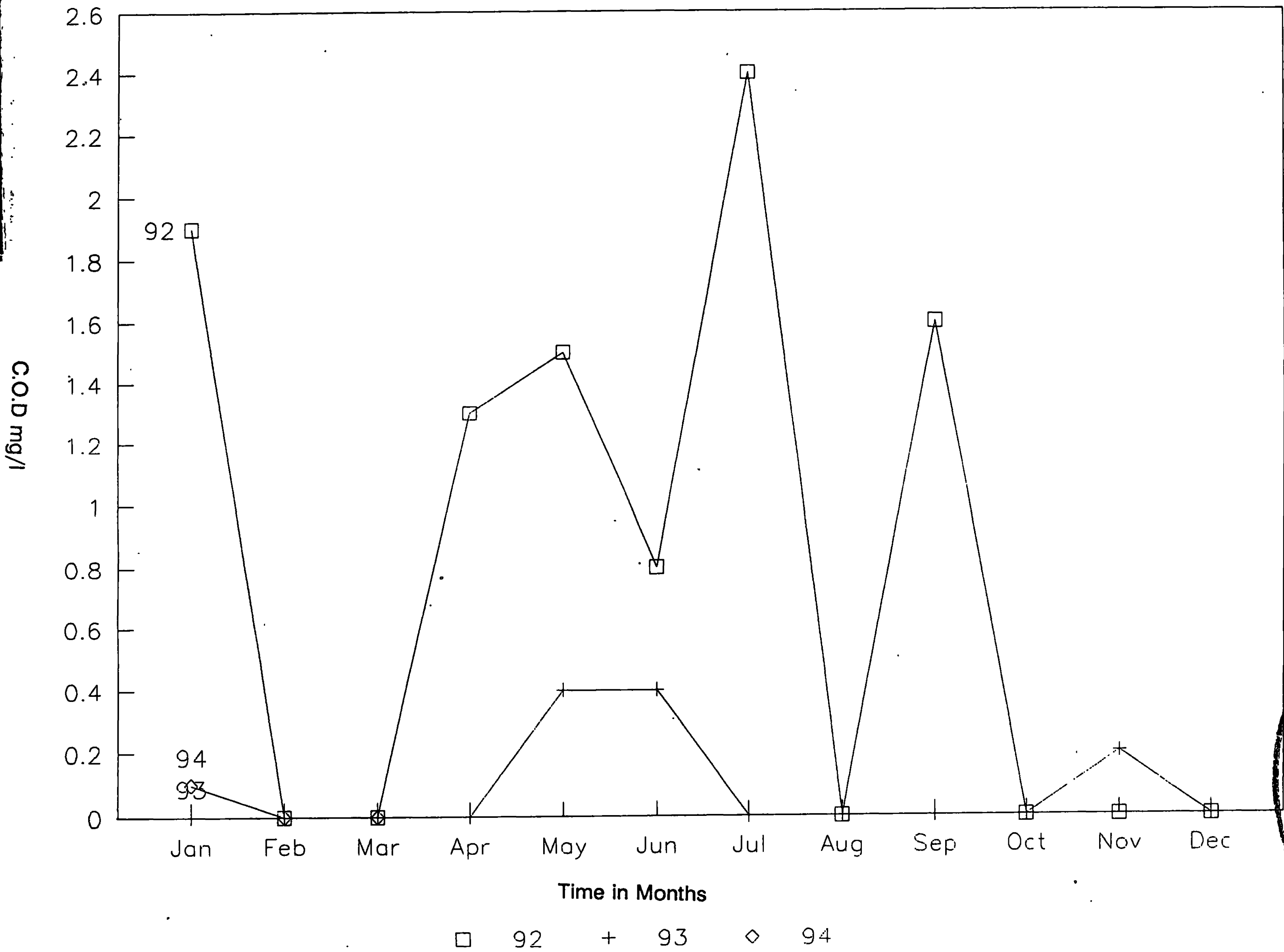


Fig 4.5.2.(3) Samanalawewa Hydroelectric Project Reservoir Surface Samples.
Total Phospherous vs Time

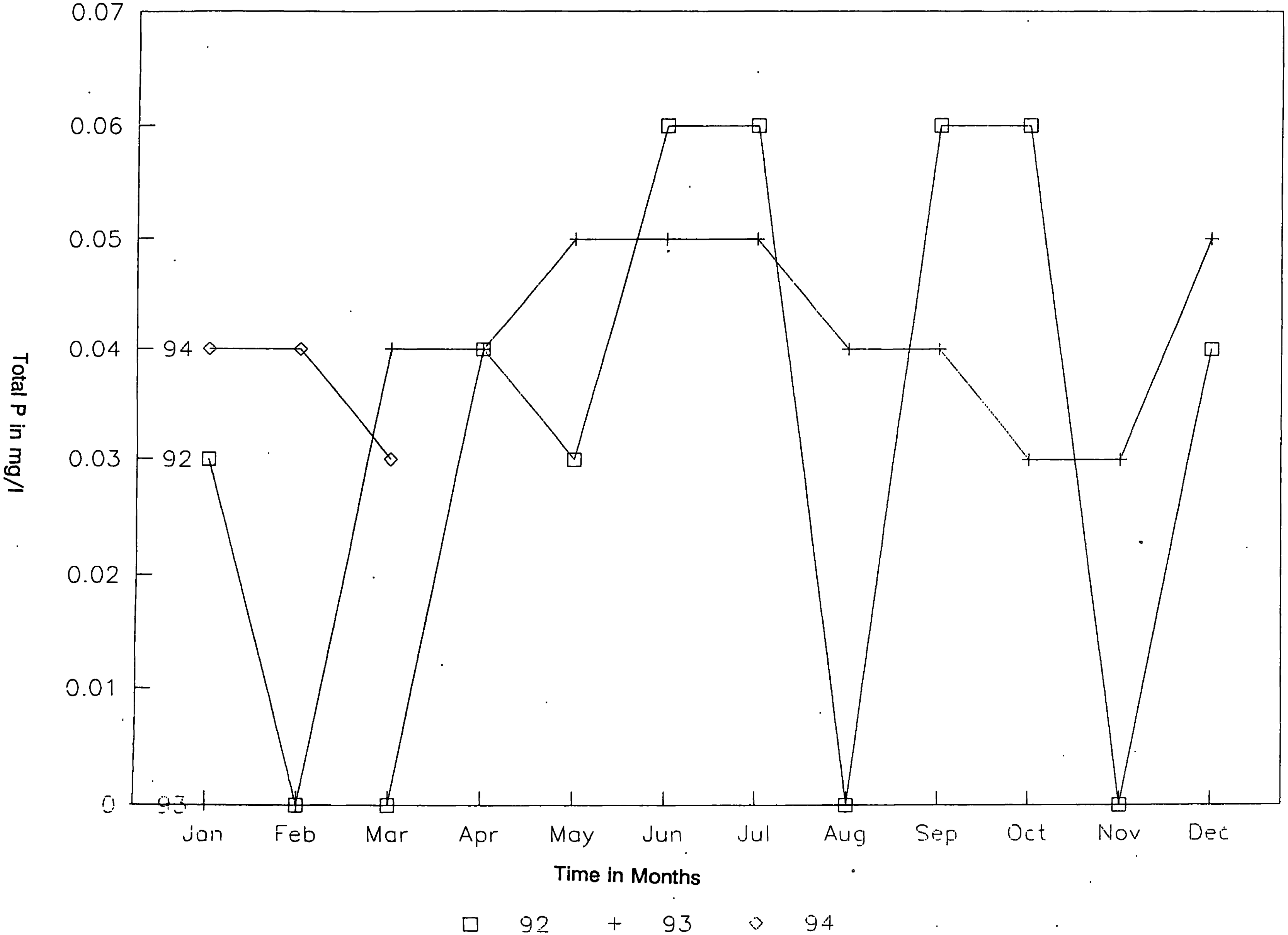


Fig 4.5.2.(4) Samanalawewa Hydroelectric Project Reservoir Surface Samples. Phospherous in Phosphates vs Time

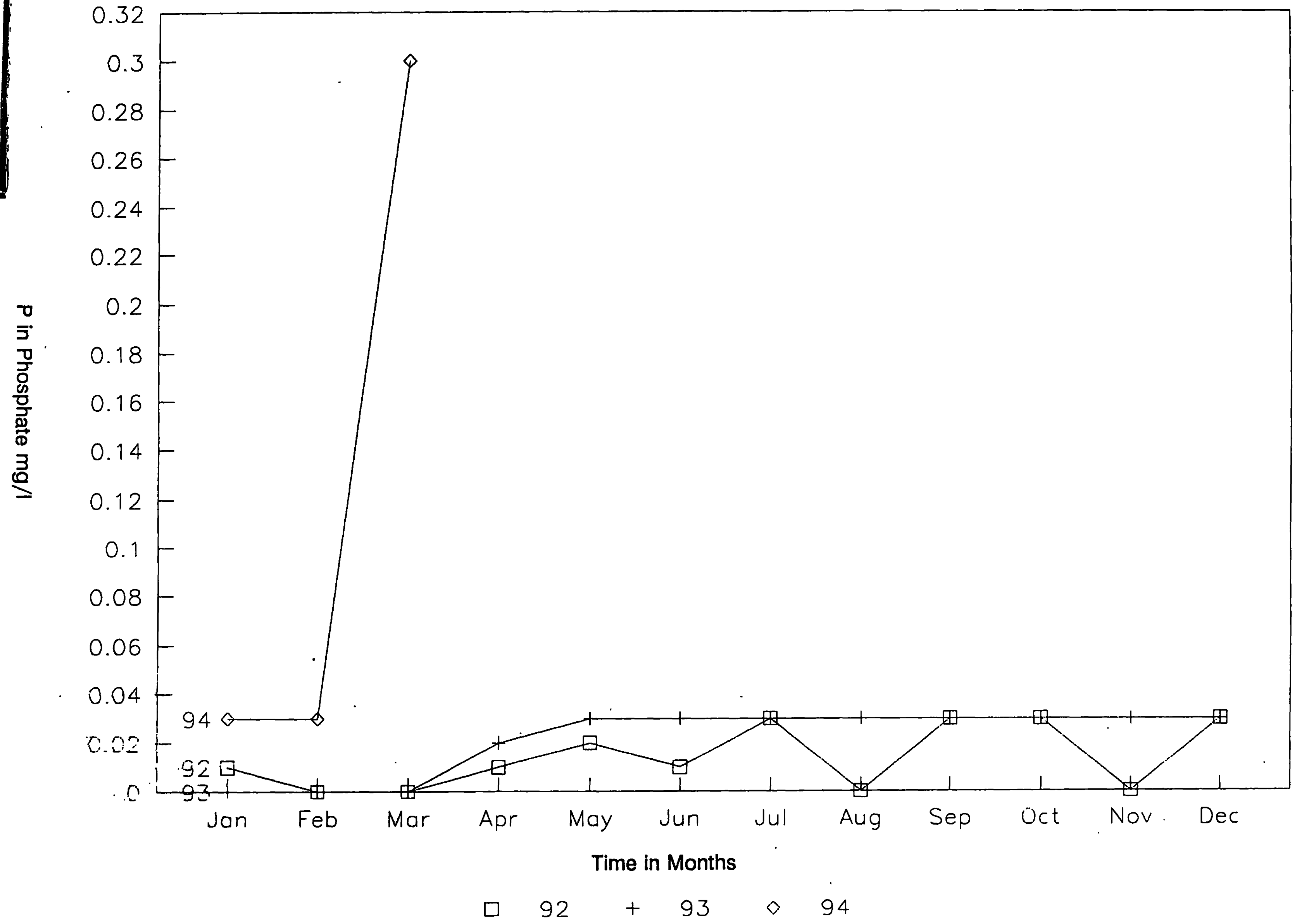


Fig 4.5.2.(5). Samanalawewa Hydroelectric Project Reservoir Surface Samples.
Nitrogen in Ammonia vs Time

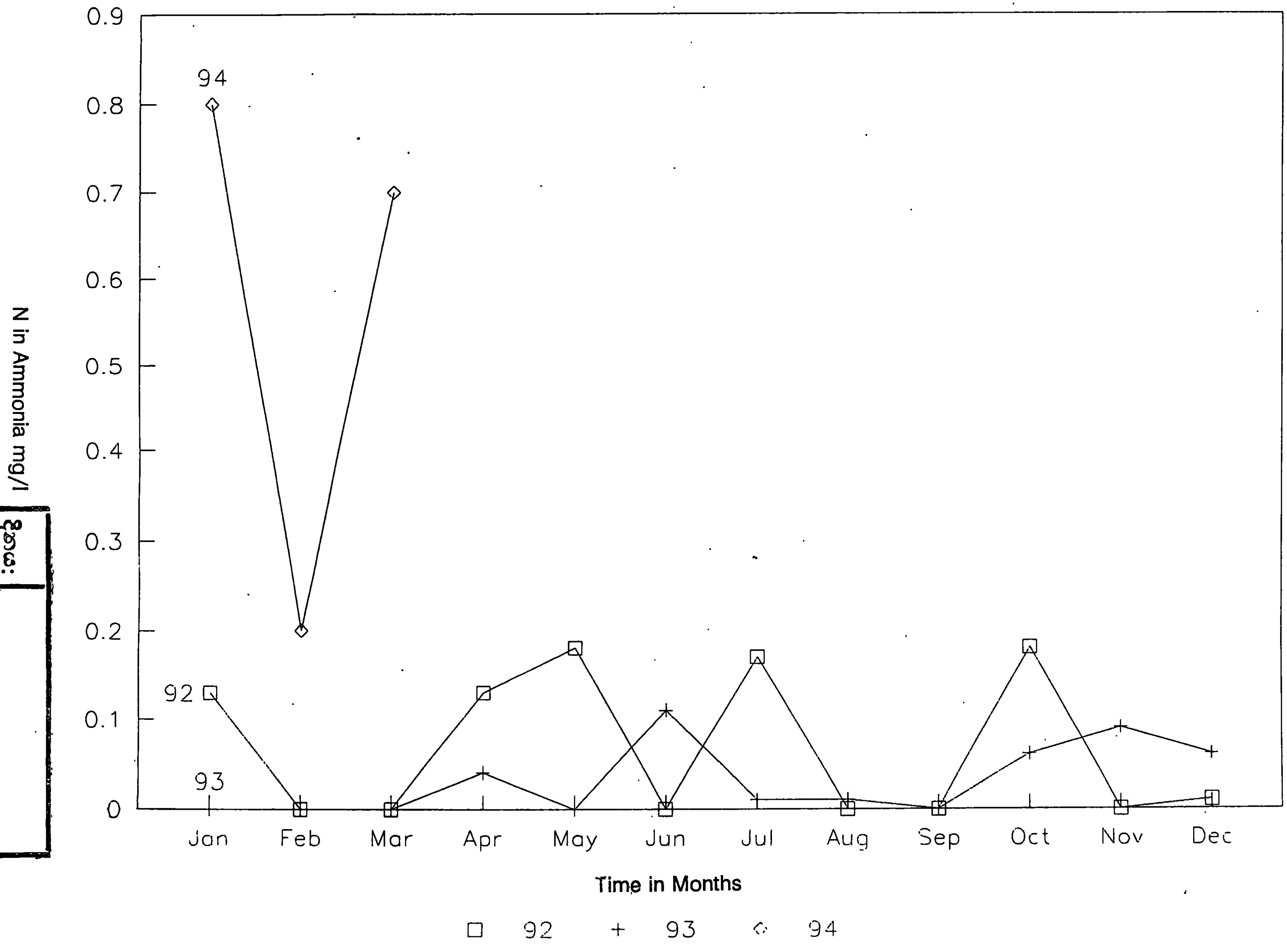
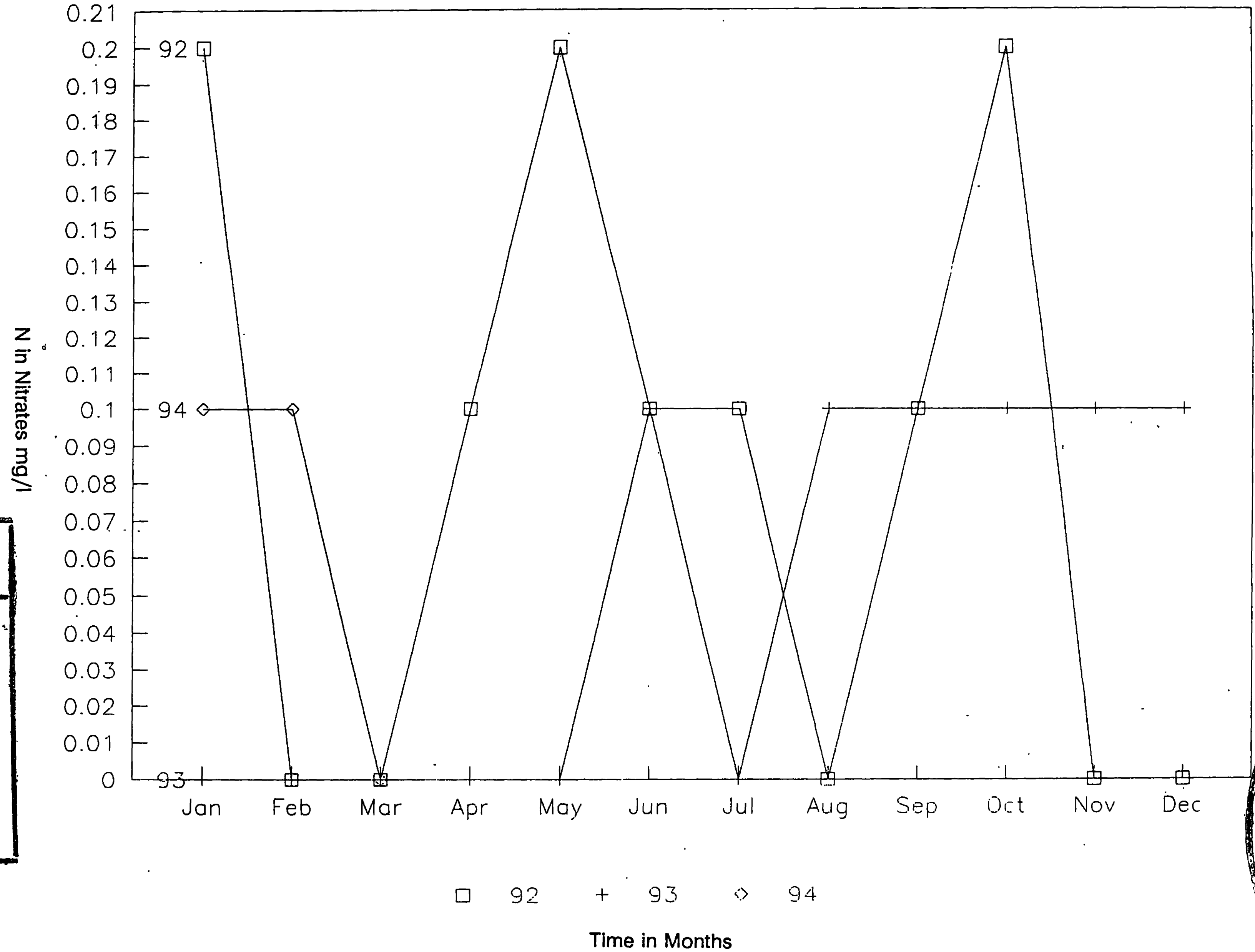


Fig 4.5.2.(6) Samanalawewa Hydroelectric Project Reservoir Surface Samples. Nitrogen in Nitrates vs Time



standing waters (lentic). In the reservoir, the main organisms are planktonic algae (phytoplankton) and planktonic animals (zooplankton). The composition and density of either phyto or zooplankton of the Samanala reservoir is unknown. Nevertheless, blue-green algae often predominate in tropical reservoirs and they are often outweighed by the biomass of diatoms. The zooplankton density in these reservoirs is fairly low and species diversity must be more or less similar to that reported for other reservoirs. Fish that may be found in the reservoir are indigenous riverine colonizers. They will never spend their entire life cycle within the reservoir system. On the other hand, it is very unlikely to find truly riverine endemic fish in reservoirs, because reservoirs are in essence transition eco-systems between running and standing water. Since Samanala reservoir has a steep shoreline, it is very unlikely to be rich in littoral organisms. In the reservoir, the benthic organisms are mainly decomposers. Since there is significant oxygen depletion below 10 m depth, most of the pelagic organisms (i.e. fish) will be confined to the oxygenated epilimnion.

There is a dense growth of attached filamentous algae (epilithic) at the leakage out-fall. The density of this algae decreases progressively downstream and no such algal mat is present after the confluence of the leakage out-fall and the Walawe river proper (about 350 m downstream of the dam). The growth of this algal mat may be promoted by nutrient enrichment either by micro-nutrients (P and N) or trace elements. It is also possible that the mono-culture type growth is due to the likely absence of macro-invertebrate grazers in the fast flowing leakage out-fall. Though unknown, the benthic communities of the Walawe river and the substrata structure indicates micro-habitat for a variety of benthic organisms. It is also likely that the river provides excellent type habitats for riverine fish either indigenous or endemic. Immediately underneath the bottom sediment of the river-bed, there is a possibility of finding hyporheic organisms. All these organisms and the chemical and physical nature of their habitats are extremely important in the structure and functioning of the entire process of the river eco-system. The proposed project activities are:

1. Extraction of blanketing materials
2. Transportation of blanketing materials on the reservoir surface
3. Barge dumping of the blanketing materials
4. Construction of roads for transportation of equipment and mchinery. The above will have negative impacts on the aquatic eco-system through habitat alteration, depletion of species diversity and population densities.

4.6 Environs of the Reservoir

4.6.1 Fauna and Flora

Flora of the entire project area belong to the intermediate submontane Forest group Ecologically, riverine vegetation serves the very useful purpose of preventing bank erosion and permitting a smoother river flow. Such areas are also a habitat for borrowing animals,reptiles,amphibians, small mammals and birds. Although some of the riverine vegetation is protected, riverine vegetation in Kinchigune borrow area has already been destroyed.

However, there is no significant natural vegetation to be protected in Kinchigune borrow area. This area will be submerged for significantly long periods of time over the year once the reservoir level is raised. So far no reforestation programs have been undertaken in and around the project area to safe guard this environment except a reforestation programme commenced by the Forest Department in the high ground between GW 13 & GW.15.

The borrow area is exposed to strong winds. There is evidence that iron production sites existed over 2000 years ago in the project area. Except for these iron production sites, there is no significant monument of archaeological or historical value.

It is understood that a reservoir reservation had been identified, though special care has not been taken to protect the immediate vicinity of the reservoir by the authorities.

4.6.2 Socio-economic conditions

There is no definite land use pattern in and around the borrow area, which is a part of the abandoned Kinchigune Village. Most of the remaining lands are derelict home gardens with coconut and other common species. But the acquired area is now becoming a natural forestry site with small scrub jungle conditions.

Small scale illicit gem mining is still going on even around the reservoir. People evacuated from the borrow area have been relocated and there is no human habitation in the borrow area. Families got land and compensation on resettlement. However some illicit gemmers, and cultivators are still present in the vicinity,

There is a existing balance between human habitat and nature in the immediate watershed of Samanala reservoir. The land in the immediate catchment of the reservoir has been acquired, and demarcation has been done using concrete posts planted every 100 m. Most of these have been removed by vandals. Growing suitable trees along the boundary is reommended. Until then there are some possibilities of encroaching these lands in the future. According to existing evidence the upper watershed of Samanala reservoir has deteriorated due to human intervention.

The existing situation of flora and fauna in the project area is well documented in previous reports. (Please refer to Reports by Environmental Consultants Ltd. (ECL - ODA), CECB, TEAMS and Wild Life and Nature Protection Society).

4.6.3 Archaeological Interests

Since 1988 an intensive archaeological survey and excavation project has been in operation in the Samanala Reservoir site funded by BBCIL and ODA and directed by Miss Gill Juleff. The project constitutes an archaeological rescue operation and forms part of the impact assessment for the Samanalawewa Hydro-Electric Scheme. The prime objective has been to locate and record all archaeological sites within the proposed reservoir, before they are lost by impounding of the reservoir. The field survey has been extended to cover an area approximately 12 km in diameter so that the sites can be fitted into a fuller picture of the surrounding archaeological landscape. The area had not been previously explored archaeologically and was considered to be of only marginal interest in terms of the early history of the island.

All the data collected during field work has now been synthesised into a three volume draft archive report, completed in March 1993. This archive will constitute the primary research tool for future work in the area. Once edited, the full archive report will be published by the Archeological Department as a special issue of its journal Ancient Ceylon. Syntheses of various aspects of the work will be subsequently published in specialist journals.

Intensive field survey over many months has located 252 sites of varying size and type. These comprise 79 prehistoric open air campsites, 33 small historic period settlements indicated by finds of pottery, and 139 sites relating to primary iron and steel production.

The latter category encompasses a 2000 year history of iron smelting, from the 2nd century BC to the early part of this century.

Within this span a diversity of technologies operated, reaching a zenith in the 7th - 10th centuries AD when industrial scale production was achieved using a previously unrecorded and unique wind powered smelting process. 77 sites of this era are situated on the extreme western edges of exposed hilltops and their furnaces are carefully designed to exploit the powerful westerly winds which blow across the area during the months of June, July and August. In addition to this west-facing iron smelting technology a very small number of crucible steel (better known as wootz, the raw material of Damascus swords) sites of more recent date have been located. Two fragments of crucible steel ingots have been collected and analysed. These fragments are the first recorded examples of crucible steel from Sri Lanka. Superseding the east facing smelting technology and contemporary with the crucible steel process another melting technology existed. This has been termed village iron smelting, as sites are situated close to villages in valley bottoms. Furnaces of this type, were bellows driven and the smelting process is well understood from 19th century documentation and the ethnographic records.

4.7 The Borrow area at Kinchigune

According to a topographic survey carried out 1.5 MCM of material is available in Kinchigune. However as the area already stripped is of a sizeable extent, the availability of the required 0.5 to 1 million cubic meters of specified materials should be confirmed by boring or pitting tests. Any intention of encroaching up slope from the limits of the present boundary of the clay pit, should be indicated and estimated. In such an event a slope conservation and management plan should be indicated which could be readily implemented and monitored.

It is also necessary to consider that in the event of the reservoir not filling, a rehabilitation and a management programme has to be developed for all stripped and disturbed areas that come within the reservoir limits.

The second alternative borrow site proposed is not favoured as it is in the area affected by leak. Therefore disturbance of slopes in the area, in addition to the high density bio mass that has to be stripped in this alternative site, cannot be recommended. The confirmation of the availability of required fill from Kinchigune site is most desirable. However availability of additional blanket material near Kinchigune at Pilipota across Belihul Oya has been identified.

4.8 Power Supply to the National Grid

Samanala Power Station is designed to operate with a rated head of 320 m and a maximum head of 331 m and 300 m minimum. The power output for all practical purposes is directly related to the head and the efficiency of the plant. Ideal conditions of operation are when the machines are under a head of 320 m.

Present restrictions of water level to 430 m El due to the leak results in reducing energy generation.

The value of energy lost due to this factor can be estimated at 74 Gwh annually, valued at Rs.296 million for thermal generation.

The loss in providing peaking capacity of 140 MW at unity power factor at full supply level and 240 MW after the future extension is equally important in maintaining proper voltage conditions in the transmission system. Other wise this loss of capacity at Samanala has to be met from other sources.

There is also a reduction in energy due to the need to supply irrigation demands downstream. The demand for water for cultivation is also expected to increase. Attempts have to be made to reduce the release for irrigation by adopting improved cultivation practices and other conservation measures to maximise the energy output from Samanalawewa.

Possibility exists to divert tail race releases to Katupath Oya (with pumping if necessary) to irrigate areas fed by the tail end of the Kaltota RB scheme; thereby reducing the releases of water from Samanala. This needs a detail study.

4.9 Irrigation requirement to Kaltota Scheme:

The Kaltota scheme has a command area of 1100 Ha and water is supplied to the scheme from the Uggal Kaltota anicut which intercepted 410 sq. kms. of the Walawe Ganga before the construction of Samanalawewa. However, since the construction of Samanalawewa, the Uggal Kaltota anicut receives water from a reduced catchment area of 68.0 sq. kms. below the Samanalawewa dam due to interception of 342 sq.kms by the dam.

By analysing 10 years of base flow in the river at Samanalawewa dam site from 1957 it was found that the minimum daily flow during this period was 3.5 cumecs at the dam site. Therefore any reduction of this quantity to the downstream users could be argued as a violation of riparian rights.

The requirement of irrigation water for the Kaltota scheme was estimated by the procedure recommended in the technical guideline No.24 of the Food and Agricultural Organisation(FAO). For this estimate, 30 year average rainfall at Ratnapura and other average climatic data such as wind velocity, humidity and temperature were used to determine irrigation requirements for paddy at Kaltota. **Table 4.9 (1)** shows the estimation of crop water requirements for long term paddy during the Maha cultivation and short term paddy during the Yala cultivation. The table also shows the average rainfall and effective rainfall at Ratnapura. From this, the theoretical water requirement at the Kaltota head works can be estimated for an average year on a monthly basis. However in order to estimate water releases from Samanalawewa, it is necessary to estimate the natural flow from the 68. sq.km. catchment above the anicut and water losses in between Samanalawewa dam and the anicut. These losses are due to evaporation and seepage along the river. In order to estimate the natural flow from 68. sq.kms of catchment, 256 sq.kms of the adjoining Weli Oya was current metered during the study and a flow rate of 4.72 cumecs. was estimated in mid May. From this, by taking the long term rain fall distribution of the area, the monthly contribution from the 68 sq.kms catchment was obtained using catchment ratios, as both catchments are hydrologically similar. Losses along the river below the Samanalawewa dam were estimated as 1.36 cumecs by carrying out several simultaneous measurements at the right bank and the left bank canal of the Kaltota scheme and the flow through the anicut. From the above observations **Table 4.9 (2)** was prepared to indicate the required releases from Samanalawewa. Detail calculations are given in the **Appendix** 4.9 (1). In this exercise a compromise between the present water use and the theoretical water requirement to the Kaltota scheme was made for the future on the assumption that the Rs.40,000,000 on-going rehabilitation programme under National Irrigation Rehabilitation will improve the performance of the irrigation system to a significant level and cut down the water waste by at least 50%. Based on this, **Fig 4.9 (1)** shows the outcome of **Table 4.9 (2)** graphically and it is evident from this figure that the present water release from Samanalawewa to the Kaltota irrigation scheme is 4.16 cu.mecs and planned water issue can be 2.99 cu.mecs for the month of May. Therefore it will be possible to reduce the water release by about 25%. It is also clear that maximum release will be in the month of February and it will be 3.47 cu.mecs.

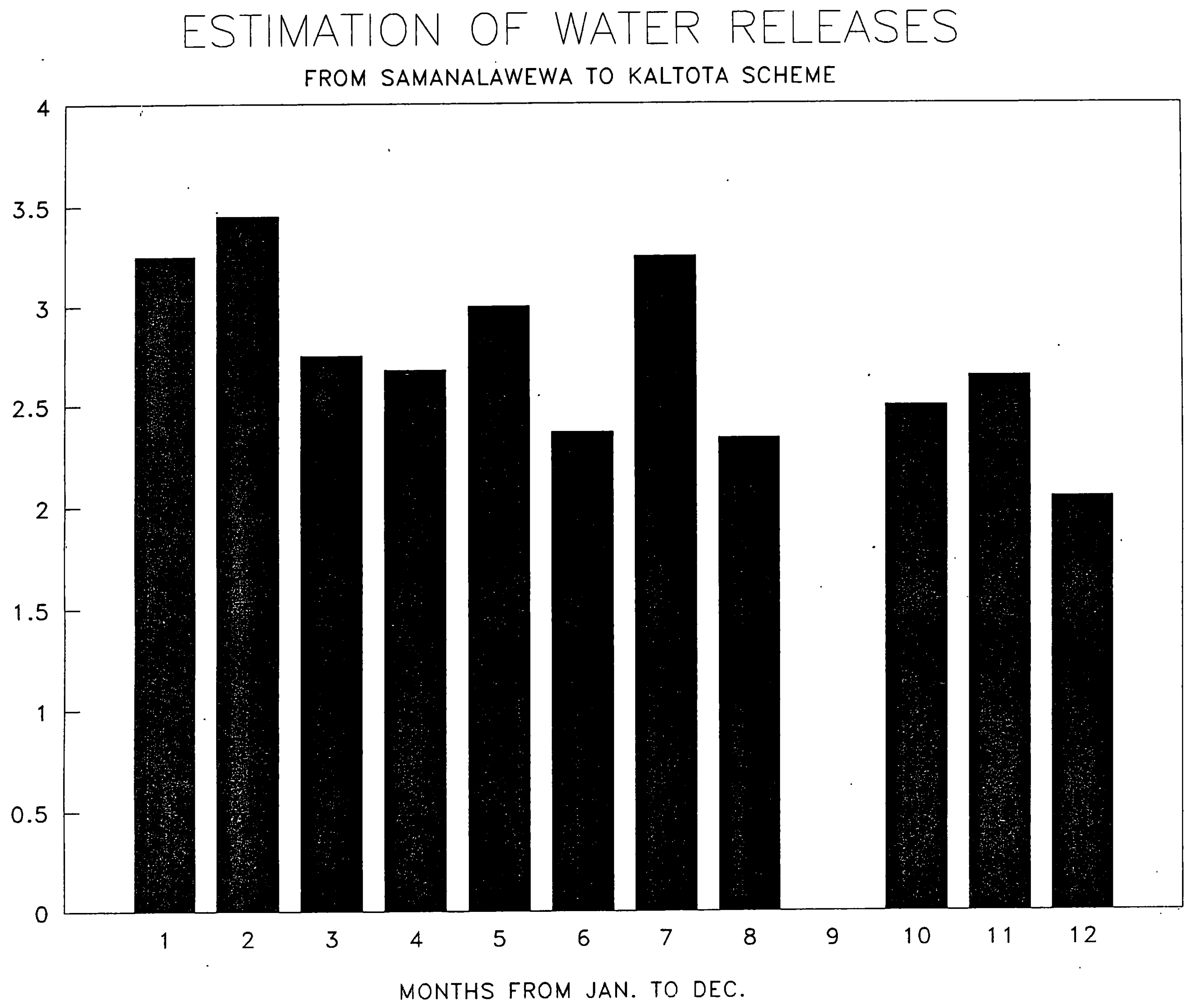

ESTIMATION OF WATER RELEASES
FROM SAMANALAWEWA TO KALTOTA SCHEME
DISCHARGE IN CU.MEC
0
0.5
1
1.5
2
2.5
3
3.5
4
1 2 3 4 5 6 7 8 9 10 11 12
MONTHS FROM JAN. TO DEC.

Fig. 4.9 (1)

TABLE - 4.9(1)

Rice Evapotranspiration and Irrigation Requirements

Climate: rat — Station: Ratnapura
Crop: PADDY (1) — Date of Transplant: 15 November

If P(m) < 230 mm then Effective Rainfall = .67 * P(m) - 17 mm (monthly values).
If P(m) > 230 mm then effective Rainfall = 0 * P(m) - 137. mm (monthly values).

Month	Decade	Stage	Area %	Coeff	ET crop mm/day	Perc. mm/dy	LPrep mm/dy	Rice Rq mm/day	EffRain mm/dec	IPReq mm/day	IRReq mm/dec.
Oct	2	N/L	0.18	1.18	0.67	1.1	3.6	5.3	4.0	4.92	24.6
Oct	3	LP	0.40	1.13	1.68	2.4	6.3	10.4	18.3	8.50	85.6
Nov	1	LP	0.70	1.07	3.29	4.2	5.4	12.9	32.0	9.70	97.0
Nov	2	L/A	0.93	1.02	4.55	5.6	2.7	12.8	42.2	8.58	85.8
Nov	3	A	1.00	1.00	4.43	6.0	0.0	10.4	45.7	5.87	58.7
Dec	1	A	1.00	1.00	3.89	6.0	0.0	9.9	47.0	5.19	51.9
Dec	2	A/B	1.00	1.01	3.55	6.0	0.0	9.6	47.7	4.79	47.9
Dec	3	B	1.00	1.04	3.85	6.0	0.0	9.8	41.0	5.75	57.5
Jan	1	B	1.00	1.08	4.22	6.0	0.0	10.2	32.3	6.99	69.9
Jan	2	B	1.00	1.11	4.54	6.0	0.0	10.5	25.6	7.98	79.6
Jan	3	B/C	1.00	1.14	5.04	6.0	0.0	11.0	26.7	8.37	83.7
Feb	1	C	1.00	1.15	5.47	6.0	0.0	11.5	27.2	8.76	87.6
Feb	2	C	1.00	1.15	5.87	6.0	0.0	11.9	28.0	9.07	90.7
Feb	3	C	1.00	1.15	5.96	6.0	0.0	12.0	33.9	8.58	85.8
Mar	1	C	1.00	1.15	6.13	6.0	0.0	12.1	41.1	8.02	80.2
Mar	2	D	1.00	1.09	5.93	4.5	0.0	10.4	47.7	5.66	56.6
Mar	3	D	1.00	0.96	5.00	2.3	0.0	7.3	47.0	2.55	25.5
Totals					738	854	180	1756	587		1169

Climate file : rat — **Climate Satation : Ratnapura**

	ETO (mm/day)	Rainfall (mm/month)	Eff. Rain (mm/month)
January	4.1	149.0	82.8
February	5.1	155.0	86.9
March	5.4	244.0	137.0
April	4.7	340.0	137.0
May	4.5	340.0	137.0
June	4.2	257.0	137.0
July	5.1	180.0	103.6
August	4.7	168.0	95.6
September	5.3	251.0	137.0
October	3.6	363.0	137.0
November	4.6	400.0	137.0
December	3.6	255.0	137.0
TOTAL Total	1663.5	3102.0	1464.8

Eff. Rain = 0.67 * P(tot) - 17 for P(tot) <230 mm/month
Eff. Rain = 0.00 * P(tot) + 137 for P(tot) >230 mm/month

Table 4.9(1) Contd...

Rice Evapotranspiration and Irrigation Requirements

Climate : rat
Crop : PADDY(s)
If P(m) < 230 mm then Effective Rainfall = .67 * P(m) - 17 mm (monthly values)
If P(m) > 230 mm then Effective Rainfall = 0 * P(m) - 137 mm (monthly values)

Station : Ratnapura
Date of Transplant : 15 May

Month	Decade	Stage	Area %	ETC crop Coeff	mm/day	Perc. mm/day	LPrep mm/day	RiceRq mm/day	EffRain mm/day	IRReq mm/day	IRReq mm/day
Apr	2	N/L	0.18	1.18	0.97	1.1	3.6	5.6	4.0	5.22	26.1
Apr	3	LP	0.40	1.13	2.10	2.4	6.3	10.8	18.3	8.97	89.7
May	1	LP	0.70	1.07	3.42	4.2	5.4	13.0	32.0	9.83	98.2
May	2	L/A	0.93	1.02	4.25	5.6	2.7	12.5	42.2	8.28	82.8
May	3	A	1.00	1.00	4.41	6.0	0.0	10.4	45.7	6.84	58.4
Jun	1	A/B	1.00	1.01	4.28	6.0	0.0	10.3	46.3	5.65	56.5
Jun	2	B	1.00	1.05	4.28	6.0	0.0	10.3	46.7	5.62	56.2
Jun	3	B	1.00	1.10	4.86	6.0	0.0	10.9	42.6	6.60	66.0
Jul	1	B/C	1.00	1.14	5.52	6.0	0.0	11.5	7.9	7.78	77.3
Jul	2	C	1.00	1.15	5.97	6.0	0.0	12.0	33.5	8.62	86.2
Jul	3	C	1.00	1.15	5.78	6.0	0.0	11.8	33.0	8.48	84.8
Aug	1	C/D	1.00	1.13	5.35	5.4	0.0	10.8	31.7	7.58	75.8
Aug	2	D	1.00	1.05	4.82	3.9	0.0	8.7	30.9	9.63	56.3
Aug	3	D	1.00	0.95	4.57	2.0	0.0	6.5	35.8	2.94	29.4
Totals					601	659	180	1424	481		944

Table 4.9 (2)

ESTIMATION OF WATER RELEASES FROM SAMANALAWEWA

Month	Monthly rain fall in mm	MAX daily Water Requirement at Kaltota in mm (Estimated)	Daily flow Rate m^3/s (Estimated)	Daily flow Rate Actual m^3/s	In flow from 68 SQ. Km m^3/s	Losses in the river m^3/s	Releases from Samanala wewa m^3/s
JUN	149	8.40	1.7	3.20	0.55	1.36	3.26
FEB	155	9.10	1.86	3.50	0.57	1.36	3.47
MAR	244	8.00	1.64	3.09	0.90	1.36	2.82
APR	340	8.97	1.82	3.43	1.25	1.36	2.73
MAY	340	7.82	2.00	3.77	1.25	1.36	2.99
JUN	257	6.60	1.34	2.53	0.94	1.36	2.35
JUL	180	8.62	1.76	3.32	0.66	1.36	3.24
AUG	168	5.63	1.14	2.15	0.62	1.36	2.38
SEP	251	0	0	0.0	0.92	1.36	0.44
OCT	363	8.56	1.74	3.30	1.33	1.36	2.55
NOV	400	9.76	1.98	3.73	1.47	1.36	2.74
DEC	255	5.75	1.16	2.19	0.94	1.36	2.09

5 ENVIRONMENTAL CONSEQUENCES

5.1 Methods of Leakage Mitigation

Several alternatives are possible to minimise the leakage at Samanalawewa. The most important of these are

a. Dry Blanketing
b. Deep grout curtain
c. Conversion to run of river project
d. Wet Blanketing by side dumping
e. Wet Blanketing by bottom dumping
f. Drainage control
g. No Blanket Scenario

The impacts of the No Blanket Scenario and the Drainage Control Scheme were discussed in Chapter 3. The environmental impacts of the remaining five are discussed below.

(a) Dry Blanketing

This has the advantage of achieving quality control but it needs complicated diversion works. This method requires extensive temporary works such as construction of two coffer dams across the Walawe arm on both sides of the ingress area; providing an additional long diversion tunnel upstream of the coffer dam; and re-opening one of the existing diversion tunnels to divert the river water Ref.Fig. 5.1 (1). Furthermore and as discussed in Chapter 3 effectiveness of this remedy could be evaluated only when the reservoir is filled again. If the dry blanket is not effective after the first laying of the blanket, the reservoir will have to be emptied again for repairing. If it fails again the operation would have to be repeated.

Power generation will have to be interrupted over the entire period of the works including re-applications of the dry blanket. In addition environmental damage is higher by this method, as reservoir has to be emptied for its execution.

(b) Deep grout curtain

A highly permeable ground has been confirmed far below the bottom of the existing grout curtain, exceeding more than 180 m below the existing grouting adits. Deepening the existing grout curtain will require construction of additional grouting adits at 100m below the existing grouting adits.

FIG. 5.1 (1)

REQUIREMENTS FOR DRY BLANKETING TO STOP SAMANALA WEWA SEEPAGE

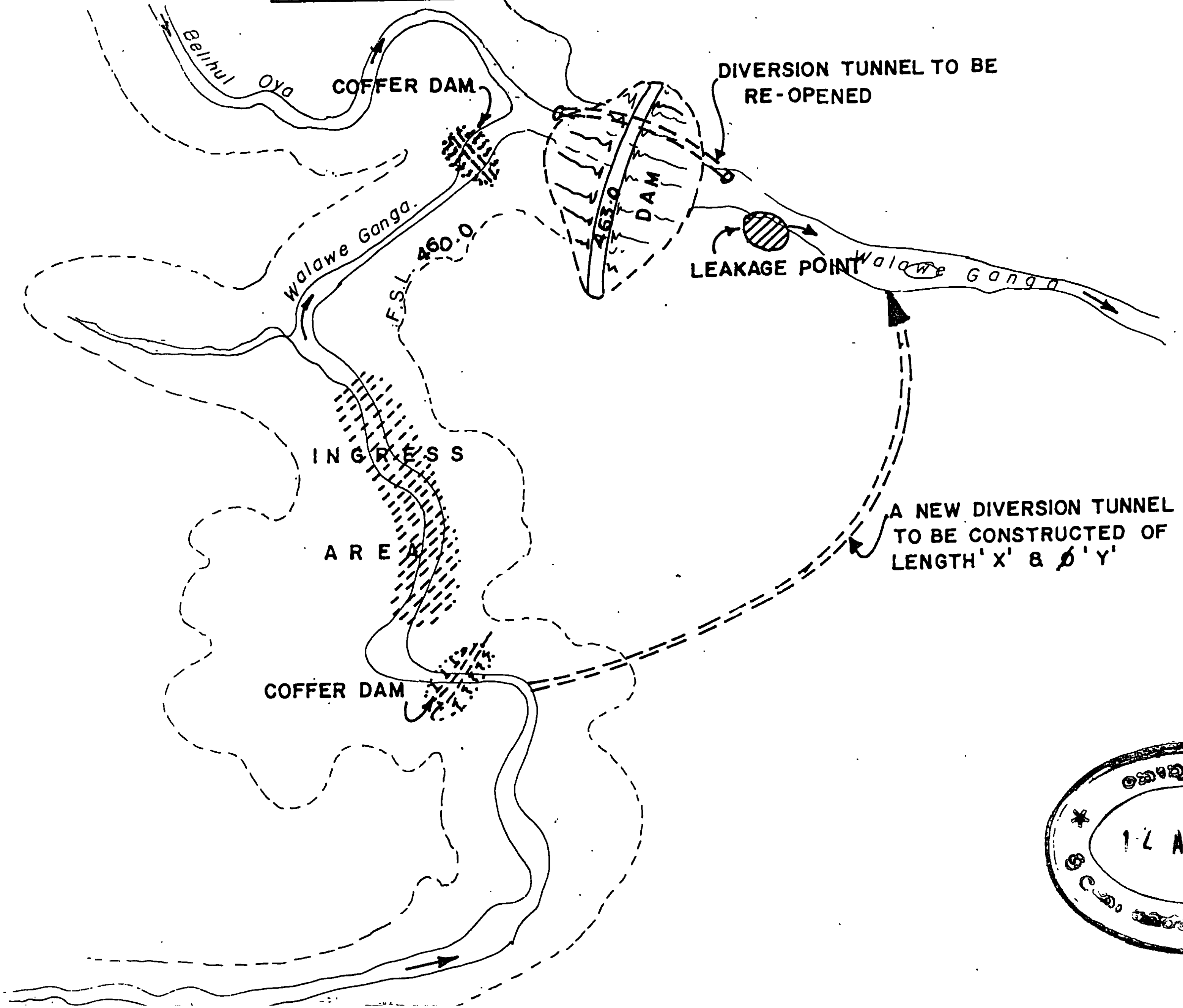


Fig 5.1 (1)

However, under high permeable ground conditions 100 m below the original river-bed, significantly large amounts of ground water will rush into the adits continuously, which will entail difficult construction works and incur prohibitive costs without certainty of any success.

(c) Conversion to Run of River

By constructing a second spill way the maximum reservoir water level will have to be controlled during floods, so that ground water level can be kept below 430 m. This will reduce the firm energy out put by 27% of the original scheme.

(d) Wet Blanketing

This method has flexibility of operation and is advantageous since the ingress area is already identified.

This is possible in 3 ways.

- dumping using dredger
- dumping using bottom dump barge
- side dumping using dump trucks

i The most advantageous merit of this method is that no stoppage of the power plant operation will be required for the remedial works.

ii Barge dumping activities are flexible in moving from location to location and in dumping materials at any reservoir water level, wherever and whenever required. Even if some ingress zones may exist on the steep slopes, though such instances are remote, by the combination of barge dumping and side-dumping using the available earth moving equipment on site, the natural blanket (weathered material) on the slopes can be thickened.

iii Effectiveness of the wet blanket can be assessed using the monitoring system already in place throughout the construction period. The system will also identify subordinate leakage paths if any, without interruption of power generation.

iv Detailed techniques to seal the water ingress area can be developed using the existing geotechnical knowledge to best suit the characteristics of the area and its working conditions. The experience obtained in other projects indicate: The technical reliability of wet blanketing in sealing the major ingress zones of a reservoir.

However, it may be possible that other zones of ingress exist beyond the anticipated major ingress zone, although this is considered a very remote case. Therefore, provision has been made for contingency work titled "follow-up blanket". This work could be carried out while impounding to level 460 m, without interupting power generation.

With effective sealing of the identified ingress points on the Walawe bed filling the reservoir to its full capacity can be undertaken with close monitoring for fresh seepages.

Although the general weathering profiles in Area A reach to depths of 20 to 30 m, of completely weathered material, moderately weathered rock extends 50 to 60m deep from the ground surface. The soil cover in some of the areas examined show not more than half to one metre, specially on the steeper slopes flanking the reservoir.

In Area B it has been observed by JVS that regardless of the ground surface elevation, moderate to slightly weathered rock reaches up to 380m El., below which level weathering characterised by iron staining is not observed.

It was observed by the team members on the 12.05.93 field visit that near the ingress area there is the occurrences of a peculiar iron stone formation. The exposed material contained cavities due to secondary alterations. Such areas need special attention. It is also to be noted that a loose specimen of "Ultra basic" rock that was collected from the same locality suggests deep hydro-thermal activity and/or tectonic activity.

The possibilities of infiltration on reservoir slopes at higher water levels could arise and therefore a detailed and close monitoring system during and after blanketing is recommended. See Chapter 7.

Aquatic Environment

All four activities referred to in section 4.5.3 may have significant negative impacts on the physical and chemical nature and on the biological composition of the aquatic environment at different magnitudes. The borrow area which is above 430 m msl will cause substantial erosion. The eroded material will increase particulate and suspended materials in the reservoir and subsequently in its downstream. Similar impacts will be possible due to surface transportation of the dump barges from Kinchigune area to the ingress area. Road construction from Kinchigune to the barge loading pier will not lead to substantive deposit of suspended and particulate matter to the reservoir and subsequently to the immediate downstream. The highest contribution of suspended and particulate materials will result from barge dumping of clay materials at the Ingress. In addition, suspended and particulate materials will substantially increase the bed load sediment content.

When the relatively high velocity and turbulent river waters enter the reservoir, slow currents will develop and coupled by barge movement and wind effects, barge dumped material will disperse and deposit throughout the reservoir. Part of these sediments may deposit in the dead storage volume proper and part in the channel and the valley bottom upstream, as a result of breakwater effects from the reservoir reducing velocities of river and flood plain flow. The coarser particles including the bed material load, settles out of the shoreline on the banks, which is named as the litter particles. The clay, especially, may move further into the reservoir or else may be retained in suspension.

Suspended and particulate materials will certainly increase the turbidity which decreases light penetration into the reservoir. Reduced light penetration will decrease photosynthetic activity and in turn the algal diversity and biomass. There may also be a possibility of increasing the algal biomass or eutrophication of dumping materials if they contain micro-nutrients and trace elements required by the planktonic algae. On the other hand, heavy metals and other toxic substances (eg. pesticides) can also be absorbed onto sediment and then transported and deposited along with it. However, there is no evidence that Kinchigune area (borrow area) is contaminated with either heavy metals or pesticides.

Some clay such as the montmorillonite group may react with dissolved salts producing early flocculation. In contrast, the kaolin clays may remain in suspension for a long period maintaining the turbidity throughout the entire reservoir. These suspended materials directly affect light penetration and the generation time needed for full development of the algal population. The high turbidity which will certainly result from clay dumping will in turn reduce the planktonic and fish population in the reservoir. Fertility of the reservoir also depends largely on the nutrient release through bacterial decomposition.

For many aquatic organisms including fish, the river channel bed is a substrata to use as a foothold, as a site for deposition or incubation of eggs, as a grit for grinding food or as a refuge from floods or to avoid predators. The stream bed surface is rich in organic matter trapped in the fits between grains which provide nutrients for organisms near the base of the food chain. Below the surface, the hyporheic zone forms an interface between the stream and the groundwater system. This region can be extremely active biologically. In addition, the particle size spectrum of the stream sediment is one of the physical habitat factors which determines the density and diversity of the stream benthos, one of the most important ecological components of the riverine eco-system.

Any excessive fines will certainly wash into the downstream ,through both leakage out-fall and the irrigation outlet during the process of barge dumping. These materials can form a mat on the top of the coarser bed materials. Fines can also work down between the coarser grain to form a type of "hard pan" layer. In-filling of gravel with fine sediments can reduce the inter-gravel flow rate, suffocate eggs, limit borrowing activity and trap emerging young. The gravel bed stream which becomes silt may show shifting in the macro-invertebrate species composition which in turn can affect the fish species composition and density as well.

The transport of particulate matter is both bane and beneficial to aquatic organisms. Organic particulate matter is a source of food for downstream organisms. However, when the flow quickens the large grains can be deadly projectiles. Fine silt and clay clog gills like a particulate smog and reduces the light needed for photosynthesis and periphyton production and interferes with foraging success of visual and filter-feeders. Accordingly, the abundance of riverine fish, both endemic and indigenous may decrease significantly as a result of clay dumping. The aquatic vegetation such as the algal mat and macrophytes will affect the bed-stability during high-flow. Therefore, movement of sediment resulting from clay dumping will have different effects on different species.

Attention is invited to **Table 5.1 (1)** matrix table showing potential impacts on aquatic life **Figure 5.1 (1)** for environmental impacts of clay extraction and wet blanketing.

5.2 Borrow Area

The borrow area for wet blanket is the same as the area that provided clay for the impervious core of the Main Samanala Dam. The area in plan is about one kilometre in length and 0.2 km in width. The elevation of the borrow area which is fairly flat with a couple of mounds left to indicate the original height is at an elevation of about 435m above sea level. The volume of spoil that can be obtained from this area is estimated at 1.5 MCM.

The volume of material needed for the wet blanketing is 500,000 m^3 for the 10 metre depth of blanket and 1 MCM for a thicker blanket.

Since reservoir water level could be lowered to say 425 El without affecting seriously the power produced, a further 2.5 MCM of material can be made available.

Alternative borrow area is located on the Right Bank on the steep reservoir side which is under forest cover at present. If this area is to be exploited it will remove some virgin forest and expose, the sides to serious erosion, that may even trigger slides from hillsides, which can cause serious dangers to the reservoir safety.

Further, as the area suggested straddles the pervious zone at 380m elevation it may not be prudent to reduce the overburden by borrowing due to risk of destabilising the area. The proposed alternative area is not recommended for borrowing blanket material.

The proposed activity would not create any additional environmental disruption as the borrow area is already
environmentally a disturbed area. Riverine vegetation, soil and fauna has been disturbed in borrow area etc.

MATRIX TABLE SHOWING POTENTIAL IMPACTS ON AQUATIC LIFE

Ecosystem	Project Activity Impact	EB	TB	BD	CR
Reservoir	Fauna				
	Benthic				
	Pelagic			+	
	Littoral	+		+	
	Flora				
	Benthic			+	
	Littoral	+		+	
	Plankton		+	+	
Downstream	Fauna				
	Benthic			+	
	Fish			+	
	Hypo-rehiec			+	
	Flora				
	Epilithic			+	
	Macrophytes			+	

EB = Extraction of Blanketing material

TB = Transportation of Blanketing material

BD = Barge dumping of Blanketing material

CR = Construction of Roads

POTENTIAL ENVIRONMENTAL IMPACTS OF CLAY EXTRACTION AND WET BLANKETING

Ecological

Terrestrial
- Forest
- Wildlife
- Biodiversity
- Endemic species

Aquatic
- Icthyofauna
- Eutrophication
- Aquatic benthos
- Aquatic weeds
- Biodiversity
- Endemic species

Physico-chemical

Land
- Soil erosion
- Soil fertility
- Bank stability
- Sedimentation
- Seismicity

Surface Water
- Flow variation
- Turbidity
- BOD
- Salinity intrusion
- Eutrophication

Ground Water
- Water table
- Reservoir leakage

Atmosphere
- Climatic changes
- Air quality

Human Interests

Health
- Parasitic diseases
- Public sanitation
- Nutrients

Socio-economic
- Crop production
- Power supply
- Irrigation
- Flood control
- Resettlement
- Highway relocation

Aesthetic & Cultural
- Archaeological resources
- Water quality
- Recreation
- Landscape

When the reservoir level is raised, borrow area will be submerged. Its duration will depend on inflow to the reservoir and the outflow through power generation and irrigation releases and the leakage loss. Impacts will depend on this time factor.

Although the impacts on terrestrial fauna were not identified from the beginning of the project, several amphibian and reptile species may have been already lost.

There are no agricultural activities in the borrow area and there is no fear of pesticide contamination into the reservoir water.

Existing illegal gem mining will affect reservoir sedimentation in the long-term. The possibility of earth slips would be high due to this process.

The blanket material is graded gravel, sand and clay, which are liable to introduce various substances into the reservoir water and could affect the quality of the latter.

The quality of the reservoir water and water in the area close by and down stream is expected to change slightly. Since the water is used for human consumption, and irrigation purposes, the quality of the water should be monitored carefully to avoid the water parameters reaching the prescribed limits by SLS for potable water.

Waste water, sewage and other waste materials discharged by the occupants of the project camps could contaminate the water resource.

Air pollution (sound and dust) would occur due to heavy wind during the operation phase of proposed activities.

If earth removal goes up to the boundary of acquired land, the possibilities of soil erosion will be high on the slopes of the borrow area.

Transport by barge: Oil spillages and other oil discharges from barges could seriously affect the aquatic life.

The <u>social impacts</u> by the proposed activities can be :-

Employment opportunity which will be minimal during the operation phase as only skilled operators will be needed.

Road improvements in the area will be beneficial for the settlers outside the reservoir margins.

Table 5.2 (1) Environmental Impact of Clay Extraction from borrow area

[Socio - Economic Aspects]

Features likely to be affected	PROPOSED ACTIVITIES							
	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Infrastructure development	+4p	+3t			+4p	+1t		
Villagers income	+2p				+2p	+2t		
Facilities improvements	+4p	+3t			+4p	+3t		
Reservoir periphery		-1t	-2t			-2t		
Employment safety			-1t	-1t			+4t	-3t
Social, cultural effects	+2p	+2t		+2p	+2p			
Reservoir sedimentation	-2p	-2t	-1t	+4p		-2t		-1t

Likely effect is symbolized as follows:

	Mild	Considerable	High	Very high	
Beneficial	+1	+2	+3	+4	Temporary = t
Detrimental	-1	-2	-3	-4	Permanent = p

1.1 Construction & improvements of roads.
1.2 Construction of temporary roads
1.3 Delivery of earth materials by barges
1.4 Installation of silt protection curtains
1.5 Provision of new power - supply line from Pambahina camp to Kinchigune along the existing village road.
1.6 Construction of temporary buildings such as site office, laboratory etc.
1.7 Temporary electricity line for night shift works and camp at the borrow area.
1.8 Construction of temporary crushing plant and batching plant.

5.3 Benefit Cost Analysis - Energy Options

The energy potential of Samanalawewa Hydro Electric Plant and its impact are analysed here with and without remedial measures for the CEB's long term generating system expansion programme. The benefits of wet blanketing, which is proposed to be carried out to eliminate leakage from the reservoir, have been evaluated by analysing the following cases.

Case 1. Present status of Samanalawewa was assumed as the Base Case scenario with $2m^3/s$ water leak from the reservoir and the maximum operating level of reservoir to be 424 m El.

Case 2. Originally planned Samanalawewa scheme was assumed with maximum operating level as 460 m El without water leakage.

Case 3. Without Samanalawewa scheme.

In order to evaluate the energy potential of the hydro power plants, simulation of system operation studies using SYSIM [1]) Reference computer programme was carried out. The computer model SYSIM is designed to optimise the combined operation of the existing and committed generating system to provide pre-defined reliabilities of irrigation & electricity supplies at the minimum cost and to investigate the potential role of new hydro projects in a system context. The main output of the model is monthly energy from respective hydro power plants.

5.3.1 System Operation Analysis Procedure

During the Masterplan Study [2]), the SYSIM simulation program was developed to model the operation of Sri Lanka's existing and prospective future integrated electricity and irrigation supply system.

The program aims to minimise the operating cost by maximising hydroelectric output to meet the demand as far as possible and operating the thermal plants in merit order to supply the balance of demand.

- Based on the simulated total system storage at the start of the month, the applicable system operating regime, and hence the thermal plants to be scheduled for operation, are determined.

- The irrigation and hydro-electric demands for the month are established,

- An iterative search is made to determine the reservoir release necessary for the water resource system to meet, if possible, the imposed irrigation and power generation demands.

- A load dispatch simulation is carried out to determine the maximum usage of the hydro plant outputs plus any necessary thermal contributions and associated operating costs.

- The results, including the extent to which the demands have been met, are accumulated, and the calculation proceeds to the next month.

5.3.2 Data and assumptions for analysis

In order to evaluate the energy potential of the Samanalawewa Hydro Power Scheme, integrated system operation simulation studies were carried out with Samanalawewa scheme as described above in Case 1 and Case 2.

Basic data used are similar to the 1993 generation expansion planning study [3]. Results of the system operation simulation studies are tabulated below.

	Average Energy (GWh/a)	Minimum Energy (GWh/a)	Maximum Energy (GWh/a)
Samanalawewa ROR FSL=424 masl	288	146	392
Samanalawewa FSL=460 masl	362	221	488

From the above analysis, it can be seen that the present average energy potential of the project is 288 GWh/a. After the completion of the remedial measures, the average energy potential will increase to 362 GWh/a, which is an increase of 74 GWh/a. The annual energy potential of the above two cases are shown graphically in **Figure 5.3.2 (1)** From the graph it could be seen that the contribution of Samanalawewa full reservoir scheme during the low rainfall years (1982/83 and 1986/87) is much higher than the ROR scheme for the corresponding years. This is due to the regulation effect of the storage. Furthermore, the average monthly energy variation is also shown in **Figure 5.3.2 (2)** which clearly illustrates the flexible operation of Samanalawewa with full storage especially during the period November to April.

5.3.3 System Expansion Analysis Procedure

For the system expansion analysis, Generation Planning Branch of CEB [4]) has carried out optimum expansion studies using the micro computer version WASP III for the period of 1995 to 2014 on a monthly time step.

The WASP III program is designed to find the economically optimal generation expansion policy for an electric generating system within user-specified constraints. It utilizes probabilistic estimation of system production costs, unserved energy costs and reliability. The optimum generation mix to meet the demand for power and energy in a particular study period is evaluated using dynamic programming techniques for comparing the costs of alternative system expansion policies.

The program can consider 12 types of thermal plants and hydro plants in two categories as candidates to meet the demand for power and energy. The hydrological information used to describe the energy capabilities of existing and candidate hydro plants have been developed by the reservoir operation simulation model SYSIM.

The analysis and optimization are based on discounted costs of the total system expansion. Both operating costs and investments for the existing and candidate plants are considered. A penalty is imposed on any amount of electricity that the system may be unable to serve and this cost is also added to the total cost. At the end of the planning horizon, a salvage value for plants is also considered in the cost function.

FIG. 5·3 2(1)

Samanalawewa Hydro Project

(Average Annual Energy)

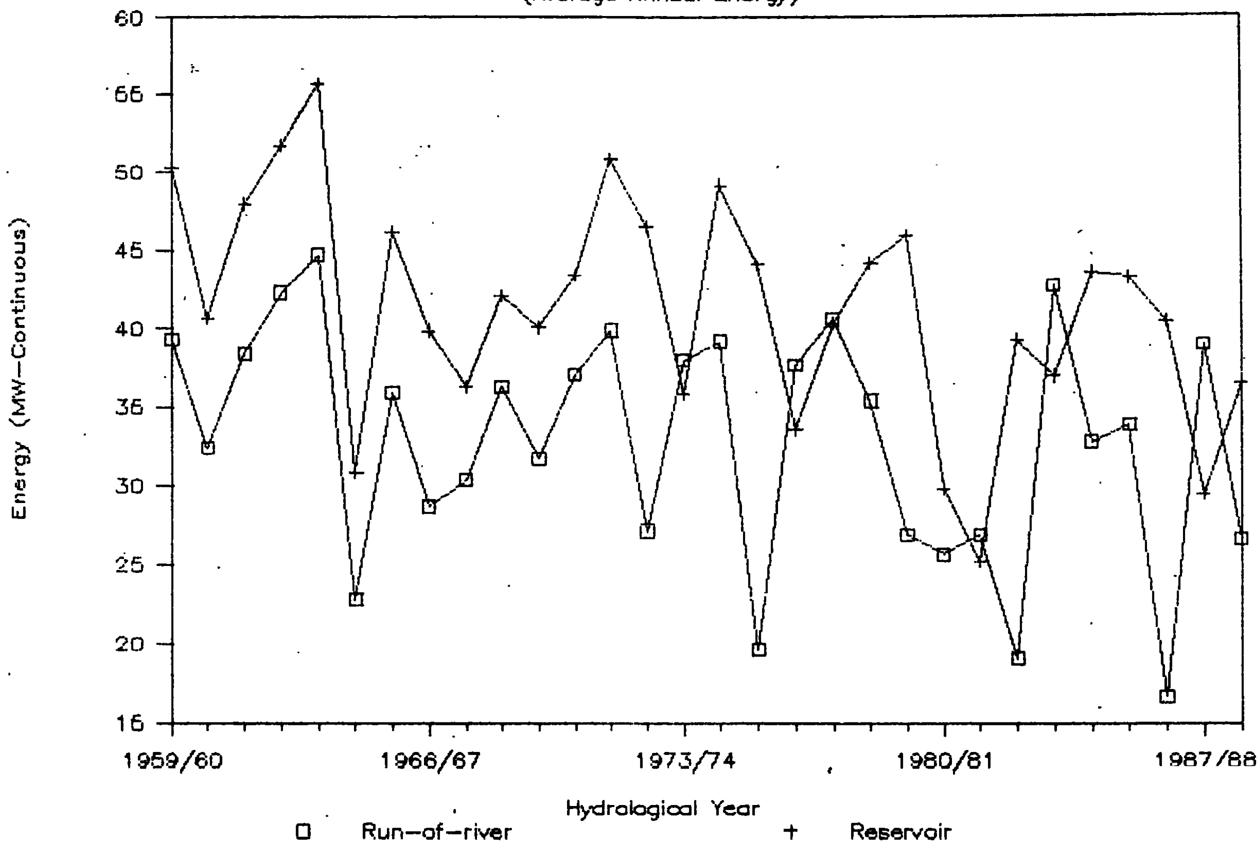
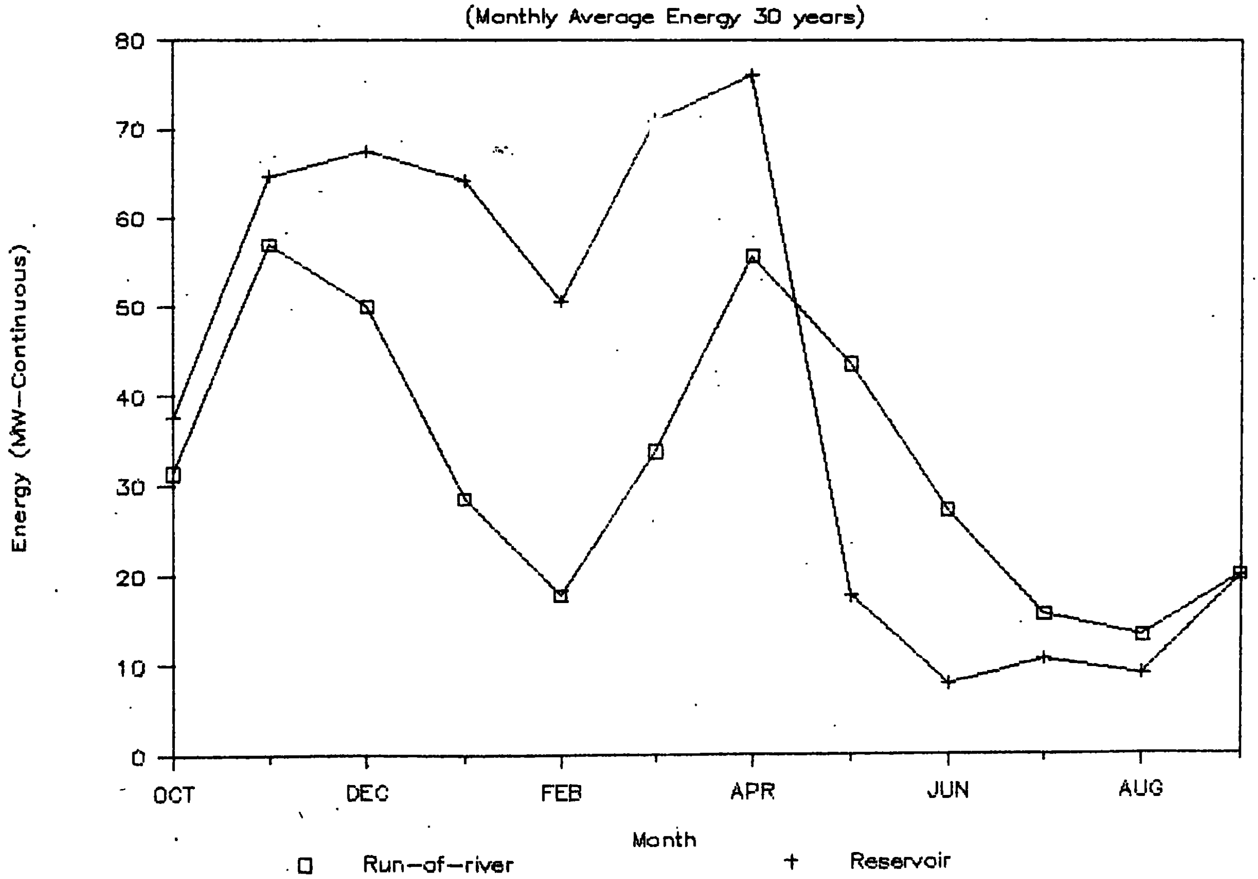


FIG. 5·3 2(2)

Samanalawewa Hydro Project

(Monthly Average Energy 30 years)



The objective cost function which has been optimized in the study using the WASP methodology is :

B = I-S+F+M+O

Where

B	=	net present value (NPV) of total costs of the expansion plan
I	=	discounted capital investment costs
S	=	discounted salvage value of investments
F	=	discounted fuel costs
M	=	discounted operation and maintenance costs
O	=	discounted outage (unserved energy) costs

The following alternative development plans were simulated using WASP III to calculate the effect of Samanalawewa HEP on the generation expansion programme of the CEB.

1. Base Case 1993, which includes the present Samanalawewa HEP with FSL of 424 masl and 2 m3/s leak from the reservoir.

2. With Samanalawewa full reservoir in operation from 1996.

3. Without Samanalawewa hydro power plant.

The results of the system expansion studies are given in **Tables 5.3.3 (1 - 3)**. The summary of total Present Value cost and the difference in PV cost compared to the Base Case are summarised below.

	Total PV Cost (Mill US$)	Difference (Mill US$)	Additional Capital Cost required (Mill. US$)
Base Case	1598.2	-	40
Samanalawewa FSL=460 masl	1586.6	-11.6	50
Without Samanalawewa	1806.0	208.4	-

Table - 5.3.3 (1)

Results of Generation Expansion Planning Studies 1993 - BASE CASE

YEAR	HYDRO ADDITIONS	THERMAL ADDITIONS	THERMAL REQUIREMENTS	LOLP %
1994	-	-	-	5.678
1995	-	-	-	8.182
1996	-	Gas Turbine 66 MW Diesel 40 MW (Ext.)	-	4.444
1997	-	Diesel 110 MW	-	0.726
1998	-	Diesel 40 MW	-	1.794
1999	Kukule 70 MW	-	-	3.302
2000	Upper Kotmale 123 MW	-	-	3.025
2001	-	Coal Trinco Unit 1 150 MW	KPS Oil Steam 2*22 MW	1.890
2002	-	Coal Trinco Unit 2 150 MW	Gas Turbine 3*18 MW (for refurbishment)	1.659
2003	-	Refurbished GT 3*20 MW	Gas Turbine 3*18 MW (for refurbishment)	4.698
2004	-	Refurbished GT 3*20 MW Coal Trinco Unit 1 300 MW	Sapu Diesel 2*16 MW	0.418
2005	-	-	-	1.814
2006	Ging Ganga 49 MW	Gas Turbine 22 MW	-	4.045
2007	-	Coal Trinco Unit 2 300 MW	-	1.069
2008	-	Gas Turbine 66 MW	Sapu Diesel 2*16 MW	3.253
Total PV Cost upto 2013		1598.2 million US$ (76,711.9 million Rs)		

Table - 5.3.3 (2)

Results of Generation Expansion Planning Studies 1993 - BASE CASE
with Samanalawewa full Storage from 1996

YEAR	HYDRO ADDITIONS	THERMAL ADDITIONS	THERMAL RETIRMENTS	LOLP %
1994	-	-	-	5.678
1995	-	-	-	8.182
1996	-	Gas Turbine 44 MW Diesel 40 MW (Ext.)	-	2.037
1997	-	Diesel 90 MW	-	0.623
1998	-	Diesel 60 MW	-	0.560
1999	Kukule 70 MW	-	-	1.604
2000	Upper Kotmale 123 MW	Gas Turbine 66 MW	-	2.682
2001	-	Coal Trinco Unit 1 150 MW	KPS Oil Steam 2*22 MW	1.393
2002	-	Gas Turbine 22 MW	Gas Turbine 3*18 MW (for refurbishment)	6.462
2003	-	Coal Trinco Unit 2 150 MW Refurbished GT 3*20 mw	Gas Turbine 3*18 MW (for refurbishment)	3.616
2004	-	Coal Trinco Unit 1 300 MW Refurbished GT 3*20 MW	Sapu Diesel 2*16 MW	0.073
2005	-	-	-	0.704
2006	-	-	-	4.709
2007	-	Coal Trinco Unit 2 300 MW	-	1.346
2008	Ging Ganga 49 MW	Gas Turbine 66 MW	Sapu Diesel 2*16 MW	3.166
Total PV Cost upto 2013	1586.6 million US$ (76,158.6 million Rs.)			

Results of Generation Expansion
Planning Studies 1993 - BASE CASE without Samanalawewa

YEAR	HYDRO ADDITIONS	THERMAL ADDITIONS	THERMAL REQUIREMENTS	LOLP %
1994	-	-	-	6.845
1995	-	-	-	13.979
1996	-	Gas Turbine 88 MW Diesel 40 MW (Ext.)	-	3.242
1997	-	Diesel 120 MW	-	0.748
1998	-	Diesel 30 MW	-	1.554
1999	Kukule 70 MW	-	-	2.511
2000	Upper Kotmale 123 MW	Gas Turbine 132 MW	-	3.765
2001	-	Coal Trinco Unit 1 150 MW	KPS Oil Steam 2*22 MW	3.086
2002	-	Coal Trinco Unit 2 150 MW	Gas Turbine 3*18 MW (for refurbishment)	2.797
2003	-	Refurbished GT 3*20 MW	Gas Turbine 3*18 MW (for refurbishment)	5.943
2004	-	Refurbished GT 3*20 MW Coal Trinco Unit 1 300 MW	Sapu Diesel 2*16 MW	0.865
2005	-	-	-	3.501
2006	-	Coal Trinco Unit 2 300 MW	-	0.572
2007	-	-	-	3.583
2008	Gin Ganga 49 MW Belihul Oya 70 MW	Gas Turbine 22 MW Combined Cycle 68 MW	Sapu Diesel 2*16 MW	3.924
	Total PV Cost upto 2013	1806.0 million US$ (86,588) million Rs.)		

The results in the above table only indicate that the present value of economic benefits of the Samanalawewa having full storage in US$ 11.6 million when compared with the present method of operation in ROR mode which has an inherent risk element without a second spillway. On the other hand if Samanalawewa becomes totally non operational due to another water burst, which is likely, it would cost 208.4 US$ million to supply its present capabilities with alternate plants.

The above costs are purely the replacement costs or benefits in the system and do not include any cost of rehabilitation or securing the reservoir.

The second spill way for securing the project is estimated to cost US$ 40 million while rehabilitation of the reservoir by blanketing is estimated to cost US$ 50 million.

The total investment requirement, and the operation and maintenance cost for the next 10 years of power generating system expansion is shown in **Figures 5.3.3 (1)** and **5.3.3 (2)** respectively.

From the above results it could be seen that the operation and maintenance cost for the scenario without Samanalawewa is very high compared to the other two cases. Investment cost for this case is also high especially in the immediate future.

The summary of hydro-thermal dispatch schedules for the next 10 years for various hydro conditions are also given in **Appendix 5.3.3.(1).**

The above analysis is based on a load forecast of a modest annual average growth rate if about 8.3% carried out in 1993.
According to the recent review of the load forecast a much greater growth rate of approximately 10% is anticipated for the next 15 years.

The assumptions made for thermal plant availability are under reconsideration in the latest planning studies being carried out.

Due to slippage in the implementation of the thermal plants, in order to tide over the expected energy situation, Board has called for offers for the following alternative plants.

a. 40 MW diesel plant on BOO basis for 1996
b. 150 MW combined cycle plant for 1995 and 1977
c. 2 x 20 MW small diesel plant for 1996

FIG. 5·3 3(1)

COMPARISON OF INVESTMENT COST

(SAMANALAWEWA EIA STUDY)

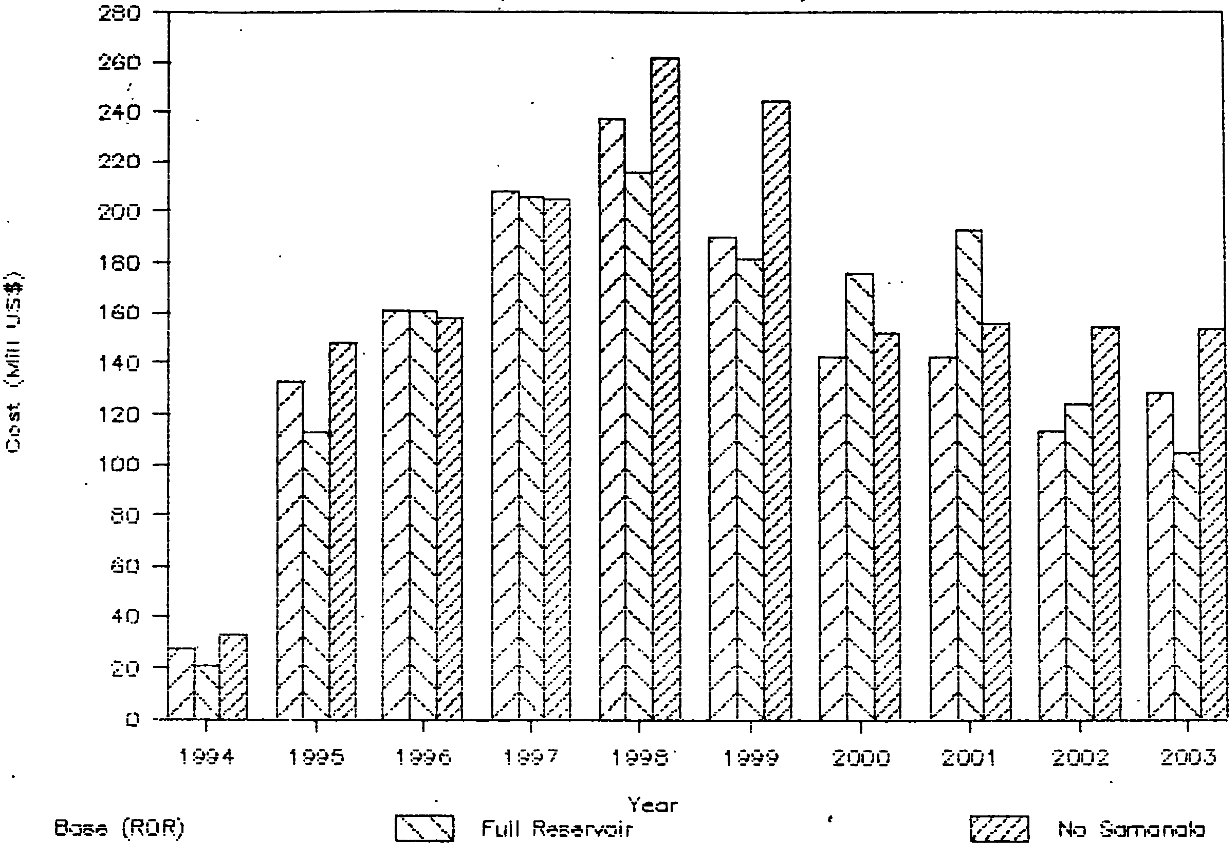
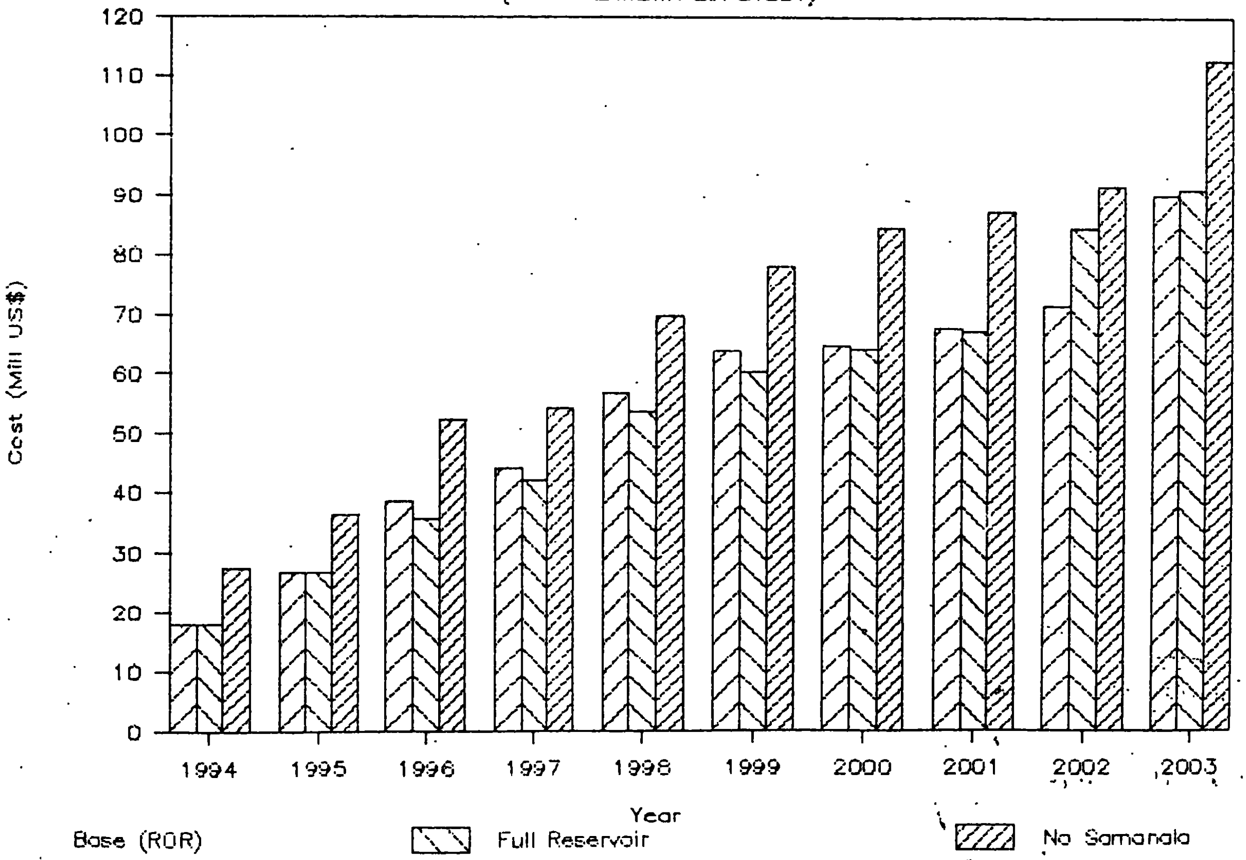


FIG. 5:3 3(2)

COMPARISON OF OPERATION COST

(SAMANALAWEWA EIA STUDY)



Though these variations will not affect the relative benefits of the alternative development plans remedial works to restore the full Samanalawewa is to be favoured considering the safety of the scheme, need to allay the public fear, flexibility of the power system operation etc.

5.4 Cost Analysis of Main Blanket for Different Alternatives

i. Wet Blanketing

Material Requirement 500,000 m^3

		Rs million
Provision of Barges & other Boats	=	437.69
Construction of Access Road	=	57.12
Construction of Silt Protection	=	67.20
Construction of Dock Yard	=	28.10
Construction of Loading Facility	=	53.05
Development of Borrow Area	=	17.40
Collection of Dumping Materials	=	287.50
Dumping of Blanket Material	=	180.40
	Total	1128.46

ii. **Side Dumping**

Material Requirement 3,200,000 m^3

Haul Distance 9 kms [As alternative Borrow area is ruled out blanket material has to be taken from Kinchigune Borrow Area]

		Rs million
Construction of Access Road	=	68.5
Construction of Silt Protection	=	67.2
Development of Borrow Area	=	17.4
Collection of Dumping Material [Rs. 63.0/m^3]	=	201.6
Haul of Blanket Material [Rs. 24.0/m^3/km]	=	691.2
Maintenance of Access Road [500 Working Days]	=	6.3
	Total	1052.2

iii. **With Suction Dredger**

Construction of Access Road	=	57.12
Construction of Silt Protection	=	67.20
Construction of Dock Yard	=	28.10
Development of Borrow Area	=	17.40
Collection of Dumping Material	=	287.50
Pumping of Blanket Material [Rs 750/m^3]	=	225.00
Provision of Dredger, Booster Pumps & Pipe line	=	450.00
	Total	1132.32

Reference

[1] System Simulation (SYSIM) model was developed during the Masterplan study.

[2] Masterplan for the Electricity Supply of Sri Lanka, Main Report, June 1989.

[3] Report on Long Term Generation Expansion Planning studies 1994-2008, August 1993, Generation Planning Branch, Ceylon Electricity Board, Colombo.

[4] Document No. GP/CE/SMNL dated 23rd March 1994 by Chief Engineer (Generation Planning) to Project Director, Samanalawewa HEP.

6 MEASURES TO MITIGATE ADVERSE ENVIRONMENTAL IMPACTS

6.1 Clay Blanket Material

The borrow material should be investigated for its solubility in reservoir water samples and the degree of contamination should also be assessed. Material which is found to contaminate the water severely should be excluded for blanketing.

6.2 Wastes

i. Preliminary testing on the solubility of soil would indicate the suitability of soil in a particular area. However when the land is excavated deeply, the quality of the soil may deteriorate. If the soil is found to introduce toxic contaminants in water, it should be excluded for dumping.

ii. Domestic wastes produced by the project staff should be collected daily and disposed by suitable means without causing any pollution to the water resources.

iii. Oil waste should be collected in barrels or suitable vessels and should be disposed without reaching the reservoir.

6.3 Operation

i. Weekly analysis of BOD, COD and total inorganic nitrogen levels of samples taken in the reservoir water, down stream and RB area should be carried out and if abnormal values are obtained, the cause is investigated and the quality of dumping material is checked up.

ii. Temperature measurements are carried out at the bottom and surface of the reservoir during dumping operation.

6.4 Water

i. Weekly analysis of all parameters in RB, LB reservoir water, river and underground water should be carried out to study the effect and contamination of clay blanketing.

ii. The dumping area should be isolated from the other portions of the reservoir by a special kind of silt protection curtain so that the suspended matter arising due to clay blanketing does not spread out and reach the intake.

iii. The quality of the down stream water should be monitored carefully to ensure that the water is safe for human consumption and for irrigation purposes.

6.5 Power Station Coolers

i. In the operation of the power house the coolers for bearings of the turbines have been subject to clogging by a form of "fungus" necessitating weekly cleaning. With clay blanketing this slimy growth can increase and should be kept under surveillance.

6.6 Fauna & Flora

i. Although recommended action will not create significant adverse impacts for existing fauna and flora, this is an opportunity to protect and improve the existing environmental conditions. Attention should be paid to the environmental protection measures proposed and consideration given to the following,

- Declaration of proposed Samanalawewa National park, and define boundaries.

- Areas around the reservoir at of least 1 km from full supply level in the immediate catchment should be maintained as reservation wherever possible.

  In areas where this is not possible, distance of at least 5 metres from bund top level elevation should be reserved.

- To prevent future soil erosion outside reservation around the project area, land use pattern of the nearby villages has to be improved using Sloping Agricultural Land Techniques (SALT) or any other method.

- Water has to be sprayed during operation period to prevent air pollution (dust). These operation methods should be environmentally friendly.

- Safety measures have to be provided at the site.

6.7 Slope Stability

It is proposed to use the previous access road to Kinchigune borrow area from dam, (used during the dam construction) by constructing necessary detours where the access road is inundated. This access road lies on steep slopes and at several places, slopes below the road have collapsed. Conservation measures are suggested to arrest further deterioration.

The camp site for Wet Blanketing Project with crushing plant, loading platform and other temporary facilities for construction are proposed to be located in and around Kinchigune borrow area which has a mild sloping terrain. It is noted that a good part of the access road is below El 460 m. The section below el 430 m now inundated and has to be raised above 430 m.

Earth has to be excavated in the borrow area in a manner that the bottom of the borrow area has a mild slope towards river, to prevent water ponding up during a draw down of reservoir.

Right bank side of the Walawe River at ingress area has a steep slope and at a few places cracks have appeared on the slope. During the rainy season, slope can collapse at these places. This will reduce the stability of slope, creating possibility for larger earth slips running to the top of slope. To prevent this occurring, earth at this slope has to be reinforced by appropriate methods and a reforestation programme with suitable varieties of plants or even anchoring and guniting steep slopes needs early consideration.

7. PROPOSED MONITORING PROGRAMME

7.1 Present Seepage Points

i. The monitoring programme carried out now, needs to be intensified with wet blanket operation. Additional test wells for piezometric measurements or ground water table data are thought necessary on both sides of grouting adit. Possible location between RB S 10 and Y 4 to the South West of RB S 10 and one to the NE. These 2 wells should monitor levels up to El 400 m.

ii. Start monitoring bore hole Y 3 which is below full supply level of 460 m as it is closest to ingress area. If this bore hole has been vandalized, a fresh hole is thought desirable.

iii Similarly, bore hole GW 8 should be re-activated if vandalized. These bore holes located on the fault zone can yield useful data during wet blanket operation.

iv All seepage points already surveyed should be marked in plans with the 3 coordinates, the third coordinate to denote elevation above mean sea level. New seepages if appearing should also be surveyed and marked in plan with the 3 coordinates.

v. Continue monitoring daily flows by vee notch or weir.

vi. Daily record of temperatures of seepage water, with wet blanket operation should be maintained.

vii. Daily, record electrical conductivity with wet blanketing. This is now done at 34 points and should be continued.

viii Water chemical analysis (anion-cation) now being done should be continued for all seepage points now monitored and any new points that can arise on impounding above 430 m elevation.

ix All seepage points related to Samanala reservoir should be shown on a plan. The area should cover a distance 1 km downstream of full supply level of 460 m elevation and include the 2 saddle areas containing the faults F_1 and F_2.

x **Seepage measuring weir**
As constructed it lies on the trajectory of the spill way and will get washed off in the event of water shooting down the spill bucket.
It is considered necessary to build the weir further upstream as this weir may have to be used for a period of 1 - 5 years depending on success of wet blanket in reducing the flow through the seepage burst.

xi **Seepage to area B**
Area B has shown erratic ground water table behaviour during impounding and also at subsequent burst. This area needs close scrutiny.

Since aquifer flow is extremely slow it needs artificial acceleration if it is to be monitored regularly. This can be done by pumping out water in a borehole to the outside or pumping into the borehole from outside.

Down Hole water flow metre eg: Oyo micro flow meter is suggested as it is compact and portable.

7.2 Geodetic Aspects

a) The dam profile levels should be checked at 10m intervals or other practically possible closer intervals after the blanketing every week, a precision instrument should be used with established concrete bench marks so that the identical spot is observed in readings.

b) All mountain tops on the RB, LB and Downstream to 2 km length of dam should be accurately levelled and observations continued weekly for a sufficient length of time until conditions are found stable.

c) Establish 2 seismographs, one on the RB on highest location on Matihakka fault and the other on firm ground between Kalunaide ara and seepage points upstream for a scientific study.

Since the dam is in a fault zone the instrumentation to measure seismic event and relevant structural response of the spill and the dam besides such instrumentation will
a) signal seismic event
b) characterise intensity
c) epicentral distance
d) frequency content

To monitor Reservoir induced seismicity, the seismographs should be maintained by trained staff and data stored for easy retrieval. Since reservoir induced seismicity is a long term study, such monitoring is recommended for a 20 year period. This should be extended to all existing major reservoirs in Sri Lanka to make the study useful.

7.3 Conservation

a) No gemming should be allowed on a 2 kilometer belt round the Full supply contour 460 m.
b) Reservoir should have a strict reserve of a 2 km strip upstream in unsettled area which should be reforested with indigenous species and native undergrowth encouraged.

7.4 Bathymetry

Reservoir bed should be surveyed by echo sounder on defined traverses and at same location on a grid basis to note any changes in bed contours. This should be done at regular intervals and also after heavy storms, to ensure that any sinkhole feature development or sinkhole expansion is quickly detected.

7.5 Reservoir slopes

Identified unstable slopes specially on RB near the seepage burst and on reservoir slopes should be stabilised by slope training and/or rock anchors and shotcrete treatment to stabilise same.

7.6 **Inclinometers**

Concrete face on spill - deflections at 2 points on downstream of each spill way recorded every month or at regular intervals.

7.7 **Joint meters**

Opening of concrete joints on spill to be recorded at regular intervals.

7.8 **Sediments**

Siltation samples should be taken at the entry points of streams feeding the Reservoir. These are identified as Walawe Ganga, Belihul Oya, Kiriketi Oya and Denagan Oya.

7.9 **Meteorological Studies**

It is advisable to establish a meteorological station near Dam site where wind speeds, humidity, and temperature, rainfall and evaporation data are daily collected which would also help to determine the influence of the reservoir on the environment.

7.10 **Wet Blanketing - Assessing Segregation**

The Wet Blanket is composed of well graded, gravelly sandy silt/silty sand cast into water at plastic state. The behaviour of the material cast into water such as segregation, final shape of settling and the thickness have to be tested and this could be done by the alpine gravity piston sampler which can give 80 feet long 3 inch samples, through even 500 feet of water.

7.11 **Wet Blanketing - Checking Thickness**

The thickness of the blanket can be measured by using flat trays lowered to the bed by wire fixed to a buoy and measuring by echo sounder. The sample too could be collected to check the gradient of the placed material. This method was tried out at Tarbela Dam repair.

7.12 **Security**

Strict security arrangement should be provided to prevent entry of unauthorised persons to the immediate periphery of the entire reservoir, to prevent illicit gemming, illicit felling, slash and burn for chena, vandalism to monitoring equipment and observation wells. For this purpose a definite reservation should be land marked to keep intruders out.

7.13 <u>Safe working conditions</u>

Ensure flow of fresh air to all parts of galleries to be inspected. Switch on ventilation at least 12 hours before inspection. Portable gas detection meters should be carried to check for CO - H_2S and CH_4, presence of H_2S may indicate leakage of reservoir water.

7.14 Algal blooms might be widespread from nutrient releases from blanketing. Nutrient monitoring is recommended.

7.15 Increased turbidity will increase water treatment costs to make it suitable for consumption.

7.16 Benthic invertebrate will be destroyed in the area of blanketing. Silt curtain proposed will only help reduce depletion of species.

7.17 <u>Monitoring Manual</u>

The Dam and Reservoir monitoring manual revised draft of 2-3-92 was examined and found to be well thought out and compiled by the Design Engineer (Sir Alexander Gibb and Partner). However the following points are thought useful.

<u>Section 3.3.6</u> Items requiring maintenance, add item (vii) clearance of debris, aquatic weeds near intake tower as part of general maintenance.

<u>Appendix I</u> add form 16 - "seismic study"
add form 17 - "vibration records"

<u>Volume I</u> Operating and maintenance manual section 4.3.7 para 4 add "sample be analysed."

<u>Section 4.3.9</u> Para (a) add "after heavy storm or rapid drawdown" at the end of first sentence.

<u>Section 4.4.1</u> Inspect all galleries for deterioration of rock and lining.

<u>Section 5.8</u> Netting should be provided to prevent rats and pigeons from infesting in the eaves or ceilings.

8 Conclusions

The EIA on the Clay Extraction and Blanketing of Samanalawewa for leakage mitigation has covered the following aspects specified in the National Environmental (Amendment) Act of 1988.

i	Project description	- Chapter 1 - Introduction
ii	Cost benefit analysis	- Chapter 5 - section 5.3
iii	Assessment of avoidable environmental effects	- Table 2.2(1), 5.1(1) and 5.2(1) shown in matrix form.
iv	Description of alternatives	- Chapter 3 and 5
v	Criteria for rejecting alternatives	- Chapter 2 section 2.3 Chapter 5 section 5.1
vi	Description of irreversible or irretrievable commitments caused by the project	- Chapter 4 Water Quality Chapter 5 Aquatic Life Kaltota Irrigation requirements will be fully regulated. Hence better water management. - Increased turbidity can seriously disturb the benthic communities and cause undue wear on the turbiness at power intake.

The project consultants recommended wet blanketing. This was endorsed by the International Third Party Panel in March 1993. Yet to date, July 1994 the situation has not changed. As the Hydrologist has pointed out this could present a disaster situation unless the leakage problem is addressed with quick implementation.

Both local and International consultants have agreed that Wet Blanketing is the solution in a situation where power production cannot be ignored. The energy developed by Samanalawewa inspite of its frailities is about 9% of the National energy demand. This has also contributed to save the country from power cuts during peak demand hours.

The facility is programmed to develop 240 MW in the second stage. Hence the necessity to carry out repair and restore Samanalawewa to its designed output is urgent. According to project consultants, material for Wet Blanket is available up to a quantity of 1 1/2 million cubic metres at the former borrow areas at Kinchigune. This quantity is sufficient for the present and any future maintenance work with the least environmental impact.

The fears of the public, living downstream of dam have to be dispelled. New water burst could create panic amongst the people and hence the urgency to remove such fears.

Reservoirs in other countries that faced such mishaps have been repaired without so much delay. Further delay in taking remedial action may lead to further deterioration.

Current leakage is through a fold on the Matihakka fault which serves as the best system of pore pressure relief. There is no need for any further drainage, provided the remedial action proposed is implemented.

9. Recommendation

i) Rise in reservoir level to El 444.0 m can be expected even from a flood of 10 year return period. This can activate a new burst of the overburden on the leakage area. Hence it is extremely urgent that wet blanket operation should commence without further delay.

ii) Monitoring of water quality, quantity, composition, EC, etc of the seepage should continue.

iii) New parameters prescribed in chapter 6 should also be monitored.

iv) Declare Samanalawewa a National Park and demarcate its boundaries.

v) Ban gemming from the reservoir shores and from the rivers feeding the reservoir.

vi) The integrity of the overburden mantle on reservoir shoreline is very fragile. Hence it should not be disturbed by road construction, drilling of holes, beaching of boats, dynamiting for fish logging or subject to speed boat wave lash.

vii) Only Kinchigune borrow area is recommended for exploitation.

viii) Strict demarcation lines should be established for reservoir reservations. The security of the area needs urgent attention due to illicit gemming, fishing and timber felling by encroachers.

ix) Promote afforestation programme with indigenous varieties only.

x) Public confidence in the safety of the reservoir should be restored.

xi) Strict water management at Kaltota will yield extra water for power generation.

xii) It is advisable to establish a meteorological station near Dam site where wind speeds, humidity, temperature, evaporation data are daily collected to determine the influence of reservoir on the environment.

LIST OF FIGURES

LIST OF TABLES

Appendix A

Public Commen

1 **Location**

The reservoir location at the site 250m downstream of confluence of Belihul Oya and Walawe rivers was first planned in 1957 by the Irrigation Department. This location gave drainage flows from 342 sq.km (132 sq.miles) of catchment. The site was agreed by ECI of Denver, USA and 2 other firms from USA and Canada.

The Engineering Study organisation of the Mahaweli Development Board, the Snowy Mountains Eng. Consultants, CECB, Hydro Institute USSR all accepted the same site. Surveys done by M/S Nippon Koei 1982, UK consultants 1984, Electrowatt Engineering 1985, CECB 1985, all accepted the location, where it was subsequently built. Location was such that the maximum generating head of 330 m could be utilised to produce 120 MW power.

2 **Seepage**

Maximum seepage observed was $7m^3$/Sec when reservoir water level rose to 440 m. With water level at 430 m the seepage became constant at about 2 to 3 m^3/ Sec. This loss is about 10% of average inflow of 19 m^3/Sec and the remedial measure is to reduce this.

3 **Safety of Dam**

Dam is founded on rock and made impervious by grout curtains along the full length and supported by blanket and consolidation grouting. Piezometer levels indicate the grout curtain is functioning and that leakage has been minimal. The international panel of experts too unanimously accept this position.

4 **Balancing Tank**

This principle could be used in small village tanks to stop leakage where the average head is below eight feet and the seepage exits from one identified point source.

The position at Samanalawewa with Karst features, solution cavities and major fault zones is a very complex situation different from that of a single seepage path in a village tank.

5 **Dry Blanket**

Dry blanket consumes much less material and has the advantage that it can be mechanically compacted. If the area of ingress is known, the quantity of material for blanketing is extremelely small.

But under the present situation, dry blanket can be undertaken only after the following major executions are done.

i Reopen the diversion tunnel constructed under the spill by removing concrete plugs by blasting or other means.

ii. A new diversion tunnel has to be constructed upstream of the ingress area to divert Walawe river water from entering the ingress area. (See Fig.4.1 (1)) This tunnel has to have a minimum diameter of 5 m and the length (to be determined) will have to traverse round the pervious area.

iii. Construct 2 coffer dams to elevation of 424 m ie., 44 metre high if the power generation is to be uninterrupted. The coffer dam could be done to a lower height to cater for once in 10 year flood if generation of power is abandoned.

iv Balance water in the ingress area and any rainfall runoff has to be pumped out to make the area fit for access roads and dumper traffic.

v These operations will take at least 2 to 3 years to carry out for which period power generation will be interrupted.

vi If after these operations a new ingress area surfaces, again the reservoir has to be drained down. Otherwise revert to Wet Blanket. Thus it is preferable to try Wet Blanket without resort to these costly exercises.

6 <u>Wet Blanket integral with dam clay core</u>

This is neither feasible nor applicable as the clay core of the dam is in the centre of the rock fill dam and the wet blanket is an overlay on the river-bed 1 km away.

7 <u>Ingress Area</u>

Area of Ingress has been identified by geotechnical investigation industry seismic (boomer) survey, and water quality chemical analysis. Further, topographically this is the fault zone. Hence ingress area for the reservoir elevation of 440 m has been identified.

8 <u>Abandoning Project</u>

This is not feasible and is the same as 'no project scenario' which is least acceptable as it is a possible danger to the people living downstream.

9 <u>Investigation</u>

Of all the construction projects in Sri Lanka Samanalawewa is the most intensely investigated, not only by local specialists but by several foreign consultants .

10 <u>Probable new leaks</u>

May occur with impounding over 440 m and such cases have to be monitored and the wet blanket remedy has to be extended once the new area of ingress has been identified.

11 <u>Terrameter Surveys (Resistivity Survey)</u>

These are useful to identify saturated strata for development of wells but are found not suitable to identify under ground water flow.

Fig. 1. Work Sequence of Side Dumping Method

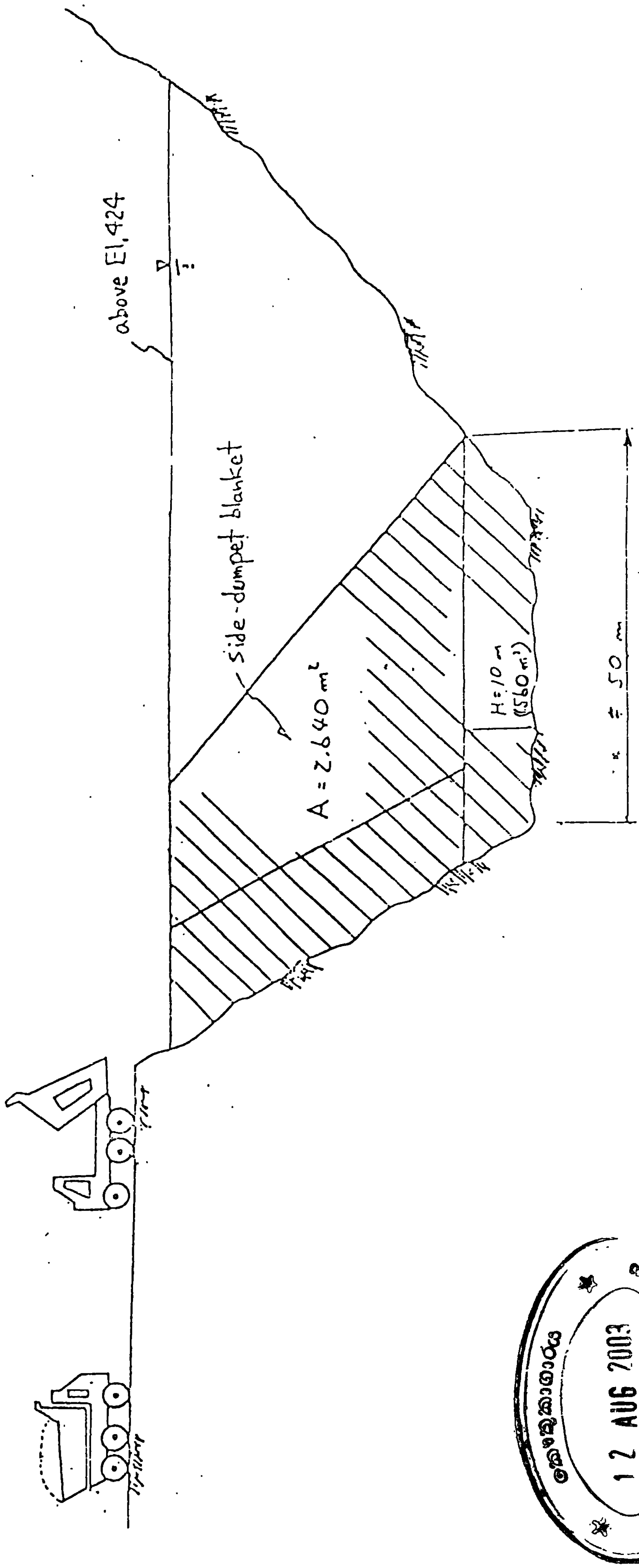


Fig. 2. Work Sequence of Damp-Barge Method

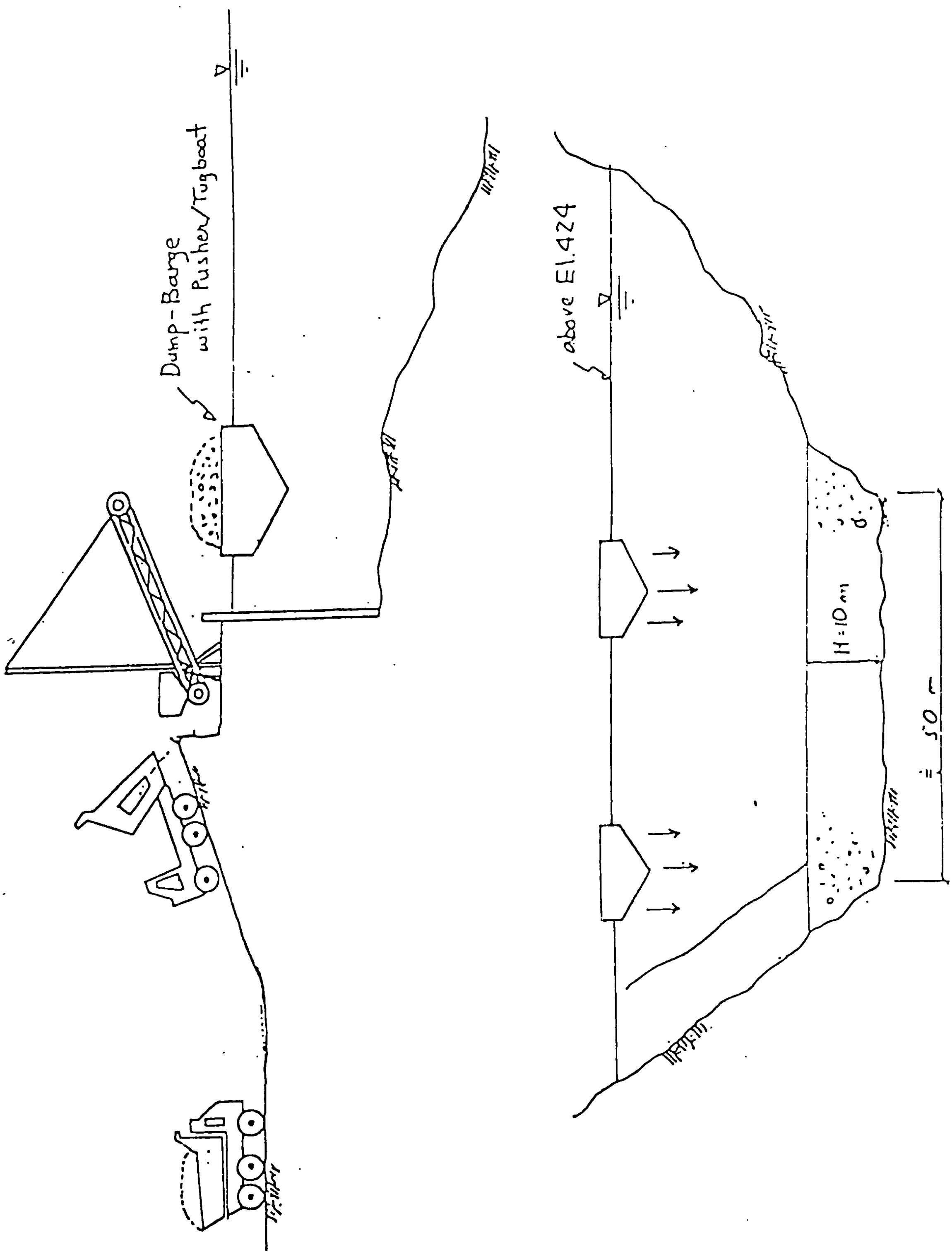
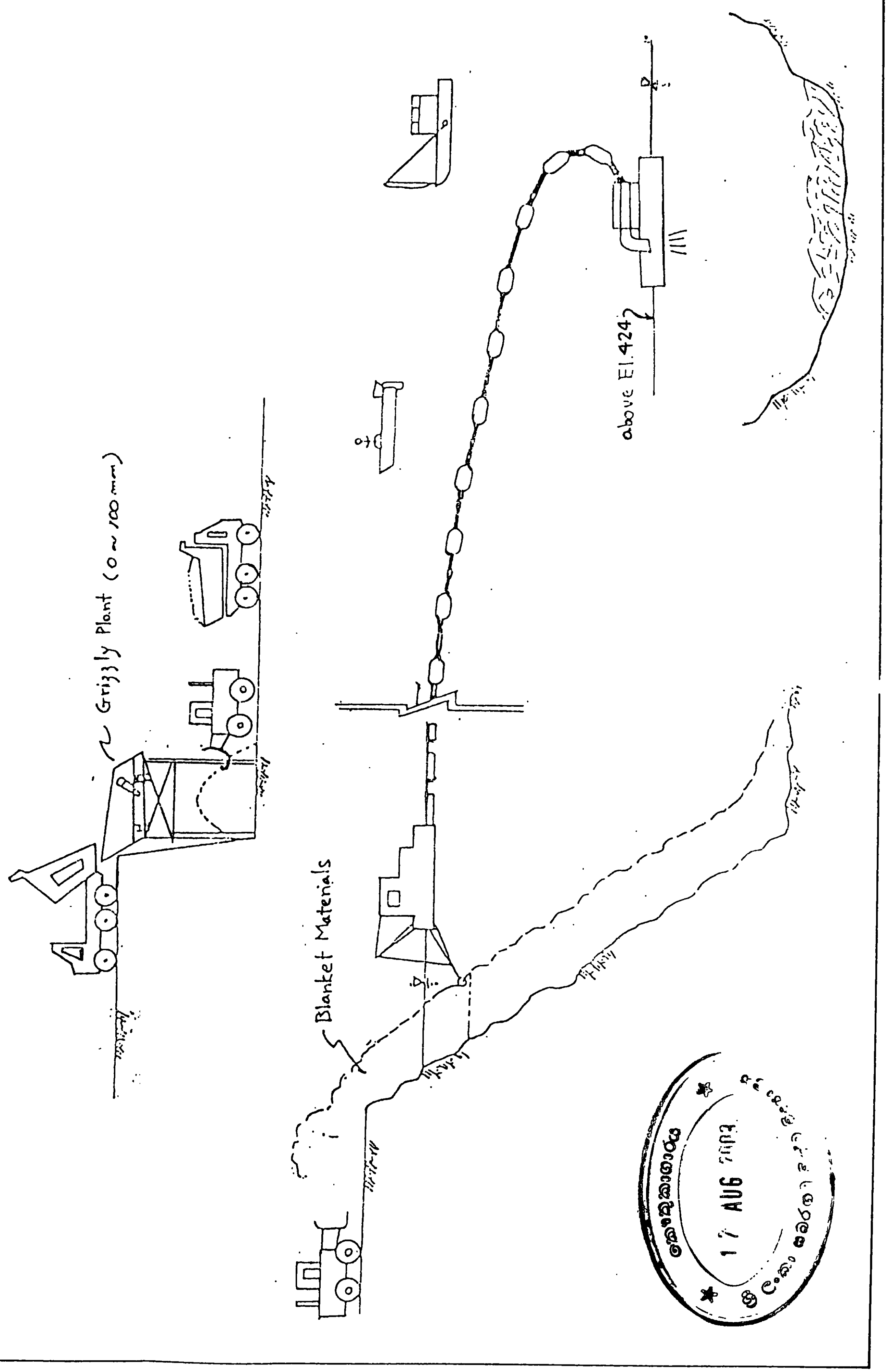


Fig. 3 Work Sequence of Dredger Method



Samanalawewa Tank
Travel Time Computation

1. Catchment area = 342 sq.km (132 Sq. miles)

2. The length of the Walawe Ganga = 40 kms (25 miles)
(longest stream in the catchment)

3. Slope of Walawe Ganga = 0.01136

4 Velocity of water $V = (1/n)\, R^{2/3}\ S^{1/2}$
$n = 0.04$ (rough)
R = Height = assume 1m (width is large)

$V = 1/0.04 \times 3.28^{2/3} \times 0.01136^{1/2}$
$V = 5.89$ ft/sec

5. Time of concentration $To = L/\,(V \times 60) + 15$

$$To = \frac{25 \times 5280}{5.89 \times 60} + 15$$

$= 388.51$ mm
$= 6.48$ hrs

6. The distance from centre of catchment to the point of Interest. Lc
Lc = 6.2 miles

Appendix 4.5.1 (2)

Walawe Ganga at Samanalawewa
Catchment area. 132 Sq Ml
Annual Maximum flood peaks (observed)

Water Year	Peak in		Remark
	cumecs	cusecs	
1939/1940	3422	120820	Estimated
1941 to 1958	-	-	Not available
1958/1959	538	19000	
1960	184	6500	
1961	170	6000	
1962	425	15000	
1963	569	20090	
1964	623	22000	
1965	914	32250	
1966	517	18250	
1967 to 1972	-	-	Not available
1972/1973	132	4660	
1974	1125	39720	
1975	419	14790	
1976	139	4900	
1977	247	8760	
1978	1700	60000	
1979	443	15623	
1980 to 1983	-	-	Not available
1983/1984	719	25381	
1985	252	8900	
1986	364	12840	

Appendix 4.5.1 (2) Contd.

Walawe Ganga at Samanalawewa annual Maximum flood peak analysis.

Water Year	Descending order peak values		Rank m	m-0.44 / n+0.12	Probability P x 100	N.E.P (100 - P)
	cumecs	cusecs				
1939/1940	3422	120820	1	0.012	1.20	98.8
1977/1978	1700	60000	2	0.034	3.40	96.6
(n=46)						
1973/1974	1125	39720	1	0.033	3.30	96.7
1964/1965	914	32250	2	0.091	9.10	90.9
1983/1984	719	25381	3	0.149	14.90	85.1
1963/1964	623	22000	4	0.208	20.80	79.2
1962/1963	569	20090	5	0.266	26.60	73.4
1958/1959	538	19000	6	0.325	32.50	67.5
1965/1966	517	18250	7	0.383	38.30	61.7
1978/1978	443	15623	8	0.442	44.20	55.8
1961/1962	425	15000	9	0.500	50.00	50.0
1974/1975	419	14970	10	0.558	55.80	44.2
1985/1986	364	12840	11	0.617	61.70	38.3
1984/1985	252	8900	12	0.675	67.50	32.5
1976/1977	247	8760	13	0.734	73.40	26.6
1959/1960	184	6500	14	0.792	79.20	20.8
1960/1961	170	6000	15	0.850	85.0	15.0
1975/1976	139	4900	16	0.909	90.9	9.1
1972/1973	132	4660	17	0.967	96.7	3.3

Appendix 4.5.1 (2) Contd.

Return Period (Years)	Estimated discharge values	
	cumecs	cusecs
2	7340	12000
5	920	32500
10	1274	45000
25	1726	61000
50	2080	73500
100	2419	85500
200	2759	97500
500	3226	114000
700	3396	120000

PROBABILITY ANALYSIS OF MAXIMUM OBSERVED FLOOD

Poisson Distribution in General is

where

= Number of years for testing
= Probability of the rare event
= No of times

Ex: What is the probability of 700 years flood occurring within next 2 years

= 700
= 2
= Number of time = 1
= $2 \times \frac{1}{700} = 0.002857$

Poisson probability $= \frac{e^{-0.002857}}{1} \times (0.002857)$

$= \frac{0.00286}{e^{0.00286}}$

$= \frac{0.00286}{1.00286} = 0.00285$

Probability of 700 years flood occurring next 2 years is 0.00285

MAXIMUM DAILY FLOW ANALYSIS
FROM JUNE,JULY,AUG, - SAMANALAWEWA

YEAR	JUNE, JULY,AUG, MAX DISCHARGE IN		REMARK
	Cumecs	Cusecs	
1960	42	1494	
1961	42	1498	
1962	62	2207	
1963	127	4500	
1964	53	1881	
1965	30	1070	
1966	17	607	
1967	12	443	
1968	-	-	Not available
1969	-	-	"
1970	-	-	"
1971	-	-	"
1972	-	-	"
1973	133	4704	
1974	577	20,391	
1975	217	7680	
1976	32	1142	
1977	91	3201	
1978	91	3218	
1979	169	6005	
1980	-	-	"
1981	-	-	"
1982	-	-	"
1983	-	-	"
1984	54	1907	
1985	178	6282	
1986	29	1023	
1987	-	-	"
1988	266	9415	

MAXIMUM DAILY FLOW ANYLISIS
FROM JUNE,JULY, AUG,- SAMANALAWEWA.

WATER YEAR	DESCENDING ORDER		RANK m	m-0.44 / n+0.12	PROBABILITY P *100	N.E.P. (100-P)
	cumecs	cusecs				
1973/1974	577	20,391	1	0.029	2.9	97.1
	266	9415	2	0.082	8.2	91.8
	217	7680	3	0.134	13.4	86.6
	178	6282	4	0.186	18.6	81.4
	169	6005	5	0.238	23.8	76.2
	133	4704	6	0.291	29.1	70.9
	127	4500	7	0.343	34.3	65.7
	91	3218	8	0.395	39.5	60.5
	91	3201	9	0.448	44.8	55.2
	62	2207	10	0.500	50.0	50.0
	54	1907	11	0.552	55.2	44.8
	53	1881	12	0.604	60.4	39.6
	42	1498	13	0.656	65.6	34.4
	42	1494	14	0.709	70.9	29.1
	32	1142	15	0.762	76.2	23.8
	30	1072	16	0.814	81.4	18.6
	29	1023	17	0.866	86.6	13.4
	17	607	18	0.918	91.8	8.2
	12	443	19	0.971	97.1	2.9

Appendix 4.5.1 (4) Contd.

RETURN PERIOD (YEAR)	ESTIMATED DISCHARGE VALUES	
	cumecs	cusecs
2	78	2,750
5	177	6,250
10	241	8,500
25	318	11,250
50	382	13,500
100	441	15,600

HYDROLOGICAL MEASUREMENTS ON 13th MAY 1994

1. KALTOTA main canal L.B	-	1.14 Cumecs
2. KALTOTA main canal R.B	-	2.63 Cumecs
3. Leak through the anicuts	-	0.28 Cumecs
4. WELI OYA - (256 sq.km catchment)	-	4.72 Cumecs
5. Release reported from Samanalawewa	-	4.16 Cumecs

a. Estimation of natural flow from 68 sq.kms. of WALAWE catchment

Specific yield of Weli Oya on May $= \frac{4.72}{256}$ cumecs/sq.k

Flow from WALAWE $= \frac{4.72}{256} \times 68$ cumecs

$= 1.25$ cumecs

This flow is distributed among other months of year according to long term monthly rain fall.

b. Irrigation Demand

Crop. rate requirement in May $= 9.82$ mm/ckm

Flow rate required to irrigate 810 ha $= 810 \times 10^4 \times \frac{9.82}{1000 \times 3600 \times 24}$

$= 0.92$ say 1.0 cumecs

Assuming 50% conveyance efficiency

Irrigation demand at the head sluice = 2.0 cu.metre./sec

This is distributed monthly according to evapo-transpiration rates.

c. Estimation of Losses in the river

Loss = Inflow from 68 sq. km + Release from Samanala - out flow Kaltota (total)

$= 1.25 + 4.16 - (1.14 + 2.63 + 0.28)$

$= 1.36$ cumecs

This loss rate was assumed through out the year.

d. Estimation of release from Samanalawewa

Release from Samanala = Head sluice water requirment at Kaltota + Loss - Natural flow from 68 sq.km.

= 2.11 cumec.

Base Case - 1993 (Samanalwewa ROR Scheme)

Year	ANNUAL ENERGY (GWh)						ANNUAL PLANT FACTORS (%)					
	Hydro Condition						Hydro Condition					
	1	2	3	4	5	Average	1	2	3	4	5	Average
1994												
3 GTKP	0	0	7	269	556	112	.0	.0	.7	28.4	58.8	11.8
4 KPST	20	43	104	202	274	120	5.1	11.2	26.9	52.3	71.1	31.1
5 DSSP	57	123	151	222	276	163	10.2	21.9	26.9	39.6	49.1	29.0
Total Thermal	77	167	261	692	1105	394						
Dispatched Hydro	3992	3903	3808	3254	2689	3623						
Hydro Spill	471	357	82	44	0	160						
Total Generation	4069	4069	4069	3946	3794	4017						
Total Demand	4069	4069	4069	4069	4069	4069						
Deficit	0	0	0	123	275	52						
1995												
3 GTKP	20	39	106	398	639	195	2.1	4.1	11.2	42.0	67.5	20.7
4 KPST	64	129	173	229	274	174	16.7	33.3	44.8	59.3	71.1	45.2
5 DSSP	118	138	215	256	276	204	21.0	24.7	38.3	45.7	49.1	36.4
Total Thermal	202	306	493	882	1188	574						
Dispatched Hydro	4169	4065	3878	3279	2689	3706						
Hydro Spill	294	194	12	19	0	77						
Total Generation	4371	4371	4371	4161	3877	4279						
Total Demand	4371	4371	4371	4371	4371	4371						
Deficit	0	0	0	210	494	91						

1996												
3 GTKP	0	0	0	257	522	104	.0	.0	.0	27.1	55.2	10.9
4 KPST	88	129	190	232	274	184	22.9	33.3	49.3	60.3	71.1	47.8
5 DSSP	126	125	216	256	276	203	22.5	22.3	38.5	45.7	49.1	36.1
6 DSLX	177	178	266	256	273	238	50.6	50.8	75.9	73.2	77.9	68.0
10 GT	25	83	144	315	451	184	4.3	14.3	24.9	54.4	78.0	31.9
Total Thermal	417	514	816	1316	1795	914						
Dispatched Hydro	4289	4191	3890	3298	2689	3752						
Hydro Spill	175	68	0	0	0	31						
Total Generation	4706	4706	4706	4614	4484	4665						
Total Demand	4706	4706	4706	4706	4706	4706						
Deficit	0	0	0	92	222	41						
1997												
3 GTKP	0	0	0	179	374	73	.0	.0	.0	18.9	39.6	7.7
4 KPST	0	47	98	204	274	117	.1	12.3	25.4	52.8	71.1	30.3
5 DSSP	68	105	156	209	276	159	12.1	18.7	27.8	37.3	49.1	28.4
6 DSLX	113	126	199	245	273	192	32.2	35.8	56.6	69.8	78.0	54.8
7 DSL	533	540	728	726	751	673	55.3	56.1	75.6	75.3	77.9	69.8
10 GT	0	4	0	206	388	81	.0	.6	.0	35.6	67.1	14.0
Total Thermal	714	822	1181	1767	2335	1295						
Dispatched Hydro	4357	4249	3890	3298	2689	3770						
Hydro Spill	106	10	0	0	0	13						
Total Generation	5071	5071	5071	5065	5024	5065						
Total Demand	5071	5071	5071	5071	5071	5071						
Deficit	0	0	0	6	47	6						

1998												
3 GTKP	0	0	0	190	429	81	.0	.0	.0	20.1	45.3	8.6
4 KPST	29	85	139	217	274	146	7.4	22.0	36.0	56.2	71.1	37.9
5 DSSP	93	118	190	234	276	183	16.6	21.0	33.9	41.8	49.1	32.7
6 DSLX	123	136	222	249	273	205	35.0	38.8	63.2	71.2	77.9	58.6
7 DSL	833	866	1021	1007	1024	969	63.4	65.9	77.7	76.6	77.9	73.7
10 GT	0	5	7	240	416	93	.0	.8	1.2	41.5	72.0	16.2
Total Thermal	1078	1210	1579	2137	2691	1678						
Dispatched Hydro	4391	4259	3890	3298	2689	3775						
Hydro Spill	72	0	0	0	0	7						
Total Generation	5469	5469	5469	5435	5380	5453						
Total Demand	5469	5469	5469	5469	5469	5469						
Deficit	0	0	0	34	89	16						
1999												
3 GTKP	0	0	0	240	479	96	.0	.0	.0	25.3	50.6	10.1
4 KPST	42	116	155	214	274	160	10.9	30.1	40.3	55.5	71.1	41.4
5 DSSP	112	129	204	245	276	195	20.0	23.0	36.4	43.7	49.1	34.8
6 DSLX	152	149	226	251	273	213	43.5	42.5	64.6	71.6	77.9	60.8
7 DSL	868	902	1024	1015	1024	982	66.0	68.6	77.9	77.2	77.9	74.7
10 GT	0	44	85	271	435	140	.0	7.6	14.7	46.9	75.2	24.3
Total Thermal	1175	1340	1695	2234	2759	1786						
Dispatched Hydro	4726	4561	4206	3595	2947	4081						
Hydro Spill	71	0	0	0	0	7						
Total Generation	5901	5901	5901	5830	5706	5867						
Total Demand	5901	5901	5901	5901	5901	5901						
Deficit	0	0	0	71	196	34						

2000												
3 GTKP	0	17	16	182	481	94	.0	1.8	1.7	19.2	50.8	10.0
4 KPST	33	103	119	237	274	146	8.6	26.7	31.0	61.5	71.1	38.0
5 DSSP	81	101	218	256	276	194	14.4	18.1	38.9	45.6	49.1	34.7
6 DSLX	141	129	227	273	273	212	40.1	36.8	64.8	77.9	77.9	60.6
7 DSL	811	840	959	1024	1024	940	61.8	63.9	73.0	77.9	77.9	71.5
10 GT	1	91	84	248	451	147	.1	15.7	14.6	42.9	77.9	25.4
Total Thermal	1067	1281	1623	2219	2777	1734						
Dispatched Hydro	5305	5090	4748	4078	3359	4599						
Hydro Spill	115	0	0	0	0	11						
Total Generation	6371	6371	6371	6298	6136	6333						
Total Demand	6371	6371	6371	6371	6371	6371						
Deficit	0	0	0	74	235	38						
2001												
3 GTKP	0	9	0	164	410	76	.0	1.0	.0	17.3	43.3	8.0
5 DSSP	27	66	91	202	276	120	4.8	11.7	16.1	36.0	49.1	21.4
6 DSLX	68	88	170	229	273	165	19.3	25.1	48.4	65.4	77.9	47.2
7 DSL	594	649	871	1014	1024	843	45.2	49.4	66.3	77.2	77.9	64.2
8 COL1	835	918	926	935	935	918	66.9	73.5	74.2	74.9	74.9	73.5
10 GT	1	50	63	210	428	120	.0	8.6	10.9	36.3	73.9	20.7
Total Thermal	1524	1779	2122	2755	3345	2243						
Dispatched Hydro	5345	5090	4748	4078	3359	4603						
Hydro Spill	74	0	0	0	0	7						
Total Generation	6870	6870	6870	6833	6704	6846						
Total Demand	6870	6870	6870	6870	6870	6870						
Deficit	0	0	0	36	165	24						

2002												
3 GTKP	0	0	0	56	160	27	.0	.0	.0	11.8	33.9	5.7
5 DSSP	0	14	25	105	250	59	.0	2.5	4.4	18.7	44.6	10.5
6 DSLX	10	32	63	164	272	93	2.8	9.2	18.1	46.8	77.7	26.5
7 DSL	352	488	702	988	1024	714	26.8	37.1	53.4	75.2	77.9	54.3
8 COL1	1662	1786	1870	1870	1870	1833	66.6	71.5	74.9	74.9	74.9	73.4
10 GT	1	1	3	117	316	56	.0	.1	.5	20.2	54.7	9.8
Total Thermal	2025	2321	2664	3300	3893	2782						
Dispatched Hydro	5387	5090	4748	4078	3359	4608						
Hydro Spill	33	0	0	0	0	3						
Total Generation	7412	7412	7412	7379	7252	7389						
Total Demand	7412	7412	7412	7412	7412	7412						
Deficit	0	0	0	33	159	23						
2003												
5 DSSP	29	76	116	247	275	141	5.1	13.6	20.7	44.1	49.0	25.2
6 DSLX	88	116	196	264	273	190	25.1	33.1	56.0	75.2	77.9	54.4
7 DSL	735	780	968	1024	1024	924	56.0	59.4	73.7	77.9	77.9	70.3
8 COL1	1721	1870	1870	1870	1870	1856	68.9	74.9	74.9	74.9	74.9	74.3
10 GT	5	47	79	249	444	136	.8	8.1	13.7	43.0	76.7	23.4
11 GTR	0	17	19	124	299	66	.0	3.3	3.7	23.7	56.8	12.5
Total Thermal	2578	2907	3249	3778	4184	3313						
Dispatched Hydro	5420	5090	4748	4078	3359	4611						
Total Generation	7997	7997	7997	7856	7543	7924						
Total Demand	7997	7997	7997	7997	7997	7997						
Deficit	0	0	0	141	454	74						

Appendix 5.3.3 (1) contd.

CEB - STUDY 1993 - Without Samanalawewa HEP

Year	Annual Energy (GWh) Hydro Condition 1	2	3	4	5	Average	Annual Plant Factors (%) Hydro Condition 1	2	3	4	5	Average
1994												
3 GTKP	37	74	134	433	647	223	4.0	7.8	14.2	45.8	68.4	23.6
4 KPST	71	127	159	220	274	167	18.3	32.9	41.3	56.9	71.1	43.4
5 DSSP	125	130	225	247	276	206	22.2	23.2	40.2	44.1	49.1	36.7
Total Thermal	233	331	519	900	1196	596						
Dispatched Hydro	3836	3738	3547	3003	2589	3409						
Hydro Spill	325	160	38	73	0	94						
Total Generation	4069	4069	4066	3903	3785	4006						
Total Demand	4069	4069	4069	4069	4069	4069						
Deficit	0	0	4	166	284	63						
1995												
3 GTKP	103	196	261	474	673	316	10.9	20.7	27.6	50.1	71.2	33.4
4 KPST	131	132	240	254	274	214	33.9	34.4	62.3	65.9	71.1	55.5
5 DSSP	185	213	250	256	276	240	32.9	38.0	44.5	45.7	49.1	42.8
Total Thermal	418	542	751	984	1222	770						
Dispatched Hydro	3950	3829	3583	3028	2589	3459						
Hydro Spill	211	69	2	48	0	45						
Total Generation	4368	4371	4334	4012	3811	4228						
Total Demand	4371	4371	4371	4371	4371	4371						
Deficit	3	0	37	359	559	143						

1996												
3 GTKP	12	19	63	355	544	156	1.2	2.0	6.6	37.6	57.5	16.4
4 KPST	143	147	238	249	274	216	37.0	38.2	61.7	64.5	71.1	56.0
5 DSSP	198	201	244	256	276	236	35.3	35.9	43.6	45.7	49.1	42.2
6 DSLX	196	219	273	248	273	249	55.8	62.6	77.9	70.8	77.9	71.2
10 GT	112	220	303	460	601	328	14.5	28.6	39.3	59.7	77.9	42.6
Total Thermal	660	808	1121	1569	1967	1186						
Dispatched Hydro	4045	3898	3585	3055	2589	3488						
Hydro Spill	116	0	0	21	0	16						
Total Generation	4706	4706	4706	4624	4556	4674						
Total Demand	4706	4706	4706	4706	4706	4706						
Deficit	0	0	0	82	150	31						
1997												
3 GTKP	0	0	0	133	266	53	.0	.0	.0	14.1	28.1	5.6
4 KPST	51	126	153	201	274	159	13.1	32.6	39.6	52.2	71.1	41.2
5 DSSP	109	106	197	239	276	186	19.5	18.8	35.1	42.6	49.1	33.2
6 DSLX	160	170	228	250	273	219	45.7	48.5	65.1	71.3	78.0	62.4
7 DSL	621	720	809	758	819	763	59.1	68.5	77.0	72.1	77.9	72.6
10 GT	27	51	99	385	567	186	3.5	6.6	12.8	49.9	73.6	24.1
Total Thermal	969	1172	1486	1966	2475	1566						
Dispatched Hydro	4102	3898	3585	3076	2589	3498						
Hydro Spill	60	0	0	0	0	6						
Total Generation	5071	5071	5071	5042	5064	5064						
Total Demand	5071	5071	5071	5071	5071	5071						
Deficit	0	0	0	29	7	7						

1998												
3 GTKP	0	0	13	231	383	89	.0	.0	1.3	24.4	40.5	9.5
4 KPST	92	129	192	228	274	185	23.9	33.3	49.8	59.2	71.1	47.9
5 DSSP	152	134	228	254	276	211	27.1	23.9	40.6	45.3	49.1	37.7
6 DSLX	182	202	252	251	273	237	51.8	57.6	71.9	71.5	77.9	67.5
7 DSL	862	975	1024	982	1024	990	65.6	74.2	77.9	74.7	77.9	75.3
10 GT	46	131	176	398	598	241	6.0	17.0	22.8	51.7	77.5	31.2
Total Thermal	1335	1571	1884	2344	2827	1953						
Dispatched Hydro	4134	3898	3585	3076	2589	3501						
Hydro Spill	27	0	0	0	0	3						
Total Generation	5469	5469	5469	5420	5416	5454						
Total Demand	5469	5469	5469	5469	5469	5469						
Deficit	0	0	0	50	53	15						

1999												
3 GTKP	10	11	40	311	482	130	1.1	1.1	4.2	32.9	50.9	13.7
4 KPST	118	129	221	237	274	201	30.7	33.3	57.4	61.5	71.1	52.1
5 DSSP	168	203	237	256	275	231	29.9	36.2	42.3	45.6	49.1	41.2
6 DSLX	186	206	253	251	273	239	53.1	58.9	72.3	71.5	77.9	68.1
7 DSL	870	995	1024	985	1024	995	66.2	75.7	77.9	75.0	77.9	75.7
10 GT	80	158	224	417	601	273	10.3	20.5	29.1	54.0	77.9	35.4
Total Thermal	1432	1701	2000	2456	2928	2067						
Dispatched Hydro	4469	4200	3901	3374	2847	3807						
Hydro Spill	26	0	0	0	0	3						
Total Generation	5901	5901	5901	5830	5775	5874						
Total Demand	5901	5901	5901	5901	5901	5901						
Deficit	0	0	0	71	126	27						

2000												
3 GTKP	0	78	41	166	171	82	.0	8.2	4.3	17.6	18.1	8.7
4 KPST	87	91	154	197	274	155	22.5	23.5	40.0	51.1	71.1	40.3
5 DSSP	107	126	238	251	276	209	19.0	22.5	42.4	44.7	49.1	37.2
6 DSLX	168	142	249	249	273	222	48.0	40.6	71.1	71.2	77.9	63.4
7 DSL	866	953	1015	1022	1024	990	65.9	72.5	77.3	77.8	77.9	75.4
10 GT	149	337	297	613	1076	431	7.7	17.5	15.4	31.8	55.8	22.4
Total Thermal	1376	1727	1995	2499	3094	2090						
Dispatched Hydro	4995	4633	4377	3757	3074	4236						
Hydro Spill	13	0	0	0	0	1						
Total Generation	6371	6360	6371	6257	6168	6326						
Total Demand	6371	6371	6371	6371	6371	6371						
Deficit	0	11	0	114	203	45						
2001												
3 GTKP	0	76	40	153	166	78	.0	8.0	4.2	16.1	17.6	8.3
5 DSSP	78	78	104	176	276	128	13.9	14.0	18.6	31.4	49.1	22.8
6 DSLX	111	107	181	227	273	178	31.7	30.7	51.6	64.9	77.9	50.7
7 DSL	650	696	958	981	1024	886	49.5	53.0	72.9	74.7	77.9	67.4
8 COL1	871	935	935	935	935	929	69.8	74.9	74.9	74.9	74.9	74.4
10 GT	150	334	275	548	941	395	7.8	17.3	14.2	28.4	48.8	20.5
Total Thermal	1861	2227	2493	3021	3616	2594						
Dispatched Hydro	5009	4633	4377	3757	3074	4237						
Total Generation	6870	6860	6869	6778	6690	6831						
Total Demand	6870	6870	6870	6870	6870	6870						
Deficit	0	10	0	91	180	38						

2002												
3 GTKP	0	20	0	78	70	27	.0	4.2	.0	16.5	14.7	5.6
5 DSSP	64	83	82	140	240	108	11.4	14.9	14.6	24.9	42.7	19.2
6 DSLX	71	92	89	162	261	120	20.3	26.2	25.5	46.2	74.4	34.1
7 DSL	477	473	749	854	1024	715	36.3	36.0	57.0	65.0	77.9	54.4
8 COL1	1709	1790	1869	1868	1870	1837	68.5	71.7	74.8	74.8	74.9	73.6
10 GT	82	315	246	466	702	333	4.3	16.4	12.8	24.2	36.4	17.3
Total Thermal	2403	2774	3035	3567	4167	3139						
Dispatched Hydro	5009	4633	4377	3757	3074	4237						
Total Generation	7412	7407	7412	7325	7241	7376						
Total Demand	7412	7412	7412	7412	7412	7412						
Deficit	0	5	0	87	171	35						
2003												
5 DSSP	102	94	133	200	275	150	18.1	16.8	23.7	35.6	49.0	26.7
6 DSLX	116	123	211	232	273	194	33.1	35.1	60.2	66.4	77.9	55.4
7 DSL	725	743	967	991	1024	909	55.1	56.5	73.6	75.4	77.9	69.1
8 COL1	1819	1870	1870	1870	1870	1865	72.9	74.9	74.9	74.9	74.9	74.7
10 GT	228	417	372	640	1061	489	11.8	21.6	19.3	33.2	55.1	25.4
11 GTR	0	64	46	93	115	61	.0	12.2	8.7	17.7	21.8	11.6
Total Thermal	2989	3311	3599	4027	4617	3668						
Dispatched Hydro	5009	4633	4377	3757	3074	4237						
Total Generation	7997	7944	7976	7784	7692	7905						
Total Demand	7997	7997	7997	7997	7997	7997						
Deficit	0	53	22	214	306	93						

Appendix 5.3.3 (1) contd.

CEB - STUDY 1993 - With Full Reservoir Samanalawewa from 1996

Year	ANNUAL ENERGY (GWh) Hydro Condition 1	2	3	4	5	Average	ANNUAL PLANT FACTORS (%) Hydro Condition 1	2	3	4	5	Average
1994												
3aGTKP	0	0	7	269	556	112	.0	.0	.7	28.4	58.8	11.8
4aKPST	20	43	104	202	274	120	5.1	11.2	26.9	52.3	71.1	31.1
5aDSSP	57	123	151	222	276	163	10.2	21.9	26.9	39.6	49.1	29.0
1otal Thermal	77	167	261	692	1105	394						
D1spatched Hydro	3992	3903	3808	3254	2689	3623						
Hy1ro Spill	471	357	82	44	0	160						
To1al Generation	4069	4069	4069	3946	3794	4017						
Tot1l Demand	4069	4069	4069	4069	4069	4069						
D1ficit	0	0	0	123	275	52						
1995												
3aGTKP	20	39	106	398	639	195	2.1	4.1	11.2	42.0	67.5	20.7
4aKPST	64	129	173	229	274	174	16.7	33.3	44.8	59.3	71.1	45.2
5aDSSP	118	138	215	256	276	204	21.0	24.7	38.3	45.7	49.1	36.4
1otal Thermal	202	306	493	882	1188	574						
D1spatched Hydro	4169	4065	3878	3279	2689	3706						
Hy1ro Spill	294	194	12	19	0	77						
Tot1l Generation	4371	4371	4371	4161	3877	4279						
Total Demand	4371	4371	4371	4371	4371	4371						
Delicit	0	0	0	210	494	91						

1996												
3aGTKP	0	0	7	304	584	122	.0	.0	.7	32.1	61.7	12.9
4aKPST	45	111	158	268	274	171	11.7	28.7	40.9	69.6	71.1	44.3
5aDSSP	83	165	210	256	276	204	14.8	29.4	37.5	45.7	49.1	36.4
6aDSLX	155	169	273	248	273	235	44.1	48.1	77.8	70.8	77.9	67.1
10aGT	3	35	94	245	300	124	.8	9.1	24.3	63.5	77.7	32.1
Total 1hermal	286	479	741	1321	1706	856						
Dispatc1ed Hydro	4420	4226	3964	3349	2888	3832						
Hydro Sp1ll	166	66	0	27	0	35						
Total Gen1ration	4706	4706	4706	4670	4594	4687						
Total Dema1d	4706	4706	4706	4706	4706	4706						
Deficit 1	0	0	0	36	112	18						
1997												
3aGTKP	0	0	0	133	434	70	.0	.0	.0	14.0	45.9	7.4
4aKPST	3	48	105	235	274	126	.8	12.5	27.1	61.0	71.1	32.7
5aDSSP	55	139	167	264	276	181	9.8	24.8	29.8	47.1	49.1	32.2
6aDSLX	83	138	204	252	273	195	23.6	39.4	58.2	71.9	77.9	55.7
7aDSL	442	472	611	570	614	558	56.1	59.9	77.5	72.3	77.9	70.8
10aGT	0	0	20	226	288	82	.0	.0	5.1	58.7	74.8	21.3
1otal Thermal	584	798	1106	1681	2159	1213						
D1spatched Hydro	4487	4273	3964	3376	2888	3853						
Hy1ro Spill	99	20	0	0	0	14						
Tot1l Generation	5071	5071	5071	5057	5047	5066						
Tota1 Demand	5071	5071	5071	5071	5071	5071						
De1icit	0	0	0	14	24	5						

1998												
3aGTKP	0	0	0	128	429	68	.0	.0	.0	13.5	45.3	7.2
4aKPST	0	38	104	241	274	125	.0	9.8	26.9	62.5	71.1	32.3
5aDSSP	55	127	159	264	276	175	9.8	22.6	28.3	47.2	49.1	31.2
6aDSLX	79	147	198	249	273	194	22.6	42.0	56.5	71.2	77.9	55.3
7aDSL	805	864	1021	972	1024	959	61.3	65.8	77.7	73.9	77.9	73.0
10aGT	0	0	22	224	286	82	.0	.0	5.8	58.1	74.2	21.4
Total 1hermal	940	1176	1505	2078	2561	1603						
Dispatc1ed Hydro	4529	4293	3964	3376	2888	3861						
Hydro Sp1ll	58	0	0	0	0	6						
Total Gen1ration	5469	5469	5469	5454	5449	5464						
Total Dema1d	5469	5469	5469	5469	5469	5469						
Deficit 1	0	0	0	15	21	5						

1999												
3aGTKP	0	0	3	222	521	98	.0	.0	.3	23.4	55.1	10.3
4aKPST	19	98	127	246	274	149	5.0	25.3	33.0	63.7	71.1	38.6
5aDSSP	57	141	188	265	275	189	10.1	25.1	33.5	47.2	49.1	33.8
6aDSLX	110	157	230	251	273	212	31.5	44.7	65.7	71.5	77.9	60.5
7aDSL	851	911	1024	980	1024	975	64.7	69.4	77.9	74.6	77.9	74.2
10aGT	0	0	48	232	299	96	.0	.0	12.6	60.1	77.6	24.8
1otal Taermal	1037	1307	1621	2194	2667	1719						
D1spatched Hydro	4864	4594	4281	3673	3145	4167						
Hy1ro Spill	57	0	0	0	0	6						
Tot1l Generation	5901	5901	5901	5868	5812	5886						
Total Demand	5901	5901	5901	5901	5901	5901						
De1icit	0	0	0	34	89	16						

2000												
3aGTKP	0	13	0	172	440	81	.0	1.3	.0	18.1	46.5	8.5
4aKPST	28	78	135	178	248	133	7.3	20.1	35.1	46.1	64.4	34.4
5aaSSP	62	103	179	236	275	173	11.1	18.3	31.9	42.1	49.1	30.9
6aDSLX	92	111	177	249	273	179	26.3	31.7	50.5	71.2	77.9	51.2
7aDSL	686	855	979	1022	1024	938	52.2	65.0	74.5	77.8	77.9	71.4
10aGT	10	96	74	359	619	184	1.0	10.0	7.7	37.3	64.3	19.1
Total T1ermal	878	1254	1545	2217	2879	1688						
Dispatch1d Hydro	5494	5117	4827	4090	3339	4655						
Hydro Spill	17	0	0	0	0	2						
Total Gene1ation	6371	6371	6371	6307	6217	6343						
Total Deman1	6371	6371	6371	6371	6371	6371						
Deficit 1	0	0	0	64	154	28						

2001												
3aGTKP	0	0	0	164	363	69	.0	.0	.0	17.3	38.4	7.3
5aDSSP	28	49	89	155	248	104	5.0	8.7	15.9	27.7	44.1	18.6
6aDSLX	44	68	136	187	258	136	12.7	19.5	38.8	53.3	73.6	38.7
7aDSL	429	630	850	1019	1024	815	32.7	48.0	64.7	77.6	77.9	62.1
8aCOL1	817	935	935	935	935	924	65.4	74.9	74.9	74.9	74.9	74.0
10aGT	40	69	31	295	601	150	4.2	7.2	3.3	30.6	62.4	15.5
1otal Taermal	1359	1752	2043	2756	3430	2198						
D1spatched Hydro	5511	5117	4827	4090	3339	4657						
To1al Generation	6870	6870	6870	6846	6769	6855						
Tot1l Demand	6870	6870	6870	6870	6870	6870						
D1ficit	0	0	0	24	101	15						

2002												
3aGTKP	2	21	0	97	252	49	.3	4.4	.0	20.5	53.4	10.3
5aDSSP	68	107	190	265	275	185	12.1	19.0	33.9	47.2	49.1	32.9
6aDSLX	94	137	210	273	273	203	26.9	39.1	59.9	77.9	77.9	57.9
7aDSL	704	912	1008	1024	1024	963	53.5	69.4	76.7	77.9	77.9	73.3
8aCOL1	919	935	935	935	935	934	73.6	74.9	74.9	74.9	74.9	74.8
10aGT	114	180	241	514	796	326	9.9	15.5	20.8	44.5	68.9	28.2
Total 1hermal	1901	2292	2585	3109	3557	2660						
Dispatc1ed Hydro	5511	5117	4827	4090	3339	4657						
Total Ge1eration	7411	7410	7411	7199	6896	7317						
Total Dem1nd	7412	7412	7412	7412	7412	7412						
Deficit1	0	2	1	213	516	95						
2003												
5aDSSP	34	55	120	168	247	121	6.0	9.8	21.4	30.0	44.1	21.5
6aDSLX	56	95	194	231	270	175	16.1	27.3	55.3	65.8	77.1	50.0
7aDSL	549	764	915	1024	1024	881	41.8	58.1	69.7	77.9	77.9	67.0
8aCOL1	1795	1870	1870	1870	1870	1863	71.9	74.9	74.9	74.9	74.9	74.6
10aGT	52	94	71	409	729	207	4.5	8.2	6.1	35.4	63.1	17.9
11aGTR	0	1	0	94	240	43	.0	.1	.0	17.9	45.7	8.2
Total Therm1l	2487	2880	3170	3797	4381	3290						
Dispatched H1dro	5511	5117	4827	4090	3339	4657						
Total Generat1on	7997	7997	7997	7887	7720	7947						
Total Demand 1	7997	7997	7997	7997	7997	7997						
Deficit 1	0	0	0	110	277	50						

Plate 1: Leakage Point at Matihakka

Plate 2: Karst Caverns on Reservoir Periphery

Annex 2
Cover sheet as specified under section (a) of
Guidelines on EIA content

1.	Project proponent	:	Ceylon Electricity Board
2.	Project approving Agency	:	Ministry of Power and Energy
3.	Implementing Agency	:	Ceylon Electricity Board
4.	Title of Project	:	Environmental Impact Assessment study of clay Extraction and Blanketing Process of Samanalawewa Reservoir for Leakage Mitigation
5.	Study Conducted by	:	TEAMS Ltd., 55, Rosmead Place, Colombo 07.
6.	Contact Person of the Study Team	:	Mr. S.H.C. de Silva Consultant, TEAMS Ltd., No. 55, Rosmead Place, Colombo 07. Tel. 692056

7. Abstract of EIA for use in Public Notice of EIA Availability for Inspection.

Samanalawewa project has suffered a certain disability by loss of storage water of 2 to 3 m^3 /Sec with reservoir water controlled at El 430 m. In spite of this constraint its contribution to the National Power Grid has been nearly 9%. With the crises in energy expected in the next year 1995 it is imperative to remedy the leaking reservoir. Besides keeping the Project as a " run of the river" is fraught with danger due to the possibility of a new burst on the right bank saddle area. Experts have advised wet clay blanket as the most economical method of repair. The present report assesses the impacts from such an exercise and suggests mitigatory action. One area of impact is provision of infrastructure like roads, power supply and temporary accommodation for workers. The likely impacts of these operations on soil erosion and contamination due to improper waste disposal can be mitigated by appropriate soil conservation measures and adequate waste disposal methods. Clay will be extracted from Kinchigune where the terrain is already heavily disturbed for soil extraction for the dam and impacts here are likely to be minimal. Bottom dumping of clay can enhance turbidity and affect the quality of water downstream and at the tunnel intake. This impact will be minimised by providing a silt protection curtain.

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List of Persons Contacted

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14.	Mr. David Chisnal	-	Engineer, Sir Alexander Gibb & Partner
15.	Mr. L.J. Robert Fernando	-	Engineer I.D.
16.	Grama Sevaka	-	Kinchigune
17.	Mr. E.A. Siriwardena	-	Environment Officer Divisional Secretariat, Balangoda
18.	Mr. Wijesekara (Rajjuruwo)	-	Ex. President Madabedda Farmers Association

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2. Samanalawewa Hydro Electric Project.
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3. Availability of Blanket Material - Letter sent by Mr. S. Takahashi, JVS to Teams Ltd. received on 28/5/94.

4. Protection curtain against ocean Pollution, Taiyo, Cogya Co. Ltd.

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THE NATIONAL ENVIRONMENTAL ACT, No 47 OF 1980

REGULATIONS made by the Minister of Environment and Parliamentary Affairs under Section 23CC of the National Environmental Act No 47 of 1980 read with Section 32 of that Act

Dr Wimal Wickramasinghe
Minister of Environment and
Parliamentary Affairs

Colombo, 18th June, 1993

Regulations

1 These Regulations may be cited as the National Environmental (Procedure for approval of projects) Regulations No 1 of 1993

2 (i) A project proponent shall not perform the functions and duties of a Project Approving Agency In the event of a Project Approving Agency becoming a project proponent the Authority shall designate an appropriate Project Approving Agency

(ii) The Authority shall determine the appropriate Project Approving Agency in case where more than one Project Approving Agency is involved

3 In respect of any prescribed project for which an Environmental Impact Assessment Report is required the Project Approving Agency shall grant its approval only with the concurrence of the Authority

4 Any devolution of the functions of a Project Approving Agency to a Provincial Council, relating to the approval of projects shall be done only with the written concurrence of the Minister

5 A project proponent of any proposed prescribed project shall as early as possible submit to the Project Approving Agency preliminary information on the project requested by the appropriate Project Approving Agency

6 (i) The Project Approving Agency shall acknowledge in writing receipt of such preliminary information within six days

(ii) The Project Approving Agency shall in consultation with the Authority subject such preliminary information to environmental scoping, in order to set the Terms of Reference for the Initial Environmental Examination Report or Environmental Impact Assessment Report, as the case may be, and in doing so the Project Approving Agency may take into consideration the views of state agencies and the public.

(iii) The Project Approving Agency shall convey in writing to the project proponent the Terms of Reference referred to in paragraph (ii) above within fourteen days in the case of an Initial Environmental Examination Report and thirty days in the case of an Environmental Impact Assessment Report from the date of acknowledging receipt of the preliminary information

(iv) Where, if on environmental scoping the Project Approving Agency considers that the preliminary information submitted by the project proponent as required in regulation 5 above, is adequate to be an Initial Environmental Examination Report the Project Approving Agency shall proceed as specified hereinafter

7 (i) Every project proponent shall submit to the Project Approving Agency such number of copies of the Initial Environmental Examination Report as required by the Project Approving Agency

(ii) Upon receipt of an Initial Environmental Examination Report the Project Approving Agency shall submit a copy thereof to the Authority and by prompt notice published in the *Gazette* and in one national newspaper published daily in the Sinhala, Tamil and English languages, invite the public to make written comments if any, thereon, to the Project Approving Agency, within thirty days from the date of first appearance of the notice, either in the *Gazette* or in the newspaper

(iii) The Notice referred to in paragraph (ii) above shall specify the times and places at which the report shall be made available for public inspection

(iv) The Project Approving Agency shall make available copies of the report to any person interested to enable him to make copies thereof

8 (i) It shall be the duty of the Project Approving Agency, upon completion of the period of public inspection, to forward to the project proponent the comments received from the public, for review and response, within six days from the date of completion of the period of public inspection

(ii) The project proponent shall in writing respond to such comments to the Project Approving Agency

9 Upon receipt of such responses referred to in regulation 8 (ii) above, the Project Approving Agency shall within a period of six days either

(i) grant approval for the implementation of the proposed project subject to specified conditions, or

(ii) refuse approval for the implementation of the proposed project with reasons for doing so

10 Upon receipt of an Environmental Impact Assessment Report the Project Approving Agency shall, within fourteen days determine whether the matters referred to by the Terms of Reference as set out in regulation 6 (ii) above are addressed, and if the Report is determined to be inadequate the Project Approving Agency shall require the project proponent to make necessary amendments and re submit the report, together with the required number of copies

11 (i) Upon receipt of the Report, as specified in regulation 10 above the Project Approving Agency shall submit a copy thereof to the Authority and by prompt notice published in the *Gazette* and in one national newspaper published daily in the Sinhala Tamil and English languages invite the public to make written comments, if any, thereon to the Project Approving Agency within thirty days from the date of the first appearance of the notice, either in the *Gazette* or in the newspaper

(ii) The notification shall specify the times and places at which the Report shall be made available for public inspection

(iii) The project Approving Agency shall make available copies of the Report to any person interested to enable him to make copies thereof

12 It shall be the duty of a Project Approving Agency, upon completion of the period of public inspection or public hearing if held to forward to the project proponent comments received for review and response within six days The Project Proponent shall respond to such comments in writing to the Project Approving Agency

13 Upon receipt of such responses as refered to in regulation 12 above, the Project Approving Agency shall with the concurrence of the Authority, within thirty days either–

(i) grant approval for the implementation of the proposed project subject to specified conditions or

(ii) refuse approval for the implementation of the proposed project, with reasons for doing so

14 It shall be the duty of all Project Approving Agencies to forward to the Authority a report which contains a plan to monitor the implementation of every approved project, within thirty days from granting of approval under regulations 9 (i) and 13 (i) by such agencies

15 The Project Approving Agency shall publish in the *Gazette* and in one national newspaper published daily in the Sinhala, Tamil and English languages the approval of any project as determined under regulations 9 (i) and 13 (i) hereto

16 (i) The Project Approving Agency shall specify a period within which the approved project shall be completed

(ii) A project proponent may, within thirty days prior to the expiry of such period, make an application in writing to the Project Approving Agency for an extension of time for the completion of the proposed prescribed project

17 (i) A project proponent shall inform the appropriate Project Approving Agency of–

(*a*) any alteration to a prescribed project approved under regulations 9 (i), and 13 (i), and/or

(*b*) the abandonment of such approved project

(ii) The project proponent shall where necessary obtain fresh approval in respect of any such alterations that are intended to be made to such project The Project Approving Agency shall in consultation with the Authority determine the scope and format of the supplemental report required to be submitted for such alterations

(iii) The project proponent shall, where a project is abandoned, restore the project site to a condition as specified by the Project Approving Agency

18 The Project Approving Agency shall communicate to the Project Proponent the administrative charges to be levied by the Project Approving Agency for the purposes of the approval of projects The Project Approving Agency shall follow the procedure set out in guidelines prepared by the Authority

19 In these regulations–

"Authority" means the Central Environmental Authority,

"Project Proponent" means any Government Department, Corporation, Statutory Board, Local Authority, Company, Firm or Individual who submits any prescribed project for approval,

"Project" means any undertaking, scheme or plan where commitment of resources, time and funds are envisaged and which comes into existence at the stage where the project proponent has a goal and is actively preparing to make a decision in achieving that goal

"Preliminary information" shall include a description of the nature, scope and location of the proposed project accompanied by location maps and any other details as may be requested for by the Project Approving Agency,

"environmental scoping" means determining the range and scope of proposed actions alternatives and impacts to be discussed in an Initial Environmental Examination Report or Environmental Impact [illegible] Report

"Report" means an Initial Environmental Examination Report or an Environmental Impact Assessment Report as the case may be and

"day" means any day other than a public holiday as defined by the [illegible] 1971

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MAP

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