Water Management of the Mae Moh Project

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SYNOPSIS

This paper presents the water management plan of the Mae Moh Project in the North of Thailand, which includes a large lignite opencast mine and thermal power plants. Lignite production will increase from the present 5.5 million tons per annum to approximately 20 million tons per annum by 1995 when the pit area will be about 20 sq.km. and the depth at over 300 meters. Seven power plants are proposed of which two are under construction. The total capacity to be installed is 2,925 MW.

The principles considered for water management are firstly flood protection, including drainage of the mining pit and diversion of the Mae Moh stream away from proposed future mining areas; and secondly, a plan to meet the water requirement of the thermal power plants, while maintaining downstream supplies for irrigation and other purposes.

The limited annual run-off of Mae Moh and Mae Chang watershed basins are inadequate for the proposed power plants. A study has been prepared to compare two approaches, namely conveying water from remote watersheds to meet the water requirement of the power plants up to total installed capacity; or by limiting future total generation, at the existing site, to only 2025 MV.

INTRODUCTION

An urgent need exists to expand power generation to cope with rapidly increasing electricity demand. The Mae Moh project forms parts of a longterm national development strategy to develop indigenous energy resources to reduce dependence on imported oil. The Mae Moh lignite mine and the power plants are located in the North of Thailand, approximately 600 km. north of Bangkok. 1500 million tons of lignite resource is known in the Mae Moh deposit and 600 million tons is presently defined as minerable reserves. Expansion of power generation and lignite production is to be developed in stages. The Mae Moh lignite mine currently produces 5.5 million tons lignite per year to fuel the power plant units No. 1-7 totalling 825 MW. Further development is planned to 20 million ton per year to support an ultimate power generation capacity of 2,925 MW.

Water resource development has been undertaken in parallel with the water requirement of the project. Two reservoirs supply water to power plant units No. 1-7 for mining activities and general downstream use. A diversion canal and new reservoir are under construction to cope with the water requirement of power plant units No. 8 and 9 (2x300M) scheduled to be operated in 1990. More units are planned, subject to the availability of sufficient water. The water resources of the Mae Moh and Mae Chang basins are sufficient to serve the power plants with capacity of 2,025 MW. Possible additional water supplies could be obtained from adjacent river basins by constructing reservoirs and water conveyance system to direct water to the project area.

WATER RESOURCE

General

The Mae Moh basin is located in the northern region of Thailand. Mae Moh stream, the biggest tributary of Mae Chang river is 35 km long and has a catchment area of about 200 sq.km. above the Mae Moh lignite mining area. It rises in the mountains between Ngow and Lampang in the northern part of the country, then flows southwards joined on its way by several creeks. It flows into Mae Chang river at Sob Moh (Figure 1). The stream profile in the head waters is 1:200 and in the valley is 1:1200. The vegetative cover at higher elevation in the watershed is moderate to heavy brush and jungle growth. The broad valley is cultivated in the form of rice paddy and cash crops. The general layout of water resource development are shown in Figure 1.

Climate

Thailand has a tropical climate with rainfall dominated by the southwest and the northwest monsoons phenomena.

The southwest monsoon, or wet season, lasts from mid May through to October. The wind travels long distances over the warm Indian Ocean, and generates a warm, very moist air mass when it arives over Thailand. It is the source of most of Thailand's rainfall.

The northeast monsoon lasts from November through mid March and brings in cool air, mostly from the northeast. In general, this is a cool, dry period.

Rainfall stations in the Mae Moh basin and surrounding areas show there is not much difference in rainfall intensity over the region. The average annual rainfall is around 1100 mm. and 90% of this rainfall occurs during the southwest monsoon season. The average temperature at the Mae Moh basin is about 25°c., with an extreme high of 43°c and extreme low of 6°c. The average annual run-off water of the Mae Moh, Mae Chang and adjacent watershed is a yield of 0.20 Mm^3 per square kilometer of area.

WATER REQUIREMENT

Water requirement of the Mae Moh project consists of cooling system and make-up water for the power plant, mining operation, construction, domestic use, reclamation and resettlement. All the thermal power plants use wet cooling system. Water for the cooling system is the main requirement. The water demand will sharply rise about 26 Mm^3/year for generating 825 MW power capacity at the present and will reach the final stage of about 64 Mm^3 for 2,925 MW by 1995. A water allocation and management plan is required for the project to cover existing and future expansion.

The water allocation and management pattern is shown in schematic diagram in Figure 2.

Existing Sources of Water Supply

The Mae Moh and Mae Chang basins have four existing fresh water reservoirs, as follows:-

- Mae Moh reservoir on the Mae Moh creek downstream about 6 km south of the mining area. It was constructed for domestic and industrial use of the Mae Moh fertilizer plant now closed.

- Huai Luang reservoir was constructed on the Mae Moh creek tributaries in 1975 to provide water supply for the early stage Mae Moh power plant units No. 1-3 (3x75 MW) and for general use. Longterm mining expansion will require this reservoir to be drained to allow for lignite mining over the reservoir area.

- Mae Chang reservoir is the biggest storage in the project area. Completed in 1984, it is the main source of water supply for power plant units No. 4-7 (4x150 MW). It also supplements water supplies to power plant units No. 1-3.

- Huai King reservoir was constructed across the valley of Huai King creek, one of the Mae Moh creek tributaries, to provide water supply mainly for housing and resettlement area only.

The existing Huai Luang and Mae Chang reservoir directly provide water supply for the project. They have a firm water supply capacity of about 26 Mm^3/year. This is just sufficient for the existing power plant and mining activities, excluding water release for downstream use.

Future Water Allocation and Management

Surface Water Sources - Proposed water supply schemes under investigation will involve water from existing or future possible impoundment.

The new water supply for power plant units No. 8-9 (2 x 300 MW) is under construction i.e. Mae Moh - Huai Sai diversion canal. This diverts water from Mae Moh creek to a new reservoir at Huai Sai and to allow flows via canal to the existing Huai Luang reservoir. There is an existing water supply system joining the Huai Luang reservoir and the regulating pond of Mae Chang reservoir, to supply water to the project.

To replace the Huai Luang reservoir which will be drained in 1992, a new reservoir will be constructed at Huai Pet to collect run-off from below the mining and power plant areas. This reservoir will connect to a water conveyance system between Huai Sai and Huai Pet reservoirs, thereby joining the two reservoirs together and also making a connection between Huai Pet reservoir and Mae Chang regulating pond.

Further water development in the Mae Moh and Mae Chang basins are planned to collect run-off from the upper reach of Mae Moh creek by constructing a weir upstream at Ban Tha Si, to divert flood run-off by a diversion canal, to a new reservoir at Mae Kam creek, above the mining and dumping areas. This reservoir will mainly provide water for reclamation work and for supplementing the project water demand.

After collecting all the sources of water from existing reservoirs and additional proposed sources in the Mae Moh and Mae Chang basins, the estimated firm water capacity will be 46 Mm^3/year allowing for downstream use. This capacity is adequate for the power plants up to a maximum of 2,025 MW capacity.

Power plant development beyond 2,025 MW will involve an additional 3 units (3x300 MW). Water availability is an important consideration in this to enable the mine expansion project to proceed smoothly. Alternatives considered involve water sources within the Mae Chang basin and adjacent Mae Wang and Mae Yom basins.

For the Mae Chang basin, the first alternative is to pump water from the proposed lower Mae Chang reservoir. This was planned by the Irrigation Department to mainly serve the Mae Chang irrigation project. However, the implementation schedule of that project is yet to be fixed. Water can be pumped from the lower Mae Chang reservoir to the regulating pond during the wet season when spilling of the lower reservoir often occurs. But the Mae Chang basin is hydrologically characterized by one wet year followed, on average, by 3-4 dry years. Thus a risk of water shortage exists for the project operation. In the early stage water pumping from the Mae Chang reservoir could meet the project requirement, but it would not allow for more water demand, for irrigation and domestic use along Mae Chang downstream, which may increase in coming years.

Mae Wang river basin is an alternative water source adjacent to the Mae Chang basin. There is an existing dam and regulating pond involved in the Mae Wang river irrigation projects and in downstream domestic use. Kew Lim dam is a main source of water supply with an average annual water run-off at the dam site of 570 Mm^3 and a storage capacity of 112 Mm^3. The size of the reservoir was restricted, because of the extreme high cost, of compensations for losses from conventional productive farm land and the town of Chae Hom. The reservoir size is considerably smaller than normally would be expected and has storage which is less than 20 percent of the average annual run-off.

An average of nearly 380 Mm^3 will be spilled from the Kew Lom reservoir each year when it is operated only for irrigation. Upstream storage will be required to reduce the spillage. The potential storage dam site above the Kew Lom reservoir is limited to a canyon reach. The Kew Kor Mar is located about 20 km upstream of Kew Lom dam site with the average run-off at the dam site of 240 Mm^3 and storage capacity of 260 Mm^3. There are two possibilities. Firstly to pump water from the Sob Ang Weir which is located downstream of Kew Lom dam. In this case, without upstream storage, the pump capacity and piping system have to be designed to cope with the water requirement of about 18 Mm^3, supplying the additional power units No. 12-14 (3x300 MW) by pumping water during the August to October spillage period. However, the risk of water shortage is considerable. It is also uneconomical to design such large size pumps and piping system to be used for only 15 percent of the year. In the case of the upstream storage at Kew Kor Mar, the integrated operation of two reservoirs must be considered. In this way the most practical and efficient program of development of the Mae Wang irrigation project can be obtained and excess water can be pumped to supply the additional power plant units year round.

A possible additional source of water for the Mae Moh Project might be water diversion obtained by pumping water from the Mae Yom river basin. In this basin a two-stage multipurpose project has been planned. Stage I of the Mae Yom dam is at Kaeng Sua Ten with live storage of 1,700 Mm^3. This volume of water could provide dry season irrigation to some 50,000 ha, mainly in the delta region of the Chao Praya Basin and also generate electricity. For Stage II, the dam is to be raised higher to provide a live storage of 3,100 Mm^3. There is still a need to increase water supply by diverting water from the other river basins. These multipurpose projects are on the national level and involve high investment cost. The staging analysis has therefore been undertaken and the result has shown that the project should be developed in stages rather than as a single project. Water supply can be available to the Mae Moh project, after the completion of Mae Yom Stage I construction, by pumping water supply from the Mae Yom dam to the Mae Moh project through a pump house, 60 km pipe and 2 km tunnel. The problem is that the Mae Yom multipurpose project is not yet provided for in the Irrigation Development Plan.

DRAINAGE SYSTEM

Surface dewatering is an important constraint for a smooth mining operation especially in tropical region. Flood control and drainage will be carried out from the mining pit, overburden/ash dump site, mine infrastructures, power plant site, reclaimed area etc.

The hydrometeorological data of the project area has only been compiled since 1954, consequently, some of the basic data employed has been taken from adjacent areas of the Mae Moh basin. Though some basins are relatively small, they have similar characteristics and the records can be adjusted, analysed and arranged so that the general pattern of all elements could be determined. The maximum rainfall in the basin and adjacent areas were recorded for a period of over 50 years, as follows:-

Maximum monthly rainfall	-	420 mm
Maximum rainfall intensity	-	220 mm/day

The rainfall intensity duration derived for the Mae Moh basin where it would be more economical to use the value of 10 year frequency as a basic design of drainage, i.e. 125 mm/day.

Mine Pit

The proposed open-cut mining area for the mine operation has been planned to cover total area of about 20 sq. km. and the final depth of the pit is about 300 meters below existing ground surface. The excavation will proceed from the existing pit, which is located on the east of the basin, and will move northwards anti-clockwise to the north of the basin and then turn to the west. The second pit will be mined in the west to 1995 and proceed in both north and south directions.

Storm rainfall during the monsoon season frequently creates the most serious flood and drainage problems in the mine pit and interrupt the mining operation. Because of the low hydraulic conductivity of the claystone strata and lignite seams, groundwater will probably not make a significant contribution. The quantity of seepage water into the pit is low in comparison with the surface water.

The mining sequence has been planned to create with pumped sumps to collect openpit catchment. These are separated in several areas and at different levels. It is uneconomical to have pumps of such capacity that mine run-off is removed from the pit immediately. The volume of the sumps and working space is designed to clear the 10 year frequency rainfall intensity flood. From past experience, in this basin, the in-pit run-off co-efficient during flood period is about 0.6. It is necessary for the design pumps for each mine catchment area to be installed at least throughout the rainy season (April to October). Where gravity flow is not possible, some small pumps will be used to transfer water into the main sump. Almost all of the sumps will be relocated as the opencut mine operation moves. The total opencast mine depth is about 100 meters. When the mine reaches greater depth, it will be necessary to install the multi stage pumps either on the floating pontoons or on the temporary benches located above the sump to avoid flood water. The drained mine water will be discharged directly into the creek. During the dry season, water will be kept in the sumps and used for dust suppression on service roads and also for emergency fire fighting purpose.

Overburden and Ash Dump

External overburden dumps will be located on both sides of the pit. Dumping will commence on the east side in the early stage and on the west side later on. On the southern part of the east dump provision is made for an ash pond. The land reclamation and slope protection will be carried out after the completion of dumping.

All dumping benches will be prepared with an inclination both in traverse and longitudinal directions. Trenches have been formed along the toes of the slopes to collect and discharge water to small pondages prepared on each dumping bench. The pondages will be lined by compacted cohesive material to prevent water seepage into the dumping slope. To drain water from one bench to the next lower one, appropriate steel pipe would be laid during the year of the dumping operation. These pipes will be replaced by open chute concrete structure with the stilling basins at the foot of the chute to dissipate excess energy. The water would then be discharged to a receiving stream.

RIVER DIVERSION

The present course of the Mae Moh creek flows through the area under which lignite is known to exist. In order to implement mining development, the relocation of Mae Moh creek had been planned by diverting the flow of the creek before it enters the proposed mining area in the north. The diversion canal will be excavated along the western perimeter of the mining area. The flow of small tributaries will be intercepted and channelled into the diversion canal which leads into the proposed Huai Sai reservoir, at the south of mining area and then flows downstream into the Mae Moh creek.

The construction of the diversion cannal and associated work involves excavation of an 11 km diversion canal, with the road on the embankment and the construction of an earthfill dam at the downstream of the diversion and including the hydraulic appurtenance structures. The diversion and inflow spillway flood of the downstream reservoir has been designed to serve for the once-in-100 year return flood. The average gradient of the channel is approximately 1:4000 (V:H) which is slightly flatter than the existing water course's gradient. The base width of the channel is 20 meters with a side slope of 1:2 and a depth of 8 meters. The construction will be commenced in 1988 and be completed in 1990.

There is a secondary diversion channel along the eastern perimeter of the mine pit to safely collect surface run-off water from small creeks and dumping areas.

WATER QUALITY

The project area is located in the Mae Moh creek valley where, to some extent, the mine operation and lignite-fired powerplant could interfere with the physico-chemical characteristic of the water in the area. The surface run-off water collected in the mine sump includes the leachate from ash and overburden dumping areas and waste water from various water processes in the power plant. If this water were to be discharged directly into its natural streams, it could give rise to a pollution hazard and affect the water resource in the basin.

A water quality monitoring program is essential for obtaining the information on the existing condition of surface water in various locations in the project area and natural river courses. The water quality data can be used as basic information for assessing the impacts and as a tool for selecting appropriate measures for water pollution abatement. Water samples have been taken in periods of low, medium and high flow conditions throughout the year. A standard procedure has been applied in sampling and analysis of water samples. The physio-chemical characteristics of surface water and waste water in the project area will include ph, total dissolved solids, colour, alkalinity, hardness, BOD, conductivity, heavy metal and etc. Sampling stations were selected in various locations ranging from the natural base-line to subsequent contamination of point and non-point source pollutant. The natural base-line sampling station is located at the Mae Moh upstream above mine, power plants and existing water supply reservoirs and is therefore free from any lignite-relating activities. The water quality of this station is considered to represent the natural run-off water in the Mae Moh basin. The outlet sampling station is provided at the Mae Moh creek reservoir which is the final receiving water body for all potential source and non-point source pollutants of the project area.

Based on the water quality analysis of the existing water supply reservoir, which is not contaminated by the waste from the mining operation, the general physico-chemical characteristics were relatively similar to the water quality of the base-line sampling station. This water is of adequate standard for community water supply irrigation water and downstream use.

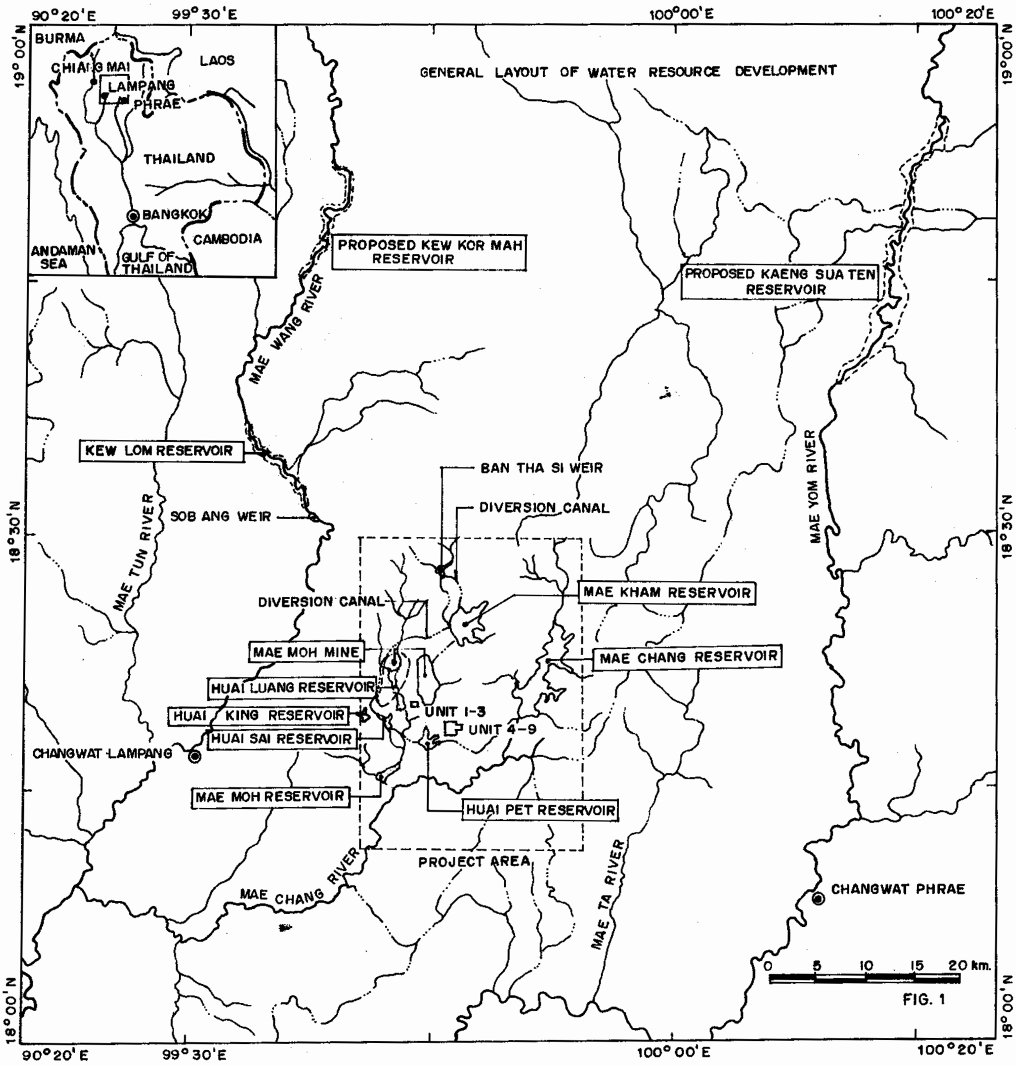
The analysis of waste water quality in the areas of a rather high contamination, for example the mine sump water is alkaline (ph 7.5 to 8.1), The conductivity is high (1900-3100 uS/cm), the hardness is high (100-1500 mg/L as $CaCo_3$) and the total dissolved solids are moderately high (200-3600 mg/L) commonly found as sulphates, calcium and magnesium. During the rainy season the drained water in the mine sump is continuously pumped out into the Mae Moh creek and mixed with the large amount of flood water. During the dry period of about 8 months all waste water will be retained in the sumps and used for dust suppression on access roads and fire-fighting puposes.

The ash pond water contains caustic alkalinity with extremely high pH (from 12 to 12.5) a conductivity of 5000-7000 umho, an alkalinity (1200-2300 mg/L as $CaCo_3$ and a hardness of 1400-2500 mg/L. Dissolved solids amount to 4500-6500 mg/L and sulphate amounts to 2200-3400 mg/L. The water has a moderately high concentration of calcium, magnesium, potassium and etc. The drained water of ash dump will be collected in the ash pond.

In general, the quality of waste water from various areas is unacceptably high in pH value, suspended and dissolved solid content, and heavy metal, even after flowing down the natural river course and retain into the Mae Moh downstream reservoir. The reservoir water is still in the range of the surface water criteria, and has a high purifying capacity which is enough to control the water pollutant problem.

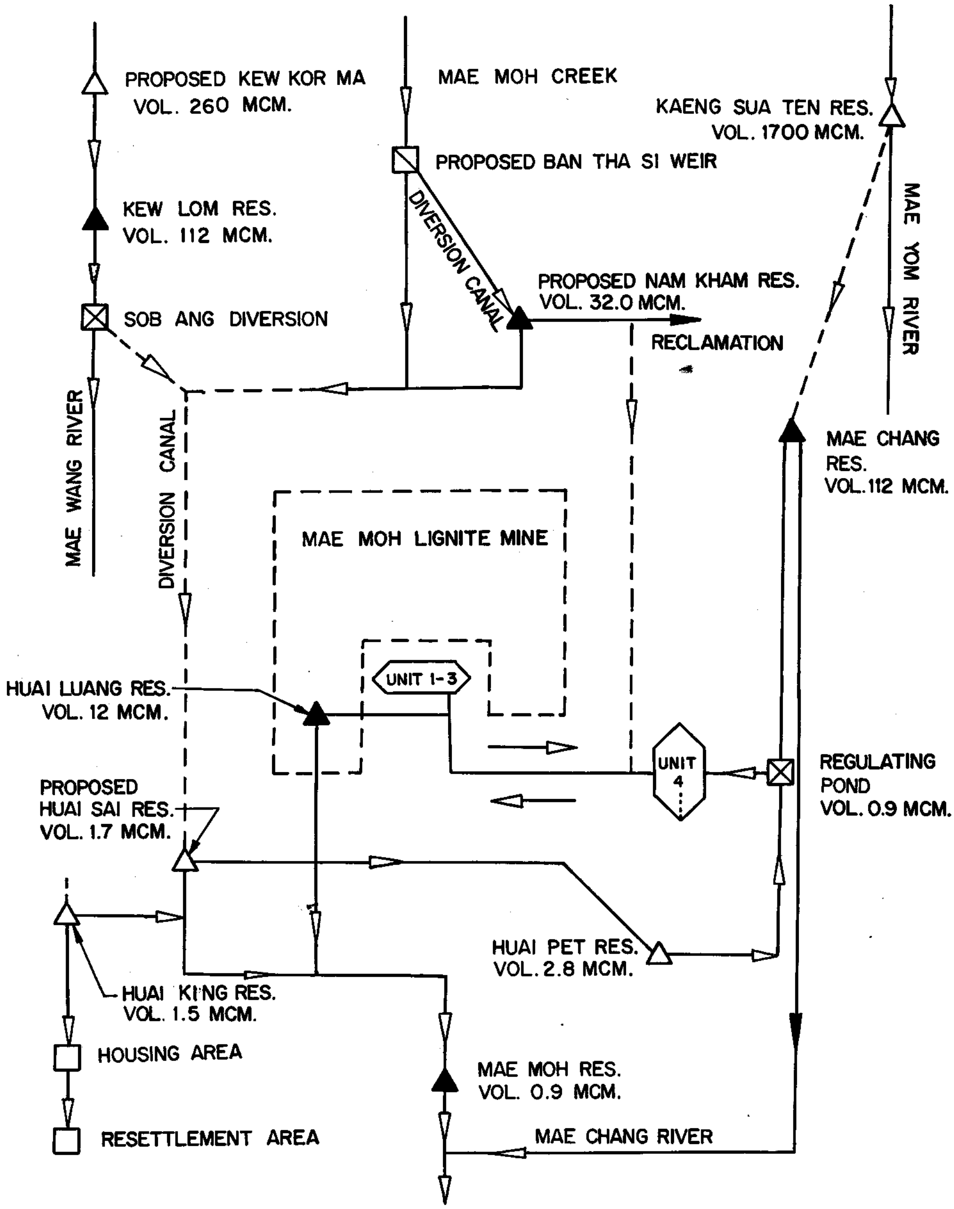
CONCLUSION

As power plant units are constructed beyond power capacity of 2025 MW, water availability to the project involves some risks of water shortage due to the limited water resource available in Mae Moh and Mae Chang basins. According to recent information, some surplus water resources are still available, leaving some adjacent river basins unutilized. The development of the upper Mae Wang river basin, with a reservoir of storage capacity of 260 Mm^3 is the most attractive scheme. More investigation on the scheme should be made to examine the maximum benefit which derives from the expansion of the water supply.



90°20'E
99°30'E
100°00'E
100°20'E
19°00'N
18°30'N
18°00'N
BURMA
CHIANG MAI
LAOS
LAMPANG
PHRAE
THAILAND
BANGKOK
CAMBODIA
ANDAMAN SEA
GULF OF THAILAND
GENERAL LAYOUT OF WATER RESOURCE DEVELOPMENT
PROPOSED KEW KOR MAH RESERVOIR
PROPOSED KAENG SUA TEN RESERVOIR
MAE WANG RIVER
KEW LOM RESERVOIR
BAN THA SI WEIR
DIVERSION CANAL
SOB ANG WEIR
MAE TUN RIVER
MAE YOM RIVER
MAE KHAM RESERVOIR
DIVERSION CANAL
MAE MOH MINE
MAE CHANG RESERVOIR
HUAI LUANG RESERVOIR
HUAI KING RESERVOIR
UNIT 1-3
UNIT 4-9
HUAI SAI RESERVOIR
CHANGWAT LAMPANG
MAE MOH RESERVOIR
HUAI PET RESERVOIR
PROJECT AREA
MAE CHANG RIVER
MAE TA RIVER
CHANGWAT PHRAE
0 5 10 15 20 km.

FIG. 1



SCHEMATIC DIAGRAM
OF
MAE MOH WATER SUPPLY MANAGEMENT

FIG. 2