

KINGDOM OF THAILAND
MINISTRY OF AGRICULTURE AND COOPERATIVES
ROYAL IRRIGATION DEPARTMENT

FEASIBILITY STUDY ON THE UPPER PASAK MEDIUM SCALE IRRIGATION PROJECT

VOLUME 1
MAIN TEXT

MARCH 1983

JAPAN INTERNATIONAL
COOPERATION AGENCY



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PREFACE

It is with great pleasure that I present this Feasibility Study Report on the Upper Pasak Medium Scale Irrigation Project to the Government of the Kingdom of Thailand.

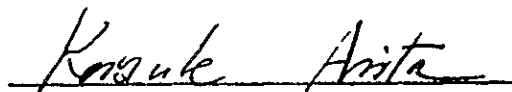
This report embodies the result of a feasibility study which was carried out in Upper Pasak river valley, Phetchabun Province from June to October 1982 by a team commissioned by the Japan International Cooperation Agency in response to the request of the Government of Thailand to the Government of Japan.

The survey team, headed by Mr. Hiroshi YAMAMOTO of Nippon Koei Co., Ltd., had a series of discussions with the officials concerned of the Government of Thailand and conducted a wide scope of field survey and data analyses.

I sincerely hope that this report will be useful as a basic reference for development of the region.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to our team.

March 1983

A handwritten signature in black ink, appearing to read 'Keisuke Arita', is written over a horizontal line.

Keisuke ARITA

President

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keisuke ARITA
President
Japan International Cooperation Agency,
Tokyo, Japan

Dear Sir,

We have pleasure in submitting herewith seventy five (75) copies of Feasibility Study Report on the Upper Pasak Medium Scale Irrigation Project in the Kingdom of Thailand in accordance with the terms of reference issued by your Agency. The report consists of four separate volumes: Main Text (Volume-1) summarizes the results of the study and presents the conclusion and recommendations; Annexes (Volume-2.1 and -2.2) provides more detailed technical informations and procedures; Drawings (Volume-3) give the general plan of each subproject area and the layouts of dams, canals, and related structures.

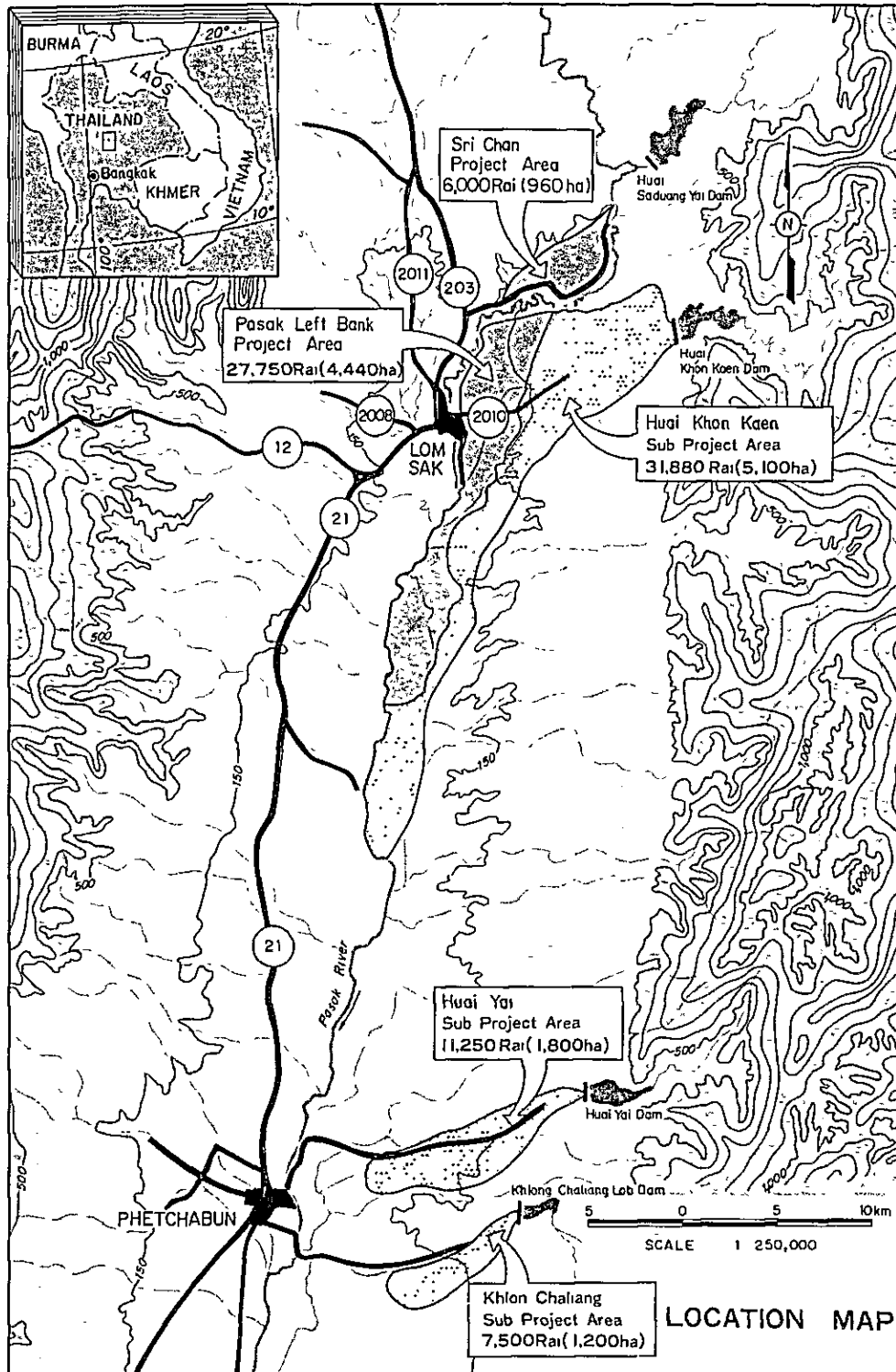
Water resources and irrigation development have recently become pressing needs all over the Pasak valley. This study has been made to formulate the feasible development plan for four (4) subprojects in the Phetchabun Province. Each subproject aims at the improvement of disparity of income and raise of living standard of the farmers in the project area through the exploitation of water resources and the development of irrigated agriculture. With implementation of the project, the annual production of rice, mungbeans and tobacco would be sharply increased in the project area and the increased amount of these products would substantially contribute to the regional economy of the Phetchabun Province. It is verified throughout the study that the project is technically sound and economically and financially viable. In view of the pressing needs and the economic contribution of the project, we would recommend that the project would be soon implemented along the conclusion presented in this report.

In submitting this report, we wish to express our sincere appreciation and gratitude to the personnel concerned of your Agency, the Embassy of Japan in Thailand and the Authorities concerned of the Government of Thailand for the courtesies and cooperation extended us during our field surveys and studies.

Very truly yours,



Hiroshi YAMAMOTO
Leader of The Study Team
for The Upper Pasak Medium
Scale Irrigation Project



SUMMARY

BACKGROUND OF THE PROJECT

01. The Kingdom of Thailand has sustained about 8% of the growth rate of GDP during the recent decade of 1970's. Such a rapid stride of the economic growth in Thailand causes serious and complex economic problems and social tensions. In order to overcome these problems and tensions, the Fifth National Economic and Social Development Plan has recently been drafted out containing long-range strategy and new approach. The major targets and objectives in the Development Plan are;

- to reduce absolute poverty and accelerate rural development in the backward area,
- to restructure the production process so as to accelerate the expansion of exports, reduction of imports, and creation of additional employment, and
- to uplift living standard as well as to strive more equitable distribution of welfare.

02. Agricultural sector makes great contribution to the export accounting for about 52% of the total amount of exports in 1977/78. In recent years, crop diversification has been rapidly accelerated particularly in the Northern Region. In order to achieve the agricultural development targets stipulated in the Development Plan, the Government puts more emphasis on raising productivity of agriculture through the development of irrigation system including on-farm development as well as water resources development.

03. Nowadays, there remains a few river system much suitable for creating reservoir in Thailand. The Development Plan clearly stipulates that the Pasak river system be one of the most potential basins for water resources exploitation in the Northern Region.

04. In order to achieve the short-run objectives of economic stability stipulated in the Fifth Development Plan, the following targets were set forth in respect to agricultural sector as follows:

- overall target: annual increase by 5%
- crop production: annual increase by 5.9%
- livestock production: annual increase by 4.3%
- fisheries production: annual increase by 5.5%, and
- forestry production: annual increase by 0.3%.

THE PROJECT AREA

05. The project area extends over the Phetchabun province situated at about 330 km north of Bangkok. Out of the four proposed sub-project areas, the Huai Saduang Yai and Huai Khon Kaen areas are located at about 15 km northeast of the Lom Sak municipality. The remaining Huai Yai and Khlong Chaliang Lab areas are located at about 20 km due east of the Phetchabun municipality.

06. About 845,000 rai (135,200 ha) of arable land resources are endowed in both the Lom Sak and Phetchabun districts. Out of them, about 394,500 rai (63,100 ha) have been developed for paddy and upland crops cultivation. The remaining resources are exploitable for only upland crops cultivation in view of shallow soil depth, undulating topography and non-availability of irrigation.

07. The project depends its water resources on the four tributaries of the Pasak river confluencing from the left bank. The drainage area and the dependable mean annual runoff of respective tributaries are;

<u>Water Source</u>	<u>Drainage Area (km²)</u>	<u>Annual Runoff (MCM)</u>
Huai Saduang Yai	96	22.4
Huai Khon Kaen	322	75.1
Huai Yai	75	19.9
Khlong Chaliang Lab	77	20.5

08. The Pasak river valley slenderly extends north to south along the Pasak river with an average width of about 45 km. The basin extending over the left bank of the Upper Pasak river is broadly divided into terrace, alluvial fan and recent alluvial flat. Many small-scale alluvial fans have been created by the tributaries. The fans are gently slanting from northeast to southwest with a topographic gradient of nearly 0.4%, and have been developed for upland crop cultivation. The recent alluvial flat formed by the Pasak river slenderly extends along the river banks and is topographically gentle and low-lying.

09. The climate in the Upper Pasak river basin is characterized by two distinct wet and dry seasons. The wet season lasts from May to October and the dry season from November to April. The annual mean temperature at the Phetchabun meteorological station is 27.6°C ranging from 33.2°C in maximum mean to 21.0°C in minimum mean. Annual mean rainfall is 1,090 mm at Phetchabun, of which about 90% falls during the 6 months of the wet season. Annual mean Pan evaporation is 1,808 mm, in which the maximum evaporation occurs in April and the minimum in September.

10. The project area is underlain by sedimentary rocks of Permian, Triassic and Tertiary, and covered with the Pleistocene and recent fluvial deposits. The sedimentary rocks form a wide zonal structure and are mutually in unconformable relationship. In the eastern mountain ranges, there exists Nam Duk Formation of Middle Permian forming 20 to 30 km wide strip. The Formation is composed of primary alternating beds of shale and sandstone folded along N-S trending axis.

11. The major soils in this area are classified into seven soil series. Among them, the Lom Sak and Nakhon Phathom series are predominant. The Lom Sak series are characterized by very deep effective soil layer, clayish texture and relatively high inherent fertility. Soil reaction is medium acid to neutral. Drainage is generally poor. This series are classified as Hydromorphic Alluvial Soil or Eutric Gleysols. The Nakhon Phathom series are formed from semi-recent riverine alluvium and found on low terraces. They are deep, slightly acid to medium acid surface over neutral to moderately alkaline subsoil, and generally medium fine textured. The drainage is generally poor. The series are classified as Hydromorphic Non-Calcareous Brown Soils or Gleyic Luvisols.

12. In the Upper Pasak river basin, there developed two medium scale and three small scale irrigation projects by RID and the Provincial Government. In addition, in each sub-project area, there are many village level irrigation facilities constructed by farmers themselves. Most of them serve only for supplementary irrigation in the rainy season. There are also tube-well irrigation systems.

13. In Phetchabun province, owner farmer is predominant. As for land holding size in Phetchabun province, about 76% of farmers are in the range from 6 rai to 50 rai. About 10% of land holding farmers still occupy about 30% of the total farm land. The average farm sizes in Lom Sak and Phetchabun districts are about 19.2 rai and 25.1 rai respectively. Most of farmers have their farm lands scatteredly, and their plot sizes are rather small.

14. The present land use in each sub-project area is summarized as given below:

<u>Categories</u>	<u>Sri Chan &</u>	<u>Huai</u>	<u>Khlong</u>		<u>Total</u>
	<u>Left Bank Area</u>	<u>Khon Kaen</u>	<u>Huai Yai</u>	<u>Chaliang Lab</u>	
	(rai)	(rai)	(rai)	(rai)	(rai)
Paddy field	31,000	20,000	10,900	7,300	69,200
Upland field	7,700	9,100	540	300	17,640
Others	11,360	9,860	3,600	1,640	26,460
Total	<u>50,060</u>	<u>38,960</u>	<u>15,040</u>	<u>9,240</u>	<u>113,300</u>

15. Present yields of paddy widely vary from 180 kg/rai to 700 kg/rai, depending on the variety, availability of irrigation water, amount of inputs etc. Yields of upland crops such as maize, mungbeans and tobacco also fluctuate year to year. The average yields of major crops in the respective sub-project areas are summarized as given below:

<u>Crops</u>	<u>Crop Yield</u>			
	<u>Sri Chan & Left Bank (kg/rai)</u>	<u>Huai Khon Kaen (kg/rai)</u>	<u>Huai Yai (kg/rai)</u>	<u>Khlong Chaliang Lab (kg/rai)</u>
Paddy				
- Local varieties	500	440	440	440
- High yield varieties	650	550	550	550
Mungbeans	120	120	120	120
Tobacco	270	270	270	270
Maize	420	420	420	420

16. The seasonal fluctuation of local market price is relatively large due to inadequate marketing system, limited storage facilities, etc. Particularly for paddy, the farmers are often compelled to sell these products to itinerant buyers immediately after harvesting. The prices of paddy, mungbeans and tobacco vary from ฿ 2.5/kg to ฿ 3.2/kg, ฿ 7/kg to ฿ 14/kg, and ฿ 25/kg to ฿ 35/kg respectively.

17. The agricultural extension activities in the Phetchabun have distinctly been improved through the introduction of the so-called "training and visit" system. The extension agent takes care of ten villages. The staff of the extension agent regularly visits about 100 selected contact farmers on the fixed date and time, and, through them, indirectly trains about 1,000 farmers.

18. There is no agricultural research station in the Phetchabun province. The Phitsanulok and Lopburi experimental stations, the nearest station to the project area, have conducted various researches on paddy cultivation. The Tako experimental station in the Nakhon Sawan has conducted various research on upland crops cultivation. While, the Chainat research station is authorized as a major center of the research on irrigated farming during the dry season. The Samchook and Phitsanulok water use experimental stations in the Suphan Buri and Phitsanulok provinces respectively have made a tangible contribution to the betterment of irrigation water management.

19. There are six agricultural cooperatives in both districts concerned. The numbers of farmers joining the cooperatives totals about 6,000 or are equivalent to 13% of the total farmers in both districts. The cooperatives give the members a wide range of support services.

20. Agricultural credits to farmers are institutionally obtainable by three types of channel, i.e. the bank for agriculture and agricultural cooperatives (BAAC), commercial bank, and cooperative organizations. About 400 farmers' groups for credit of the BAAC have been set up in the Phetchabun district, enrolling 6,600 farmers, about 31% equivalence of the total district farmers. While, about 230 farmers' groups have been set up in the Lom Sak district, gathering 3,500 farmers, 14% equivalence of the district farmers.

21. Most of the input distributions are still fully controlled by private sectors. Some limited farmers have purchased their agricultural inputs at subsidised low prices through the intervention of the public sector. The farmers' marketing organizations, however, distribute seeds directly to farmers through the provincial extension office. The Thai Tobacco Monopoly also provides input distribution services for tobacco growers. The inputs are generally sold on credit terms.

AGRICULTURAL CONSTRAINTS AND PROJECT NEEDS

22. The major constraints foreseen in the project area are:

- (1) Serious shortage of irrigation water,
- (2) Annual shortage and uneven seasonal distribution of rainfall,
- (3) Lack of perennial irrigation system,
- (4) Improper water management,
- (5) Improper application of agricultural inputs, and insufficient and improper control of disease and insects,
- (6) Insufficient agricultural support services,
- (7) Insufficient farm road networks,
- (8) Insufficient of marketing system,
- (9) Insufficient agricultural institutions, and
- (10) Scattered land holding and small-scale field plot.

The decisive constraints among them are serious shortage of irrigation water resources and lack of perennial irrigation system.

23. Despite the provision of irrigation system in the Upper Pasak river basin, most of them are still subject to serious shortage of irrigation water during the dry season. In the river basin, most paddy field of about 840,000 rai (134,000 ha) still remain under rainfed condition, resulting in low land productivity. Hence, irrigation and water resources development has recently become pressing needs in the valley.

PROSPECTIVE DEVELOPMENT

24. The basic concepts for agricultural, water resources, and irrigation developments are;

- (1) to increase unit yield of wet season paddy,
- (2) to stabilize wet season paddy with stable water supply,
- (3) to improve the living standard of extended rural population through extensive agriculture,
- (4) to orientate a diversified agriculture in conformity with the national development program,
- (5) to introduce the optimal cropping pattern in due consideration of water economy,
- (6) to make great impacts on farm economy,
- (7) to orientate the maximum exploitation of endowed water resources,
- (8) to incorporate potable and domestic water supply into the project, and
- (9) to incorporate existing irrigation systems into the proposed system.

25. Water resources are one of basic re-cycling resources composing of environment. The following measures are essential in order to overcome the future shortage of water resources all over the Pasak river basin:

- (1) Cropping intensity should be severely restricted within 135% all over the basin in view of long-range prospects of water balance in the basin,
- (2) Irrigation water saving should be made all over the basin through up-grading of existing irrigation systems,
- (3) Domestic, municipal and industrial water resources mainly depending on natural flow at present should be replaced by groundwater in future, and
- (4) In future full development stage of the basin, a large scale transbasin works will be essential.

26. Based on the results of water balance study, the optimum scale of the project is determined as given below:

<u>Component</u>	<u>Huai Saduang Yai</u>	<u>Huai Khon Kaen</u>	<u>Huai Yai</u>	<u>Khlong Chaliang Lab</u>
Useful Storage (MCM)	27.0	30.0	13.3	6.7
Cropping Intensity (%)	135	135	135	135
Irrigable Area (rai)	33,750	31,880	11,250	7,500

27. Paddy is selected as a main wet season crop, and mungbeans and tobacco are picked out for dry season crops. The crop intensity of 135% is proposed in view of irrigation water balance, i.e. 100% of wet season paddy comprising 70% of high yield varieties and 30% of improved local varieties, and 35% of dry season upland crops comprising 20% of tobacco and 15% of mungbeans.

28. With introduction of improved farming practices and proper water management, the crop yields are substantially increased. The target yield of each proposed crop is set up as given below. The build-up period for these target yields are expected to be within 5-years after commencement of the project operation.

Paddy	
- local varieties	640 kg/rai
- high yield varieties	800 kg/rai
Mungbeans	240 kg/rai
Tobacco	400 kg/rai

29. At the full development stage of the project, the surplus of rice after local consumption will be 30,800 tons in the project area. The surplus will be exported to the Bangkok or abroad. At the same time, about 3,000 tons of mung beans are expected to be produced in the project area, and most of them will be marketed to Bangkok. About 6,700 tons of tobacco are also expected to be produced, and most of them will be dealt not only for domestic consumption but also for export abroad. The normal marketing flow of tobacco will be through the Tobacco Monopoly Office under cooperation of marketing organization for farmers.

30. From the farmers' viewpoint, the financial evaluations for the cases of "with project" and "without project" are made for the typical farmers in the respective sub-project areas as tabulated below:

Description	(Unit: Baht)							
	Huai Saduang Yai		Huai Khon Kaen		Huai Yai		Klong Chaliang Lab	
	with project	without project	with project	without project	with project	without project	with project	without project
Gross income	56,578	35,694	57,940	32,404	59,313	29,326	57,168	29,970
Farm outgo	48,830	34,908	49,902	32,357	49,527	29,273	49,044	29,921
Balance or capacity to pay	7,748	786	8,038	47	9,785	53	8,124	49
(US\$ equivalence)	(337)	(34)	(349)	(2)	(136)	(2)	(353)	(2)

31. The net incremental benefit of the project, which is defined as the difference between the respective net production values under "with-project" and "without project" conditions, is estimated as summarized below:

(Unit: 10^3 B)

Sub-Project	With Project	Without Project	Net Incremental Benefit
Huai Saduang Yai	248,274	113,609	134,665
Huai Khon Kaen	234,933	71,556	163,377
Huai Yai	82,799	23,874	58,925
Khlone Chaliang Lab	55,157	18,235	36,922
TOTAL	621,163	227,274	393,889

32. In order to ensure the proposed agricultural development plan and to reap the fruitful project returns, three agricultural setups would be recommended as listed below:

- i) technical advisory committee at the field level for better coordination among various agricultural offices concerned,
- ii) seed multiplication farm in the project area, and
- iii) water users' association at each sub-project.

33. Irrigation water requirements are calculated for the proposed cropping pattern. The peak water requirements and total diversion requirements for respective sub-project areas are estimated as shown below:

Sub-Project	Unit Design Water Requirements	Diversion Requirements
Huai Saduang Yai	1.0 lit/sec/ha	5.4 m ³ /sec
Huai Khon Kaen	"	5.1 m ³ /sec
Huai Yai	"	1.8 m ³ /sec
Khlone Chaliang Lab	"	1.2 m ³ /sec

34. The design drainage requirements are estimated for 3-day consecutive rainfall with a 10-year return period, using the rainfall data observed at the Lom Sak and Phetchabun Stations. The design drainage requirements thus estimated are 4.5 lit/s/ha in all the service areas.

35. The water stored by the Huai Saduang Yai dam would be released into downstream and conveyed to the Sri Chan and Pasak Left Bank service areas through the Huai Saduang Yai and the Pasak river. The released water would be offtaken from the Pasak river to each service area by the existing weirs respectively, and distributed to the service area of 5,400 ha through the existing irrigation canal network.

36. The Huai Khon Kaen reservoir would command 31,880 rai (5,100 ha) of paddy fields extending along the eastern boundary of the Pasak Left Bank area. The irrigation water for the service area would be offtaken directly from the Huai Khon Kaen reservoir and conveyed to the irrigation area through Right and Left Main Canals. About 54 km of the main canals are aligned in this service area, comprising 8 km of Right Main Canal and 46 km of Left Main Canal. Three lateral canals of about 52 km would be networked all over the service area. The drainage water from paddy field would be eliminated to the Pasak river through the Huai Khon Kaen and/or 21 improved or newly constructed drainage canals. The length of the newly proposed drainage canals totals about 24 km.

37. The Huai Yai reservoir would command 11,250 rai (1,800 ha) of paddy fields which are delineated along both banks of the lower Huai Yai. The area would be served by one main canal with a total length of about 9 km. Three laterals stretch out from the main canal. The length of lateral canals totals about 18 km. The drainage canal of 5.0 km would be newly aligned to supplement natural drainage creeks.

38. The Khlong Chaliang Lab commands 7,500 rai (1,200 ha) of paddy fields. The irrigation water for the service area would be released directly from the dam to the main canal. The main canal of about 7 km would be aligned through the left bank area of the Khlong Chaliang Lab. Three lateral canals of about 14 km would be networked over the area. About 3 km of collector drains would be proposed to drain excess water into the existing natural creeks.

PROPOSED PROJECT WORKS

39. The foundation at each dam site comprising sandstone interbedded with shale is sufficiently stable to support earth embankment. The base rock at the site is partly weathered and cracked. There exist no geological fault and/or fractured stratum.

40. Impervious materials for core zone are obtainable in and around the reservoir site. But these materials are slightly fine for core zone. Some amount of coarse materials must be blended with these materials for increase of shearing force and better workability. The random materials for shell zone would be borrowed at hillside around the reservoir site. Concrete aggregates and riprap materials would be purchased and hauled from the existing quarry sites.

41. The crest width for the Huai Khon Kaen dam is determined to be 10 m, and those for the other three dams are 8 m respectively. The freeboard for the Huai Khon Kaen dam is conservatively proposed to be 4.5 m, and those for the other three dams are also conservatively proposed to be 3.5 m. A relatively gentle slope of 1 to 3.0 would be provided for the upstream of embankment of each dam against the rapid drawdown. A slope of 1 to 2.5 would be conservatively provided for the downstream of embankment. A 2 m thick vertical filter would be aligned just behind the core zone to lower the phreatic line. To smoothly drain the seepage water, horizontal drains would be laid from the foot of vertical filter to the downstream toe.

42. Ungated side channel type is selected for the service spillway. The service spillway for each dam would be aligned also to the top of abutment at each dam site. The service spillway for the Khlong Chaliang Lab dam would be jointly constructed with the emergency spillway because of topographic constraints. The main features of the service spillway are as given below:

Service Spillway	Design Discharge (m ³ /sec)	Crest Length (m)	Surcharge Head (m)	Side Channel		Chute	
				Bredth (m)	Depth (m)	Bredth (m)	Depth (m)
Huai Saduang Yai	445.7	105	1.62	6.0-10.0	7.2-14.2	12.0-18.0	5.0-12.50
Huai Khon Kaen	821.1	110	2.51	10.0-20.0	8.6-15.1	25.0	5.0-16.0
Huai Yai	289.5	65	1.66	6.0- 8.0	6.8-16.8	10.0	4.0-14.0
Khlong Chaliang Lab	244.2	70	1.55	6.0- 8.0	6.5-11.5	10.0	5.0-14.0

The emergency spillway has a supplemental function for the service spillway under an extraordinary flood of 500-year probability. Ungated overflow type spillway would be proposed for the emergency spillway. The main features of the emergency spillway can be summarized as:

Emergency Spillway	Design Discharge (m ³ /s)	Discharge Shared for Service S (m ³ /s)	Discharge Shared for Emergency S (m ³ /s)	Crest Length of weir (m)	Surcharge Head (m)
Huai Saduang Yai	577.3	546.5	22.5	70.0	1.91
Huai Khon Kaen	1,069.9	1,025.5	24.4	80.0	2.93
Huai Yai	367.9	338.3	30.2	100.0	1.96
Khlong Chaliang Lab	310.1	244.2	62.1	70.0	1.75

The outlet works comprise an intake tower with an access bridge and an outlet conduit. The intake tower would be constructed by reinforced concrete, equipped with regulators. The outlet conduit would be initially constructed for the river diversion during embankment period, and then would be given a function of outlet facilities. The main features of the outlet works for each dam are as tabulated below:

Outlet	Intake Discharge (m ³ /s)	No. of Regulator (Nos)	Size of Regulator (m) x (m)	Size & Height of Tower (m) x (m)	Span of Bridge (m)	Size & Length of conduit (m) x (m)
Huai Saduang Yai	5,496	4	1.2 x 1.2	4.0 x 4.0 x 29.0	59	2.0 x 145
Huai Khon Kaen	5,468	5	1.2 x 1.2	4.0 x 4.0 x 37.0	105	2.0 x 200
Huai Yai	1,875	4	0.7 x 0.7	4.0 x 4.0 x 37.5	105	2.0 x 140
Khlong Chaliang Lab	1,277	4	0.6 x 0.6	4.0 x 4.0 x 25.5	62	2.0 x 160

43. Based on the results of reservoir operation study, the annual reservoir yield of 5-year probability is estimated as tabulated below, together with the usable index or the yield by useful capacity. The Huai Khon Kaen dam produces the maximum yield.

Reservoir	Useful Storage Capacity (MCM)	Firm Reservoir Yield (MCM)	Usable Index
Huai Saduang Yai	27.00	28.11	1.04
Huai Khon Kaen	30.00	49.77	1.66
Huai Yai	13.25	13.53	1.02
Khlong Chaliang Lab	6.73	9.87	1.47

44. The operation study for each reservoir is made by monthly basis for 17 years from 1964 to 1980. The results of study show that all of the proposed reservoirs are efficiently operated even in the 20% recurrence of drought year.

45. The proposed irrigation/drainage facilities comprise main and secondary irrigation canals and their related structures, drainage canals and their related structures, and farm roads. The main irrigation canal would be trapezoidal and lined with 6 cm thick plain concrete.

The secondary irrigation canal would be also trapezoidal and unlined. The related structures, such as turnout, check and drop, inverted siphon, aqueduct, culvert, bridge, spillway, cross drain, and water measuring devices, would be of reinforced concrete. The newly proposed collector drain is trapezoidal and unlined. Its related structures, such as cross drain and culvert, would be also of reinforced concrete. All the inspection roads would be so designed as to have an effective width of 5 m and to be laterite-paved. The lateral inspection roads would be provided with an effective width of 3 m.

46. The general features of four projects proposed in this study are briefly tabulated as follows:

<u>Description</u>	<u>Name of Sub-project</u>			
	<u>Huai Saduang Yai</u>	<u>Huai Khon Kaen</u>	<u>Huai Yai</u>	<u>Khlong Chaliang Lab</u>
<u>I. Reservoir Plan</u>				
(1) Drainage Area (km ²)	96.0	322.0	75.0	77.0
(2) Total Storage (MCM)	28.0	33.2	14.0	7.5
(3) Useful Storage (MCM)	27.0	30.0	13.3	6.7
(4) Dead Storage (MCM)	1.0	3.2	0.8	0.8
(5) Full Water Level (m)	EL.195.5	EL.216.5	EL.216.5	EL.206.5
(6) Reservoir Area at Full Water Level (km ²)	2.1	1.6	1.1	0.7
<u>II. Dam Plan</u>				
(1) Dam Type	zoned	zoned	zoned	zoned
(2) Dam Crest EL. (m)	EL.199.0	EL.221.0	EL.220.0	EL.210.0
(3) Dam Height (m)	38.0	57.0	38.0	35.3
(4) Dam Crest Length (m)	467.0	950.0	816.0	1,259.0
(5) Embankment Volume (MCM)	1.00	3.33	0.77	0.79

<u>Description</u>	<u>Name of Sub-project (cont'd)</u>			
	<u>Huai Saduang Yai</u>	<u>Huai Khon Kaen</u>	<u>Huai Yai</u>	<u>Khlone Chaliang Lab</u>
<u>III. Irrigation Plan</u>				
(1) Service Area (rai) (ha)	33,750 (5,400)	31,880 (5,100)	11,250 (1,800)	7,500 (1,200)
(2) Crop Intensity (%)	135	135	135	135
(3) Irrigation Water Requirement (MCM/year)	37.2	35.1	11.7	7.8
(4) Canal Length (km) (Main and Lateral)	-	105.7	26.6	21.2
<u>IV. Drainage Plan</u>				
(1) Canal Length (km)	-	72.3	36.7	20.0

CONSTRUCTION PLAN AND COST ESTIMATE

47. In case the gorge is shallow and narrow, the saddle and low ridge would be year-roundly embanked. The main gorge would be quickly embanked to the proposed crest by the end of the last dry season. In case there is no saddle or low ridge as the Huai Saduang Yai dam site, the embankment would be commenced at both abutments and gradually proceed to the river channel. But the embankment of less than 200,000 m³ would be left for the last dry season accounting for the capability of embankment. In case the main gorge is extremely wide and deep as the Huai Khon Kaen dam site, the embankment would be started at the main gorge after diverting the existing channel into the nearest vale. The embankment at the narrowest vale would be finally embanked within the last dry season as quickly as possible.

48. In accordance with the implementation priority of the sub-project concluded in the Pre-Feasibility Study, the project would be divided into two packages for stagewise construction as given below:

Package - I	Huai Yai sub-project Huai Khon Kaen sub-project
Package - II	Huai Saduang Yai Sub-project Khlone Chaliang Lab Sub-project

The dam construction under Package-I would be commenced simultaneously in the early 3rd year after commencement. The construction of the Huai Khon Kaen and Huai Yai dams would last for four years and three years respectively. The construction of the irrigation canal under the Huai Khon Kaen and Huai Yai sub-projects would simultaneously be started in the early 5th year after commencement and last for 2.5 years and 1.5 years respectively. The construction of both dams under Package-II would also be commenced simultaneously in the early 7th year after commencement. The construction of the Huai Saduang Yai dam and Khlone Chaliang Lab dam would last for three years respectively. The canal

construction of the Khlong Chaliang Lab sub-project would be commenced in the middle of the 9th year after commencement and last for 1.5 years until the end of the 10th year after commencement.

49. The project costs for the four sub-projects are estimated to be as given below on the financial basis in 1982 including price contingency during disbursement period:

	Whole Project	Package - I	Package - II
Foreign Currency Portion 10 ⁶ ₭ (10 ⁶ US\$)	2,024 (88)	1,280 (56)	744 (32)
Local Currency Portion 10 ⁶ ₭ (10 ⁶ US\$)	2,460 (107)	1,462 (64)	998 (43)
Total Amount 10 ⁶ ₭ (10 ⁶ US\$)	4,484 (195)	2,742 (119)	1,742 (76)

PROJECT EVALUATION

50. The project evaluations are made in order to ascertain the feasibility of the project in view of economic, financial and socio-economic aspect. The economic feasibility of the project is evaluated in terms of the internal rate of return (IRR) and the net present value (NPV) at the discount rate of 10%. The calculated results are shown below:

Sub-Project	IRR (%)	NPV (10 ⁶ ₭)
Huai Saduang Yai	14.0	183.6
Huai Khon Kaen	14.2	321.2
Huai Yai	14.7	119.6
Khlong Chaliang Lab	10.4	7.7
Package - I Development	14.3	440.8
Package - II Development	13.1	191.3
Whole Development	13.9	632.1

The financial evaluation of the project is made by examining the repayment capability for the capital cost for the project. In the examination of repayment capability, the prospective water charge of ₭ 215/rai/annum is collectable on an average from the beneficial farmers, which is equivalent to the required O & M cost.

51. In the examination of repayment capability, it is assumed that the capital cost required for the project implementation will be arranged under the following conditions:

- the foreign currency portion of the capital cost is financed by bilateral or international organizations with an interest rate of 3.5% per annum for a repayment of 30 years including 10-year grace period;
- the local currency portion of the capital cost is financed by the budget allocation of the Government with no repayment.

52. The results of examination indicate that the direct revenue cannot cover the annual repayment of the fund in all the sub-project areas, and the repayment of the fund has to be made by the subsidy of the Government.

53. In addition to the direct benefits stipulated in the economic evaluation, the following secondary direct benefits and favourable intangible socio-economic impacts are expected from the implementation of the project:

- i) Foreign exchange earning,
- ii) increase of employment opportunity to local people,
- iii) improvement of local transportation,
- iv) improvement of environmental sanitation,
- v) increase of potential fish production, and
- vi) possibility of hydropower generation.

ECOLOGICAL AND ENVIRONMENTAL CONSIDERATIONS

54. The implementation of project facilities, particularly dam and reservoir, and irrigated agricultural development after the project would bring about various ecological and environmental changes to the area. These are:

- i) impacts of dam construction;
 - inundation of farmlands and houses in the reservoir areas,
 - flood mitigation,
 - biological impacts of the reservoir,
 - increase of tourism opportunity,
 - degradation of riverbeds.
- ii) impacts of irrigated agricultural development;
 - water pollution owing to the use of fertilizers and agro-chemicals,
 - increase of water-borne diseases, and
 - deterioration of soil productivity.

ORGANIZATION FOR PROJECT EXECUTION

55. The RID will be the executive agency for the Upper Pasak MSIP. The project construction office consists of one main office and four branch offices. The main office has four sections, such as engineering, construction, operation and administrative sections.

56. After completion of the project construction work, the project construction office is re-organized into the project O & M office under the Region III Office, RID. The office consists of one main office, two branch offices and six field offices. The office consists of five sections such as engineering, operation and maintenance, workshop, agricultural services and administrative sections.

57. Water users' group will be organized by about 100 farmers for the O & M of the irrigation and drainage systems in terminal irrigation unit. For good coordination and operation federation of the water users' groups, the so-called water users' association is set up in each irrigation system of the sub-project through affiliation of the water users' groups. After establishing the water users' group, the group leader is elected by the members of the group. The leader and members take responsibility for operation and management of the terminal irrigation units under mutual cooperation.

CONCLUSION

58. It has been verified through the study that both packages of the project are technically sound and economically and financially feasible. Thus, it has been concluded that, for the time being, the proposed Package-I should be immediately financed and implemented as a first step of the project.

RECOMMENDATION

59. The fishculture on the water surface of the newly created reservoir will surely secure considerable amount of benefits and contribute to the local supplies of animal protein for the rural population. It is therefore recommendable that the fishculture development should be intensively studied and implemented in each reservoir near future.

60. The Huai Khon Kaen reservoir has a considerable potential for a micro hydropower generation. For the future development, a penstock facility for generator should be initially installed in the outlet works of the Huai Khon Kaen dam.

61. The supplemental topographic survey and geological and soil investigations specified in the course of the study should be immediately implemented and terminated before the commencement of the detailed design works.

62. The water gauging staffs installed in respective dam sites by the study team should be better maintained and operated by the division concerned to obtain reliable runoff data for the future stage of the project.

63. The river flow of each tributary concerned is extremely depleted during the dry season due to the sprawl of shifting cultivation. The planless land reclamation prevailing over the basin should be strictly controlled by the administration concerned. In addition, reforestation works should be planned and implemented in the watershed of four relevant tributaries in parallel with the implementation of the project in order to stabilize the annual inflow of respective reservoirs.

64. Only about thirty (30) humble shanties have been irrigally settled, and the shanty people have cultivated about 300 rai in the submerged areas of four proposed dams. The resettlement and compensation of them will never be one of socialological and administrative constraints for the project implementation.

65. Construction of the project will cause several kind of effects on ecological and environmental conditions allover the watershed of relevant tributaries and the project area as listed below:

- i) Flood mitigation to the main stream of the Pasak river,
- ii) Stable domestic water supply to the downstream riparian people,
- iii) Slight impacts on fauna and flora with the creation of reservoir,
- iv) Sporadical lands slidings at the periphery of reservoir,
- v) Less water pollution because of less population and less agricultural activities in the relevant watershed,
- vi) Degradation of riverbed due to the less supply of sediment loads after completion of dam,
- vii) Harmful effects on wildlife and human which are caused by fertilizer and agro-chemicals under irrigated agriculture,
- viii) Spreading and propagation of water-borne diseases under irrigated agriculture, and
- ix) Slight change of soil productivity caused by application of fertilizer and chemicals under irrigated agriculture.

But unfavourable effects on ecology and environment are assessed to be negligible, and they will be minimized by taking proper considerations and measures.

66. Based on the ecological and environmental assessment, the following considerations and measures are recommendable:

- i) To lessen pollutants which will enter stream during construction period,
- ii) To avoid the destruction of vegetation in the reservoir for future fishery development,
- iii) To make provision for the maximum recreational benefit from the completed reservoirs,
- iv) To flatten the slope for borrow area to conform with the surroundings,
- v) To keep scenic overlooks for viewing the dam and reservoir,
- vi) To avoid flowdown of excessive siltation created during construction period,
- vii) To spoil unusable materials in the reservoir area,
- viii) To vegetate borrow area with grasses, trees and shrubs, and
- ix) To provide roads, cutslopes, and borrow areas with terraces, berms, and/or other check structures as required.

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GLOSSARY OF TERMS AND ABBREVIATION

1. Glossaries

Changwat	:	Province
Amphoe	:	District
Tambon	:	Township
Muban	:	Village
Muang	:	Administrative Center of Province
Mae Nam	:	River
Khwae	:	Main tributary of a river
Huai	:	Stream, creek or small tributary
Khleng	:	Canal
Baht	:	Unit of Thai Currency (US\$1.00 = Baht 23)

2. Abbreviations

ACFT	:	Agricultural Cooperative Federation of Thailand
ALRO	:	Agricultural Land Reform Office
BAAC	:	Bank for Agriculture and Agricultural Cooperatives
DAE	:	Department of Agricultural Extension
EGAT	:	Electricity Generating Authority of Thailand
EL	:	Elevation above mean sea level
FMO	:	Farmers Marketing Organization
HYV	:	High Yielding Variety
JICA	:	Japan International Cooperation Agency
MOAC	:	Ministry of Agriculture and Cooperatives
NEA	:	National Energy Administration
NESDB	:	National Economic and Social Development Board
OAE	:	Office of Agricultural Economics
O&M	:	Operation and Maintenance
RID	:	Royal Irrigation Department

3. Area and Volume

rai	:	0.16 hectare
ha	:	hectare
m ²	:	square meter
km ²	:	square kilometer
l	:	liter
m ³	:	cubic meter
MCM	:	million cubic meter
kg	:	kilogram
t	:	ton

4. Derived Measure based on the Same Symbols

mm/day	:	millimeter per day
l/sec/ha	:	liter per second per hectare
cm/sec	:	centimeter per second
km/sec	:	kilometer per second

m^3/sec	:	cubic meter per second
$m^3/km^2/year$:	cubic meter per square kilometer per year
kg/cm^2	:	kilogram per square centimeter
t/m^2	:	ton per square meter
t/ha	:	ton per hectare

5. Others

%	:	Percent
No.	:	Number
Nos.	:	Numbers
HWL	:	High Water Level
FWL	:	Full Water Level
DWL	:	Dead Water Level
MSL	:	Mean Sea Level

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CHAPTER - 1

INTRODUCTION

1.1 AUTHORITY

This report is prepared in accordance with Article 4 of the Scope of Works for the Pre-Feasibility and the Feasibility Study on the Upper Pasak Medium Scale Irrigation Project (hereinafter referred to as "the project") agreed upon between the Government of Thailand and the Government of Japan on April 22, 1981.

This report presents the results of field survey and study containing the findings of the present conditions in and around the project area, development concepts and prospective development plan, proposal for major project works and economic and financial justification of the project. This report was finalized based on the comments raised by the Thailand Authorities concerned and the advices and suggestions made by the Supervisory Committee of the Japan International Cooperation Agency (hereinafter referred to as "JICA").

1.2 PROJECT HISTORY

Agricultural development in the Upper Pasak river valley has been left and never been focussed for a long time, because the Government's effort toward the agricultural development has mainly been concentrated in the Chao Phraya basin. The committee for Reconciliation and Promotion of Water Resources Development under the Office of Prime Minister of the Government has recently recognized that the irrigation water resources development in the Upper Pasak river valley should urgently be implemented in the light of the basic strategy of the Fourth National Economic and Social Development Plan.

After consultation with the Royal Irrigation Department (RID), executing body for irrigation water resources development, the Committee reached the conclusion that feasibility study should promptly be made for the first step to the water resources development in the valley. Meanwhile, since 1970's, RID has envisaged medium scale irrigation water resources development in the tributaries of the Pasak river and formulated 18 medium scale tank irrigation projects in the valley based on the detailed reconnaissance study.

In compliance with the conclusion of the Committee and the urgent request from the farmers concerned, RID picked out the four projects out of the 18 projects for pre-feasibility study in due consideration of their positions held in the overall development of the entire valley. While, RID understood that one-package implementation of these four projects would be beyond the capability of RID in terms of both budget and technical manpower.

On the basis of the understanding above-mentioned, the Government made a request to the Government of Japan to extend a technical cooperation for the pre-feasibility and the feasibility study on the said four projects. In response to the request of the Government, the Government of Japan decided to offer the technical assistance for the pre-feasibility and the feasibility study on the projects as a part of the technical cooperation program to Thailand.

In early April 1981, the JICA dispatched a Scope of Works Mission for the Upper Pasak Medium Scale Irrigation Project, headed by Mr. A. Kazama, Construction Department, the Bureau of Agricultural Structure Improvement, Ministry of Agriculture, Forestry and Fisheries. The mission discussed the scope of works for the pre-feasibility and the feasibility study on the said projects with the Thailand Authorities concerned. On the basis of the agreed "Scope of Works", the pre-feasibility study was commenced in early September 1981. The study lasted until the end of December 1981, and the final pre-feasibility report was submitted to the Government on early March 1982 after undertaking intensive home office work in Japan.

Following the pre-feasibility study, the JICA dispatched a study team to the project site on early June 1982 to implement the feasibility study in accordance with the Scope of Works agreed upon between both Governments. The study team had completed field survey and preliminary study by the end of September 1982 and submitted the Interim Report to the Government of Thailand in early October 1982.

1.3 OBJECTIVES OF THE STUDY AND SUMMARY OF THE SCOPE OF WORKS

As specified in the Scope of Works agreed upon between both Governments, the feasibility study contains two major work programs as presented below:

- | | |
|-----------|---|
| Program 1 | To formulate an irrigated agricultural development project and identify the feasibility of the project, |
| Program 2 | To determine the optimum water resources plan, and |
| Program 3 | To undertake transfer-of-knowledge to the counterpart personnel in the course of the study. |

The Scope of Works undertaken by the study team comprises the field work and office work in the project site and home office work. These works cover the following contents (ATTACHMENT-1):

(1) Field Works

- Reconnaissance of the project area,
- Supplemental collection and review of the relevant data and information,

- Supplemental meteorological investigation,
- Supplemental survey on dam foundation and construction materials,
- Canal route survey,
- Inventory survey of the existing irrigation/drainage facilities,
- Soil and land use survey,
- Regional economic survey,
- Agricultural and agro-economic survey, and
- Construction costs survey.

(2) Office Works at the Site

- Provisional water resources development plan,
- Provisional agricultural development plan,
- Provisional irrigation development plan,
- Provisional dam and reservoir plan, and
- Provisional economic and financial evaluation.

(3) Home Office Work

- Review of the interim report which was submitted before leaving the project site,
- Definite plan of water resources, agricultural and irrigation development,
- Preliminary design,
- Economic and financial evaluation of the project, and
- Recommendation to the Government.

1.4 ACTIVITIES OF THE STUDY TEAM

On the basis of the careful review of the pre-feasibility study and the findings through field reconnaissance undertaken in advance of the commencement of the study, the study team envisaged technical approach to the project and practical plan of operation for the study, and compiled them in the Plan of Operation Report. The report was submitted to the Government immediately after the study team had arrived in Thailand. The discussion on the report was held at the RID office, Bangkok, at the middle of June, between the Thailand Authorities concerned and the study team. The approach to the project and the plan of operation proposed in the Plan of Operation Report were basically approved by the Authorities concerned through the discussion.

In the course of the study, several meetings had been held between the study team and the counterpart personnel to coordinate the field activities and to smoothly execute the field work. Work progress and technical matters encountered in the course of the study had been mainly reported and discussed in the meetings. Furthermore, informal discussions had frequently been made on the specific technical matters, as required, between the personnel concerned.

In the course of the study, the Supervisory Committee headed by Mr. Y. Suematsu, Senior Officer, Design Division, Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forest and Fisheries, also visited Thailand to inspect the project site and the study undertaken by the study team. A lively discussions were made between the Committee and the study team during the period of the Committee's stay in Bangkok. The study implemented by the study team was basically approved by the Committee after the discussions, offering some technical comments.

The study team had prepared and submitted the Interim Report by the early October 1982 in accordance with the Scope of Works. Immediately after the submittal of report, the interim meeting was held between the Thailand Authorities concerned and the study team to discuss the interim study results. The comments made by the Government on the Interim Report were issued to the study team in the middle of November 1982.

Immediately after arriving in Tokyo in the beginning of October 1982, the study team started the further detailed study and the finalization of the report following the comments made by the Government on the Interim Report. The Draft Final Report was prepared by the study team and submitted to the Government of Thailand in December 1982.

After discussing the contents of the draft report in the joint meeting in the end of January, 1983, the draft report was thoroughly accepted by the RID and finalized hereby by the Team in mid. of March, 1983.

ATTACHMENT-2 hereof shows the RID Official concerned, the members of Supervisory Committee and the study team of the project.