2. 2. 2 Lifestyles in Delta Area

(1) Noi- Lop Buri Flood Plain

This elevation of Noi-Lop Buri flood plain is lower than its surrounding area. There are impressive number of large and tangled river lines along complex mounds and rises. The water depth of the lowland behind the natural dikes leach more than 4 m deep customarily. Single rice cropping is still seen in this area. The life is said to be easier than Rangsit area because of easy access to water, and their houses are surrounded by trees that provide shades during dry season. Moreover, flood water will not threat their life during rainy season because the people are living on natural banks that are higher than flood water level. Variety of agriculture can be practiced on the natural banks. In the area behind natural banks where water depths become tremendous, floating rice is grown. Those who do not have lands on natural banks live on small mounds in the floating rice area, and since single cropping is possible in the area, they leave their home and work during off-season. During dry season, the group of women catch fish that are captured in ponds for their food.

(2) Rangsit Area (east side of new delta)

The topography of Rangsit area is extremely flat. All the area will be calmly inundated during rainy season by water coming from other areas and rainfall in the Rangsit area, however, without the irrigation systems, it terns out to be totally waterless land during dry season. Houses are built along klongs for easiyer access for navigation and water use purposes. After construction of Chai Nat-Pasak canal and introduction of mechanized cultivation, the irrigation system of Rangsit area made intensive rice agriculture possible. Today, Rangsit area is in strong influence of Bangkok metropolitan area, and conversions of the rice field into fruit trees are commonly seen and new settlements have rapidly been developed along freeways to Bangkok. Along the coastal line of Gulf of Thailand, there are salt pans and blackish or freshwater aquaculture ponds.

(3) West Bank (west side of new delta)

During flood season, over-flown water from the right bank of Chao Phraya river below Pa Mok, 20 km upstream of Ayuthaya, flows into West Bank area. The area becomes like a shallow wet basin, whose depth is about 1.0 - 1.5 m, during wet season. There are no high natural banks as they are seen in Noi-Lop Buri Flood Plain. West Bank receives weakened-flood water. After completion of Klong Phak Hai-Chao Ched in 1960, West Bank area is used as flood retarding basin for protection of Bangkok during flood season. Because of the flood control measure, the farmers in the West Bank area are needed shift to dry season cropping using water supplied by the irrigation system. Houses are built along klongs in here also. Today, the land use pattern of southern half of West Bank is mostly for fruits and vegetables. The coastal area, a band of 5 - 15 km, is used for brackish water aquaculture and for salt pans.

Chapter 3. PROBABLE ENVIRONMENTAL EFFECTS

3. 1 River Training

Heightening of dikes or construction of embankment, shortcut and widening of river channel are proposed as measures for mitigating flood damage of urban and agricultural fields in the Chao Phraya basin. In this section, the specific location and the dimension of the project are not concerned since they are not defined. The largest facilities are tentatively supposed as the final outcomes of the master plan study, and the impacts are briefly assessed.

3. 1. 1 Physical Resources

(1) Surface Water Hydrology

(a) Probable Environmental Impact

(i) Embankment may interrupt water channel through which river water is supplied to animals' habitats or for human uses.

(ii) Embankment may blockade water that goes back to the Chao Phraya river and create waterloggings.

(b) Further Research

(i) Research to find out specific changes in surface water hydrology by proposed embankment and excavation.

<Personnel>
Speciality in: River engineer,
Number of staff: 1,
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

Try not to separate water body such as swamps and lakes, and the Chao Phraya river by the embankment as much as possible, to avoid fragmentation of natural river system that sustains the natural environment. Formulate plans to keep the Chao Phraya river and the surrounding water bodies interchangeable while containing flood water during wet season.

(2) Surface Water Quality

(a) Probable Environmental Impact

(i) Degradation of stagnated water occurs if effluent can not be discharged into the Tha Chin or the Chao Phraya river by blockage of embankment.

(b) Further Research

(i) clarification on occurrence of waterloggings for estimation of water quality degradation. The staff assigned in "Surface Water Hydrology" should also serve for this purpose.

(c) Recommendation to the Study Team

Refer to the recommendations in "Surface Water Hydrology".

(3) Ground water

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Ground water.

(b) Further Research

Not necessary

(4) Soils

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Soils.

(b) Further Research

Not necessary

(5) Noise and Vibration

(a) Probable Environmental Impact

Noise and vibration occur during construction, the degree of impact is negligible small.

(b) Further Research

Not necessary

3. 1. 2 Ecological Resources

(1) Aquatic Ecosystem

(a) Probable Environmental Impact

Embankment may cut off habitats, such as lakes and ponds, of aquatic lives that are now connecting to the Chao Phraya river. There might be a crucial path for certain aquatic life in between the main river and the adjacent water bodies. There are several species may receive adverse impacts by the separation. Fish species defined as endangered species by Ecological Research Institute of Scientific and Technological Research such as Silver Shark/ Bala Shark (*Balantiocheilos melanopterus*), Siamese Giant Carp (*Catlocarpio siamensis*), Jullien's Golden Carp (*Probarbus jullieni*), Chao Phraya Giant Catfish (Pangasius sanitwongsei) need static water for their spawning ground which is connected to main rivers*. However, no specific location of embankment is selected yet. The impact could be significant, depending on the location of the construction sites.

(b) Further Research

The probable environmental impacts which require further research in feasibility study period.

(i) Reviewing the importance of aquatic ecosystem is necessary at the site where biological impacts are expected, and recommendation should be formulated based on the types of the impacts.

<Personnel>
Speciality in: river biology,
Number of staff: 3,
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

Refer to the recommendations in "Surface Water Hydrology".

(2) Forests

(a) Probable Environmental Impact

There is no forests existing along the rivers at the starches in lower central plain except mangroves at coastal line.

(b) Further Research

Not necessary

(3) Terrestrial Wildlife

(a) Probable Environmental Impact

Embankment will not be a major obstacles for animals' traveling, however there are some no hunting areas along the Chao Phraya river and the tributary in the lower central plain,

namely, Wat Tam-En, Wat Phai Lom-Wat Umputwararam, and Bung Chawak*2). Especially attention shall be paid to Wat Phai Lom-Wat for being Open Billed Storks' important breeding habitat*4).

(b) Further Research

Reviewing the importance of terrestrial ecosystem is necessary at the site where biological impacts are expected, and recommendation should be formulated based on the types of the impacts.

(c) Recommendation to the Study Team

Embankment route should avoid non-hunting area by off-setting its course toward inland.

(4) Endangered Species

Refer prior "Aquatic Ecosystems" section

3. 1. 3 Human Use Values

(1) Navigation

(a) Probable Environmental Impact

Embankment may interrupt navigation. Navigation is still a important means of transportation to the area, and number of canals are developed in the Delta area.

(b) Further Research

The probable environmental impacts which require further research in feasibility study period. Clarification is needed on klongs' usages, frequencies, and importance where embankment is planned to be constructed on them.

<Research Personnel>
Speciality in: social survey,
Number of staff: 5,
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

Navigation locks should be incorporated into the design of embankment if there is an interruption of navigation would occur. Review the similar projects for mitigation and compensation, and social disputes if there are. Since navigation locks may not overcome all the disturbances that embankment may causes, other mitigation measures together with compensation plan should be concerned.

(2) Land Transportation

(a) Probable Environmental Impact

Cross section with highways and railways will be incorporated to embankment design. The other smaller roads may be terminated by embankment.

(b) Further Research

Clarification is needed on roads' usages, frequencies, and importance where embankment is planned to be constructed on them. Mitigation plans and compensation plan should be formulated based on the further research.

(3) Flood Control

(a) Probable Environmental Impact

Frequencies of flood occurrence will be decreased in the area along the new embankment, but the flood water will be transported to the down stream. The embankment cancel the natural flood mitigation function of the Chao Phraya river that disseminates flood water in upper part of the new delta, which eventually mitigate the damage in Bangkok. The optimum plan of embankment is being sought in the master plan study.

(b) Further Research

Not necessary in terms of environmental studies.

(4) Agriculture

(a) Probable Environmental Impact

Natural supply and drainage of irrigation water may be disturbed. The agriculture will need to depend on irrigation and drainage system in the area. Transformation of crop variety to high yield variety may occur, and since the high yield varieties require more financial input than the traditional ones, subsistent farmers may not adjust to the artificially created new environment.

(b) Further Research

Impacts on subsistent or traditional agriculture caused by interruption of natural water supply and drainage by construction of embankment. The significance and types of impacts should be studied.

<Personnel>
Speciality in: agronomy
Number of staff: 2
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

Natural flood inundation with natural drainage has been substantial components for agriculture in the Chao Phraya delta. The study team may need to keep the natural inundation cycle as much as it can be for those who practice "refined" cropping patterns to cope with the natural flood environment, according to the results of further research. If impacts on subsistent farmers and on others are not inevitable, the team should formulate compensation plan.

(5) Industries

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Industries.

(b) Further Research

Further research for probable impacts on Industries by construction of embankment is not necessary .

(6) Mineral Development

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Mineral Development.

(b) Further Research

Further research for probable impacts on Mineral Development by construction of embankment is not necessary .

3. 1. 4 Quality of Life Values

(1) Socio-economic Values

(a) Probable Environmental Impact

There are probable environmental impacts, assessed in IEE, may be caused by river training facilities. Although the specific sites of proposed sites are not decided yet, generally occurring Socio-economic Values is observed in Bangkok Metropolitan area.

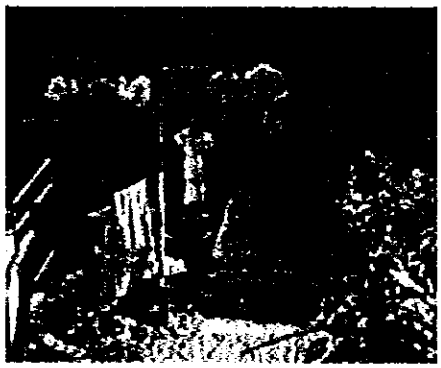
(i) Accessibility to reach the Chao Phraya river will be downgraded by interrupted by the embankment or heightening of the embankment, also to the other side of the river.

(ii) Construction of embankment or heightening of the embankment disrupts transportation within riverside commercial districts.

(iii) Loading and Unloading of commodities using ships will be difficult by

construction of embankment.

Stairs-shaped dike at shopping arcade near a port of commuting boats. The shop owners are complaining for inconveniences. This dike was destroyed by locals last year.



Newly constructed dike in built-in residential area, built by BMA in 1997. Heightened dike serve as pedestrian path.

(b) Further Research

Survey of economic and social activities of project sites is necessary to assess the impacts of construction or heightening of embankment, widening and short-cutting of river channel in terms of socio-economic values.

<Personnel>
Speciality in: Social survey
Number of staff: 3
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

The design of river training facilities should be integrated to Socio-economic functions that the area possesses. Deliberate and interactive conversations are crucial to accomplish this purpose. If impacts are not mitigable, compensation plan should be formulated.

(2) Cultural and Archaeological Values

(a) Probable Environmental Impact

Impacts on Cultural and Archaeological Values caused by river training works cannot be assessed since exact location is not decided yet as of March, 1998.

(b) Further Research

Further research for probable impacts on Cultural and Archaeological Values should be examined after the location of construction site is specified.

(c) Recommendation to the Study Team

After sites are specified and if there is Cultural and Archaeological Values in the site, river-training facilities need to detour the site. It is illegal to make structural changes to the temple which is on the list of archeological significance under the term of the Archaeological Site and Museum Act (1961) without prior permission from the Fine Arts Department.

(3) Aesthetic Values

(a) Probable Environmental Impact

Heightening of dikes in urban area such as Bangkok may have impacts on Aesthetic Values, impact will be significant without mitigation measures.

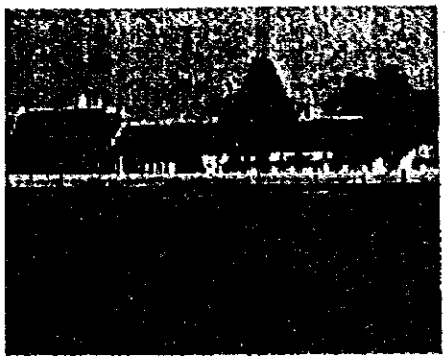
(b) Further Research

Further research for probable impacts on Aesthetic Values by construction of embankment is necessary especially in cities that are designated as "World Heritage" sites by World Heritage Committee: Ayuthaya, Sukhothai, and Bangkok.

(c) Recommendation to the Study Team

It is important to begin with review of the similar cases for construction of new embankment or heightening of dikes. There are remarkable precedents that BMA have already demonstrated. In all cases, BMA have had deliberate discussions with local residents.

[aesthetic impact]
Park-surrounding dike with drive lamp attached. Attention is paid for aesthetic value and functions of the infrastructure.



[aesthetic impact]
Dike outside of King's Palace. The height is lower than other stretch of dike for aesthetic purpose.

The dike penetrates middle of a restaurant facing the Chao Phraya river. BMA is holding numerous discussions with the residents.

(4) Resettlement

(a) Probable Environmental Impact

Since the specific locations for the project sites of river trainings are not been decided yet, the probable impacts can not be specified.

(b) Further Research

Construction of embankment, shortcut and widening of river channel may require large number of resettlement, depending on the project size. Further research on distribution and number of houses, number of people, their income, and other social status that are needed for compensation plan. It should be noted that there may be impacts on landless farmers, and other local people who does not hold land titles. Social impacts on those local people must take into account and be evaluated in some ways.

<Personnel>
Speciality in: social survey
Number of staff: 3
Total duration of study: 6.0 months

(c) Recommendation to the Study Team

If there would be houses that are needed to be relocated, or farm land, or land for other values need compensation, deliberate compensation plan should be formulated based on further research stated above.

(5) Public Health and Safety

(a) Probable Environmental Impact

There are no notable impacts may be caused by construction of river training works found in IEE on public health and safety.

(b) Further Research

Not necessary .

(6) Recreation

(a) Probable Environmental Impact

There are no notable impacts may be caused by construction of embankment or short-cut of rivers found in IEE on Recreation.

(b) Further Research

Not necessary .

(7) Dedicated Area Uses

(a) Probable Environmental Impact

There are some dedicated areas and cites along the Chao Phraya river and its tributary, listed as below.

Dedicated Area along Chao Phraya River

Location	Designation	Designated by
Ayuthaya, and associated historic towns	World Heritage	World Heritage Committee, UNESCO
Sukhothai, and associated historic towns	ditto	ditto
Krung Rattanakosin, The Grand Palace and the Temple of Emerald Buddha (King's Palace, Bangkok)	ditto	ditto
Bung Boraphet, Wat Tarn-En, Wat Phai Lom-Wat Umputwararam	Non-Hunting Area	Royal Thai Government
Mangrove Forest, along Gulf of Thai land	Endangered Species (Habitat)	ditto

River training works must avoid the locations listed above.

(b) Further Research

Following clarification is necessary.

(i) Verification of no-existence of any other dedicated areas in the proposed project cite.
(ii) Research on the biological functions of the non-hunting area which may receive indirect impacts from river training facilities such as embankment.

<Personnel>
Speciality in: river biology
Number of staff: 1
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

Immediate action for modification of river training works' design will be necessary if gives impacts on the dedicated area.

3.2 Flood Diversion Channel

3.2.1 Physical Resources

(1) Surface Water Hydrology

(a) Probable Environmental Impact

(i) Silt transportation by the Chao Phraya river during flood will be decreased. Instead, silt accumulation may occur at near the gates to be installed in the diversiosn channel and at coastal line near outlet of the diversion channel.

(ii) Construction of the diversion channel will alter the physical and hydrological status of klongs in the channel's course.

(b) Further Research

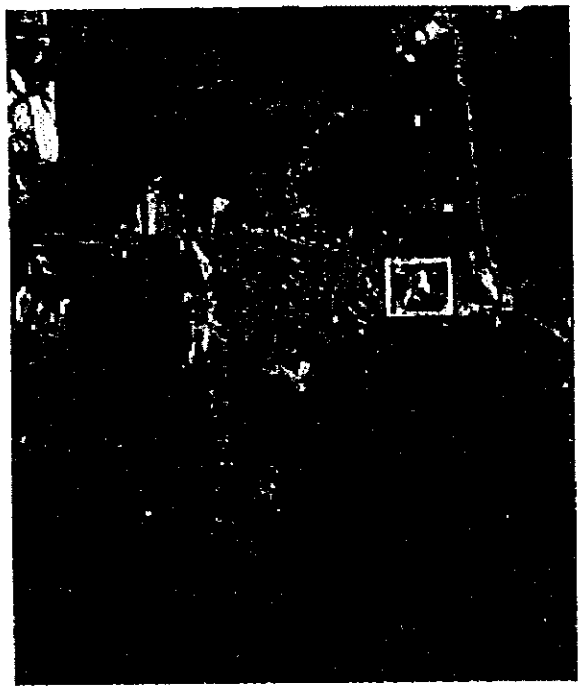
(i) Clarification of impacts of the diversion channel on silt transportation and accumulation. The result must state what amount of silt accumulation is estimated at where, and the impacts.

(ii) Clarification on physical changes of klongs, including natural streams, and change of the flow. The outcome should state that if there is degradation of water quality. If there is, state the impacts on the water's users.

<Required Personnel for Further Study>
·Speciality in: river engineering
Number of staff: 2
Total duration of study: 1.0 month
·Speciality in: water quality
Number of staff: 2
Total duration of study: 1.0 month

(c) Recommendation to the Study Team

The outlet is planed to be near Ban Klongs Dan, using the local river, Klong Phra Ong Chaiuan Utit (Khlomg Ban Hia). Ban Klong Dan is developed on the sides of Khlomg Ban Hia, and coastal fishery is the town's main industry. It is expected that the silt released from the discharge channel will change morphology of the coastal line. The Study Team should change the location of outlet of diversion channel because of expected siltation and sedimentation problem.



Aerial photograph of Ban Klongs Dan (center) and Klongs Ban Hin near Gulf of Thailand

(2) Surface Water Quality

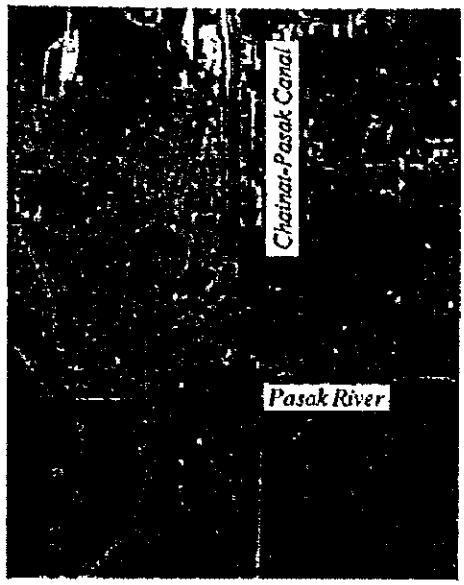
(a) Probable Environmental Impact

(i) Silt runoff, and sanitary wastes may degrade water quality of klongs in vicinity during construction period.

(ii) Silt runoff, pesticides, fertilizers, domestic water effluents may degrade water in the discharge channel.

(iii) Turbid water will be unloaded into Gulf of Thailand by the discharge channel. It may give impacts on coastal aquiculture.

(iv) Streams and klongs will be fragmented by construction of dikes. Water quality degradation may occur at the section where natural flow is to be ceased.



Confluence of Pasak river and Chinat-Pasak irrigation canal

Sharp change of Pasak river's color represents heavy load of silt from the irrigation canal.

(b) Further Research

The following clarifications are needed by further research or study during Feasibility Study period for formulation of mitigation plan.

(i) Clarification on usage of water in discharge canal.

(ii) Clarification on water quality standard for planned usage.

(iii) Estimation of water quality of diversion channel and fragmented klongs.

(iv) Estimation of quantity of sediment runoff to the Gulf and sedimentation occurrence. The assessment of the impacts on fishery and navigation.

<Required Personnel for Further Study>
Speciality in: Water quality
Number of staff: 1
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

By modification of the original design in following manner listed below, in feasibility study period, may reduce probable environmental impact caused by diversion channel.

(i) It is important to decide usage of the water in diversion channel at very begging of the feasibility study to formulate adequate mitigation plan.

(ii) During construction, turbidity mitigation measures should be implemented for water quality of klongs.

Mitigation measures should be formulated, during feasibility study period, for water

quality degradation still existing after modification of facilities' design.

(3) Ground water

(a) Probable Environmental Impact

(i) Ground water table in vicinity of the diversion channel may be depressed depending on water table of the channel.

(ii) Water loggings may occur at vicinity of the discharge channel depending on water table of the channel.

(b) Further Research

Estimation of occurrences of water table depression and water loggings in the vicinity, and their impacts.

<Required Personnel for Further Study>
Speciality in: ground water
Number of staff: 1
Total duration of study: 1.0 month

(c) Recommendation to the Study Team

(i) Review of Chainat-Pasak Irrigation canal should give helpful information on impacts of ground water changes and mitigation measures for the impacts.

(ii) Water level of the discharge channel should carefully be designed with attention to impacts on ground water level.

(4) Soils

(a) Probable Environmental Impact

There is no notable impacts expected by IEE on Soils.

(b) Further Research

Further research on Soils is unnecessary.

(5) Noise and Vibration

(a) Probable Environmental Impact

There is no notable impacts expected by IEE on Noise and Vibration.

(b) Further Research

Further research for probable impacts on Noise and Vibration by discharge channel is unnecessary.

3. 2. 2 Ecological Resources

(1) Aquatic Ecosystem

(a) Probable Environmental Impact

As the the diversion channel goes through Rangsit district, the environment for aquatic lives may be altered.

(b) Further Research

Research on aquatic ecosystem and fisheries in the vicinity of the diversion channel and the coastal line. Evaluation of values of impacts on them should be conducted.

<Required Personnel for Further Study>
Speciality in: aquatic biology
Number of staff: 3
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

Changes of present value needs to be appropriately assessed, and the mitigation measures shall be incorporated to the projects's design.

(2) Forests

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Forestry. The Mangrove forest had existed on eastern side of the Chao Phraya river, however, there are only fragmented trees around fish ponds are existing today.

(b) Further Research

Further research for probable impacts on Forests is unnecessary .

(3) Terrestrial Wildlife

(a) Probable Environmental Impact

As the diversion channel goes through Rangsit district, it may alter the terrestrial environment.

(b) Further Research

Research on terrestrial wildlife in the visinity of the diversion channel and the coastal line are needed be reviwed by further research during feasibility study period to enchance formulation of mitigation plan.

<Required Personnel for Further Study>
Speciality in: Terrestrial biology
Number of staff: 1
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

Changes of present value are needed to be appropriately assessed, and the mitigation measures shall be incorporated to the projects's design.

(4) Endangered Species

(a) Probable Environmental Impact

There could be environmental impacts on endangered species such as alternation of endangered species' habitats, interference of travel routes, or depression of baits. etc.

(b) Further Research

Review if there are existense of endengered species in the vicinity. If there are, clarification of the living environment, and impacts caused by the diversion channel should be evaluated.

<Required Person for Further Study>
Speciality in: Biology survey
Number of staff: 1
Total duration of study: 0.5 months

(c) Recommendation to the Study Team

If adverse effects on of endangered species' habitats are found, and they are inevitable, mitigation or revival measures, such as creation of similar habitats in nearby area, should be formulated to compensate for adverse impacts.

3. 2. 3 Human Use Values

(1) Navigation

(a) Probable Environmental Impact

(i) By cutting through mesh of klongs in Rangsit area, the diversion channel will

interrupt local navigation.

(ii) Sedimentation may change coastal morphology which gives adverse impacts on coastal navigation near Ban Klongs Dan.

(b) Further Research

The following clarifications are needed by further research during Feasibility Study period for formulation of mitigation plan.

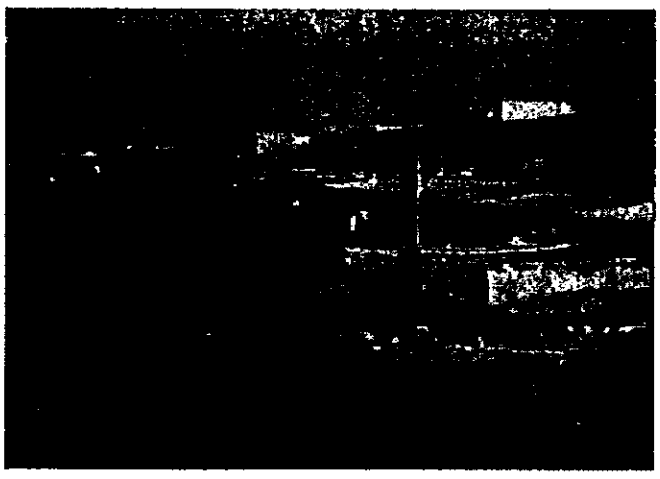
(i) Clarification on the impacts caused by fragmentation of klongs by construction of the diversion channel. The outcome should state the frequencies, purposes, departure and arrival place of the navigation along whole stretch of the diversion channel.

(ii) Clarification on magnitude of sedimentation at downstream of sea barrier, and the impacts on port of Ban Klongs Dan, and coastal navigation nearby ocean.

<Required Personnel for Further Study>
•Speciality in: social survey
Number of staff: 5
Total duration of study: 3.0 months
•Speciality in: sedimentation
Number of staff: 1
Total duration of study: 1.0 month

(c) Recommendation to the Study Team

(i) As a mean of local transportation, navigation is still being a principal traffic measure. An installation of navigation locks is recommended to reduce the impacts. The specification and location should be in accord with the necessity of the local residents. The needs may be collected in the survey.



Klongs Ban Hin
near Bang Bo,
3 km upstream of
Ban Klong Dan

(ii) The location of outlet of diversion channel should carefully be determined with

attention paid to results of study on impacts caused by sedimentation discharged.

(2) Land Transportation

(a) Probable Environmental Impact

The diversion channel will cut-off roads and rail roads on its course. Flyovers will be constructed for major roads and all rails; however, small roads will be terminated by the dikes.

(b) Further Research

The following clarifications are needed by further research during Feasibility Study period for formulation of mitigation plan.

(i) Survey on functions of all the roads that will be interfered by diversion channels, and then assess the impacts on the area.

(ii) Study to formulate plans for mitigation or complementatoin.

<Required Personnel for Further Study>
Speciality in: Social survey
Number of staff: 5
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

Careful selection of locations of flyovers should be made by attentions to the results of surveys on importance of the roads to the local communities. The public hearing s will be important occasions for a consensus among related locals.

(3) Flood Control

(a) Probable Environmental Impact

Canals in Rangsit area have a function to disseminate flood water. The embankments of proposed discharge channel, which is higher than 5 m, may plug natural flows of canals and streams in the vicinity, and it may result appearances of inundations in areas where it is not supposed to be. The inundation may stay longer than that without the diversion channel.

(b) Further Research

An estimation should be made for occurrence of inadequate drainage in the vicinity of the diversion channel during feasibility study period for formulation of mitigation plan.

<Required Person for Further Study>

Speciality in: River engineer
Number of staff: 1
Total duration of study: 0.5 month

(c) Recommendation to the Study Team

If results of further study indicate that unusual inundation will occur because of construction of the diversion channel, then mitigation measures such as ditches along the embankment, incorporation of drainage of vicinity areas into the diversion channel, etc. should be concerned.

(4) Agriculture

(a) Probable Environmental Impact

(i) Undesirable length of period and depth of inundation may give adverse impacts on rice cultivation in the Rangsit area where high-yield varieties (with rotation) are planted. Refer to Figure 2.2.

(ii) Existing irrigation systems will be altered by the diversion channel, and the impacts on water supply in the project area.

(iii) Subsistent farmers may experience higher maintenance cost for the new water suppy system.

(b) Further Research

Utilize results of research on unusual inundation, described in "(3) Flood", and study the project area's cropping patterns, and estimate adverse impacts of inundation, mulfunctioning of existing irrigation systems, and probable cost for mainenance of new irrigation system.

<Required Personnel for Further Study>
•Speciality in: agronomyy (rice cropping)
Number of staff: 1
Total duration of study: 3 months
•Speciality in: civil enginnering
Number of staff: 1
Total duration of study: 3 months

(c) Recommendation to the Study Team

(i) Review the results of survey on "unusual inundation" at earlier stage in the feasibility study period, then the design of drainage system should be incorporated to the design of the diversion channel.

(ii) Diversion channel will alter the courses of irrigation canal. Functions of existing

irrigation systems must be kept.

(iii) If new irrigation system is to be design, the maintenance cost should not be burden to the local farmers.

(5) Industries

(a) Probable Environmental Impact

There is no notable impacts expected by IEE on Industries.

(b) Further Research

Further research for probable impacts on Industries by discharge channel is not necessary. Refer to Resettlement section for compensation for relocation.

(6) Mineral Development

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Mineral Development.

(b) Further Research

Further research for probable impacts on Mineral Development by discharge channel is unnecessary .

3.2.4 Quality of Life Values

(1) Socio-economic Values

(a) Probable Environmental Impact

(i) By penetration of the diversion channel through Rangsit area, transaction between both sides of the channel will be less frequent than without the diversion channel as it will take more time and become inconvenient. The diversion channel will likely be a boundary of local economic activities.

(ii) Unfavorable inundation may occur at vicinity of the channel without proper drainage works. The inundation may give adverse impacts on high-yield variety rice.

(b) Further Research

The following clarifications are needed by further research during Feasibility Study period for formulation of mitigation plan.

(i) Evaluation should be made on impacts caused by separation of local economic

activity regime along all stretch of the discharge channel.

(ii) Design of drainage system should be incorporated, if necessary.

<Required Personnel for Further Study>
Speciality in: social survey
Number of staff: 3
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

If serious impacts on social activities are found by further research, the Study Team should consider alternative routes. If change of the route is inevitable, mitigation plans and a complementary plan should be formulated. The needs of locals may vary, and single type of mitigation plan may not apply to all. Close consultation will be necessary.

(2) Cultural and Archaeological Values

(a) Probable Environmental Impact

Sites of cultural or archaeological values may be in the route of diversion channel.

(b) Further Research

The following clarifications are needed. Review if there is any cultural and archaeological values in the route of the diversion channel. State what is there, and the importance.

<Required Personnel for Further Study>
Speciality in: social survey
Number of staff: 1
Total duration of study: 1.0 month

(c) Recommendation to the Study Team

In IEE study, no archaeological site is found in the vicinity, but historical buildings may exist in the routes. The surveyor needs to consult with National Museum. The best solution is to avoid the historical building at very begging of the route setting. However, if modification of historical building is inevitable, the Study Team needs to receive approval from Fine Arts Department in advance.

(3) Aesthetic Values

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on aesthetic values.

(b) Further Research

Further research for probable impacts on aesthetic values by discharge channel is unnecessary .

(4) Resettlement

(a) Probable Environmental Impact

Resettlement is necessary and inevitable in all proposed cases, listed in a table below, however, resettlement varies largely, according to the routes.

NUMBER OF HOUSES IN THE COURSE OF DIVERSION CHANNEL

Diversion Route (Distance -km)	Case-a*	Case-b*	Case-c*
Tha Chin R. (319)	6,500	4,000	1,500
Chainat-Pasak-Rahpipat-Sea (260)	2,400	2,200	1,700
Chainat-Pasak-Rapipat-Ban Pakong River (362)	3,000	2,800	2,000
Pasak-Rahpipat Sea (127)	1,400	1,200	1,000
Pasak-Rapipat-Ban Pakong R.(229)	2,000	1,900	1,300
Ayuthaya-West Bank- Sea (105)	3,200	2,900	2,200
Ayuthaya-West Bank- Tha Chin (160)	3,600	2,500	1,500
Ayuthaya-East Bank-Sea (96)**	1,600	1,500	1,400
Chao Phraya II (57)	11,000	8,000	5,700
Green Belt -Sea (78)	2,500	2,300	2,300

* Case-a: 1,500 m3/s, Case-b:1,000 m3/sec, Case-c:500 m3/sec
** considered to be most advantageous route from engineering stand point of view

(b) Further Research

(i) Clarification on types and values of properties to be covered by the diversion channel facilities, including the socio-economic characteristics.

(ii) Other socio-economic data for formulating the appropreate resettlement plan.

(iii) Study for formulation of compensation plan.

<Required Personnel for Further Study>
Speciality in: public relations
Number of staff: 5
Total duration of study: 5.0 months

(c) Recommendation to the Study Team

Objectives of compensation plan should not be limited to payment for properties, but should include rehabilitation plan for those who receive inconspicuous social impacts

caused by construction of the discharge channel. The Study Team should emphasize on formulation of deliberate compensation plan.

(5) Public Health and Safety

(a) Probable Environmental Impact

(i) If water in diversion channel is heavily polluted, it may threat local residents who use the water.

(ii) If the diversion channel take large amount of water during dry season, salt intrusion will be extended toward upstream of the Chao Phraya river. At present, water intake for Bangkok is rarely polluted by salt, but additional water withdraws at upstream by the diversion channel may accelerate the phenomenon.

(b) Further Research

(i) Study on water demand of probalbe recipients, and possibility of water supply by the diversion channel in terms of quantity and quality, then estimate if degradation of public health occur by supply of water in the diversion channel.

(ii) By reviewing trend of the development of water supply source and the demand, estimate impacts of salt intrusion into the Chao Phraya river, and state a probable maximum amount of additional water withdraws by the diversion channel.

<Required Personnel for Further Study>
•Speciality in: social survey
Number of staff: 2
Total duration of study: 2.0 months

•Speciality in: water quality
Number of staff: 1
Total duration of study: 1.0 months

•Speciality in: hydrology
Number of staff: 1
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

The demand of water in the vicinity should be studied throughout a year. Estimate the water quality of the diversion channel, and find whether it meets standard for the certain usage. Study if it can be improved by measures such as water treatment, increasing quantity of water flow, and others.

(6) Recreation

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Recreation.

(b) Further Research

Further research for probable impacts on Recreation by discharge channel is unnecessary.

(7) Dedicated Area Uses

(a) Probable Environmental Impact

There is no notable impacts expected by IEE* on dedicated area uses.

(b) Further Research

Following clarification is necessary.

(i) Review if there is any other dedicated areas on the project site.

<Required Personnel for Further Study>
Speciality in: biology/environmental Study
Number of staff: 1
Total duration of study: 0.1 month

3.3 Retarding Basin

3.3.1 Physical Resources

(1) Surface Water Hydrology

(a) Probable Environmental Impact

There are probable environmental impacts which may be caused by construction of retarding basin.

(i) Inundation period will be prolonged with retarding operation.

(ii) The depth of inundation will be kept at the highest level of flood.

(ii) Flow rate of downstream river will not be decreased as fast as the condition under without the retarding basin.

(b) Further Research

The following clarifications are needed by further research during feasibility study period

for formulation of mitigation plan.

(i) Clarification of prospected inundation regime in detail

(ii) Clarification on length of time for inundation, and the depth according to the month.

(iii) Clarification on period of time that downstream river will receive discharge from the retarding basin.

<Required Person for Further Study>
Speciality in: river engineering
Number of staff: 1
Total duration of study: 1.0 month

(c) Recommendation to the Study Team

Prolongation of inundated period should be as short as possible to keep environmental impacts small. If retarding basin plan needs to be implemented, non-facility measures should be formulated simultaneously.

(2) Surface Water Quality

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Surface Water Quality.

(b) Further Research

Further research for probable impacts on surface water quality by retarding use of inundation area is unnecessary.

(3) Ground Water

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on ground water.

(b) Further Research

Further research for probable impacts on Ground Water by retarding use of inundation area is unnecessary.

(4) Soils

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on Soils.

(b) Further Research

Further research for probable impacts on Soils by retarding use of inundation area is not necessary.

(5) Noise and Vibration

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on noise and vibration.

(b) Further Research

Further research for probable impacts on noise and vibration by retarding use of inundation area is unnecessary.

3.3.2 Ecological Resources

(1) Aquatic Ecosystem

(a) Probable Environmental Impact

(i) Gates to be installed to retain inundated water may interrupt fish and other aquatic lives' migration between swamps and rivers.

(ii) Prolongation of high turbidity of the river's water at the downstream may affect aquatic lives' feeding habit and/or their reproduction.

(iii) Artificial retention of river water for prolonged time period may deplete dissolved oxygen. When it is released, aquatic lives that are sensitive to polluted water, such as Freshwater Drab (*Macrchirichtys macrochirus*), may suffer.

(b) Further Research

The following clarifications are needed by further research during feasibility study period for formulation of mitigation plan.

(i) Clarification on migration of aquatic lives at all the location the gates to be installed. Result of the further research should state species which may receive impacts by the gates' installation, and period of migration of each, and formulate mitigation plan. If the impacts are inevitable, evaluate the adverse importance.

(ii) Adverse impacts which may be caused by discharge of polluted water, such as low dissolved oxygen or high turbidity, should be clarified at all the location where the gates to be installed, and evaluate the importance. Then formulate mitigation plan if

the impacts are inevitable.

<Required Personnel for Further Study>
Speciality in: freshwater biology
Number of staff: 2
Total duration of study: 4.0 months

(c) Recommendation to the Study Team

If significant impacts on aquatic ecosystem are found by the further research, mitigation plans should be formulated. It may include a modification of gates' operation for migration fish, installation of fishways, and others, or no gates as one of the alternatives.

(2) Forests

(a) Probable Environmental Impact

Notable impacts expected on Forestry was not clear by IEE. The central plain's distribution of natural vegetation is shown in Figure 2.1. According to the figure, there is no large forest remained in the proposed retarding area. The lowland forests are severely reduced in the lower central plain.

(b) Further Research

Clarification on remained forest in the project area and the importance should be evaluated thoroughly.

<Required Personnel for Further Study>
Speciality in: biology
Number of staff: 3
Total duration of study: 3.0 months

(3) Terrestrial Wildlife

(a) Probable Environmental Impact

(i) There may be important areas for birds' habitat. Since the lowland forest is severely reduced, the remained trees may be supporting important fauna. Prolongation of flood water inundation may interrupt breedings.

(ii) Prolongation of inundation gives impacts on animals feeding activities.

(b) Further Research

(i) Clarification on existing fauna in the area, and the down steam.

(ii) Clarification on changes of the habitats by implementation of the retarding basin

plan.

<Required Personnel for Further Study>
Speciality in: terrestrial biology
Number of staff: 3
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

(i) According to the impact on terrestrial wildlife, the Study Team need to modify the operation plan of the retarding basin.

(ii) Mitigation measures should be actively sought by using data found in further research.

(4) Endangered Species

(a) Probable Environmental Impact

Endangered species such as Silver Shark (*Balantiocheilos melanoptus*), Siamise Giant Carp (*Catlocarpio siamensis*), Jullien's Golden Carp (*Probarbus jullieni*), Siamese Tigerfish (*Datnioides microlepis*) may encounter migration problems. The interruption of routes between swamps, the spawning ground, and the Chao Phraya river by gates to be installed may occur.

(b) Further Research

Clarification on distribution of endangered species in the project area, and the surroundings. The season of migration and life cycles, and how the gate may interrupt the migration.

<Required Personnel for Further Study>
Speciality in: aquatic biology
Number of staff: 5
Total duration of study: 4.0 months

(c) Recommendation to the Study Team

Immediately after the Study Team finds out the impacts on aquatic biology, mitigation measures and modification of operations, including no-project as one of the alternatives, should be sought.

3.3.3 Human Use Values

(1) Navigation

(a) Probable Environmental Impact

Inland navigation will be interrupted by the gates to be installed.

(b) Further Research

Numbers of ships passing the gate area are needed be clarified. The departure sites and the destinations, the purposes should also be surveyed to formulate mitigation and/or compensation measures.

<Required Personnel for Further Study>
Speciality in: social survey
Number of staff: 10
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

According to the significance of the impacts on navigation, the Study Team should decide that for which sites navigation locks will be installed. The Study Team needs to establish an agreeable standard for installation of a navigation lock. No-project may also be one of the alternatives.

(2) Land Transportation

(a) Probable Environmental Impact

Because of prolongation of high-water-leveled inundation, the land transportation may be disabled in some parts of the project site.

(b) Further Research

Site survey is needed to clarify the impacts of inundation on land transportation in the project area during highest flood in the past The out come should quantify the inconveniences may be caused by prolongation of the flood in the future.

<Required Personnel for Further Study>
Speciality in: social survey
Number of staff: 2
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

According to results of the survey and estimation for land transportation problem during operation period of retarding basin, the Study team should modify operation rules of retarding basins, with "no project" as one of the alternatives.

(3) Agriculture

(a) Probable Environmental Impact

The proposed area for retarding basin is predominantly used for traditional variety rice cultivation. If a period of high-water-level inundation is prolonged, the timing of harvesting will be altered. Decay of grown up crops may began resulting from prolongation of inundation.

(b) Further Research

Clarification is necessary on existing cropping patterns in the proposed project site, especially the timing of harvesting, land use for other agricultural purposes, and their values. Evaluation should be made on adverse impacts on agricultural products.

<Required Personnel for Further Study>
•Speciality in: agriculture
Number of staff: 2
Total duration of study: 2.0 months
•Speciality in: economy
Number of staff: 1
Total duration of study: 1.0 month

(c) Recommendation to the Study Team

The impacts on traditional variety rice cultivation may be significant. The impact should not be evaluated only by the economic values. Traditional cropping farmers in the proposed site may not have other ways of income source as the substitution. The Study team should consider on modification of operation rules of retarding basins if the impact is inevitable. Thorough understanding of their life styles will be necessary for establishing mitigation measures.

3.3.4 Quality of Life Values

(1) Socio-economic Values

(a) Probable Environmental Impact

Prolongation of inundation in the area gives significant impacts on local socioeconomic values, such as on the agriculture, the land transportation, the commercial activities, changes of the land values, the land use patterns, etc.

(b) Further Research

Identification of existing and the future local socioeconomic activities and living condition to be affected by implementation of retarding basin project. The impacts should be assessed, and the deliberate mitigation plans and compensation plans should be

formulated to keep standard of living no lower than the standard before implementation of the project.

<Required Personnel for Further Study>
•Speciality in: social survey
Number of staff: 5
Total duration of study: 5.0 months
•Speciality in: economy
Number of staff: 1
Total duration of study: 3.0 months

(c) Recommendation to the Study Team

The impacts may be significant. The Study Team should consider modification of the initial plans, including abandoning of the plan as one of the alternatives.

(2) Cultural and Archaeological Values

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on cultural and archaeological values.

(b) Further Research

Further research for probable impacts on cultural and archaeological values by retarding use of inundation area is needless.

(3) Aesthetic Values

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on aesthetic values.

(b) Further Research

Further research for probable impacts on aesthetic values by retarding use of inundation area is needless.

(4) Resettlement

(a) Probable Environmental Impact

Although inundation of the area by flooding is a common phenomena, prolongation of inundation may lead to changes of the living since the local agriculture is heavily depending on the climate and natural water hydrology. For those who may not able to continue existing cropping pattern, they may be forced to change their ways of income and relocate. Aquaculture of cattle fish and flogs may also be affected.

(b) Further Research

The following clarifications are needed by further researches during Feasibility Study period for formulation of mitigation plan.

(i) Clarification on who will be receiving impacts and need to resettle.

(ii) Clarification on socioeconomic baseline data on the families to be resettled.

(iii) Formulation of resettlement plan and compensation plan.

<Required Personnel for Further Study>
Speciality in: social survey
Number of staff: 5
Total duration of study: 6.0 months

(c) Recommendation to the Study Team

The Study Team should consider the modification of the initial plans, including abandoning of the plan as one of the alternatives.

(5) Public Health and Safety

(a) Probable Environmental Impact

Although infection rate of water-borne diseases such as malaria, dengue fever is not very common in the proposed site, stagnation of inundated water may provide reproduction grounds for water-borne diseases.

(b) Further Research

Clarification is necessary on possibility of spreading the existing water-borne diseases, and the causes.

<Required Personnel for Further Study>
Speciality in: health science
Number of staff: 2
Total duration of study: 2.0 months

(c) Recommendation to the Study Team

The Study Team should consider modification of the initial plans, including abandoning of the plan as one of the alternatives.

(6) Recreation

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on recreation.

(b) Further Research

Further research for probable impacts on recreation by retarding use of inundation area, is not necessary.

(7) Dedicated Area Uses

(a) Probable Environmental Impact

There are no notable impacts expected by IEE on dedicated area uses.

(b) Further Research

Further research for probable impacts on dedicated area uses by retarding use of inundation area, is not necessary.

Chapter 4. CONCLUSION

4. 1 Summary

Objectives of this Initial Environmental Examination (IEE) are the following:

(1) to asess probable environmental impact to be caused by proposed projects,
(2) to estimate for what environmental values, or categories, the Study Team should conduct environmental studies to conduct further environmental studies, and to make a term of reference (TOR) for the environmental studies, and
(3) to present recommendations for the feasibility study to the Team.

The subjects of the IEE are the three proposed flood mitigation measures such as river improvement, diversion channel, and retarding basin (these alternatives are still being modified and not the finalized ones, however, it is assumed for IEE that the largest scale of the plan will be implemented). As the result, it is found that the retarding basin plan affects the natural and social environmental values of the site significantly. The IEE also found that river improvement and diversion channel plans give significant impacts on the sites and the surroundings; however, it is also assumed that they can be either mitigated or compensated by appropriate countermeasures. Significance of probable impacts caused by the proposed flood control measures, and contents of the further stydies are summarized in Table 4. 1.

4. 2 Probable Impacts of River Training

(1) Roop-cut and Widening

Impacts of roop-cut at Pra Prapadaeng, just off south of Bangkok Metropolis, are expected to be limited because of its size, 0.7 km long, and the site's sparse population density. In addition, there is a canal, Klong Pak Lat, already existing. Houses required to be relocated will also be very limited. Widening of river will require relocations and other necessary infrastructure renovations, however, cautious studies on the existing functions should manage the impacts by either appropriate mitigations and adequate compensations.

(2) Embankment

Construction of embankment for *all* stretch of the Chao Phraya river will affect the natural and social environment significantly, and some of the impacts are inevitable, and some can not be compensated fully because of its irreversible characteristics.

Impacts on Physical Resource Values

• Embankment will separate the Chao Phraya river and natural ecosystem along the river by shutting off natural water movements. It will alter the natural environment significantly and, further, alteration of phase of aquatic and terrestrial lives may happen.

Impacts on Human Use Values

• Embankment will interrupt local navigation between the left and right banks. It eventually may separate the communities along the Chao Phraya river.

• Many existing irrigation canals need to be reworked simultaneously with the embankments. Farmers who practice subsistent farming may be forced to support more intensive cultivation because of changes in water supply and drainage systems.

Impacts on Quality of Life Values

• Large number of resettlement will be necessary; moreover, the residents will lose immediate access to river water.

• It may alter the natural characteristics of non-hunting areas such as Wat Tarn-En and Wat Phai Lom-Wat Umputwararan.

4. 3 Probable Impacts of Diversion Channel

Implementation of proposed diversion channel is considered to be environmentally sustainable only with deliberate environmental countermeasures for resettlement, local transportation, community separation, and sedimentation problems near the outlet of the channel at coastal line.

Impacts on Physical Resources Values

• A portion of silt which has been transported down originally by the Chao Phraya river will be diverted to the diversion channel, and will be released by the coastal town, Ban Khlong Dan. Silt may alter the coastal topography and the aquatic lives' habitats significantly. It may also give impacts on the vigorous local fishing industries.

Impacts on Ecological Resources Values

• It may drain wetland's water and alter the characteristics of lower plain where important habitat of, for example, water fowls.

Impacts on Human Use Values

• As the route goes through in the "mesh" of klongs in Rangsit area, the diversion channel will change navigation patterns.

• Because the embankments of diversion channel may interrupt receding water which goes back to the Chao Phraya river, prolongation of inundation may occur at some part in the vicinity of discharge channel in the end of wet season.

Impacts on Quality of Life Values

• Although low-population-density areas are chosen for the proposed route of diversion channel, there is possibility of splitting communities, as it may make local residents' accesses over the diversion channel difficult.

• More than one thousand houses, built along the klongs, are in the route of the diversion channel. Although the houses do not have to move far, large number of resettlement will be necessary.

• If large quantity of water is withdrawn from the Chao Phraya river by the diversion channel during dry period, it may accelerate salt intrusion toward upstream of the Chao Phraya river. It eventually may threat water intake of Bangkok, Sam Lae, in Pathum Thani.

4. 4 Probable Impacts of Retarding Basin

Proposed retarding basin plan has many environmental disadvantages. Implementation of the retarding basin plan should give profound environmental impacts.

Impacts on Physical Resources Values

- In the project-proposed site, highest water level during flood will be kept until the end of flood period. The natural hydrology will be altered significantly.
- At the end of flooding period, water which retained in the retarding basin will be released gradually. Turbid water will be released after the flood period for longer time than the period without the project.

Impacts on Ecological Resources Values

- Gates will be installed to retain the flood water. The gates will interrupt migration of aquatic ecosystems. For some, including endangered fish species, connections of swamps and rivers are crucial for accessing their reproduction grounds.
- Aquatic ecosystem may receive impacts by flow of turbid water for longer time in downstream of retarding basin.
- Characteristics of habitats for water fowls may be altered by prolongation of inundation, so as their reproduction cycles.

Impacts on Human Use Values

- Inland navigation will be interrupted by the gates to be installed.
- Land transportation also will be disconnected for longer period of time because of inundation.
- Harvesting period of traditional-variety rice may be delayed and disabled.
- Some fish species may fail to migrate through the gates and local fish catch could be reduced.

Impacts on Quality of Life Values

- Land use pattern will be restricted because of the flood retarding operations. It gives profound impacts on land values and the compensation fee will be considerable amount.
- Some existing local industry may not be suitable for longer period of submergence in flood water. Compensation will also be needed for disabled local industries.

Table 4. 1 TABULATION OF IEE RESULTS

ENVIRONMENTAL PARAMETERS / PROJECT COMPONENTS	DEGREE OF IMPACT											
	RIVER TRAINING (new embankment)				DIVERSION CHANNEL				RETARDING BASIN			
	Slight	Moderate	Significant	Irreversible	Slight	Moderate	Significant	Irreversible	Slight	Moderate	Significant	Irreversible
Physical Resources												
(1) Surface Water Hydrology			X				X				X	
(2) Surface Water Quality	X					X					X	
(3) Ground water	X					X			X			
(4) Soils	X				X				X			
(5) Noise and Vibration	X				X				X			
Ecological Resources												
(1) Aquatic Ecosystem			X	X		X					X	X
(2) Forests	X				X					X		X
(3) Terrestrial Wildlife	X				X					X		X
(4) Endangered Species			X	X		X					X	X
Human Use Values												
(1) Navigation			X				X				X	
(2) Land Transportation	X					X					X	
(3) Flood Control	X					X						
(4) Agriculture			X			X					X	
(5) Industries	X				X						X	
(6) Mineral Development	X				X				X			
Quality of Life Values												
(1) Socio-economic Values			X				X				X	
(2) Cultural and Archaeological Values	X				X				X			
(3) Aesthetic Values	X				X				X			
(4) Resettlement			X				X				X	
(5) Public Health and Safety	X					X				X		
(6) Recreation	X				X				X			
(7) Dedicated Area Uses		X			X				X			

Specific Background Studies and Reports

Physical Resources

(1) Surface Water Hydrology

_ Takaya, Yoshikazu. *Agricultural Development of a Tropical Delta: A Study of the Chao Phraya Delta.* Kyoto: Kyoto University, 1987

_ Takaya, *Agricultural Development*

_ Kasetsert University, ORSTOM. *Agricultural and Irrigation Patterns in the Central Plain of Thailand - Preliminary analysis and prospects for agricultural research and development.* Nakhon Pathom, Thailand, 1996

_ Netherlands Engineering Consultants (NEDECO). *A Study on the Siltation of the Bangkok Port Channel.* Hague: 1965

(2) Surface Water Quality

_ Office of National Environmental Board. *Development of a Framework for Water Quality Management of Chao Phraya and Thachin Rivers.* Bangkok: Thailand Development Research Institute, 1988

_ Minami, Isao, Prasert Milintangui. *Present Situation of Water Quality in Estuaries (Bang Pakong, Chao Phraya, Tha Chin and Mae Klong) of Thailand.* Bangkok: Irrigation Engineering Center, Royal Irrigation Department (RID), 1991

_ Kongrut, Anchalee. "Fish dying en masse in Lat Krabang." Article. *Bangkok Post,* December 2, 1997

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(3) Ground water

_ Beek, Steave Van. *The Chao Phraya -River in Transition.* New York: Oxford University Press, 1995

(4) Soils

_ Takaya, *Agricultural Development*

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_ NEDECO. *A Study on the Siltation*

_ Regional Office for Asia and the Pacific (RAPA), Food and Agriculture Organization of the United States (FAO). *Problem of Soils of Asia and the Pacific -Report of the Expert Consultation of the Asian Network on Problem Soils.* Bangkok: GPO, 1990

(5) Noise and Vibration

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Ecological Resources

(1) Aquatic Ecosystem

_ Smith, Hugh M. United States. Smithonian Institution, United States National Museum. *The Fresh-Water Fishes of Siam, or Thailand.* Washington: GPO, 1945

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(2) Forests

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_ Noikorn, Uamdao. "Biologists moved to save at-risk mangrove forest." Article. *Bangkok Post,* February 17, 1997

_ Hongthong, Pennapa. "Care for environment ends tin mining plan." Article. *The Nation,* February 26, 1998

(3) Terrestrial Wildlife

_ Cubbit, Gerald, and Belinda Stewart-Cox. *Wild Thailand.* Bangkok: Asia Books Co., Ltd., 1995

(4) Endangered Species

_ Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment. *Thailand's Biodiversity.* Bangkok: GPO, 1996

_ Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment. *Implementing the Convention on Biological Diversity in Thailand.* Thai-Swedish Symposium on Biodiversity and Biotechnology. Bangkok: GPO, 1996

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_ Thailand. Ecological Research Department, Thailand Institute of Scientific and Technological Research. *Endangered Species and Habitats of Thailand.* Bangkok: Kurusapha Ladprao, 1993

_ Graham, Mark, and Philip Round. *Thailand's Vanishing Flora and Fauna.* Bangkok: Finance One Public Company Ltd., 1994

_ Inchukl, Kanittha. "Biodiversity Center to safeguard Thai nature." Article. *Bangkok Post,* February 16, 1997

Human Use Values

(1) Navigation

_ Montgomery, Jock, William Warren. *Menam Chao Phraya -River of Life and Legend.* Bangkok: Post Books, 1994

_ Beek, *The Chao Phraya*

(2) Land Transportation

_ Beek, *The Chao Phraya*

(3) Flood Control

_ Beek, *The Chao Phraya*

_ Takaya, *Agricultural Development*

(4) Agriculture

_ Montgomery, *Menam*

_ Beek, *The Chao Phraya*

_ Tanabe, Shigeharu. *Ecological and Practical Technology -Peasant Farming Systems in Thailand.* Bangkok: white Lotus Co., Ltd, 1994

_ Takaya, *Agricultural Development*

_ Kasetsert University, *Agricultural and Irrigation*

(5) Industries

_ "Fishermen are victims of progress." Article. *The Nation,* February 15, 1997

(6) Mineral Development

Quality of Life Values

(1) Socio-economic Values

_ Montgomery, *Menam*

_ Beek, *The Chao Phraya*

_ Takaya, *Agricultural Development*

(2) Cultural and Archaeological Values

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_ Office of the National Environmental Board. *Sukhothai and associated cities.* Bangkok: GPO, 1993

_ Montgomery, *Menam*

_ Beek, *The Chao Phraya*

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(3) Aesthetic Values

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TERMS OF REFERENCE

FOR

ENVIRONMENTAL IMPACT ANALYSIS

ON

THE MIDDLE CHAO PHRAYA RIVER IMPROVEMENT PROJECT

FOR

THE STUDY ON INTEGRATED PLAN FOR FLOOD MITIGATION IN CHAO PHRAYA RIVER BASIN

AUGUST 1998

JICA STUDY TEAM
JAPAN INTERNATIONAL COOPERATION AGENCY

1. INTRODUCTION

1.1 Purpose and Objective of Terms of Reference

For the environmental study (E-Study), described below, is to be incorporated into JICA study scheme, the Middle Chao Phraya River Improvement Project (the Study). The purpose of this Terms of Reference (TOR) is to describe the requirements for the E-Study to be prepared by Japan International Cooperation Agency (JICA) study team for the Integrated Plan for Flood Mitigation in the Chao Phraya River Basin (the Study Team) proposing to undertaking the Study, so that the resulting E-Study report will be suitable for review by National Environment Board (NEB). Assuming an adequate E-Study report is submitted to NEB, NEB will be able to quantify the effects of the project in environmental values and thus, to privide comments for implementing and carrying out project.

1.2 Background Information

The City of Bangkok has been suffered by flooding cronically, and agricultural lands in the low elevation areas are also receiving flood damages. The recent biggest flood occurred in 1995 and 1996, which left huge economic loss in Bangkok and the surrounding cities, and on agricultural lands. On the other hand, the existing capacity of rivers, canals and drainage system in the Chao Phraya River Basin are insufficient to drain heavy rainfall in the basin.

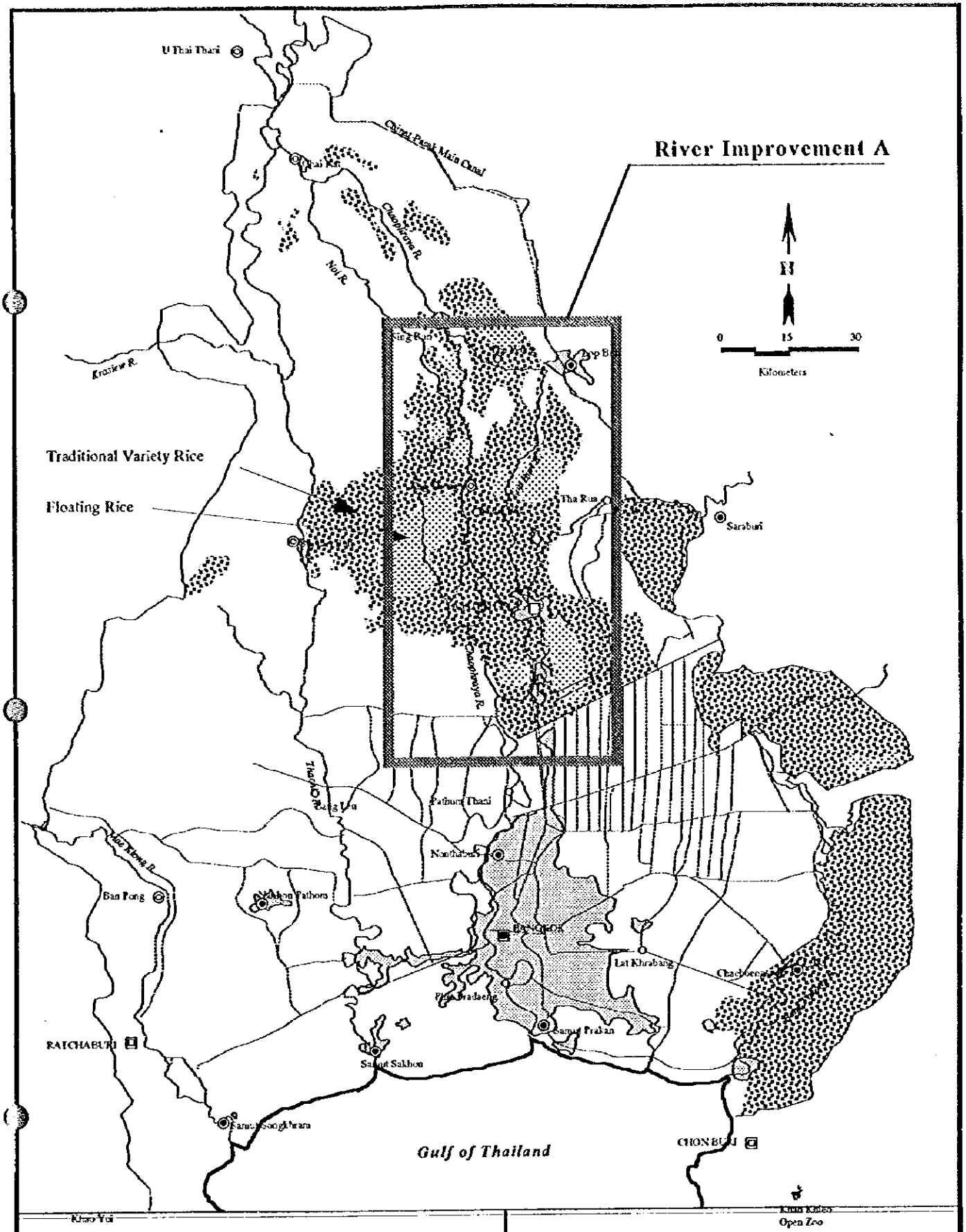
2. PROJECT OUTLINE

Purpose of the Study is to concentrate to mitigate flood damages on agricultural areas in the middle Chao Phraya river basin, inbetween Pathumthani and Chai Nat, to once in ten year period, by construction of low dikes and or hightening of existing dikes (**Figure 1**). By reviewing existing conditions, structural and nonstructural flood damage-reducing measures will be proposed as the outcomes. This E-Study shall estimate adverse environmental impacts of the Study plans before the basic design would be formulated. Mitigation plans, which include changes of basic design and or facilities attached, and compensation, shall then be proposed and incorporated to the Study.

3. WORK PLAN

3.1 General Description

For the E-Study for this particular project, it is envisioned that following specialized skills and knowledge will be needed:



STUDY AREA OF
MIDELE CHAO PHRAYA RIVER
IMPROVEMENT PROJECT

CTI ENGINEERING CO., AND INA CORPORATION

Figure 1
PROPOSED RIVER IMPROVENT

1. E-Study management

Physical Resources

2. Hydrology
3. Water quality

Biological Resources

4. Fisheries and aquatic ecology
5. Terrestrial river line biology

Human Use Values

6. Transportation and Land Use
7. Agriculture

Quality of Life Value

8. Socioeconomic/ Public consultation
9. Compensation
10. Cultural values and archaeology
11. Health Science

3.2 Detailed Description of Tasks

3.2.1 Expected Impacts and Work Tasks

(a) Physical Environment

(i) Surface Water Hydrology

Separation of rivers from klongs may be occurred by construction of embankment and other flood mitigation facilities. Reviewing related information, analyses of data, assessment of the impacts, and recommendation to the Study Team shall be made.

(ii) Surface Water Quality

Without appropriate mitigation measures for stagnation of klongs' water, it may affect water usage of local residents, and further, may affect public health of local residents. Relevant literature should be reviewed, field observation shall be carried out and the data shall be analyzed for future estimation of water degradation and the impacts on local public.

(b) Ecological Environment

(i) Aquatic Ecosystem, Fisheries, and Aquatic Endangered Species

Flood fisheries which have been practiced in the Chao Phraya Basin traditionally, may receive impacts of lessened flood frequencies. Relevant literature shall be reviewed, necessary researches will be conducted and future impact assessed, then the appropriate mitigation measures shall be proposed.

(ii) Terrestrial River Line Wildlife and Terrestrial Endangered Species

Waterfowls' and other terrestrial wildlife's habitat may be disturbed by construction of embankment or other form of flood control measures. Relevant literatures shall be reviewed, field research to be conducted, and impacts on wildlife and on the habitat shall be assessed; then appropriate mitigation measures shall be proposed to the Study team.

(c) Human Values

(i) Navigation (transportation)

Construction of embankment may cut off klongs and roads, and they disrupt navigation and other means of transportation. Relevant literatures and precedent cases shall be reviewed; necessary field survey shall be conducted. Then the impacts of flood control facilities should be assessed, and for the impacts, mitigation measures shall be proposed to the Study Team as early as possible.

(ii) Agriculture

Traditional agriculture practices, so-called "flood agriculture" are commonly found in the Chao Phraya River Basin. Lessening of flood frequencies may give adverse impacts on the agriculture practice. Construction of embankment may also interrupt irrigation canals. Reviewing existing information and field survey shall be conducted for where sufficient data are not available. Impacts on agriculture in the project site shall then be assessed for formulating mitigation plan.

(iii) Land Use

The Riverside land of proposed embankment may be restricted because flood water will probably be confined between the dikes. Land value may be changed because of the hydrological changes. Relevant-existing information shall be analyzed; the impacts will be assessed; the suggestions or proposals should be formulated promptly, to be incorporated into the flood control facilities' design.

(d) Quality of Life Values

(i) Socioeconomic Values / Public consultation

Riverside land of embankment and land in the course of embankment may need compensation. In addition, access to the river may be interrupted by the dikes; hence, the land use may receive certain degree of social changes. Relevant information, complemented by field survey, is analyzed and then the impacts shall be assessed. Public consultation shall be carried out with well-experienced personnel who understand the projects and also able to communicate with local residents. Proposals or suggestion to the Study Team should be formulated promptly to be incorporated in the design of flood control facilities.

(ii) Cultural and Archaeological Values

Cultural values or archeological values may be in the course of the embankment or other flood control facilities. For the evaluations and decisions what to do with them according to the Archaeological Site and Museum Act (1961) or equivalent, relevant literature shall be reviewed and the site survey shall be conducted if necessary, and information shall be analyzed and assessed.

(iii) Resettlement /compensation

For the land owners and others who uses lands which are in the course of proposed embankment will probably need to be compensated. Reduced land value resulting from the changes in hydrology (see category, Land Use), or changes of traffic, such as interruption of navigation routes shall be assessed and suggest the Study Team the amount of compensation. The assessment shall be conducted by reviewing relevant literature and field survey, if necessary, and the collected data shall be analysed.

(iv) Public Health

Indicated in "Surface Water Quality"

(v) Dedicated Area Uses

Indicated in "Aquatic Ecosystem" and "Terrestrial River Line Wildlife"

(e) Management of E-Study

The E-Study manager is responsible for supervision of above written personnel and integration of each task to suffice the object of this E-Study.

3.2.2 Justification of Equipment

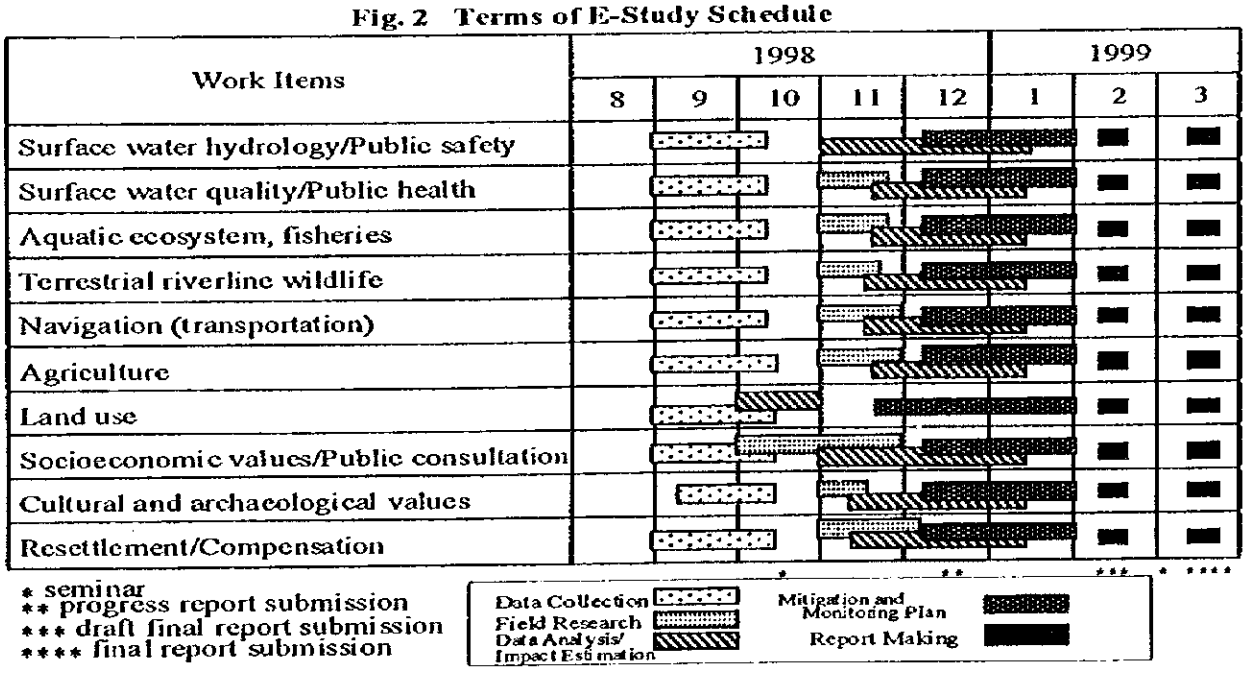
The field researches required for the study are quantified as in the list shown below.

•Water Quality/ Aquatic Ecology - more than 10 stations
•Terrestrial Ecological/Wetland Survey
•Land Use Survey
•Compensation Survey
•Socioeconomic Survey - more than 200 cases
•Public Consultation - more than 10 small group meetings - more than one seminar
•Archaeological Survey

3.3 Schedule of Work

The E-Study shall be started in August 1998, and be completed before March 1999. A tentative schedule is described in Figure 2. In addition to the work items, an in charging staff for the E-Study will be attended for whole study period for responding for inquiries from other organizations and supervising the each work tasks.

Fig. 2 Terms of E-Study Schedule



3.4 Review Sessions

Review sessions will take a form of seminar which the Study Team will conduct presentation of the Study; the E-Study will be incorporated in the presentation. Inter-ministerial Steering committee, of which the representative from Office of Environmental Policy and Planning (OEPP) of the Ministry of Science, Technology and Environment is a member, will also be conducted by the Royal Irrigation Department and the Study Team. Other than the presentation, the Study team will have discussions with OEPP for receiving comments and advises for the process of Study. Local specialized personnel, conducting the E-Study, shall participate JICA seminars and other formal and informal meetings, on the request of the JICA study team, and to prepare relevant explanatory documents in relation with the E-Study.

4. PROJECT REPORTS

The E-Study report will be written in both Thai and English language as they are shown below.

-Draft Final Report in Thai (Main report + Summary report)
-Draft Final Report in English (Main report only)
-Final Report in Thai and English

****end of TOR****

SECTOR XV

TOPOGRAPHIC SURVEY

SECTOR XV: TOPOGRAPHIC SURVEY

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1. RIVER CROSS SECTION, PROFILE SURVEY, FIRST ORDER LEVELING AND DIGITAL PHOTO MOSAIC IN THE MASTER PLAN STUDY

1.1 General

For the integrated flood mitigation plan of Chao Phraya River Basin, the following survey works have been conducted:

(1) Cross section survey (5 streams) and profile survey (3 streams) along the Chao Phraya River Basin;

(2) First order leveling along the lower reach of the Chao Phraya River where land subsidence has been detected, and

(3) Digital photo mosaic production of the area along the Chao Phraya River. (The Study Team entrusted all survey works to the Thai Mapping Service Co., Ltd.)

1.2 Target Area and Scope of Work

Fig. 1.2.1 shows the target area of river cross section and profile surveys. Fig. 1.2.2 shows the first order leveling routes and Fig. 1.2.3 shows the area covered by the digital photo mosaic. Many bench marks have been lost and this increased the leveling route for the cross -sections to more than those in the survey plan.

The work is summarized in the following tables.

Item	Target Area	Content	Volume of Work	
			Plan	Accomplished
River Survey	Lopburi River	Number of GPS Points	40	44
		Leveling kilometers	100	104.3
		Number of Cross-sections	20	22
		Cross-section kilometers	40	45.9
River Survey	Noi River	Number of GPS Points	60	68
		Leveling kilometers	150	168.7
		Number of Cross-sections	30	34
		Cross-section kilometers	60	69.8
River Survey	Chao Phraya River	Number of GPS Points	52	44
		Leveling kilometers	130	112.6
		Number of Cross-sections	26	22
		Cross-section kilometers	52	44.7
River Survey	Ping River	Number of GPS Points	0	2
		Leveling kilometers	0	1.2
		Number of Cross-sections	0	1
		Cross-section kilometers	0	1.8
River Survey	Nan River	Number of GPS Points	60	58
		Leveling kilometers	0	27.4
		Number of Cross-sections	30	29
		Cross-section kilometers	15	60.0
River Survey	Yom River	Number of GPS Points	52	56
		Leveling kilometers	0	35.4
		Number of Cross-sections	26	28
		Cross-section kilometers	13	59.7
Total (River Survey)		Number of GPS Points	264	272
		Leveling kilometers	380	449.6
		Number of Cross-sections	132	136
		Cross-section kilometers	180	282.0
First Order Leveling	Lowest reach of Chao Phraya	Number of Water Gauges	10	9
		Leveling kilometers	100	34.7.
Digital Photo Mosaic	Delta area and Lower Reach of Nan and Yom	Digital Photo Mosaic, km^2	27,000	27,000
		Aerial Photos purchased	283	283

1.3 Survey Method and Required Accuracy

1.3.1 Monumentation

Two permanent concrete pile monuments were placed at each cross section along the Lopburi, Noi and Chao Phraya rivers. Temporary steel pipe monuments were set up along the Nan and Yom rivers. The monuments were set up on the same side of the riverbank so as to have a fix direction of the cross sections.

1.3.2 Leveling along Rivers

Ordinary spirit leveling was performed in two directions with reading accuracy of 1 mm.

Leveling lines of three rivers (Chao Phraya, Noi, Lopburi) were started and closed at the existing first order bench marks. The leveling routes were connected to the monuments.

At the Nan and Yom rivers, leveling was performed at several points and the heights were fixed according to the GPS observation.

Accuracy of leveling was set at 15 mm$\sqrt{S}$, where S is the observed distance in kilometers.

1.3.3 GPS (Global Positioning System) Observation

GPS instruments were used to observe the coordinate of all the new monuments and a GPS network was established in each river. Each GPS network was close to the GPS points surveyed by the Royal Thai Survey Department at the lower and upper rivers. Table 1.3.1 shows the GPS observation results.

1.3.4 Cross Section Survey

Cross section surveys were carried out by using theodolites, levels, electro-optical distance meters and tape measures.

Based on the posts prepared on the cross section lines, the sounding surveys were carried out by using the total station and echo-sounder.

1.3.5 Profile (Chao Phraya, Noi and Lopburi Rivers)

The profile was drawn using the cross section survey results. The profile drawings included: (1) station number, (2) distance, (3) elevation of deepest section of the riverbed, (4) elevation of highest sections on the right and left banks, and (5) the highest section of the roads or the bank of canals along the river.

1.4 First Order Leveling

First order leveling was carried out along the Chao Phraya River for determining the elevation of water level gauges which are not of uniform height.

1.4.1 Ground Height

Ground height was established by using the 1996 data of the Department of Mineral Resources in 1996 on the land subsidence in Bangkok Area.

1.4.2 Accuracy

Accuracy of leveling was set at 5 mm$\sqrt{S}$, where S is the observed distance in kilometers.

1.4.3 Results

The results of the first order leveling are shown in Table 1.4.1.

1.5 Digital Photo Mosaic

1.5.1 Aerial Photos

Aerial photos taken by the Royal Thai Survey Department at a scale of 1:50,000 from 1994 to 1997 were used. The inner area of at least 27,000 km² was covered by mosaic.

Purchased for the Study were 283 photos covering the important areas.

1.5.2 Method of Photo Mosaic

The aerial photos were digitized by scanning and compiled as photo mosaic data in the following manner:

(1) Scanning and digitalization of aerial photos

Aerial photos were scanned with resolution of 800 dpi.

(2) Digital Mosaic

Digital photo data were retrieved and shown on screen, and the photo images were connected one by one.

(3) Compilation and Original Mosaic

Each mosaic sheet was determined according to the index map. Main cities, roads, railways, rivers, etc., were annotated on the monitor as original mosaic data. Original mosaic data were completed with marginal information such as photo mosaic scale, sheet number, adjoining sheet map, north direction, etc.

(4) Output

Final results were produced by a laser plotter at 800 dpi resolution.

(5) Main equipment used

- Software: ER Mapper 5.2 (made in Australia)
- Scanner: UMAX ; Mirage II, CPU; Pentium 150, hard disk, 2.5 GB
- Computer: CPU; Pentium 166 (RAM 64 MB), hard disk, 6 GB
- Laser Plotter: Lightjet 5000 (Symbolic Science Inc., USA)

(6) Details of Aerial Photos

Table.1.5.1 shows the list of purchased photos (contact prints for sections outside of the area covered in mosaic). Table 1.5.2 is a list of diapositives used for the mosaic and Table 1.5.3 is a list of photos for the mosaic and the study, which also show all purchased contact prints.

1.6 Final Results

(1) River Cross Section

- Observation data and calculation sheet 1 set
- List of results 1 set
- Original cross section (size A1, V=1:200, H=1:5,000) 1 set
- Duplicate of original cross section 1 set
- Blue copy of cross section 1 set
- Cross section map 1 set
- Leveling route map (Scale: 1:50,000) 1 set
- Floppy disk of cross section data 1 set

(2) River Profile

- Original profile (size A1, V=1:200, H=250,000) 1 set
- Duplicate of Original Profile 1 set
- Blue copy of profile 1 set
- Floppy Disk of Profile 1 set

(3) First Order Leveling

- Observation Data and Calculation Sheet 1 set
- List of Results 1 set
- Leveling Route Map (Scale 1:50,000) 1 set

(4) Mosaic Photo

- Final mosaic sheet by ink-jet printer for checking 1 set
- Final Mosaic Sheet by Laser Printer 3 sets
- Final Mosaic Film by Laser Printer 1 set
- Digital Mosaic in CD-ROM 1 set

2. RIVER CROSS SECTION, PROFILE SURVEY AND MAPPING IN THE FEASIBILITY STUDY

2.1 Outline

2.1.1 Contract

The survey work for the Study on Integrated Plan for Flood Mitigation in Chao Phraya River Basin was subcontracted by the JICA Study Team to the Thai Mapping Service Co., Ltd. under a contract dated 19 September 1998.

2.1.2 Scope of Work

The survey area included Chao Phraya River, Khlong Bang Bal, Khlong Bang Luang, Khlong Bang Kaeo and Khlong Bang Pla Mo. Mapping also included the Pasak, Noi and Lop Buri rivers. Ground control points were monumented according to the plan of existing mosaics at the scale of 1:50 000. New points were established as pairs with visibility between the monument locations. One monument point of the pair was tried to be located so that the place can be identified on aerial photographs. Monument points were pricked on the aerial photographs and identified by measuring the angle and distance from monument to point visible on a photo. Additional GPS stations were established and pricked on the aerial photographs near the outer boundaries of the photogrammetric block.

Spirit leveling was carried out along the riverbank of each river, connecting the new ground control points to each other. Each leveling route was started and closed at the existing first order bench marks or to already calculated elevation points.

Two kilometers wide cross-section lines were surveyed in every five kilometers at each river based on the direction of the new monuments, which were established as pairs. In river crossings, the survey of the river bottom was carried out using echo-sounding instruments.

Map was produced at the nominal scale of 1:10 000 using the latest aerial photos in a scale of 1:50 000 over the total 800 km².

2.1.3 Work Volume

The total volume of work in each project phase was as follows:

River/Item	Volume of Work	
	Plan	Accomplished
Chao Phraya River		
-Number of new GPS points	108	108
-Leveling kilometers	185	253.4
-Number of Cross-sections	54	54
-Cross-section kilometers	108	108
Khlong Bang Bal		
-Number of new GPS points	10	10
-Leveling kilometers	15	16.3
-Number of Cross-sections	5	5
-Cross-section kilometers	10	10
Khlong Bang Luang		
-Number of new GPS points	8	8
-Leveling kilometers	15	15.3
-Number of Cross-sections	4	4
-Cross-section kilometers	8	8
Khlong Bang Kaeo		
-Number of new GPS points	8	8
-Leveling kilometers	15	23.1
-Number of Cross-sections	4	4
-Cross-section kilometers	8	8
Khlong Bang Pla Mo		
-Number of new GPS points	6	6
-Leveling kilometers	10	12.3
-Number of Cross-sections	3	3
-Cross-section kilometers	6	6
TOTAL FOR ALL RIVERS		
-Number of new GPS points	140	164
-Leveling kilometers	240	375.8
-Number of Cross-sections	70	82
-Cross-section kilometers	140	140
Mapping (scale: 1:10 000)		
-Size of area (km^2)	800	800

2.1.4 Work Period

The period of survey work and mapping was as below:

- Commencement: August 1998
- Field work completion: 06 November 1998
- Production of mapping completion: 30 November 1998

2.2 Survey Supervision and Contractor's Key Personnel

2.2.1 Survey Supervision

Mr. Masahi Suzuki supervised the survey work and mapping on behalf of the JICA Study Team.

2.2.2 Contractor's Key Personnel

- Project Supervisor: Col. Vilas Pantana
- Project Manager: Mr. Janne Filpus
- Field Manager: Mr. Attapol Sonyai
- Producer of Mapping: Mr. Matti Lindfors
- Producer of Mapping: Miss Sukanya Sritanawiboonchai
- Producer of Mapping: Mr. Kamol Jangruangtong

2.3 Details of Survey Work and Mapping

2.3.1 Technical Method of Survey Work

(1) Monumentation

Monuments were installed along each river according to planned cross-section lines on mosaics at the scale of 1:50000. Monuments were located so that visibility between two monuments is clear making it possible to observe by theodolite from one monument to another.

Monuments were numbered according to the following method:

- Name of River:

  S = Chao Phraya River (Nontha Buri – Ayutthaya)

  P = Chao Phraya River (Ayutthaya – In Buri)

  SBB = Khlong Bang Bal

  SBL = Khlong Bang Luang

  SBK = Khlong Bang Kaeo

  BPM = Khlong Bang Pla Mo

- Number of cross-section line (cross-section S start from number 16)
- Number of monument (1 or 2), (1 = monument nearer the river, 2 = monument further from the river). For example, **S25-1**

(2) Leveling Along the Rivers

Leveling method was ordinary spirit leveling in two directions. Micrometers were not used and accuracy of reading was 1 mm. Three readings were observed

in each observation location. Leveling lines of each river were started and closed at the existing first order bench mark. Leveling lines connected the new survey monuments of cross-section locations to each other.

Based on the Technical Specifications, allowable limitation of accuracy was 15 mm/km.

Closing errors of main leveling lines were as below:

Chao Phraya River

Line N:o (BM-BM)	Length (km)	Error	Allowable error
1 (BMP227-BMS8865)	89.195	0.058	0.141
2 (BM1698-BM994)	32.081	0.056	0.084
3 (BM994-BMP999A)	55.875	0.021	0.112
4 (SBK1_1-BMP1509)	34.118	0.021	0.087
5 (BMP1509-BMP1511)	14.800	0.013	0.057
6 (BMP1511-BMP1512)	10.779	0.011	0.049
7 (BMP1514-BMP1512)	16.567	0.030	0.061

Khlong Bang Bal, Khlong Bang Pla Mo and Khlong Bang Luang

Line No. (BM-BM)	Length (km)	Error	Allowable error
1 (BM10-BM14)	44.023	0.037	0.099

Khlong Bang Kaeo

Line No. (BM-BM)	Length (km)	Error	Allowable error
1 (RID-L5_2)	23.105	0.039	0.072

(3) GPS Survey

Coordinates of all new monuments and points for photogrammetry triangulation were surveyed by GPS instruments. Each GPS network was closed at lower and upper river to existing GPS points. One monument point of the pair was tried to be located so that the place can be identified on aerial photographs. Monument points were pricked on the aerial photographs and identified by measuring the angle and distance from monument to point visible on a photo. Additional GPS stations were established and pricked on aerial photographs near the outer boundaries of the photogrammetric block. GPS points along the Chao Phraya River were calculated in two networks.

Misclosures of loops of the GPS networks were as below:

Chao Phraya River:

	Length (km)	DX (m)	DY (m)	DZ (m)
NET1:	209.714	-0.103	-0.807	+0.034
NET2:	217.502	+0.079	-0.159	+0.036

Khlong Bang Bal, Luang and Pla Mo:

Length(km)	DX (m)	DY(m)	DZ(m)
68.892	+0.002	+0.032	-0.074

Khlong Bang Kaeo:

Length(km)	DX (m)	DY(m)	DZ(m)
33.709	+0.048	-0.167	+0.298

(4) Cross-Section Survey

Cross-section survey was carried out using total station. Cross-section measurement started always from monument using another monument as a direction point. Angle, distance and height difference were measured to every point. Traverse calculations and intersection calculations were done within the measurements.

Elevations and distances were surveyed including:

- Both river banks
- Sides of the roads and top of the roads
- Highest points of dikes (if existing along cross section)
- Remarkable changes of elevation of the ground
- Edges of town or village (if existing along cross section)

Cross-section survey teams installed wooden poles on both riverbanks along the cross-section line and leveled the elevations of these poles. Echo-sounding teams used the poles as reference points for echo sounding, determining the current elevation of water level and for surveying the position of shorelines along the cross-section line. After echo sounding the water depth from the sounding chart was reduced to the elevation system of Mean Sea Level (RTSD datum).

2.3.2 Method of Mapping

Mapping was carried out at nominal scale of 1:10,000 using the latest aerial photos in a scale 1:50,000 over the total 800 km². Mapping area included the Chao Phraya, Pasak, Noi and Lop buri rivers and Khlong Bang Bal, Khlong Bang Pla Mo, Khlong Bang Luang and Khlong Bang Kaeo. Those GPS stations established for cross-sectioning,

that could be identified on aerial photographs, were used as XYZ ground control points in photogrammetric mapping. Remaining cross-sectioning points were used as Z control points only. Additional GPS stations were established and pricked on aerial photographs near the outer boundaries of the photogrammetric block to ensure the required accuracy.

Original maps were completed, by preparing marginal information including photographic map scale, sheet number, adjoining sheet map and north direction.

2.3.3 Existing GPS Points and Bench Marks

Transformation parameters from WGS84 to Indian Datum 1975 are:

≅X = 206
≅Y = 837
≅Z = 295

Existing GPS points used at survey of Chao Phraya River:

No.	WGS 84	Indian 1975	UTM
3550/2	14°23'01.67004	14°22'55.8500	1590415.927
	100°31'43.31307	100°31'55.1800	665158.996
	-	6.548	6.548
3544	13°46'35.46608	13°46'29.4794	1523103.364
	100°19'40.19070	100°19'51.9347	643876.518
	-26.174	-10.025	-
3006	14°55'31.06080	14°55'25.41233	1650153.402
	100°16'33.36440	100°16'45.14447	637564.075
	-15.337	-3.083	13.212

Existing Bench marks used at leveling of Chao Phraya River:

No.	Elevation
BMS 277	1.665
BM 1698	2.593
BM 994	4.493
BMP 999A	6.377
BMP 1509	11.810
BMP 1511	10.857
BMP 1512	12.821
BMP 1514	13.709
BMS 8865	3.244 (Calculation data)

Existing GPS points used at survey of Khlong Bang Bal, Khlong Bang Luang and Khlong Bang Pla Mo :

No.	WGS 84	UTM
P2-2	14°25'09.25664	1594314.363
	100°29'49.12021	661712.733
	-	7.039
P3-1	14°26'01.43705	1595896.902
	100°28'00.23665	658441.326
	-	5.025
P3-2	14°26'02.13426	1595917.690
	100°27'56.92439	658341.164
	-	7.861

Existing Bench marks used at levelling of Khlong Bang Bal, Khlong Bang Luang and Khlong Bang Pla Mo:

No.	Elevation
BM 10	6.913 (Calculation data)
BM 14	7.359 (Calculation data)

Existing GPS points used at survey of Khlong Bang Kaeo:

No.	WGS 84	UTM
C7A-1	14°35'24.60201	1613194.675
	100°27'14.19768	656952.450
	-	7.953
L5-2	14°29'54.66100	1603125.444
	100°33'10.85147	667695.543
	-	6.388

Existing Bench marks used at levelling of Khlong Bang Kaeo:

No.	Elevation
RID-W.S	8.196 (Calculation data)
L5-2	6.388

2.3.4 Final Coordinates and Elevations of Established Monuments

CHAO PHRAYA:

No.	Northing	Easting	Elevation
S16_1	1529014.694	662680.853	2.474
S16_2	1529113.693	662640.019	2.475
S17_1	1531578.299	660637.734	2.214
S17_2	1531684.554	660704.940	2.579
S18_1	1535254.728	661112.367	2.325
S18_2	1535152.767	661234.377	2.071
S19_1	1537141.797	659350.884	2.227
S19_2	1536845.227	659144.077	2.131
PK1_1	1537380.165	661505.436	1.858
PK1_2	1537370.500	661647.021	2.600
S20_1	1538902.071	662247.266	1.804
S20_2	1538834.656	662341.617	2.495
S21_1	1541463.862	663626.663	2.280
S21_2	1541383.899	663679.995	2.512
S22_1	1543407.592	666727.928	1.753
S22_2	1543410.644	666887.903	2.238
S23_1	1546728.981	665761.925	2.461
S23_2	1546518.831	666065.894	2.704
S24_1	1550460.305	666553.795	2.547
S24_2	1550465.404	666786.158	3.011
S25_1	1553580.839	668386.692	2.393
S25_2	1553675.511	668608.883	2.042
S26_1	1556589.967	665041.434	1.257
S26_2	1556685.131	665080.840	1.957
S27_1	1560115.491	667865.749	2.254
S27_2	1560112.668	668020.643	3.359
S28_1	1562310.808	664849.669	2.471
S28_2	1562378.083	665016.591	2.724
S29_1	1564718.314	664018.240	2.935
S29_2	1564945.852	664554.903	3.786
S30_1	1568362.946	662824.785	3.987
S30_2	1568358.938	663121.032	3.828
S31_1	1569201.231	665851.561	3.966
S31_2	1569100.789	666105.834	3.889
S32_1	1570421.097	669271.477	2.007
S32_2	1570259.153	669588.526	5.360
S33_1	1575443.773	671217.443	3.682
S33_2	1575685.573	671166.780	4.135
S34_1	1581562.688	669504.031	4.499
S34_2	1581742.366	669677.333	4.559
S35_1	1584288.781	670276.893	3.369
S35_2	1584259.812	670358.805	4.058
S36_1	1586480.788	669570.209	4.133
S36_2	1586417.058	669430.730	5.076
S37_1	1586383.670	666935.112	5.686

S37_2	1586519.152	666992.330	5.919
S38_1	1590320.381	664397.970	4.685
S38_2	1590394.799	664571.785	5.874
P1_1	1591108.082	664025.510	4.962
P1_2	1591070.504	664105.970	6.406
P2_1	1594215.708	661639.105	4.064
P2_2	1594314.363	661712.733	7.039
P3_1	1595896.902	658441.326	5.095
P3_2	1595917.690	658341.164	7.861
P4_1	1598079.339	657490.579	8.134
P4_2	1598050.475	657300.997	7.401
P5_1	1600882.922	656866.820	7.185
P5_2	1600743.862	656554.658	7.344
P6_1	1605233.233	657879.603	6.324
P6_2	1605449.953	657532.048	8.269
P7_1	1608830.853	656127.836	6.302
P7_2	1608871.203	655809.061	8.298
C7A_1	1613194.675	656952.450	7.953
C7A_2	1613040.152	657018.998	6.788
P8_1	1614386.698	657829.392	9.426
P8_2	1614284.334	657774.451	7.487
P9_1	1616680.434	656877.778	9.266
P9_2	1616652.496	656685.213	9.292
P10_1	1618817.585	657546.848	9.921
P10_2	1618833.213	657357.197	8.911
P11_1	1621779.084	657715.269	9.771
P11_2	1621740.971	657574.889	9.096
P12_1	1624127.489	656455.768	9.864
P12_2	1624003.776	656481.338	9.771
P13_1	1627219.807	655118.930	8.585
P13_2	1627039.585	654817.308	9.344
P14_1	1629331.529	655158.691	10.337
P14_2	1629420.161	654898.937	10.571
P15_1	1632029.077	655548.129	9.677
P15_2	1632202.858	655245.028	11.047
P16_1	1634323.021	654880.379	11.099
P16_2	1634379.385	654693.124	10.680
P17_1	1635230.672	656551.635	10.165
P17_2	1635157.864	656654.097	9.624
P18_1	1638021.747	655547.323	11.693
P18_2	1637990.717	655765.978	11.667
P19_1	1640961.370	655747.467	10.214
P19_2	1640852.018	655734.328	10.411
P20_1	1642113.452	653181.056	11.819
P20_2	1642249.197	653262.690	11.376
P21_1	1644158.309	651492.018	11.650
P21_2	1644627.251	651498.107	11.774
P22_1	1647342.241	651252.293	11.788
P22_2	1647287.640	651445.531	11.069
P23_1	1648189.761	649524.300	11.127

P23_2	1648197.292	649705.476	12.046
P24_1	1649790.402	648102.890	13.764
P24_2	1649862.213	648295.579	13.358
P25_1	1653678.983	647059.189	11.342
P25_2	1653591.966	647138.432	11.453
P26_1	1654965.938	645498.581	12.109
P26_2	1654959.968	645625.824	12.763
P27_1	1657267.673	644261.015	11.953
P27_2	1657367.217	644511.440	12.908
P28_1	1659285.335	643409.432	12.092
P28_2	1659335.844	643458.259	12.455
P29_1	1661170.606	643572.776	12.505
P29_2	1661345.766	643804.594	14.810

KHLONG BANG BAL:

No.	Northing	Easting	Elevation
SBB1_1	1584397.545	658375.957	4.319
SBB1_2	1584303.589	658436.760	4.492
SBB2_1	1587152.996	659584.894	4.226
SBB2_2	1587036.034	659615.787	4.609
SBB3_1	1590489.386	660418.981	4.489
SBB3_2	1590427.983	660305.640	5.160
SBB4_1	1593305.887	659273.759	5.046
SBB4_2	1593202.383	659230.797	4.985
SBB5_1	1594944.547	660319.839	6.119
SBB5_2	1594851.474	660313.939	6.473

KHLONG BANG PLA MO:

No.	Northing	Easting	Elevation
BPM1_1	1587680.657	653197.620	3.577
BPM1_2	1587561.421	653261.664	5.756
BPM2_1	1586499.990	654858.593	3.209
BPM2_2	1586489.315	654958.400	4.813
BPM3_1	1584514.456	654702.157	3.180
BPM3_2	1584558.877	654848.109	5.963

KHLONG BANG LUANG:

No.	Northing	Easting	Elevation
SBL1_1	1590417.554	655009.946	4.125
SBL1_2	1590313.092	655163.040	5.526
SBL2_1	1592903.582	655059.582	6.035
SBL2_2	1592739.066	655092.855	6.008
SBL3_1	1596662.094	656036.196	5.978
SBL3_2	1596639.190	656178.905	6.773
SBL4_1	1597245.612	657510.206	5.803
SBL4_2	1597116.363	657496.278	5.929

KHLONG BANG KAEO:

No.	Northing	Easting	Elevation
SBK1_1	1613250.755	658001.985	7.578
SBK1_2	1613112.113	657978.953	7.879
SBK2_1	1613045.450	661700.094	6.892
SBK2_2	1613101.207	661548.020	6.955
SBK3_1	1609373.310	662262.433	6.371
SBK3_2	1609335.951	662458.924	7.441
SBK4_1	1607089.570	664823.299	6.598
SBK4_2	1607108.927	664922.386	7.197

LIST OF PHOTO IDENTIFYING POINTS

No.	Northing	Easting	Elevation
9801	1526700.064	667917.314	2.193
9802	1524398.805	659208.109	2.616
9803	1539636.677	667185.528	1.593
9804	1556329.535	669628.067	1.990
9805	1564731.713	668582.772	3.910
9806	1571803.723	658832.893	3.445
9807	1571723.167	673733.457	2.603
9808	1579316.399	659074.453	2.451
9809	1587791.912	674227.678	6.921
9810	1582155.646	650189.841	6.098
9811	1587935.020	652570.804	5.462
9812	1597073.217	646932.441	4.709
9813	1596282.122	668691.396	6.327
9814	1603383.145	650606.986	4.614
9815	1604264.199	687623.456	8.400
9816	1611211.754	692632.812	11.661
9817	1613277.098	678354.183	7.288
9818	1612316.934	669609.337	4.913
9819	1627211.902	673921.527	9.187
9820	1635432.528	652123.838	10.518
9821	1641307.074	675282.275	12.183
9822	1642461.447	664694.541	8.496

2.4 Final Results

2.4.1 River Cross Sections

- Observation data and calculation sheets — 1 set
- List of results — 1 set
- Originals of cross section drawings (SizeA1,V=1:200,H=1:5 000) — 1 set

•	Duplicates of original cross sections	1 set
•	Blue copies of cross sections	2 sets
•	Location map of cross sections at scale of 1:50 000	2 sets
•	Route maps of levelling at scale of 1:50 000	2 sets
•	Floppy disk of cross section input data	1 set

2.4.2 River Profile

•	Originals of profiles (Size A1, V=1:200, H=1:250 000)	1 set
•	Duplicates of original profiles	1 set
•	Blue copies of profiles	2 sets
•	Floppy disk of profile input data	1 set

2.4.3 Topographic Mapping

•	Station descriptions of permanent ground markers constructed for mapping and existing permanent survey stations used in the mapping	1 set
•	Station descriptions and list of heights of existing permanent bench marks used in the mapping	1 set
•	Preliminary maps / Scale 1:10 000	1 set
•	Diagram of sheet layout and sheet numbering system	1 set
•	Original topographic maps / Scale 1 : 10,000	1 set
•	Duplicate of original topographic maps	1 set
•	Blue copy of topographic maps	1 set
•	Floppy disk or CD-ROM of digital data in DXF format	1 sets

2.4.4 Report

•	Report	3 sets

Tables

Table.1.3.1 (1/10) COORDINATE AND ELEVATION OF MONUMENTS

Lopburi river

N:o	Northing	Easting	Elevation
L1-1	1584885.198	670536.361	4.357
L1-2	1584756.645	670583.452	4.151
L2-1	1590189.246	668604.654	4.420
L2-2	1590145.670	668486.653	4.900
L3-1	1594858.477	667296.211	6.028
L3-2	1594846.806	667204.753	5.030
L4-1	1599064.895	667032.361	5.774
L4-2	1599133.928	667696.958	5.980
L5-1	1602910.639	667452.914	4.902
L5-2	1603125.444	667695.543	6.388
L6-1	1607163.565	665220.231	6.588
L6-2	1607258.991	665294.968	5.922
L7-1	1610873.942	666555.945	5.187
L7-2	1610885.229	666714.231	4.807
L8-1	1613886.781	667022.825	6.234
L8-2	1613825.457	667431.715	3.976
L9-1	1617397.232	668198.828	6.279
L9-2	1617423.857	668260.632	4.011
L10-1	1619404.734	670398.403	6.964
L10-2	1619419.227	670531.907	5.460
L11-1	1622219.471	672819.520	8.549
L11-2	1622211.529	673036.437	6.247
L12-1	1625598.288	672150.806	7.506
L12-2	1625666.804	672270.782	6.654
L13-1	1629106.488	672717.911	8.416
L13-2	1629025.212	672852.068	7.470
L14-1	1633714.212	672759.295	8.220
L14-2	1633774.889	672887.742	6.106
L15-1	1635845.970	673478.686	10.103
L15-2	1635797.216	673667.528	9.700
L16-1	1637611.730	671676.882	9.227
L16-2	1637708.712	671680.815	9.007
L17-1	1637664.241	666072.160	10.359
L17-2	1637853.537	666059.641	9.967

Table.1.3.1 (2/10) COORDINATE AND ELEVATION OF MONUMENTS

N:o	Northing	Easting	Elevation
L18-1	1638670.055	662038.327	8.908
L18-2	1639025.368	661926.111	7.670
L19-1	1640644.493	658812.142	9.159
L19-2	1640740.668	658934.090	7.643
L20-1	1643939.341	656000.624	10.547
L20-2	1643994.947	656114.051	9.785
L21-1	1643311.990	652967.046	12.010
L21-2	1643581.818	653229.546	12.176
L22-1	1645466.181	652541.245	11.302
L22-2	1645615.938	652551.143	11.974

Table.1.3.1 (3/10) COORDINATE AND ELEVATION OF MONUMENTS

Chao Phraya and Ping river

N:o	Northing	Easting	Elevation
C1-1	1676659.548	625863.2291	5.492
C1-2	1676776.083	625804.5791	5.112
C2-1	1678750.767	621968.6591	5.111
C2-2	1678637.132	621960.9161	5.210
C3-1	1682604.825	620012.3581	5.615
C3-2	1682709.547	619959.2701	5.805
C4-1	1685377.301	616439.1381	7.059
C4-2	1685562.020	616513.8221	8.010
C5-1	1687680.892	614182.0661	8.381
C5-2	1687536.317	614259.7681	8.503
C6-1	1691278.306	617386.0751	8.712
C6-2	1691228.391	617235.8721	7.690
C7-1	1695073.617	619601.6541	7.666
C7-2	1694936.636	619565.6582	0.961
C8-1	1699003.882	615882.1891	7.633
C8-2	1699090.604	615951.7541	7.575
C9-1	1700280.756	619772.6912	0.711
C9-2	1700122.295	619648.8462	1.625
C10-1	1704040.553	617636.3392	2.127
C10-2	1704114.684	617742.3842	2.339
C11-1	1705169.460	623314.6553	0.082
C11-2	1705276.100	623248.8942	9.794
C12-1	1709211.522	620980.0091	9.867
C12-2	1709303.536	621038.0272	0.277
C13-1	1711144.969	619658.5392	1.243
C13-2	1711347.392	619729.1692	1.281
C14-1	1714946.071	619307.2021	9.601
C14-2	1714946.048	619462.8391	9.582
C15-1	1717915.607	619489.7502	1.419
C15-2	1717826.936	619390.1972	1.707
C16-1	1719656.573	617066.7402	1.693
C16-2	1719758.938	617036.5322	1.682
C17-1	1723531.885	618792.8022	3.108
C17-2	1723490.711	618915.5562	2.575

Table.1.3.1 (4/10) COORDINATE AND ELEVATION OF MONUMENTS

N:o	Northing	Easting	Elevation
C18-1	1727184.460	617624.0192	0.191
C18-2	1727078.034	617626.1822	0.521
C19-1	1731372.546	619451.9922	3.419
C19-2	1731518.545	619479.9612	3.471
C20-1	1733266.071	619405.9062	5.012
C20-2	1733104.705	619429.6162	5.379
C21-1	1733794.374	621306.5082	5.780
C21-2	1733904.145	621346.7082	5.620
C22-1	1735384.440	623169.2082	5.482
C22-2	1735308.297	623036.7852	5.710
P1-1	1736320.970	622858.2712	0.474
P1-2	1736384.382	622907.480	-

Table.1.3.1 (5/10) COORDINATE AND ELEVATION OF MONUMENTS

Noi river

N:o	Northing	Easting	Elevation
N1-1	1570075.529	662358.568	2.528
N1-2	1569960.314	662216.763	1.841
N2-1	1573911.259	659687.706	1.287
N2-2	1573893.480	659532.775	1.984
N3-1	1578936.436	660393.635	1.914
N3-2	1579056.625	660056.648	2.387
N4-1	1580506.260	657500.842	2.350
N4-2	1580357.178	657429.220	1.892
N5-1	1583579.920	655714.817	1.811
N5-2	1583417.976	655743.201	1.585
N6-1	1583479.997	650850.637	2.257
N6-2	1583326.749	650655.833	2.676
N7-1	1587298.162	652179.191	3.159
N7-2	1587264.882	651942.914	2.641
N8-1	1591177.716	650993.070	3.020
N8-2	1591152.692	650477.333	2.514
N9-1	1594464.778	649269.791	3.041
N9-2	1594327.159	649080.393	4.089
N10-1	1598111.707	647830.848	4.719
N10-2	1598128.434	647616.455	2.973
N11-1	1602410.237	647375.662	3.507
N11-2	1602433.075	647252.258	3.495
N12-1	1606979.054	647008.371	4.067
N12-2	1607048.130	646818.805	3.742
N13-1	1610158.561	646643.152	6.551
N13-2	1610111.227	646532.073	5.934
N14-1	1615882.634	645875.656	5.703
N14-2	1615878.674	645769.237	5.773
N15-1	1617777.423	648706.732	7.192
N15-2	1617802.992	648558.274	5.597
N16-1	1620864.516	650801.154	5.506
N16-2	1621053.618	650736.591	5.347
N17-1	1623232.911	652417.184	5.835
N17-2	1623305.056	652309.508	5.577

Table.1.3.1 (6/10) COORDINATE AND ELEVATION OF MONUMENTS

N:o	Northing	Easting	Elevation
N18-1	1625639.574	652057.472	6.715
N18-2	1625472.225	651912.109	6.600
N19-1	1630291.964	652223.575	7.731
N19-2	1630441.920	652075.692	8.419
N20-1	1632901.976	649171.679	8.109
N20-2	1632937.870	649053.343	7.450
N21-1	1635530.014	649675.084	9.271
N21-2	1635317.879	649672.519	8.638
N22-1	1639217.988	646154.728	9.852
N22-2	1639163.589	645854.937	8.607
N23-1	1642895.128	646458.422	9.522
N23-2	1642670.572	646344.799	9.335
N24-1	1644860.714	642157.060	10.245
N24-2	1644770.086	642032.386	10.098
N25-1	1647974.685	639243.380	12.034
N25-2	1647942.299	639143.755	10.776
N26-1	1651143.170	636321.522	11.346
N26-2	1651087.524	636188.814	11.816
N27-1	1654434.338	634629.818	12.337
N27-2	1654427.245	634484.521	12.487
N28-1	1656249.542	633040.637	13.617
N28-2	1656171.212	632955.024	12.340
N29-1	1658277.206	630215.283	13.896
N29-2	1658167.693	630096.310	12.522
N30-1	1662251.915	628870.626	14.513
N30-2	1662112.209	628779.670	13.334
N31-1	1663370.552	625072.584	15.680
N31-2	1663276.978	624971.799	14.221
N32-1	1667497.378	622627.436	14.266
N32-2	1667468.159	622523.939	14.942
N33-1	1672319.162	623008.720	15.981
N33-2	1672335.574	622879.924	15.326
N34-1	1675626.187	623133.609	17.464
N34-2	1675754.106	622976.796	15.252

Table.1.3.1 (7/10) COORDINATE AND ELEVATION OF MONUMENTS

Nan river

N:o	Northing	Easting	Elevation
NA1-1	1736638.519	624797.854	26.362
NA1-2	1736505.879	624980.410	27.106
NA2-1	1739945.264	632109.971	26.782
NA2-2	1739910.436	632257.518	23.542
NA3-1	1746730.242	635284.895	26.966
NA3-2	1746668.317	635763.862	26.002
NA4-1	1753560.136	634978.437	26.124
NA4-2	1753669.031	635118.087	25.110
NA5-1	1754601.106	636533.691	27.706
NA5-2	1754569.456	636701.984	26.918
NA6-1	1758363.285	640725.666	28.900
NA6-2	1758276.211	640881.783	27.523
NA7-1	1763652.373	640230.624	29.155
NA7-2	1762930.352	640178.471	28.553
NA8-1	1767858.466	644338.973	28.902
NA8-2	1767756.029	644465.010	29.263
NA9-1	1776076.548	648149.149	29.183
NA9-2	1776217.806	647933.761	31.107
NA10-1	1783305.503	649702.252	29.793
NA10-2	1783398.864	649306.495	29.865
NA11-1	1790929.555	650096.743	30.816
NA11-2	1790978.842	649832.810	30.247
NA12-1	1799852.366	650906.528	32.981
NA12-2	1799861.859	650748.943	34.419
NA13-1	1807141.416	649045.973	34.329
NA13-2	1806849.765	648628.908	34.051
NA14-1	1811814.896	647578.042	35.109
NA14-2	1811919.459	647432.692	33.846
NA15-1	1818851.133	644088.058	36.598
NA15-2	1819259.742	644593.911	36.315
NA16-1	1826247.467	641664.828	37.148
NA16-2	1826162.117	641469.485	38.183
NA17-1	1826817.360	635339.665	39.188
NA17-2	1826524.809	635234.832	40.992

Table.1.3.1 (8/10) COORDINATE AND ELEVATION OF MONUMENTS

N:o	Northing	Easting	Elevation
NA18-1	1833327.383	632179.761	39.839
NA18-2	1833397.457	631849.729	42.085
NA19-1	1838171.576	633484.055	42.605
NA19-2	1837941.592	633304.758	40.075
NA20-1	1843367.051	633208.054	43.353
NA20-2	1843488.124	633070.898	42.728
NA21-1	1845329.058	635274.394	41.490
NA21-2	1845347.394	634971.399	43.779
NA22-1	1851515.323	629938.877	41.783
NA22-2	1851425.832	629568.639	44.135
NA23-1	1857068.540	631371.166	44.177
NA23-2	1856752.464	631421.616	44.170
NA24-1	1859414.091	634500.025	45.818
NA24-2	1859430.831	634151.479	46.505
NA25-1	1862262.305	634893.233	46.275
NA25-2	1862260.850	635139.026	45.650
NA26-1	1868280.406	631828.520	45.334
NA26-2	1868351.438	632122.081	45.088
NA27-1	1873891.317	628821.655	45.647
NA27-2	1873980.155	629046.278	46.909
NA28-1	1880464.304	626398.958	47.932
NA28-2	1880563.563	626508.325	49.245
NA29-1	1884704.185	626063.287	51.724
NA29-2	1884703.409	625980.667	52.677

Table.1.3.1 (9/10) COORDINATE AND ELEVATION OF MONUMENTS

Yom river

N:o	Northing	Easting	Elevation
Y1-1	1754451.848	635572.985	26.580
Y1-2	1754367.167	635578.175	26.944
Y2-1	1757912.035	634168.902	27.893
Y2-2	1757883.485	633815.727	26.619
Y3-1	1760541.615	635715.137	28.757
Y3-2	1760546.211	635517.070	27.878
Y4-1	1765002.998	635190.576	28.461
Y4-2	1764931.847	635336.886	29.588
Y5-1	1769238.285	636605.910	29.544
Y5-2	1769237.767	636696.970	30.546
Y6-1	1776468.527	635269.837	29.782
Y6-2	1776409.736	635103.109	28.776
Y7-1	1783742.473	634941.146	29.990
Y7-2	1783744.326	634743.046	30.307
Y8-1	1789491.426	632448.976	32.507
Y8-2	1789519.503	632288.433	30.603
Y9-1	1796364.405	633625.297	32.036
Y9-2	1796312.816	633422.737	32.525
Y10-1	1802610.905	635737.338	33.755
Y10-2	1802723.940	635584.111	32.810
Y11-1	1808881.907	634989.896	33.807
Y11-2	1808637.898	634444.906	36.354
Y12-1	1814516.700	630175.474	34.523
Y12-2	1814515.437	629943.533	34.258
Y13-1	1820216.879	631984.461	36.499
Y13-2	1820196.166	631846.898	36.815
Y14-1	1827102.444	629966.088	36.952
Y14-2	1827078.551	630136.558	39.983
Y15-1	1835123.660	630866.942	37.363
Y15-2	1835107.510	630719.943	37.354
Y16-1	1841562.435	627175.270	39.506
Y16-2	1841445.538	627059.189	38.582
Y17-1	1846300.605	625263.475	41.493
Y17-2	1846073.715	624726.460	41.925

Table.1.3.1 (10/10) COORDINATE AND ELEVATION OF MONUMENTS

N:o	Northing	Easting	Elevation
Y18-1	1848557.299	623943.072	40.934
Y18-2	1849426.458	623673.605	41.810
Y19-1	1855507.610	616546.029	40.848
Y19-2	1855538.898	616698.870	40.460
Y20-1	1859666.986	614120.863	41.310
Y20-2	1859764.111	614258.968	41.099
Y21-1	1864952.306	611336.429	40.962
Y21-2	1865054.861	611448.772	40.942
Y22-1	1869223.080	606478.783	42.641
Y22-2	1869468.668	606527.937	42.455
Y23-1	1871209.429	601648.181	43.445
Y23-2	1871020.992	602121.272	43.471
Y24-1	1871466.787	596908.018	44.567
Y24-2	1871320.229	596963.671	44.977
Y25-1	1870240.631	591634.557	46.450
Y25-2	1870526.510	591547.835	44.636
Y26-1	1873588.815	588103.705	48.511
Y26-2	1873480.680	588524.798	47.085
Y27-1	1879618.608	588253.378	48.512
Y27-2	1879428.096	588163.009	47.735
Y28-1	1889789.770	588215.771	50.977
Y28-2	1889915.278	588461.058	51.417

Table.1.4.1 RESULTS OF FIRST ORDER LEVELING

Water Level Station, (Administrator)	Used BM. Height	Locton of Water Level Station	1. Result of Leveling	2. Using Height (Year)	Difference (1 - 2)
2. Port Phrachul (Port Authority)	BKK.526 1.9597 m	STA.2:Top of the hole at Fort Phrachul	3.0096	+ 3.60 (1991~1997)	-0.5904
3. Pak Nam (Port Authority)	BM.31 2.4817 m	STA.3:Top of the hole at Paknam Station	1.7770	+ 2.08 (1993~1997)	-0.3030
4. Phra Pra Deang (Port Authority)	BKK.526 1.9597 m	STA.4:Top of the hole at Phrapradeng Station	2.8876	+ 3.40 (1996~1997)	-0.5133
5. Bangkok Port (Port Authority)	CI.13-1 1.4172 m	STA.5:Top of the hole at Port Authority Station	1.9112	+ 2.38 (1996~1997)	-0.4208
6. Sathu Pradit (Port Authority)	BM.3008 2.1993 m	BM.PA:BM. Near Sathupradit Station	2.1751	...	...
		STA.6:Top of the hole at Sathupradit Station	2.2011	2.50 (1996~1997)	-0.2959
7. Memorial Bridge (Roylal Irrigation Department : RID)	BKK.103 2.2455 m	BM.3:In front of Flag Pole	1.9386	...	...
		BM.2:.Near Sta.4 C4	2.1513	2.13578 (1992~1997)	0.015552
		STA.7:Top of Scale Sta.C4 (Memorial Bridge)	2.1274	...	...
8. HD (NAVY) (Hydrographic Dept.)	BKK.613 3.1184 m	BMP:In front of HD.,Navy	1.8147	1.8154 (1991~1997)	-0.0007
		BM.4: Near Port of HD.	2.3672	2.3629 (1992~1997)	0.0013
9. RID OFFICE (RID Office)	NB.32 1.9283 m	RID Office	1.9156	1.97667 (1992~1997)	-0.06107
		STA.9:Top of Scale STA.C12 (RID Office)	2.9102	...	...
11. BM STA.11 (RID Pak Kret)	BM.17 1.9009 m	BM.STA.11 Near Sta.C22	2.9006	2.918 (1997)	-0.0174

Table.1.5.1 LIST OF THE PURCHASED PHOTOS

Contact prints

Map sheet	Run No.	Roll No.	Amount	Photo No.
ND 47-3	2	PCD 5/38	6	161 ~ 163, 175 ~ 177
ND 47-4	3	PCD 6/38	6	150 ~ 148, 223 ~ 221
	4	PCD 6/38	6	186 ~ 184, 169 ~ 171
	5	PCD 6/38	6	104 ~ 106, 121 ~ 119
	6	PCD 6/38	6	86 ~ 84, 69 ~ 71
	7	PCD 6/38	6	12 ~ 14, 28 ~ 26
	8	PCD 5/38	6	241 ~ 239, 223 ~ 225
	9	PCD 5/38	16	124 ~ 122, 98 ~ 110
	10	PCD 4/38	17	163 ~ 165, 191 ~ 178
	11	PCD 7/38	7	15 ~ 21
	11	PCD 4/38	3	146 ~ 144,
ND 47-7	12	PCD 4/38	9	80 ~ 82, 107 ~ 102
ND 47-8	13	PCD 4/38	6	51 ~ 56,
	13	PCD10/38	3	152 ~ 154,
	14	PCD 3/38	3	263 ~ 265,
	14	PCD 4/38	6	27 ~ 22,
	15	PCD 3/38	9	186 ~ 184, 159 ~ 164
	16	PCD 3/38	9	107 ~ 110, 133 ~ 129
	17	PCD 3/38	6	13 ~ 18
ND 47-3	33	PCD 13/39	6	187 ~ 192
NE 47-15	34	PCD 15/39	6	255 ~ 250
NE 47-11	35	PCD 13/39	6	228 ~ 223
	36	PCD 14/39	6	168 ~ 173
	37	PCD 22/39	6	89 ~ 94
	38	PCD 13/39	6	263 ~ 268
	39	PCD 14/39	6	96 ~ 101
	40	PCD 14/39	6	43 ~ 48
	41	PCD 14/39	6	210 ~ 215
	42	PCD 14/39	6	184 ~ 189
ND 47-4	43	PCD 18/39	29	49 ~ 77
ND 47-16	44	PCD 17/39	28	233 ~ 260
ND 47-12	45	PCD 17/39	30	203 ~ 232
		Total	283	
		Grand Total	283	

Table.1.5.2 LIST OF THE DISAPOSITIVES USED FOR MOSAIC

Diapositives

Map sheet	Run	Roll No.	Amount	Photo No.
ND 47-3	Ex. 1	RTSD12/40(3)	7	216, 218, 220, 222, 224, 226, 228,
ND 47-4	2	PCD 5/38(1)	7	162, 164, 166, 168, 170, 172, 174,
	3	PCD 6/38(1)	7	224, 226, 228, 230, 232, 234, 236,
	4	PCD 6/38(1)	7	172, 174, 176, 178, 180, 182, 184,
	5	PCD 6/38(1)	7	106, 108, 110, 112, 114, 116, 118,
	6	PCD 6/38(1)	7	73, 75, 77, 79, 81, 83, 85,
	7	PCD 6/38(1)	7	14, 16, 18, 20, 22, 24, 26,
	8	PCD 5/38(1)	7	227, 229, 231, 233, 235, 237, 239,
	9	PCD 5/38(1)	7	110, 112, 114, 116, 118, 120, 122,
	10	PCD 4/38(4)	11	165, 167, 169, 171, 173, 175, 177, 179, 181, 183, 185,
	11	PCD 4/38(1)	10	126, 128, 130, 132, 134, 136, 138, 140, 142, 144,
ND 47-7	12	PCD 4/38(1)	12	80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102,
ND 47-8	13	PCD 4/38(1)	11	56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76,
	14	PCD 3/38(1)	4	264, 266, 268, 270,
	14	PCD 4/38(1)	9	6, 8, 10, 12, 14, 16, 18, 20, 22,
	15	PCD 3/38(1)	6	175, 177, 179, 181, 183, 185,
	15	PCD 7/38(1)	5	62, 64, 66, 68, 70,
	15	PCD 3/38(1)	3	165, 167, 169,
	16	PCD 3/38(1)	7	107, 109, 111, 113, 115, 117, 119,
	16	PCD 7/38(1)	4	51, 53, 55, 57,
	16	PCD 3/38(1)	3	124, 126, 128,
	17	PCD 3/38(1)	11	19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39,
	18	PCD 2/38(1)	13	226, 228, 230, 232, 234, 236, 238, 240, 242, 244, 246, 248, 250,
	19	PCD 2/38(1)	13	152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176,
	20	PCD 2/38(1)	13	93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113, 115, 117,
	21	PCD 2/38(1)	13	15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39,
	22	PCD 1/38(1)	16	203, 205, 207, 209, 211, 213, 215, 217, 219, 221, 223, 225, 227, 229, 231, 233,
	23	PCD 1/38(1)	16	135, 137, 139, 141, 143, 145, 147, 149, 151, 153, 155, 157, 159, 161, 163, 165,
	24	PCD 1/38(1)	16	80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110,
	25	PCD 1/38(1)	15	10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38,
ND 47-11	26	PCD 4/38(1)	15	203, 205, 207, 209, 211, 213, 215, 217, 219, 221, 223, 225, 227, 229, 231,
ND 47-12	27	PCD 7/38(1)	3	94, 96, 98,
	27	PCD 5/38(1)	15	56, 58, 60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84,
	28	PCD 5/38(1)	16	4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34,
	1	PCD 53/39(1)	5	10, 12, 14, 16, 18,
	1	PCD 55/39(1)	12	82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104,
	1	PCD 55/39(1)	1	30,
	2	PCD 52/39(1)	5	174, 176, 178, 180, 182,
	2	PCD 55/39(1)	9	64, 66, 68, 70, 72, 74, 76, 78, 80,
	2	PCD 55/39(1)	3	39, 41, 43,
	3	PCD 52/39(1)	8	201, 203, 205, 207, 209, 211, 213, 215,
	3	PCD 53/39(1)	8	243, 245, 247, 249, 251, 253, 255, 257,
	4	PCD 52/39(1)	11	220, 222. 224, 226, 228, 230, 232, 234, 236, 238, 240,
	4	PCD 55/39(1)	4	142, 144, 146, 148,
		Total	389	

Diapositives

Map sheet	Run	Roll No.	Amount	Photo No.
ND 47-11	4	PCD 55/39(1)	5	48, 50, 52, 54, 56,
ND 47-12	5	PCD 52/39(1)	4	257, 259, 261, 263,
ND 47- 3	33	PCD 13/39	4	178, 180, 182, 184,
NE 47-15	34	PCD 15/39	4	258, 260, 262, 264,
NE 47-11	35	PCD 13/39	4	231, 233, 235, 237,
	36	PCD 14/39	13	159, 161, 163, 165, 167, 169, 171, 173, 175, 177, 179, 181, 183,
	37	PCD 22/39	6	107, 109, 111, 113, 115, 117,
	37	PCD 12/39	7	52, 54, 56, 58, 60, 62, 64,
	37	PCD 22/39	4	94, 96, 98, 100,
	38	PCD 20/39	12	84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106,
	38	PCD 13/29	3	270, 272, 274,
	39	PCD 14/39	12	73, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95,
	40	PCD 14/39	13	47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69, 71,
	41	PCD 14/39	14	185, 187, 189, 191, 193, 195, 197, 199, 201, 203, 205, 207, 209, 211,
	42	PCD 19/39	13	188, 190, 192, 194, 196, 198, 200, 202, 204, 206, 208, 210, 212,
ND 47- 4	43	PCD 13/39	13	49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69, 71, 73,
NE 47-16				
NE 47-12				
		Total	131	
		Grand Total	520	

Table.1.5.3 LIST OF PHOTOS FOR THE MOSAIC AND THE STUDY

Contact Prints

Map Sheet	Run No.	Roll No.	Amount	Photo No.
ND 47-3	EX1	RTSD12/40(3)	7	216, 218, 220, 222, 224, 226, 228,
ND 47-4	2	PCD5/38(1)	17	161～177
	3	PCD9/38(1)	5	146～150
	3	PCD6/38(1)	16	221～236
	4	PCD6/38(1)	18	169～186
	5	PCD6/38(1)	18	104～121
	6	PCD6/38(1)	18	69～ 86
	7	PCD6/38(1)	17	12～ 28
	8	PCD5/38(1)	19	223～241
	9	PCD5/38(1)	27	98～124
	10	PCD4/38(4)	29	163～191
	11	PCD7/38	7	15～ 21
	11	PCD4/38(1)	24	123～146
ND 47-7	12	PCD4/38(1)	28	80～107
ND 47-8	13	PCD4/38(1)	26	51～ 76
	13	PCD10/38	6	152～157
	14	PCD3/38(1)	8	263～270
	14	PCD4/38(1)	23	5～ 27
	15	PCD3/38	13	174～186
	15	PCD3/38(1)	12	159～170
	15	PCD7/38(1)	9	62～ 70
	16	PCD3/38(1)	14	107～120
	16	PCD7/38(1)	8	51～ 58
	16	PCD3/38(1)	11	123～133
	17	PCD3/38(1)	27	13～ 39
	18	PCD2/38(1)	27	226～252
	19	PCD2/38(1)	28	149～176
	20	PCD2/38(1)	28	93～120
	21	PCD2/38)(1)	33	7～39
	22	PCD1/38(1)	34	203～236
	23	PCD1/38(1)	34	132～165
	24	PCD1/38(1)	34	80～113
	25	PCD1/38(1)	32	7～ 38
ND 47-11	26	PCD4/38(1)	31	201～231
ND 47-12	27	PCD7/38(1)	6	94～ 99
	27	PCD5/38(1)	31	54～ 84
	28	PCD5/38(1)	33	4～ 36
	1	PCD53/39(1)	9	10～ 18
	1	PCD55/39(1)	23	82～104
	1	PCD55/39(1)	7	26～ 32
		Total	797	

Contact Prints

Map Sheet	Run No.	Roll No.	Amount	Photo No.
ND 47-11	2	PCD55/39(1)	10	173～182
ND 47-12	2	PCD55/39(1)	10	37～ 46
	2	PCD52/39(1)	18	64～ 81
	3	PCD52/39(1)	15	201～215
	3	PCD53/39)1)	18	241～258
	4	PCD52/39(1)	21	220～240
	4	PCD55/39(1)	9	141～149
	4	PCD55/39(1)	12	47～ 58
	5	PCD52/39(1)	6	258～263
NE 47-11	33	PCD13/39	16	177～192
NE 47-15	34	PCD15/39	16	250～265
ND 47- 3	35	PCD13/39	3	208～210
	35	PCD13/39	16	223～238
	36	PCD14/39	26	158～183
	37	PCD22/39	12	89～100
	37	PCD12/39	14	51～ 64
	37	PCD22/39	12	106～117
	38	PCD13/39	13	263～275
	38	PCD20/29	24	84～107
	39	PCD14/39	29	73～101
	40	PCD14/39	29	43～ 71
	41	PCD14/39	31	185～215
	42	PCD19/39	29	184～212
NE 47-12	43	PCD18/39	29	49～ 77
NE 47-16	44	PCD17/39	28	233～260
ND 47- 4	45	PCD17/39	30	203～232
		Total	476	
		Grand Total	1,273	