

N-13 - 23

Paper W 3

**APPLICATIONS OF MULTISPECTRAL IMAGERY TO WATER RESOURCES
DEVELOPMENT PLANNING IN THE LOWER MEKONG BASIN (KHMER
REPUBLIC, LAOS, THAILAND AND VIET-NAM)**

Willem J. van Liere, *Mekong Committee Secretariat, Bangkok, Thailand*

1. ABSTRACT

The use of ERTS imagery for water resources planning in the lower Mekong basin relates to three major issues:

- it complements data from areas, which have been inaccessible in the past because of security; this concerns mainly forest cover of the watersheds, and geological features.
- it refines ground surveys; this concerns mainly land forms, and soils of existing and planned irrigation perimeters.
- it provides new information, which would be almost or entirely impossible to detect with ground surveys or conventional photography; this concerns the mechanism of flooding and drainage of the delta; siltation of the Great Lake and mapping of acidity, possibly also of salinity, in the lower delta; sedimentation and fisheries in the Mekong Delta estuarine areas.

Examples are given of all these major issues (see Fig. 1, Fig. 2, Fig. 3-3 III, Fig. 4 and Fig. 5).

There are also other uses, not directly related to water resources planning, but still of prime importance to the holistic concept of river basin planning. These relate to the delimitation of national reserves and to the identification of antiquities.

Examples of these are given too (see Fig. 3 and Fig. 6).

Complementary explanatory notes on ERTS images are given also directly on the different figures and images attached herewith, in conjunction with the corresponding ERTS frames.

The satellite data are particularly valuable also because their repetitive coverage gives an insight in the gradual transformation of changing features such as the extent of flooding and moisture retention in various soil types. Furthermore the availability of satellite imagery is most timely as it fills gaps in

basic data necessary for completion of development plans for the Mekong basin. These, in turn, are urgently needed, in order to finalize a realistic post-war development programme for the lower Mekong basin.

2. COMPARISON BETWEEN ERTS-1 IMAGES AND EXISTING GEOLOGICAL MAP AND FURTHER APPLICATION TO FORESTRY

2.1 Analysis (see Fig. 1, Fig. 2, in conjunction with ERTS Image 1 and Photo 1, Image 1-I and Image 2)

A comparison has been made in Fig. 1 between ERTS-1 frame No. 1111-02543 enlarged to a scale of 1 to 500,000 with an existing geological map which has been established to the same scale from a field study by J. Fromaget from 1923 to 1927 and published by the National Geographic Service of Viet-Nam 1963. This comparison leads to the following conclusions:

(i) The different gray tone scale steps found on the above ERTS-1 frame approximately correspond to the elements of regional geological structure shown on the map. As the latter is established from an old and imprecise survey, we definitely believe that ERTS imagery will help delineate more precisely the major terrain units.

(ii) With the help of both band 7 and band 5 prints, we can delineate and identify easily at least 5 major terrain units i.e. alluvium, upper Indosinias (mainly massive arenaceous group with subordinate siltstone; shale, with well-defined escarpment features); middle Indosinias (red micaceous shale, sandstone and siltstone, with basal conglomerate); calcareous series (mainly massive limestone with pronounced relief, subordinate shale and sandstone); and intrusive igneous rocks (Granite, granodiorite).

(iii) A triangular shape of fault was found east of Thakhek on the middle indosinias terrain, which is not mentioned in the existing geologic map. In addition, new lineaments were found which show rock fractures perpendicular to the NW-SW direction of the limestone outcrop north of Thakhek.

(iv) In the region of Savannakhet, the ERTS-1 image seems to demonstrate that the existing geological map allocated an exaggerated area to the upper indosinias terrain, which we also find on the opposite Thai side in the form of the jurassic Phu Phan and Phra Wihan formation (max. altitude 628 m above MSL), all Indosinias formations forming a fold-belt around the Khorat cretaceous basin.

A recent spot survey by a forestry consultant with wide experience in tropical watershed management and forest conservation revealed that during the last two decades the lower Mekong basin has experienced an unprecedented destruction of

its forest resources and deterioration of its watershed conditions. He estimated that clearing of forest lands on account of shifting and semi-shifting cultivation and the clearing of trees for timber and fuel is progressing at the rate of one million hectares per year; moreover, information gathered from the satellite imagery and other sources indicates more than four million hectares of primary forests have been seriously degraded by war action. The ERTS imagery gives us for the first time a tool for periodic examination of progressive forest degradation and identification of remote areas requiring remedial action. Such an inventory is now being prepared.

2.2 Conclusions:

(i) An updated geological map of the lower Mekong basin showing new tectonic features, especially fold, fault and dome, is now feasible for the first time, thanks to the availability of ERTS imagery. The work will serve as a basis for a more detailed reconnaissance geological map, to be prepared when the whole lower Mekong basin becomes accessible for ground survey work.

(ii) Further application to forestry in remote and inaccessible areas is also possible since it is obvious that the geological structures are directly reflected by the types of forest cover. Three major vegetational cover units were identified, in Northern Laos and Thailand where the security conditions do not permit accessibility.

3. HYDROLOGICAL DATA (FLOOD PLAIN AND SEDIMENTATION OF RESERVOIRS). see also Fig. 3, Fig. 3-I, Fig. 3-II and Fig. 3-III and the corresponding images of ERTS-1 frames)

Using band 5 and band 7 positive transparencies (9.5 inch) we can delineate on an overlay and with the help of a light table, the contour of the reservoir area affected by sedimentation, since on band 5 transparency the latter area is represented by a lighter tone step than on band 7 transparency.

This comparison has identified extensive arms of two existing new tributary reservoirs which are heavy with sediment. Since no field observations had noted this phenomenon, the Mekong Secretariat is investigating to determine if siltation in these arms is beyond design forecasts and to locate excessive watershed erosion or other causes.

The flood plain and inundated areas near Phnom-Penh, Khmer Republic, or in the entire Mekong Delta, can be delineated without any difficulty. As we know the gradient of the Mekong river in this reach, through gage heights, we shall be able to follow the pattern of natural flooding as well as that of natural drainage

through the whole rainy season. This is a new and invaluable tool for flood control analysis, the Mekong Committee flood forecasting programme, and for design of agricultural polders in the flood zone. Delimiting flood areas will also serve as a guide to the zones of fish spawning in the drowned forest areas of the Khmer Republic.

4. UPDATING SOIL MAP (see Fig. 4, Image 4 and Image 4-I)

The existing general soil map of the whole lower Mekong basin (a basin of over 600,000 km² in size) unfortunately presents a variable degree of reliability. A high level of reliability based on systematic soil survey can be claimed only for 25% of the area; fair reliability based on reconnaissance survey can be conferred on another 25% of this area; and the data for the remaining 50% is based only on general information and can be assigned only a poor degree of reliability.

A comparison of ERTS-1 images with selected areas of the existing soil map has been made. An example of this is given in Fig. 4, which shows a comparison between the upper Nam Mun tributary basin and the corresponding ERTS-1 frame No. 1094-03303, taken on 25 October 1972.

We found that the grey tone units on the ERTS-1 frame correspond well to the different types of soil of the soil map.

Both band 7 and band 5 transparencies especially can help in delineating the soil-type units. The above finding will permit our staff to extrapolate the findings to other uncloudy ERTS-1 frames of the lower Mekong basin, and greatly improve the potential for quality mapping.

5. SEDIMENTATION AND FISHERIES AT MEKONG DELTA ESTUARINE AREAS (see Fig. 5 and Images 5-I, 5-II, 5-III)

Suspended materials at the estuaries from the various branches of the Mekong river can easily be delineated from various bands of the same ERTS-1 frame. This also leads to a knowledge the gradient of the surface of the mass of suspended silt which is entering into the sea as well as the passages through which fishes could be caught because it has been established that the density of plankton growth is directly related to the density of sediment load in any particular zone of the estuary, and the density of plankton is also directly related to the numbers and types of commercially valuable fish per square kilometer in these waters.

6. APPLICATION TO ARCHAEOLOGY (see Fig. 6, Image 6 and archaeological Map 6-I)

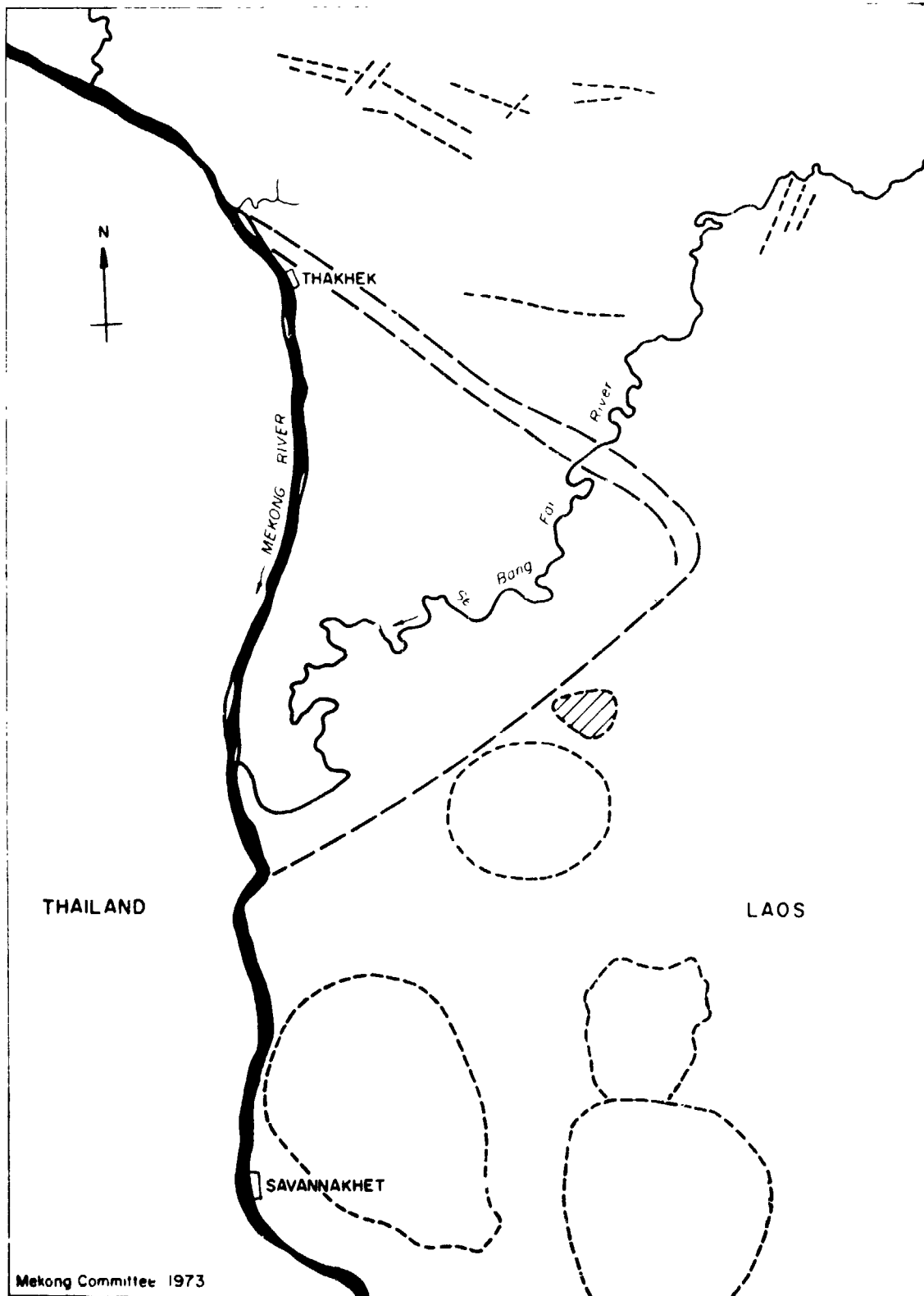
New artificial tanks and features found on the ERTS frame for the Angkor Wat region indicate interesting possibility for the delineation of archaeological sites, on the Northern shore of the Great Lake in the Khmer Republic.

The Angkor area as it existed in the 14th century has been mapped by the French archaeologist, Bernard Groslier, after exhaustive excavation and extrapolation. To our amazement, many of the features on Groslier's reconstructed map are clearly identifiable on ERTS imagery, although ground identification is difficult (some of Groslier's locations and dimensions are also shown to be slightly in error). This raises the intriguing possibility of ERTS imagery identification of heretofore unknown ancient ruins, particularly more of the reservoir and irrigation works of the Khmers and other early civilizations in the basin which might be subject to rehabilitation.

7. CONCLUSIONS

ERTS-1 data output by its timely repetitive and multispectral aspect is of tremendous value to the planning of the integrated development of all related resources of the lower Mekong basin. Band 5, Band 6 and Band 7 multispectral images can meet nearly all our needs.

Fig. 1 GEOLOGICAL FEATURES



(ERTS-I frame 1127-02451)

Fold, Fault, Dome
Fracture

N.B. Dotted lines are new features discovered

IMAGE 1



Mekong Committee 1973

(From ERTS - I frame 1127 - 0245)

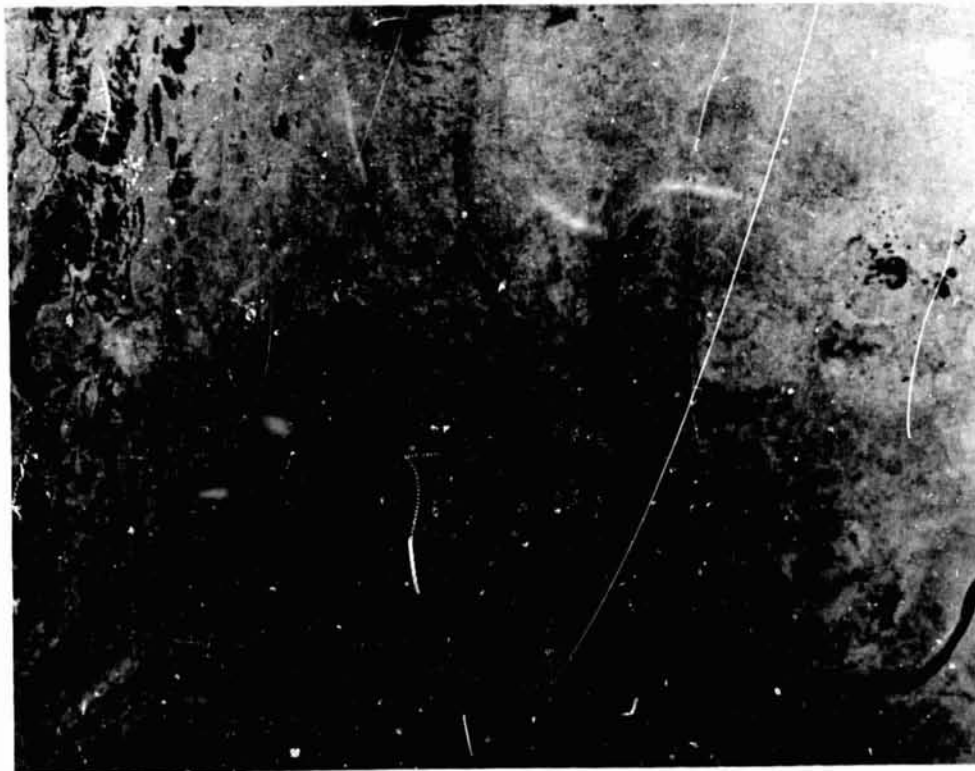
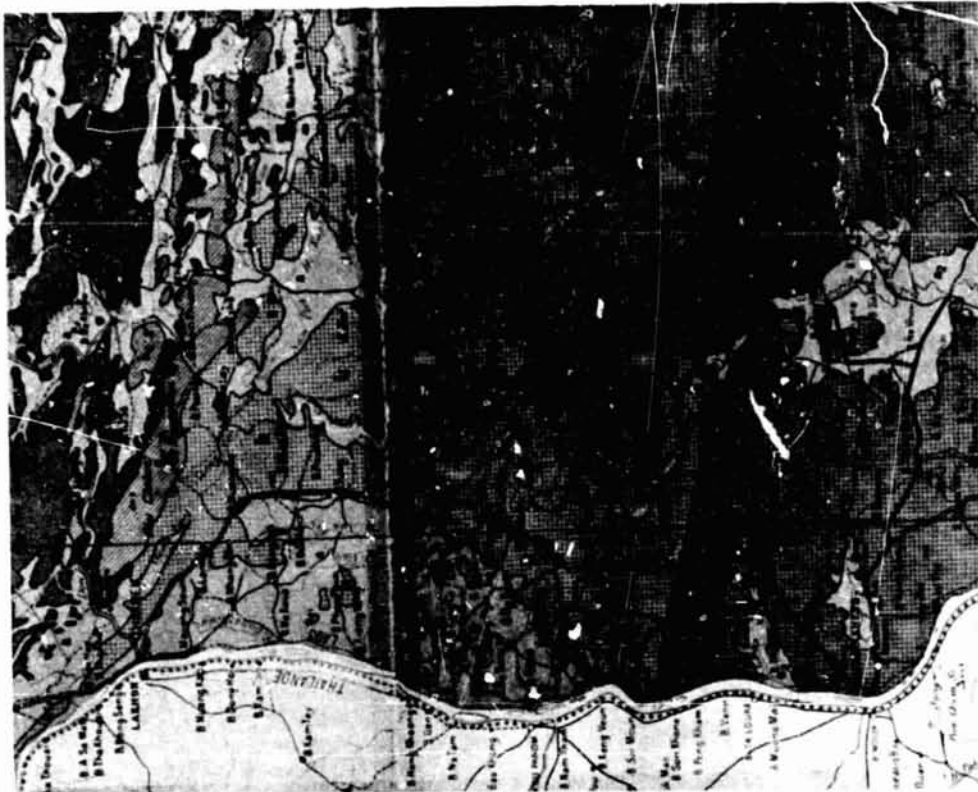
PHOTO - I
(EXISTING GEOLOGICAL MAP)



I1 = Middle Indosinias
 II = Upper Indosinias
 h₃⁴ = Calcareous series
 B₁ B₂ = Alluvium
 (♂) = Salt

Mekong Committee 1973

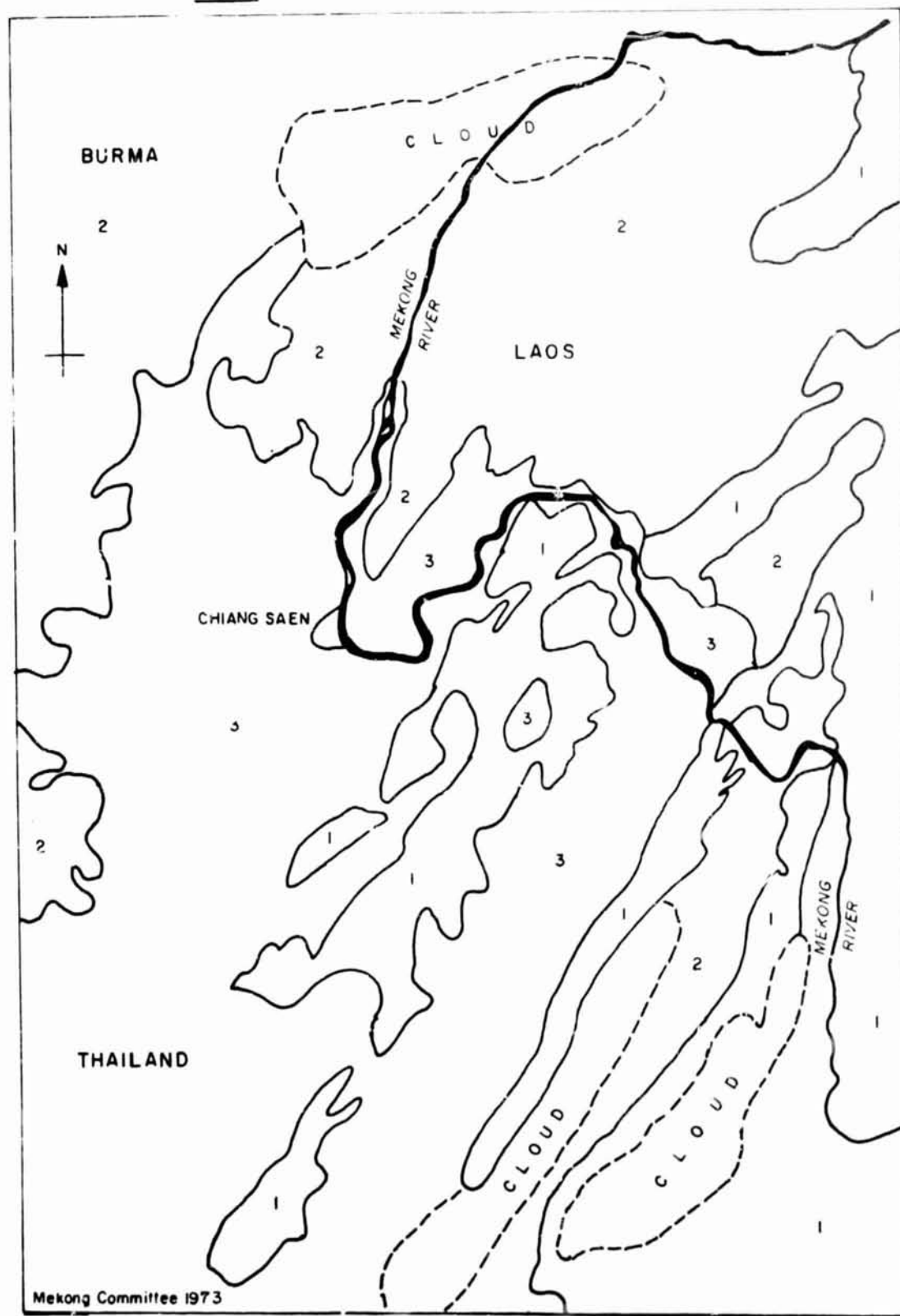
IMAGE 1 - 1
(THAKHEK - SAVANNAKHET REGION , LAOS)



ERTS-1 frame 1127 - 02451 &
EXISTING GEOLOGICAL MAP

Mekong Committee 1973

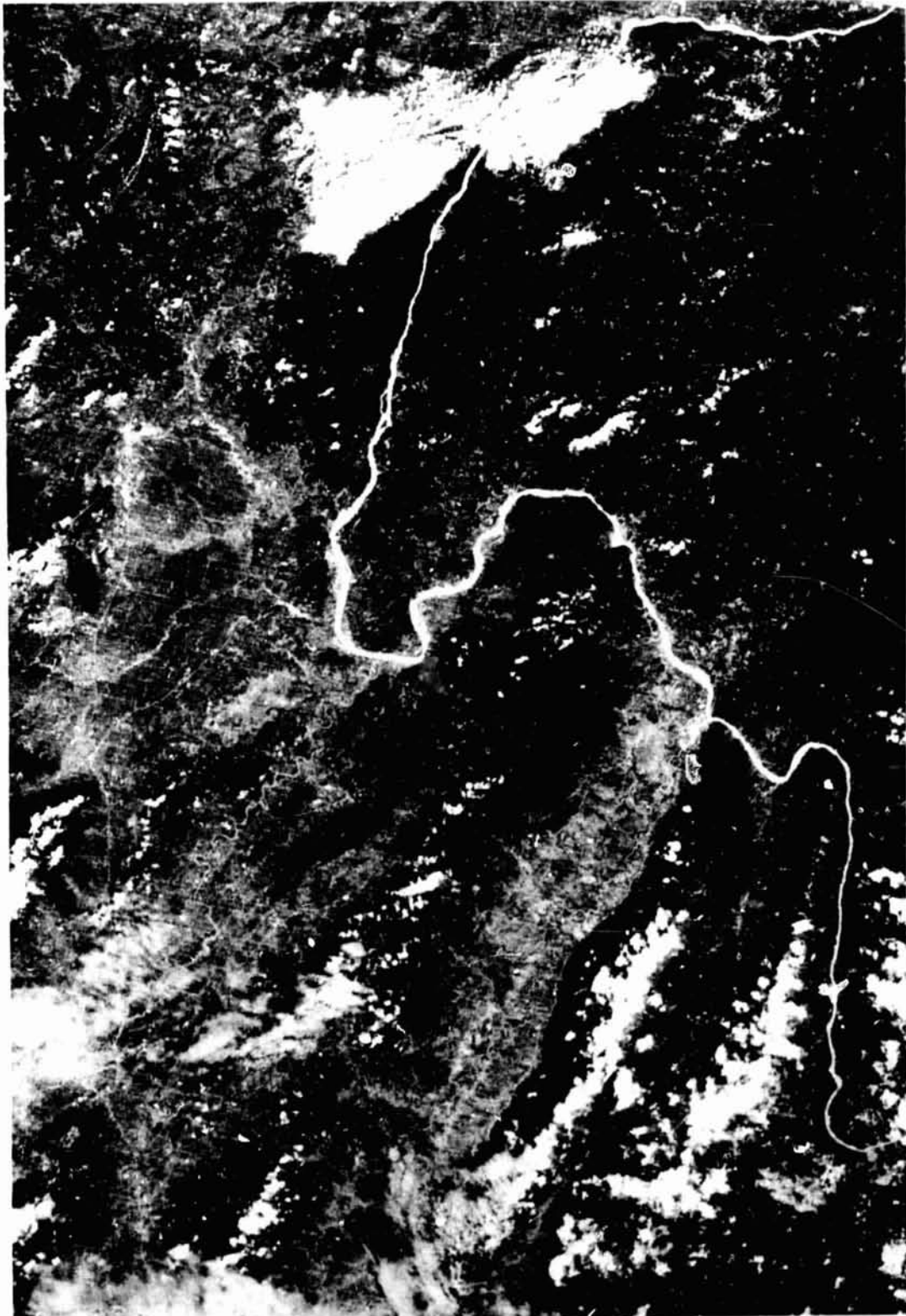
Fig. 2 FOREST COVER OF WATERSHED



1 Primary forest, 2 Degraded forest, 3 Agricultural lands

(ERTS-1 frame 1097 - 03163)

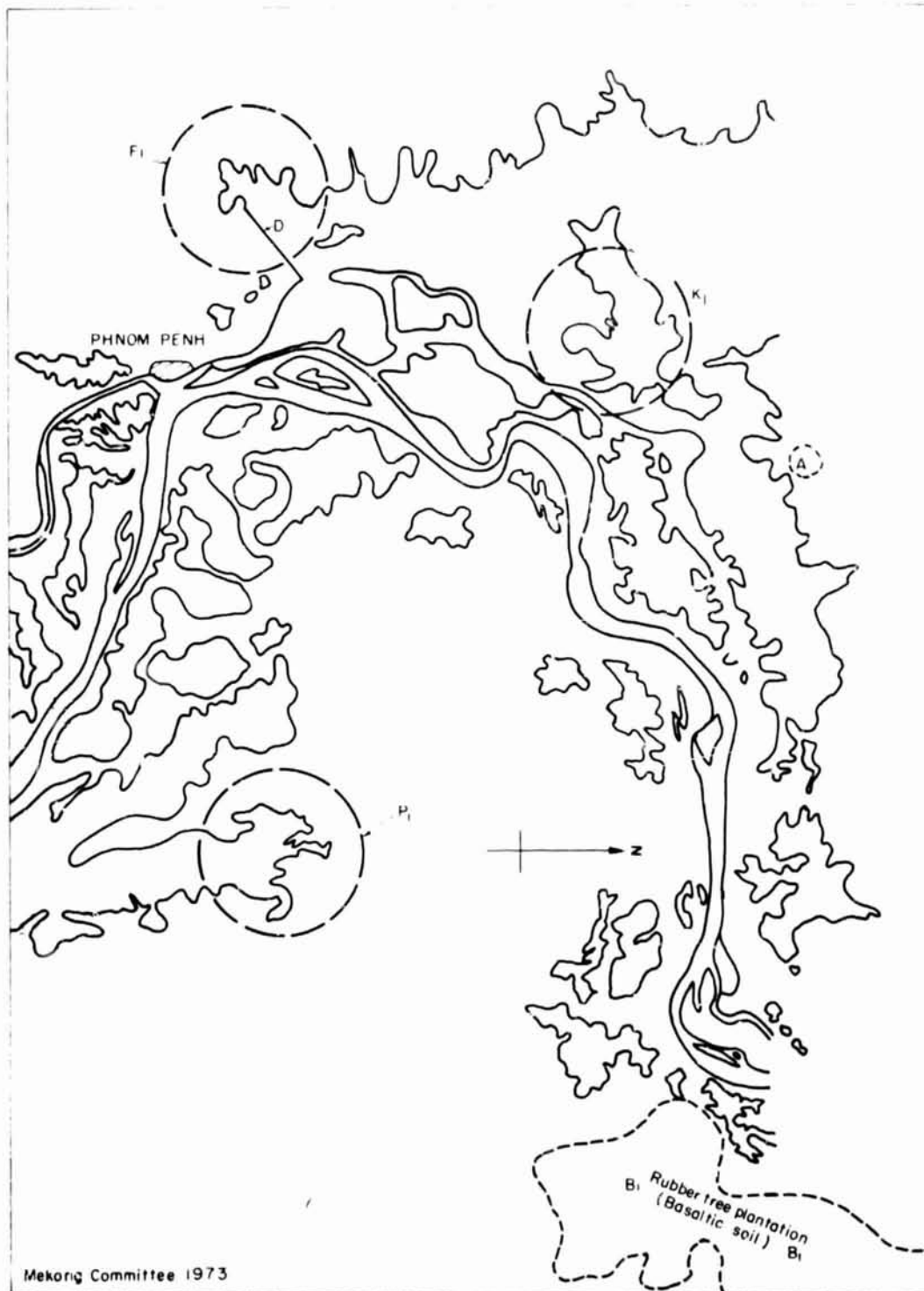
IMAGE 2
(CHIANG SEAN FORESTRY, THAILAND)



ERTS - I frame 1097 - 03163

Mekong Committee 1973

Fig 3 23 OCT 72 FLOOD PLAIN NEAR PHNOM - PENH KHMER REPUBLIC



N.B. Compare circled areas F1, K1 and P1 with same areas of flooding covered on 10 Nov. 72. To study drainage pattern water level recorded at Phnom Penh was 3.91 m above Mean Sea Level. (ERTS-1 frame 1092-02501-6)

Flood area
 Phnom Penh Polder dike
 Acacias forest reserve

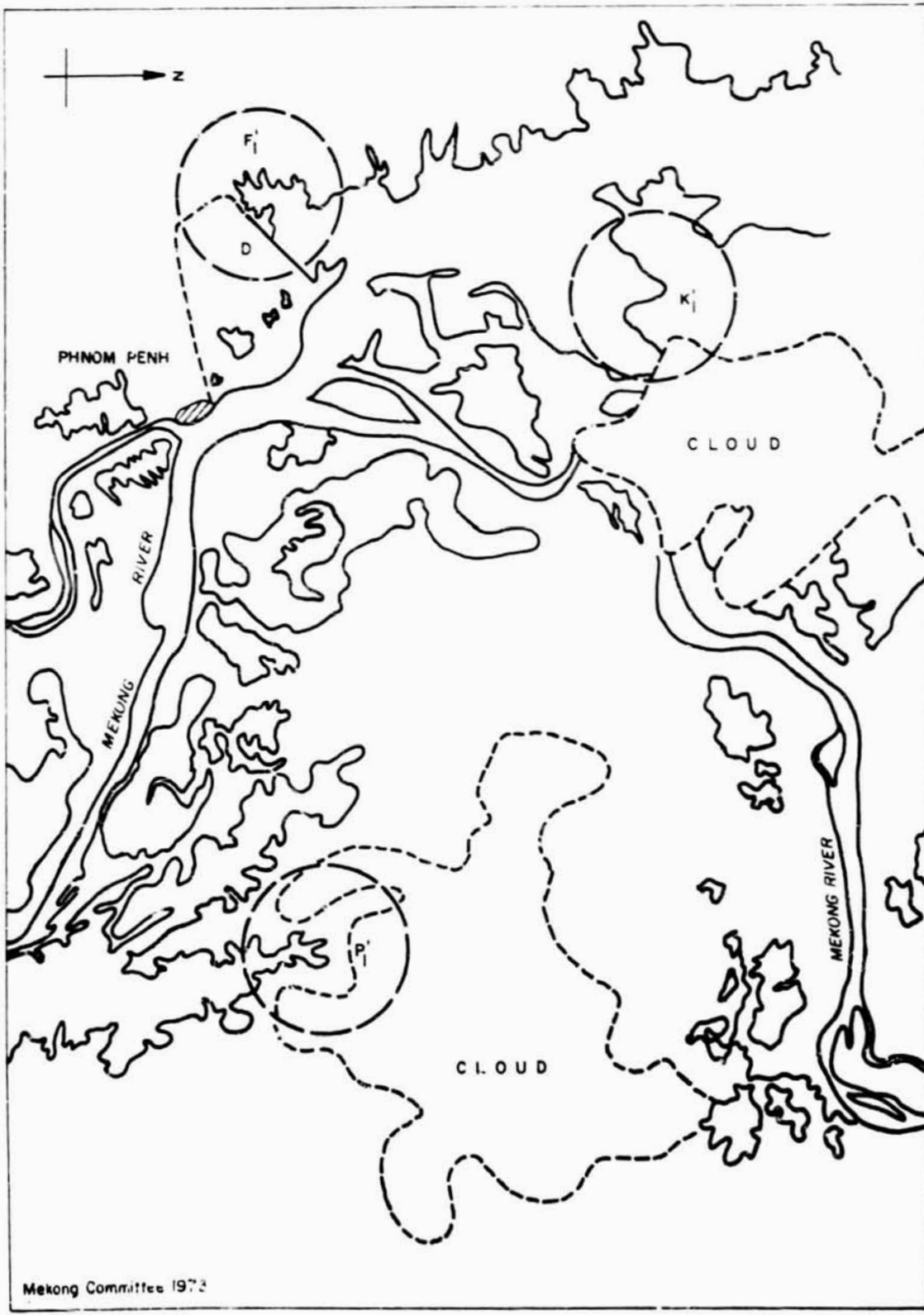
IMAGE 3



Mekong Committee 1973

(From ERIS - I frame 1092 - 02501-6)

Fig 3-1 10 NOV. 72 FLOOD PLAIN NEAR PHNOM - PENH KHMER REPUBLIC



Mekong Committee 1972

N.B. Water level recorded at Phnom Penh on 10 Nov. 72 was 3.25 m. MSL. Compare with Fig 3

 Flood area

(ERTS -1 frame 1110 - 02503 - 6)

C

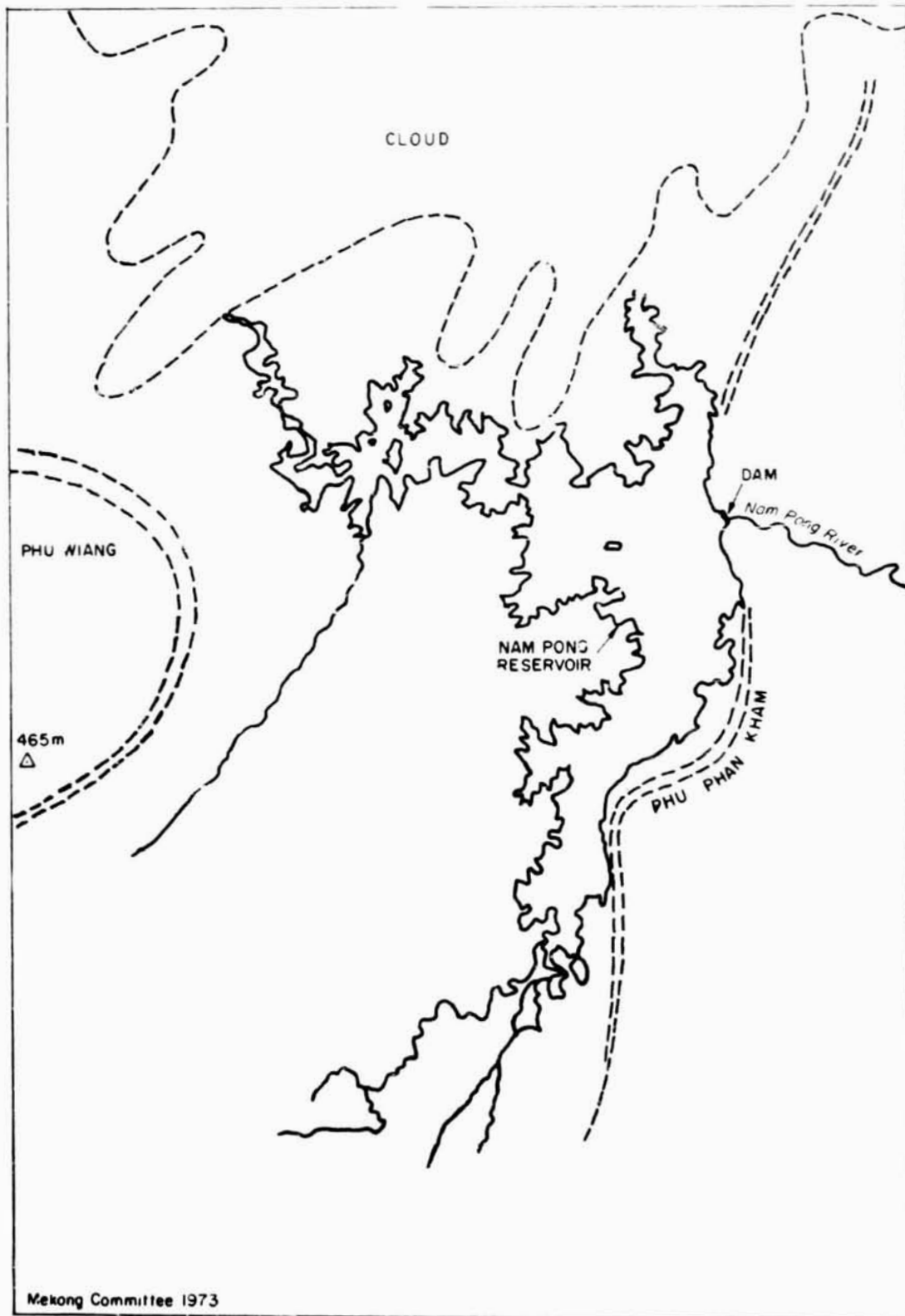
IMAGE 3-1



Mekong Committee 1973

(From ERTS-1 frame III O-02503-6)

Fig. 3 - II NAM PONG RESERVOIR (NORTHEAST THAILAND)
Band 7 image



N. B. See sedimentation of Nam Pong Reservoir on Fig. 3 - III

(ERTS-1 frame 1095-03055)

BAND 7, IMAGE 3
(NAM PONG RESERVOIR , THAILAND)

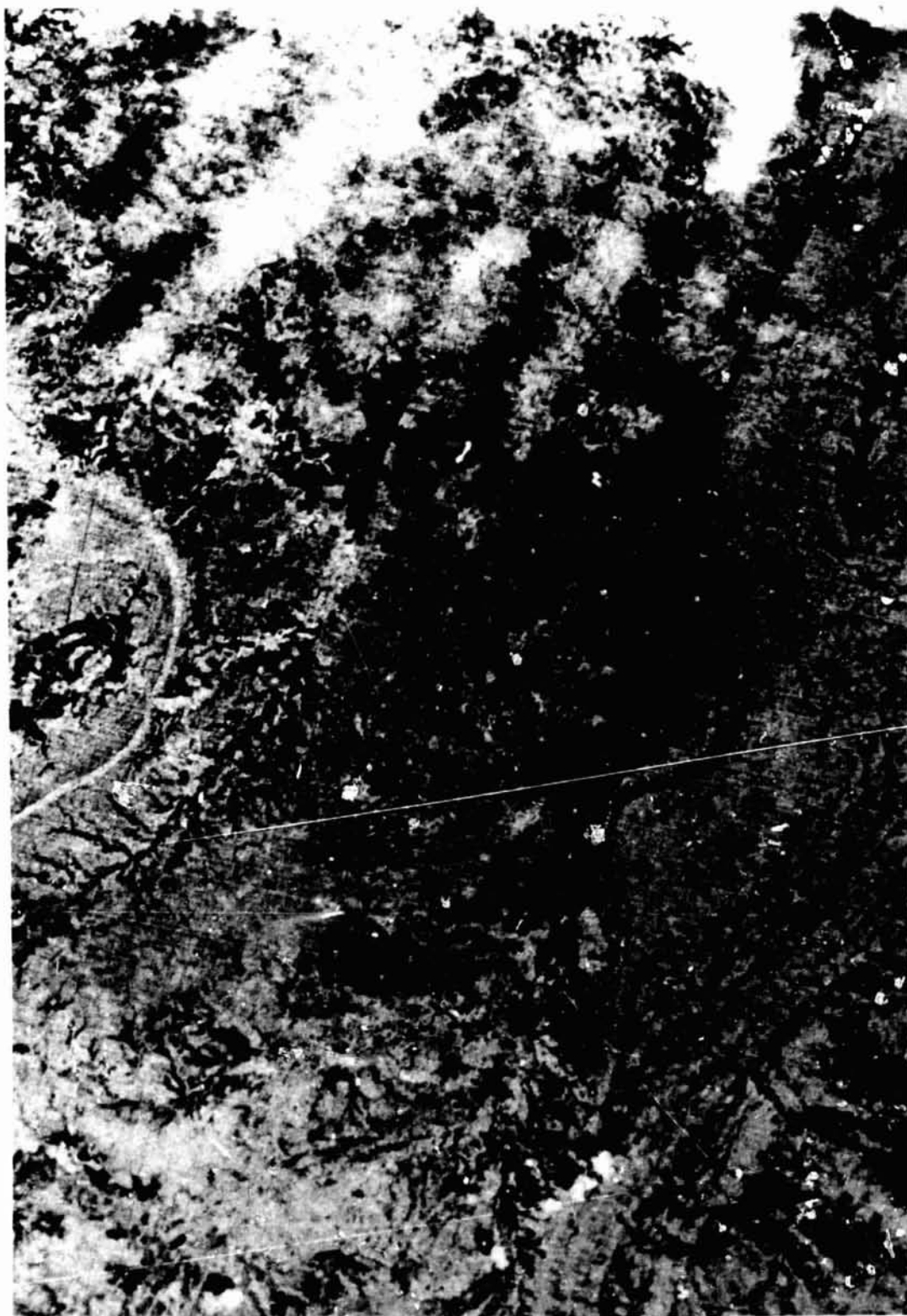


Fig. 3 - III SEDIMENTATION NAM PONG RESERVOIR



Sedimentation areas seen on Band 5 image

(ERTS-1 frame 1095 - 03055)

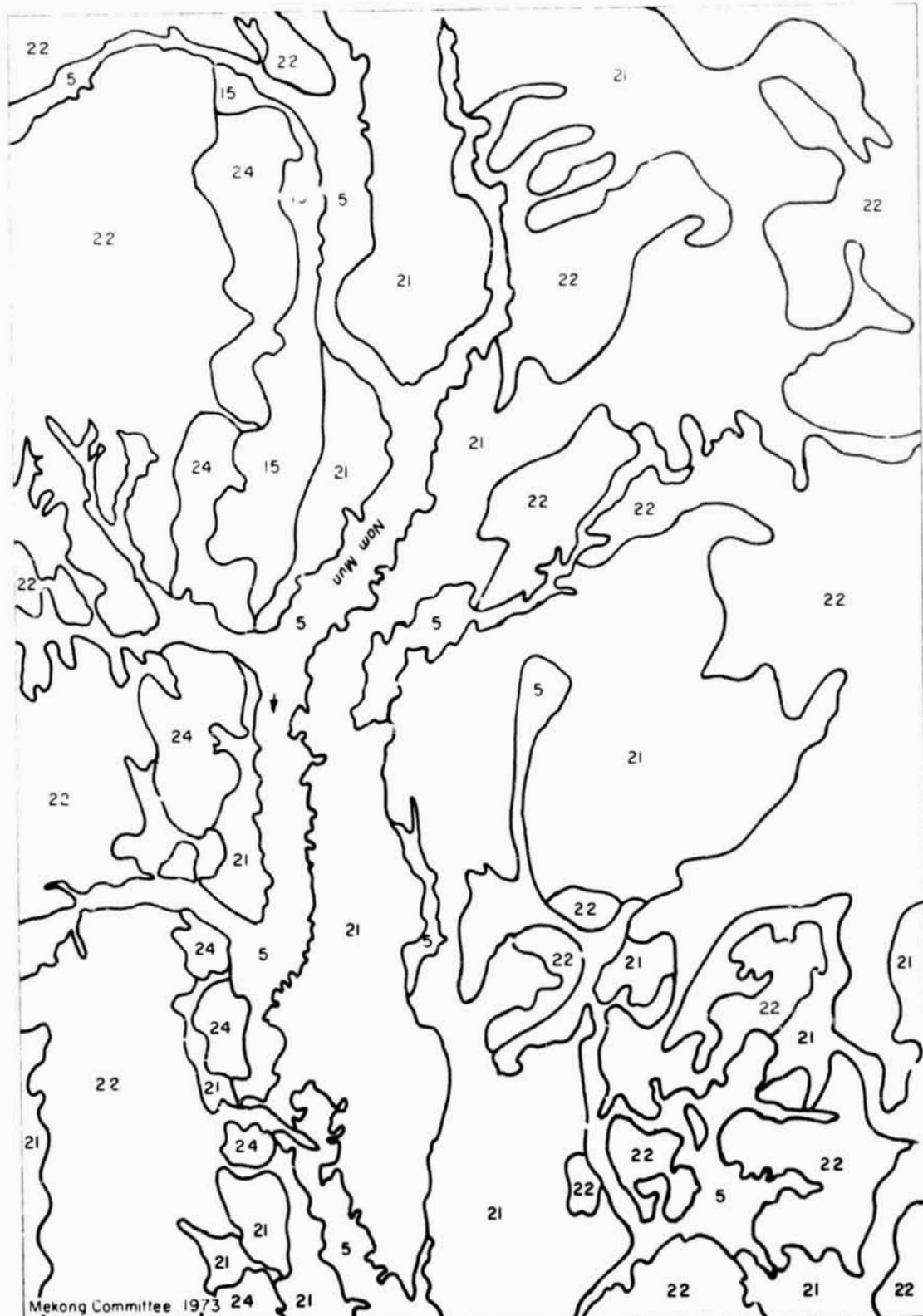
BAND 5, IMAGE 3
(NAM PONG RESERVOIR, THAILAND)



ERTS - I frame 1095 - 03055

Mekong Committee 1973

Fig. 4 UPDATED SOIL MAP



5 = Eutric gleysoils (inundated areas), 15 = Ferralic cambisols, 21 = Gleyic Acrisols with Ferric Acrisols
 22 = Gleyic Acrisols, undulating slope of 0 to 8 per cent, 24 = Orthic Ferralsols.

(ERTS-1 frame 1094-03003-7)

IMAGE 4



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(From ERTS frame No. 1094 - 03003 - 7)

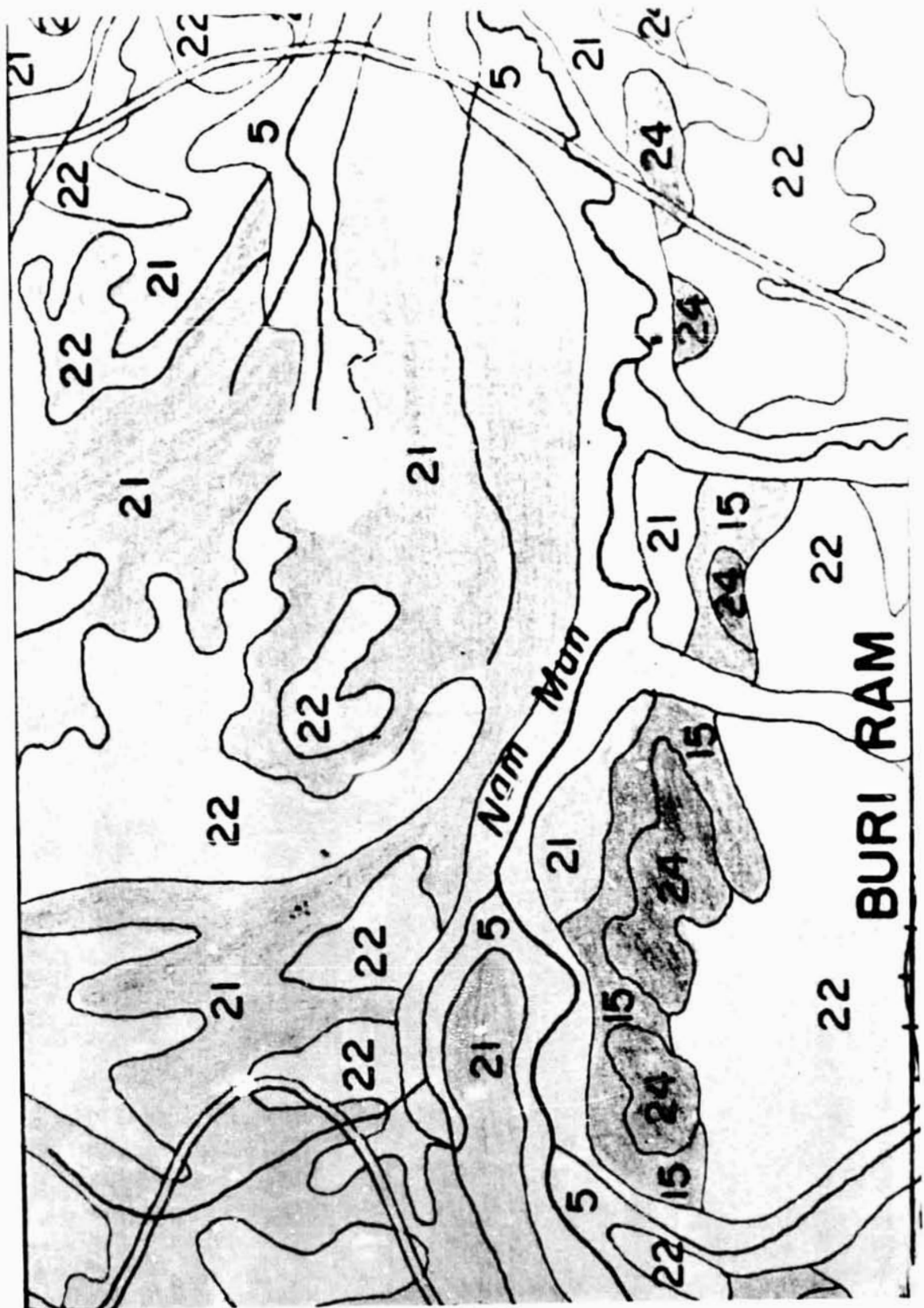


IMAGE 4-1
(UPPER NAM MUN - N.E. THAILAND)

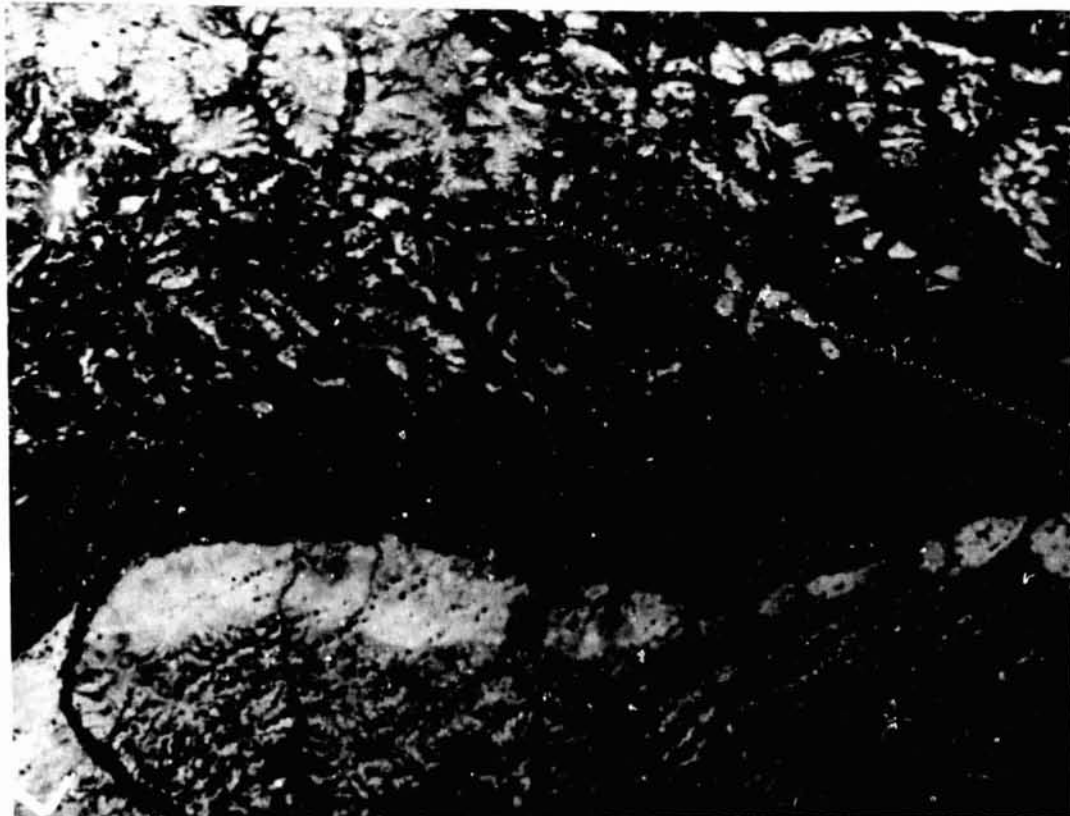
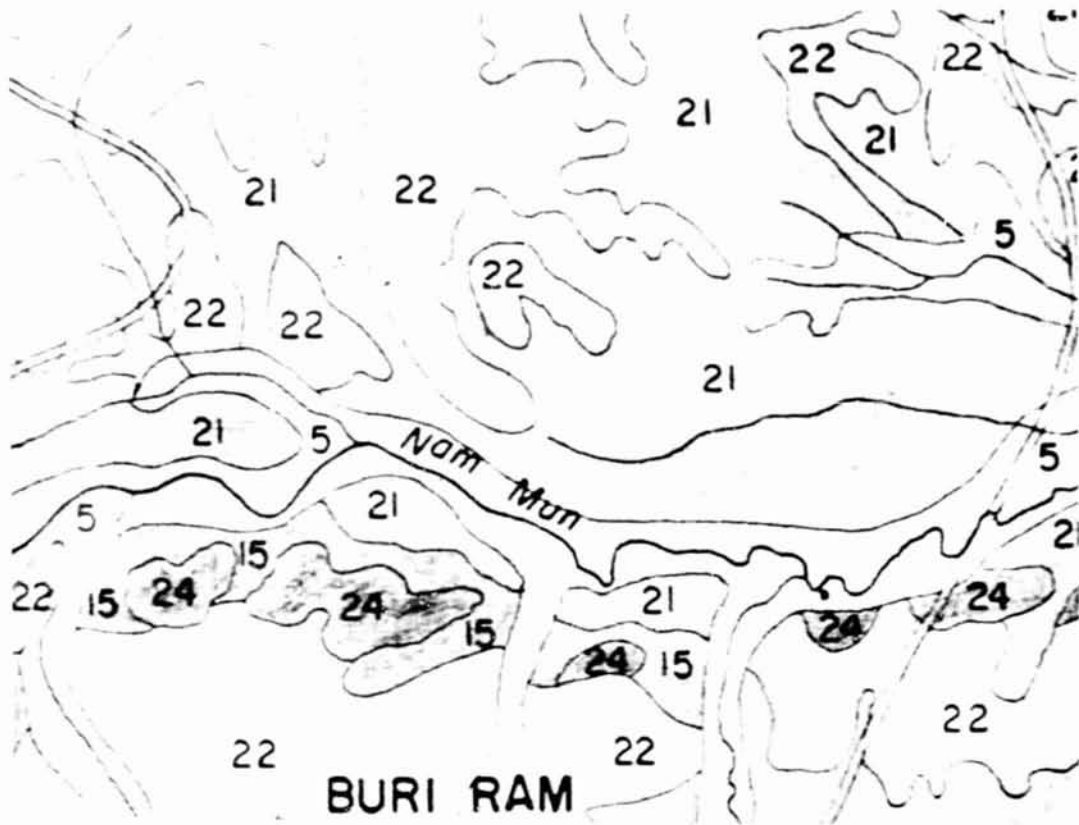
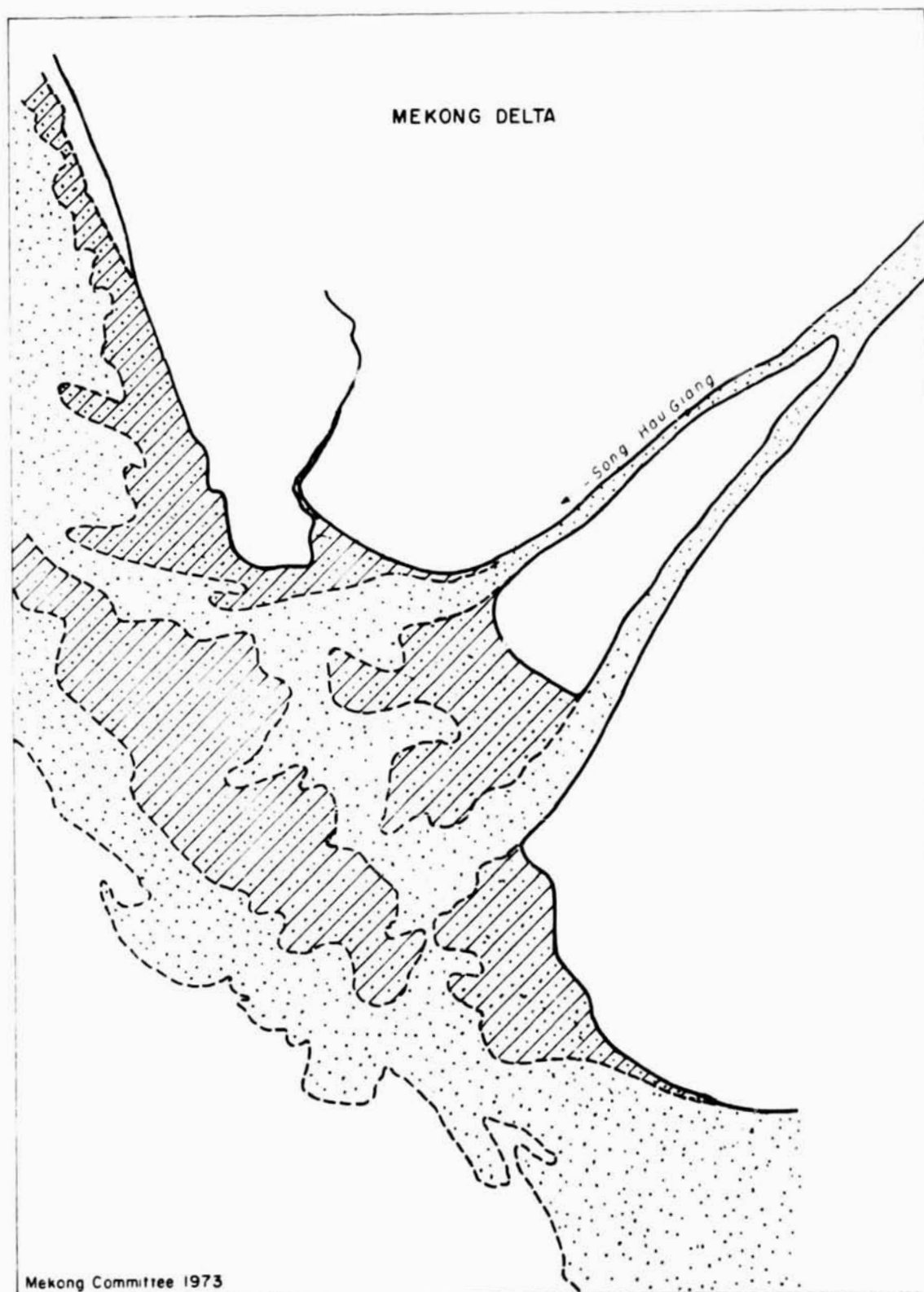


Fig 5 MEKONG ESTUARIES (VIET-NAM)



Sedimentation areas in Band 6



Sedimentation areas in Band 5

(ERTS - 1 frame 1127 - 02451)

BAND 5, IMAGE 5
(MEKONG ESTUARIES, VIET - NAM)



BAND 6, IMAGE 5



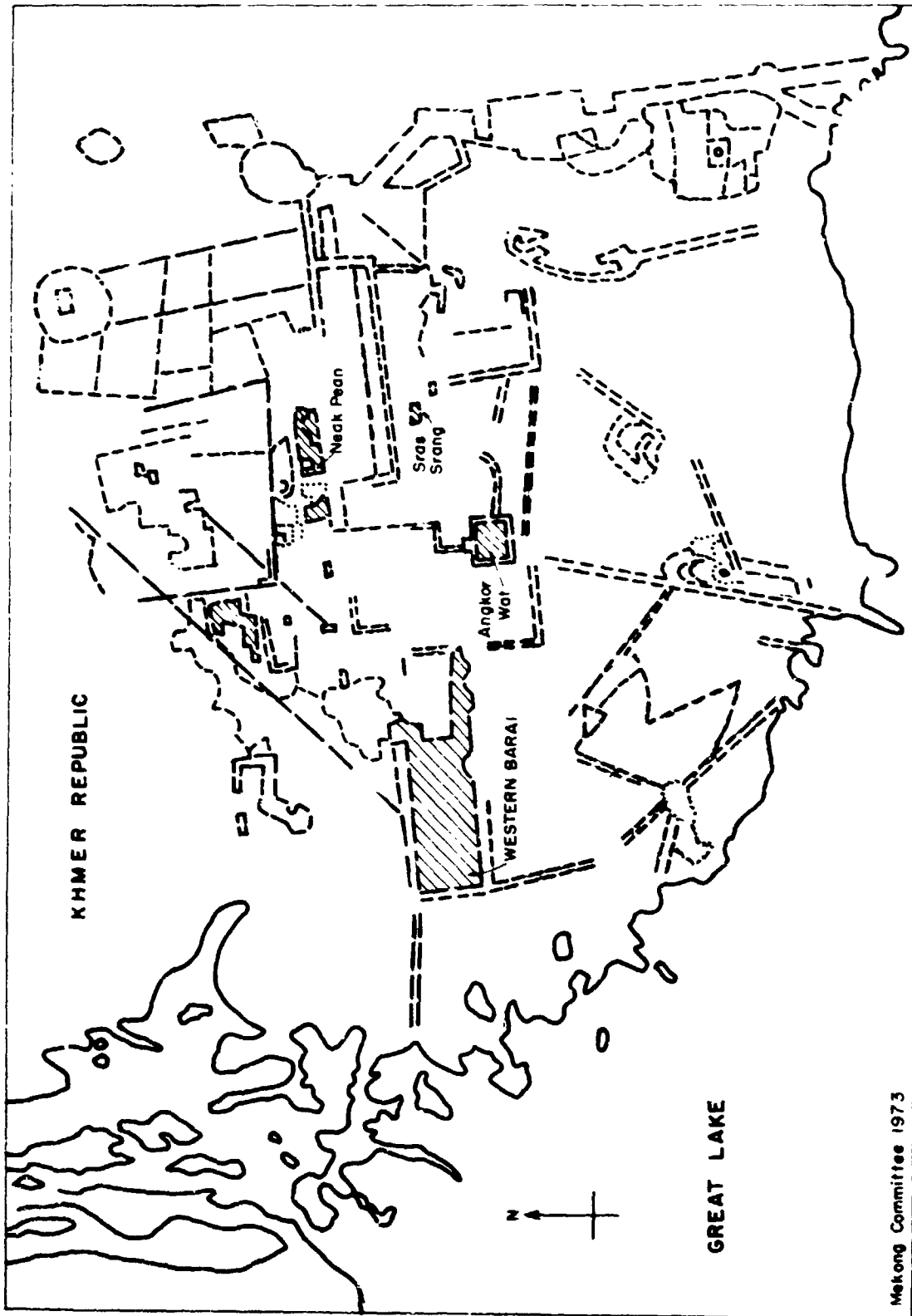
ERTS - 1 frame 1127 - 02451

Mekong Committee 1973

IMAGE 6
ARCHAEOLOGICAL SITE. (Angkor W.T. KHMER REP.)



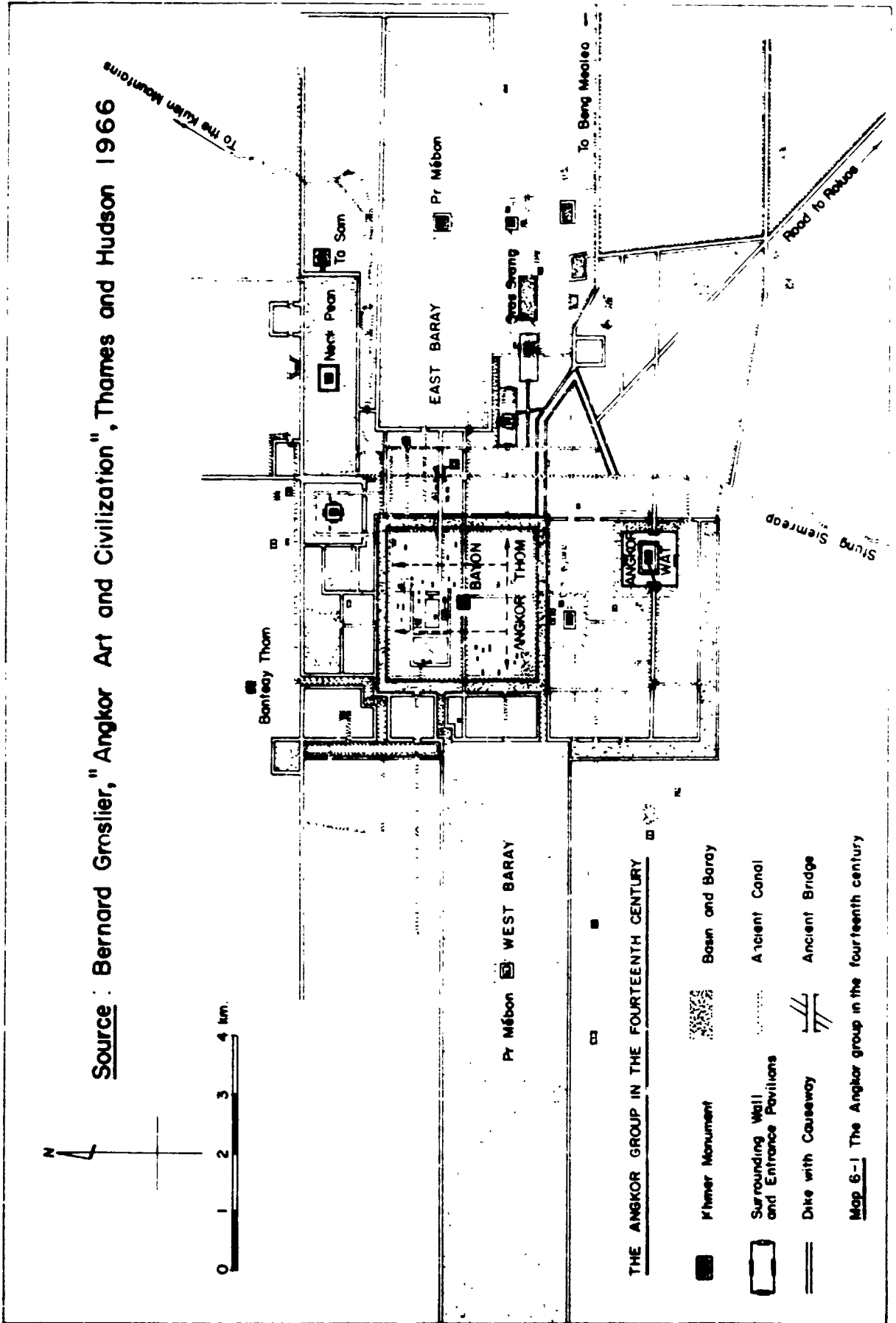
Fig. 6 ARCHAEOLOGICAL SITES (Angkor Wat area)



Mekong Committee 1973

(ERTS-1 frame 1093-02553-7)

Source : Bernard Groslier, "Angkor Art and Civilization", Thames and Hudson 1966



THE ANGKOR GROUP IN THE FOURTEENTH CENTURY

- Khmer Monument
- ▭ Surrounding Wall and Entrance Pavilions
- ≡ Dike with Causeway
- ▨ Basin and Baray
- ⋯ Ancient Canal
- ⌌ Ancient Bridge

Map 6-1 The Angkor group in the fourteenth century