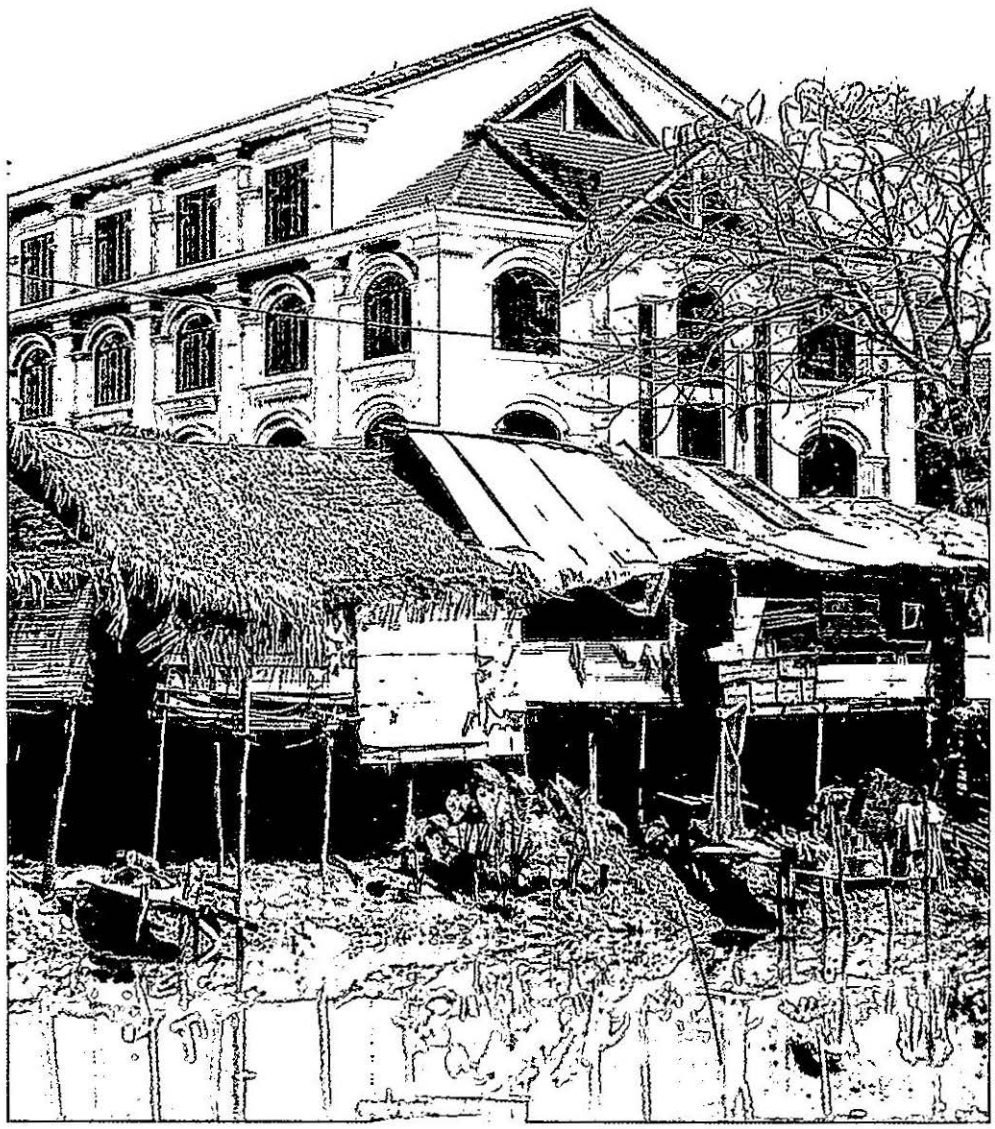
CHAPTER ONE

The Angkor / Siem Reap Region



In order to understand the area of Angkor / Siem Reap today, it is necessary to briefly consider the geological foundations which make up the area as well as the history of human settlement which led to the population of the region. I present here a partial summary of the analysis of Southeast Asian geology offered in the work of J.P. Carbonnel who in turn cites J. Fromaget.

The geological development of Southeast Asia

As J. Fromaget (1941) has explained, the Indochinese peninsula is a succession of rings formed between two tectonic plates located to the south and northwest of mainland Southeast Asia (figure 8). The area between these two plates is

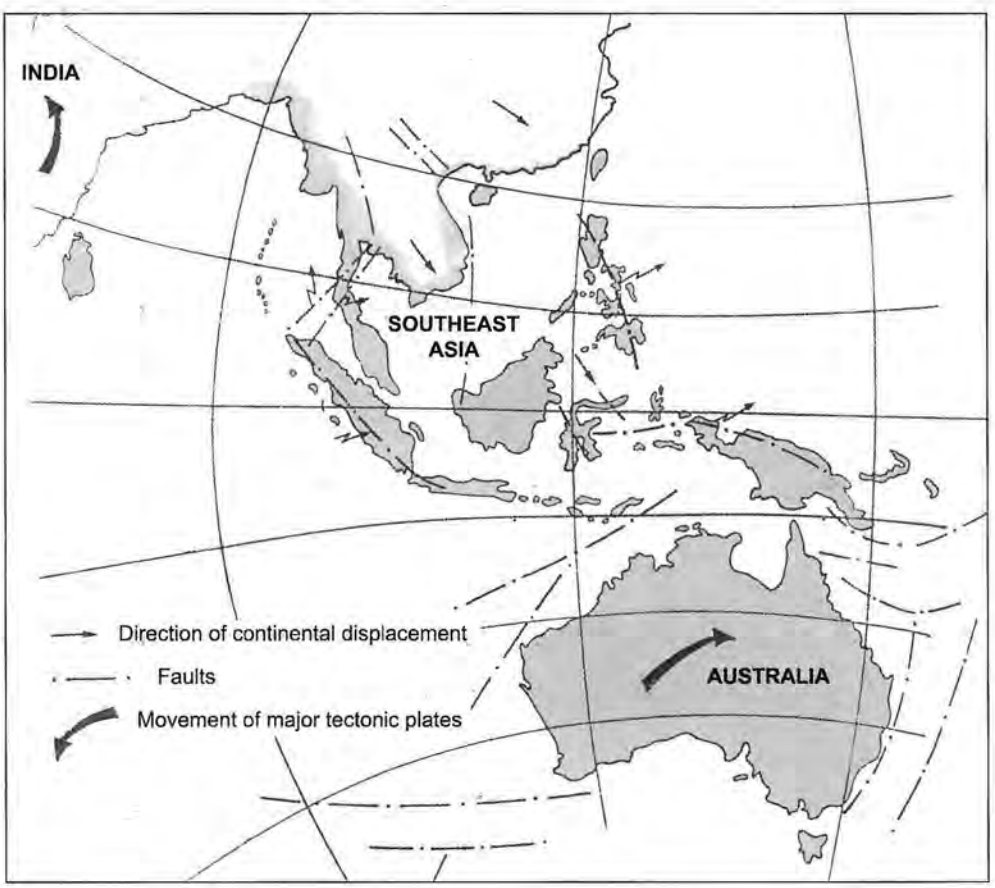


Figure 8: *Tectonic Movements in and around Southeast Asia*

"characterised by continental elements, laid out as garlands or elongated clusters which are separated by marine depressions of an obviously disjunctive origin"(Fromaget). A micro-tectonic plate called "Indosinia" makes up the low lying area of Thailand and Cambodia as well as its mountainous borders. The area of "Indosina" is characterised by heavy covers of sedimentation.

The structure of Central Cambodia

In 1965, J.P. Carbonnel proposed a geological description in which key structures of Central Cambodia were organised along a northwest / southeast axis, following the plain of the Great Lake and its extension south towards the Vietnamese border along the valleys of the Mekong and Bassac Rivers. Features of this underlying axis can be read off the surface of the land, and distinct zones of northwest / southeast orientation can be traced from the Gulf of Thailand. These zones include (figure 9) :

- the coastlands of the Gulf of Thailand
- the interior of the Cardamom chain, where a series of fractures have produced basaltic gullies running from Pailin to Koh Kong through Kbal Sung and Veal Veng
- the eastern border of the Cardamom Mountain range with a system of faults running along this border. (The faults are easily recognisable in the rift valleys which are found between the mountains and the southern massif of Kchol in the area of Phum Ampil - Phum Kravea)
- the valley of the Great Lake, the Tonle Sap River and the Mekong River, bordered to the east by a band of pre-Jurassic formations.

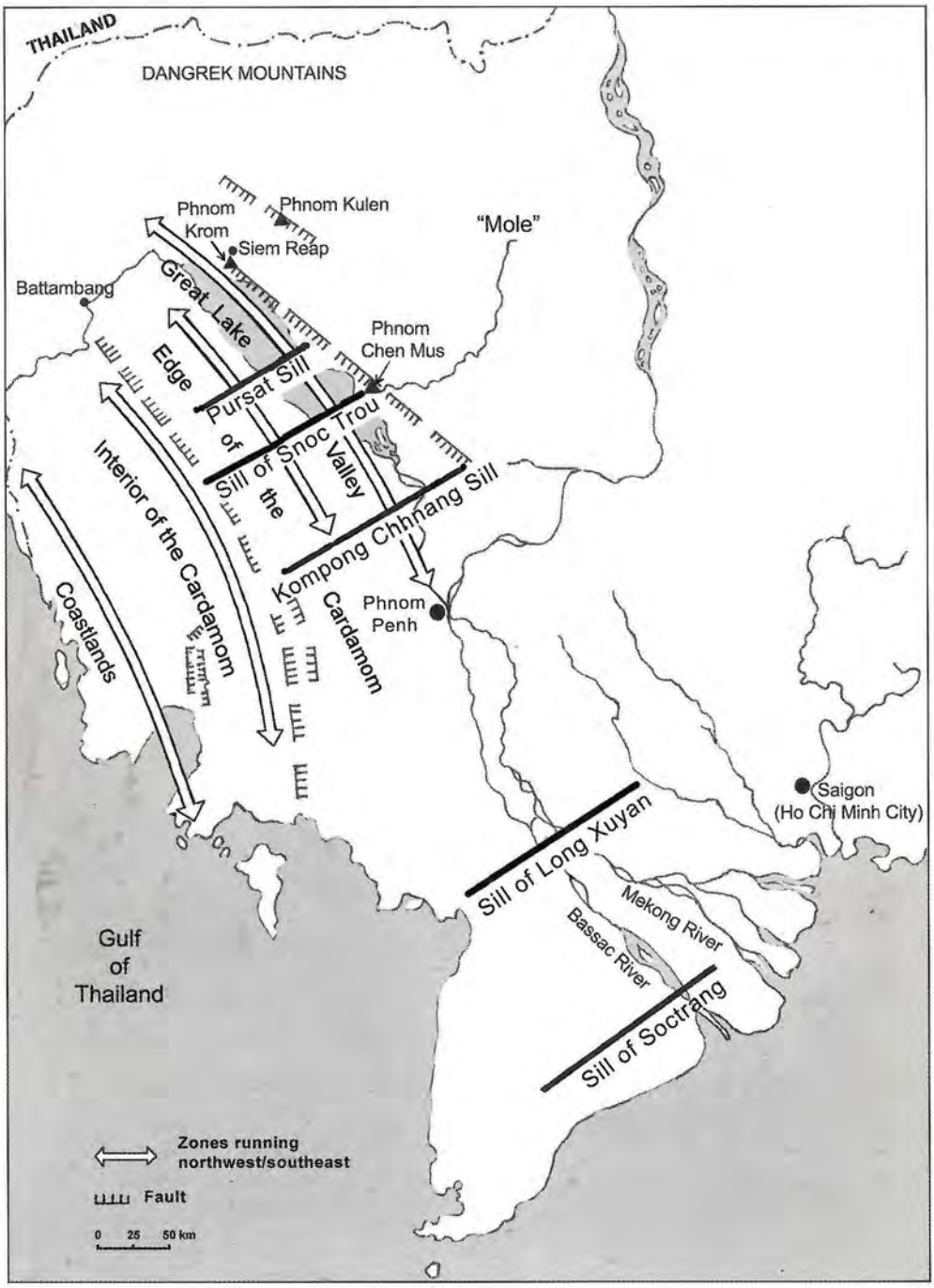


Figure 9: *The zones running northwest / southeast are intersected by sills running in a northeast / southwest direction*

The northwest / southeast axis is visible as well to the east and northeast of the Great Lake. Between the Lake and the road from Kompong Thom to Siem Reap, two hills emerge from recent alluvial deposits: Phnom Krom (143 meters high, to the south of Siem Reap), and Phnom Chen Mus (68 meters high, 47 kilometers to the west of Kompong Thom). Both hills are composed of sandstone and rest on bases dating to the early or middle Jurassic Period.

The primary northwest / southeast axis described above is intersected by a series of geological "shelves" or "sills" (figures 9, 10), running in a northeast / southwest direction. These "sills" or "shelves" are zones of upheaval, perpendicular to the main axis of the Great Lake. In the area of the Great Lake, three sills are found, each separated from the next by sunken zones which are generally flooded during the rainy season. From south to north, the sills and their sunken zones are:

- The sill of Kompong Chhnang, which covers the area from Phnom Penh to Kompong Chhnang. This sill separates the Mekong Delta from the plain of the Great Lake.

- The sunken zone of Veal Phok (the plain of swamps), a very large flood zone which serves as a trap for sediments flowing into the Great Lake with the flood waters of the Mekong River.

- The sill of Snoc Trou (which is less pronounced than the one of KompongChhnang). Here a sloping base of superior sandstones is covered by a shallow bed of sedimented deposits with almost no rock outcrops.

- The small lake, a sunken flood zone which is much smaller than the sunken zone of Veal Phok.

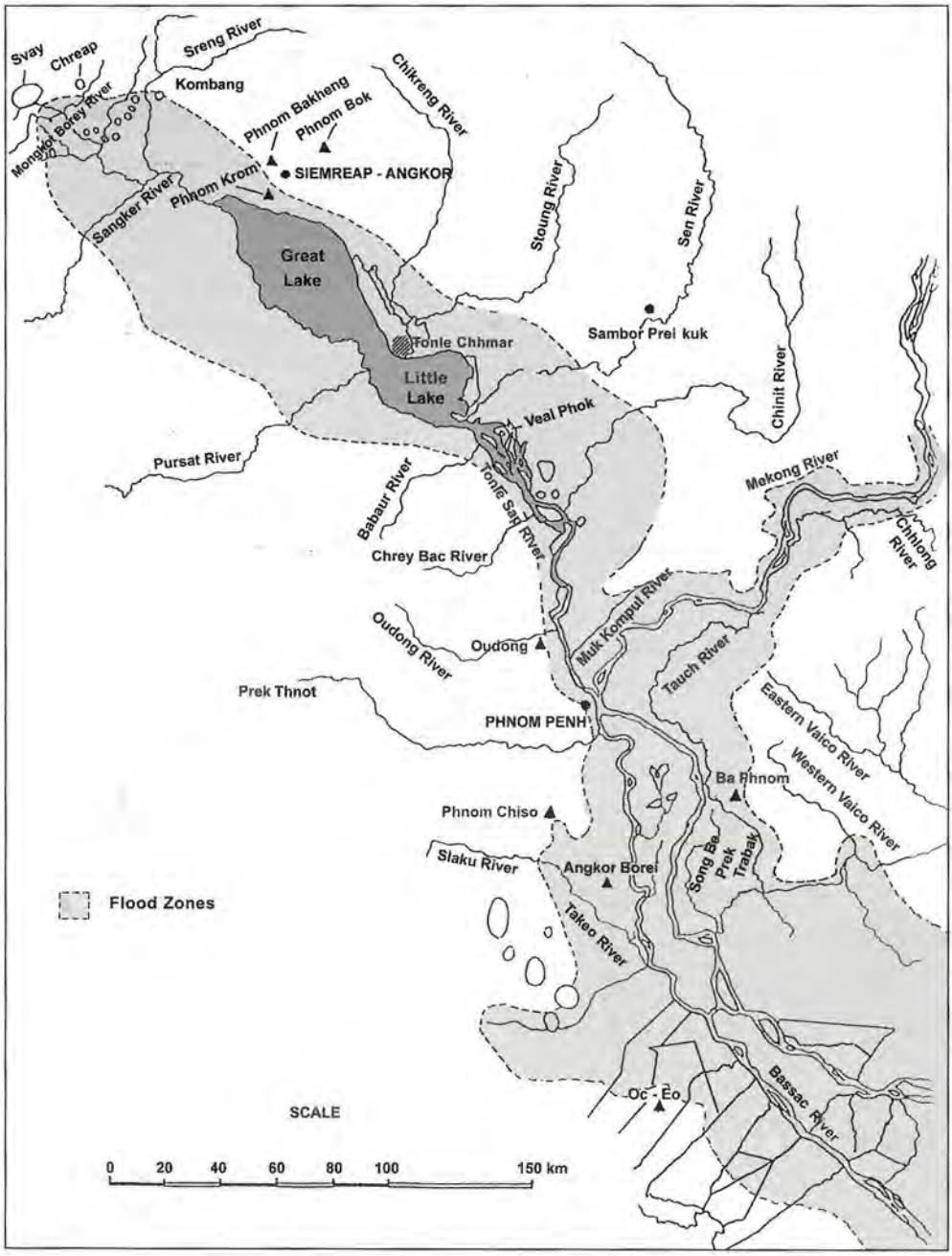


Figure 10: *Flood zones of the Great Lake and the "Four Faces"*

- The sill of Pursat, a band of terrain stretching from the delta of the Pursat River to the Tonle Chhmar. At the eastern extremity of this sill, a depression functions as a trap for sediments. This area has the greatest rate of ongoing sedimentation today.

- The actual Great Lake, bordering the sill of Pursat. The thickness of the bed of silt on the bottom of the Great Lake diminishes to almost nothing at the northwestern extremity of the Lake.

The sills appear less and less pronounced as they proceed from southeast to northwest. The set of sills as a whole has a fractured northern flank, while their southern flank extends under the current delta of the Mekong River. We can conclude that the underlying structure of the central plain of Cambodia consists of an ancient axis running northwest / southeast which is cut by a system of more recent fractures running in a northeast / southwest direction. These intersecting fractures seem to have emerged primarily during the Quaternary Period, which is the most recent period of prehistory.

Zones of the Great Lake

The basin of the Great Lake can be divided into three zones: the zone of the Great Lake itself, the plains to the west of the Lake, and the plains to the east of the Lake.

1. The Great Lake

The Great Lake occupies the center of an area with an average altitude of 15 to 20 meters above sea level. The basin of the Great Lake is bordered to the north by the Dangrek Mountains which form the southern edge of the Korat plateau. To the west and to the south, the basin of the Great Lake is bordered

by the Cardamom Mountains which begin as a series of foothills. To the south, the sill of Kompong Chhnang hems in the lake while to the east the basin of the Lake stretches towards the "pier" or "mole", a jutting plateau which is higher than the basin of the Great Lake.

2. The plains to the west of the Lake

Drilling near Battambang has revealed very deep alluvial deposits of at least 250 meters. The deepest section of these deposits is a layer of hardened sand which is about 43 meters thick. The thickness of the alluvial deposits clearly points to a subsidence, or sinking, of the northwestern end of the Great Lake basin. Sedimentation in this area apparently occurred in two distinct time periods. During the first period of sedimentation, large elements such as stones, pebbles, and sand were deposited, mixed with some clays and lime. The second phase of sedimentation left the 119 meters of deposits closest to the surface which consist of fine elements only (clay and some lime). This stratigraphy reveals an evolutionary process with two distinct periods of sedimentation: first, a violent period of rapid deposit followed by a later period of calmer sedimentation consistent with the type of silting found in lakes and deltas. Samples taken further to the southeast at Pursat show layers of alluvial deposits only 56 meters thick. This relatively thin layer of alluvial deposits correlates to the advance towards the east of the sandstone massif of the Cardamom Mountains.

3. The plains to the east of the Lake

The plain of Kompong Thom stretches along the length of National Route 6, curving around the eastern end of the Great Lake from Skoun to Siem Reap. Alluvial deposits on this plain are less deep than to the northwest (the bottom of the alluvial deposits has been located at -30, -61, and -80 meters respectively).

These alluvial deposits fill in a more ancient topography since the area was once the valley of the Sen River, today still the largest river of the Great Lake basin.

The plain of the Angkor / Siem Reap Region has alluvial deposits less than 58 meters deep, and is covered with important rock outcrops and hills such as Phnom Krom, Phnom Bakeng, Phnom Bok, and Phnom Dei. These hills or outcrops can reach heights of 100 meters or more and were used by the Khmer as holy sites. The sacred mountain or "phnom", linked to the plains below by the water which irrigated them, remains a ritual constant of land use by the Khmer.

Sedimentation in the Great Lake

Samples taken from the bottom of the Great Lake propose several layers of sedimentation. On the surface, a layer of fluid mud is in the process of sedimenting and thus remains very sensitive to the slightest current. Below this fluid layer, a layer of silt is found which consists of a very fine grey-blue mud, more or less oxidized on its surface. Under this, a small layer of sediment is found which has a greater granularity. Deepest of all lies a layer of ancient alluvial deposits. The homogeneity and consistency of samples taken from all over the bottom of the Great Lake show that the top of its silt surface is very flat and uniform, unpitted by elevations or depressions. The highly variable thicknesses of this uppermost silt layer indicate that a deeper ancient topography, characterised by a strong relief, lies underneath it.

Zones of sedimentation in the Great Lake

One can distinguish several sedimentary zones in the Great Lake. The depth of silt at the center of the Great and Little Lakes indicates that the Great Lake was very early on already separated into two distinct parts (figure 11). These narrow central zones of deep silt deposits follow the northwest / southeast axis of the Lake.

A second sedimentary zone is found in the region of Tonle Chhmar, a vast marsh on the eastern side of the Great Lake which partially cuts the Great Lake off from the Little Lake, as well as in the area north along the Lake shore to the village of Kompong Khleang. In the marsh, one finds a huge area of sedimentation in which silt depths exceed five meters in some places. In this zone, the top layer of silt lies below sea level. One must therefore imagine that this zone has undergone a progressive sinking during the period in which the silt was deposited. Today the region appears to function as a trap for sediment. The rest of the Great Lake generally has depths of silt of less than one meter. Sonar equipment has allowed us not only to map the surface of this recent silt

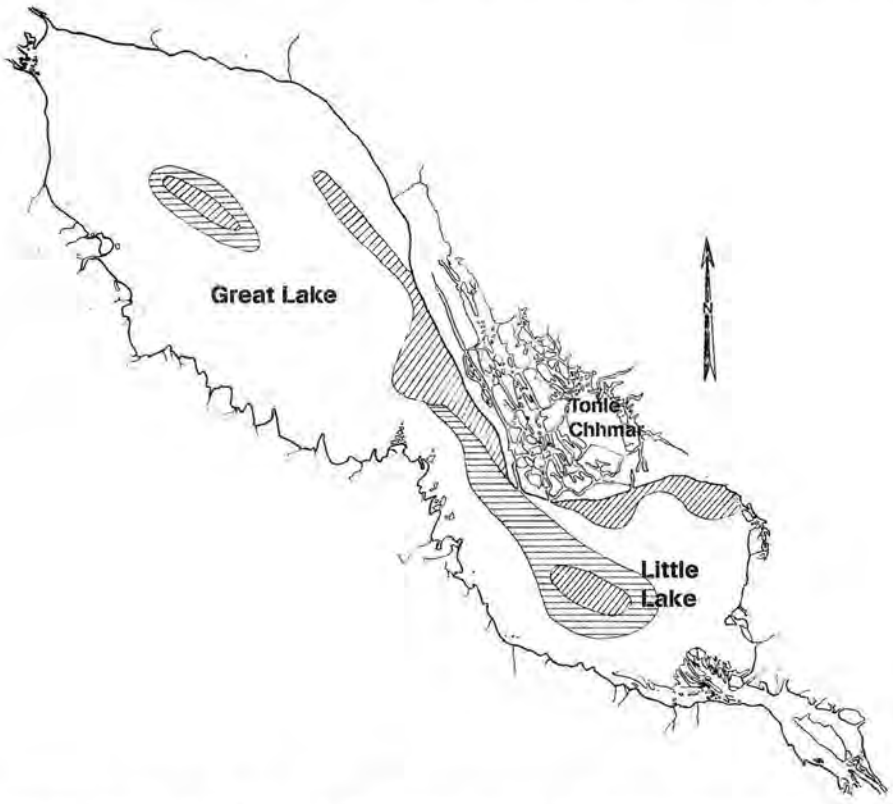


Figure 11: *Basin of the Great Lake. White areas have silting of less than one meter in depth. Areas with horizontal lines have silting between one and two meters, and areas with diagonal lines have silt deposits of more than 2 meters.*

layer but also to study its underlying layer of ancient silt deposits. It seems that the recent silt layer found on the Great Lake bed uniformly fills in an ancient topography whose surface was scored by erosion. This underlying ancient topography forms a fluvial depression, a kind of valley or river bed 250 meters wide, which runs down the center of the Great Lake bed. Today this valley is covered by seven to eight meters of sedimentary deposit. The lowest part of this fluvial depression lies at 12.7 meters below sea level. Either this depression was hollowed out in the course of the regression of the sea, or the region sunk after its emergence from the sea.

Archaeology: The origin of the Khmers

Human inhabitation developed on the terrain structured by the geological formations described above. Archaeological evidence indicates that the plain of Siem Reap was inhabited by human beings many centuries before the establishment of the civilisation of Angkor, and well before the introduction of Brahmanic culture to the Indochinese peninsula. At the very latest, it is estimated that the plain of Siem Reap was inhabited by the first century BCE. At the site of Roluos, for example, several prehistoric mounds have been found emerging from and connected to waterways. According to B.P. Groslier, these mounds:

> are rare but typical traces of the same type as those of the culture of Samrong Sen (dating from 1200 BCE). At the foot of Phnom Bakheng, and in the surroundings of Baksei Chamkrong, important Iron Age settlements have also been found dating from the same chronological period as the prehistoric mounds at Roluos and appearing to be of the same culture.[8]

Where did the prehistoric inhabitants come from and what was the extent of the geographical area which they inhabited? Patterns of settlement and early

[8] Groslier, B.P. "La cité hydraulique angkorienne : exploitation ou sur exploitation du sol?" in *BEFEO*, LXVI. 1979, p.165.

forms of inhabitation are well described in a recent account offered by Michael Vickery in his *Society, Economics and Politics in Pre-Angkor Cambodia: the 7th-8th Centuries* (1998) which I summarize here. Vickery claims that communities organised into "supra-villages", with populations of 500 to 2,000 persons, developed in the present-day regions of Thailand, Cambodia and Vietnam during the prehistorical period. These communities developed social stratification, establishing hierarchies between leaders and the general population. Communities in the interior began to exchange valuables and rare commodities, while coastal communities developed ship construction skills which allowed them to sail as far as India.

Funan

Funan was the first "supra-village" known to have been located in the region inhabited by the Khmer. The Kingdom of Funan seems to have centered on the southern coast of Cambodia in the zone adjacent to Vietnam. The Kingdom extended along the coast, perhaps even into what is today southeastern Thailand. Funan probably controlled the coast of the South China Sea as well as the estuaries of the rivers found on the plains of present-day south and central Cambodia. Funan was therefore a crucial link in the commercial routes linking China, Southeast Asia, and India.

Funan was probably neither a unified political entity nor an empire. Rather it seems to have been a group of allied ports, similar to those which constituted Srivijaya. Funan was certainly already a structured society with a population practicing advanced techniques of controlling water and growing rice. Because of an absence of local written sources (with the exception of some Sanskrit sources), the ethnic identity of the local population of Funan is unknown but could have been Khmer, Cham, Mon, or mixed Mon-Khmer groups. The use of Khmer language expanded greatly at the beginning of the 7th century,

although the assimilation of certain Austronesian terms in old Khmer strongly suggest that Khmer speaking peoples had already settled in southern Cambodia during prehistoric times. Although Oc-Eo was an important port of Funan, Chinese reports note that the capital of Funan was in the interior of the country, very probably at Angkor Borei. The name given to this capital in Chinese records, "T'e-mu", has not yet be connected to any local name, although Vyadhapura (Ba Phnom) can be ruled out as the site of the capital of Funan.

Perhaps because of the growing demand in China for products coming from or acquired in Southeast Asia, Funan rapidly expanded to become a commercial maritime power. The Chinese demanded products which came either from India or from even further west, and for this reason the merchants of Funan increasingly established relations with India. Steadily increasing wealth through trade led to greater social stratification and the development of a more complex society. This expansion and social development perhaps led to Funan's attempts to exert greater control inland, or at least to procure more inland products such as ivory which trade with China demanded.

The leaders of Funan carried the Mon-Khmer title "pon" although some took Indian names with the suffix "varman" attached. A "pon" was the chief of a large village or a "supra-village" housing several hundred to two thousand people. Villages were generally located on or near a pond which was sometimes man-made. Such settlements were capable of growing at least as much rice as was needed for self-sufficiency. Certain settlements had several "pon", each heading a community the size of a hamlet, with a head chief ruling the settlement as a whole. Each community ruled by a "pon" regarded itself as a clan which worshipped its own gods. The "pon" was considered the representative and purported descendent of these divinities. The rank of "pon" was inherited matrilineally and there was an informal hierarchy amongst the

"pon" themselves, based on their wealth and political influence. At its height, Funan accumulated most of its riches through the lucrative maritime trade of its coastal settlements. The "pon" of these coastal settlements were called "Kings" in Chinese accounts.

Trade relations with India fostered an interest in the religions of India. During the first five centuries of the Common Era, both Hindu and Buddhist elements were adopted and adapted in Funan. By the 5th century CE at the latest, the most powerful "pons" had declared themselves Kings, adopting Indian names and titles in the process. By the 7th century CE, even ordinary "pon" were using Indian names although this practice was still probably relatively new since, particularly at the beginning of the century, there were still "pon" with indigenous Khmer names as well.

Chenla

During the 6th and 7th centuries, maritime traffic between China, Southeast Asia and India began to shift from existing routes skirting the coasts to more direct routes across the South China Sea from Indonesia to Southern China and Northern Vietnam. Since Funan depended heavily on maritime trade, its fortunes began to wane, and power shifted to a new entity called "Chenla" in Chinese accounts.

Remaining inscriptions indicate that, at the time of the decline of Funan, the heart of Chenla lay in an area stretching along a north / south axis from Ba Phnom to Kompong Thom. Initially, the territory of Chenla probably did not extend far to the east but included the Mekong and the Tonle Sap River valleys while extending across these rivers to Kompong Speu, Takeo, and Kampot in the south. When Funan was still a prosperous maritime power, the leaders of Chenla might have had direct connection to, or even been part of, the ruling

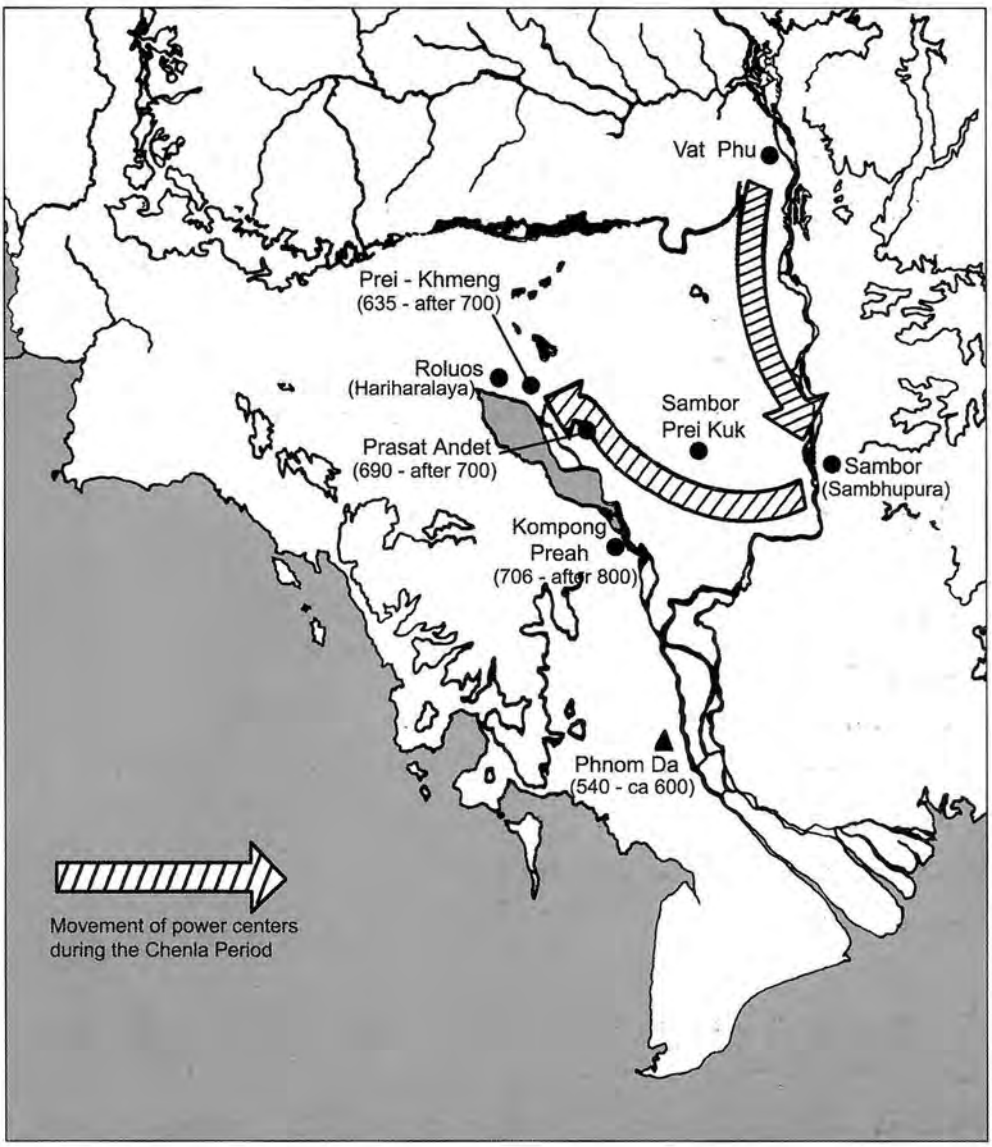


Figure 12: *Chenla*

class of Funan. They were not, however, completely dependent on maritime commerce and increasingly their sources of power stemmed from the inland control of territory and people. A rivalry emerged between the developing Chenla and the established empire of Funan, particularly as coastal Funan attempted to extend into the interior, and interior ruling groups attempted to gain control of coastal zones.

During the last decades of the 6th century, some rulers of Funan organised expeditions towards the north. These expeditions could have been spurred by Funan's quest for commercial products, or by the need to claim more territory and subjects as the maritime role of the Kingdom declined. The expeditions are known today because of the short inscriptions which Bhavavarman I and his son Citrasena - Mahendravarman left behind. These inscriptions describe conquests both to the north and to the south of the Dangrek mountains, from Kratie in the east to Ta Phraya in the west. In the end both Bhavavarman and Mahendravarman established themselves in the area of Kompong Thom, the first at Bhavapura, and the second close by in Sambor Prei Kuk. The city which Mahendravarman founded came to be called Isanapura during the reign of his son, Isanavarman. Isanavarman controlled two regions which were somewhat more distant as well. One region under his control was located on the south coast in the present-day province of Kampot (an area which had once been without doubt a part of Funan); the other region under his control lay to the northwest in present-day Thailand in the district of Ta Phraya. Inscriptions noting the name Isanavarman have been found in Takeo, Prey Veng, Kompong Cham and Kandal Provinces as well, although this does not necessarily prove his sovereignty over the region. In all, seventeen people are named in these inscriptions with titles that could indicate that they were "kings", "queens", or at least "ruling chiefs" during this period. More local inscriptions remain from the 7th century than from the earlier centuries. These

inscriptions offer accounts notably different from those written by Chinese travelers in the preceding centuries. Although resonances and connections can be made between Chinese accounts and Khmer inscriptions, the Khmer inscriptions present Cambodia from a different point of view.

Some Chinese accounts claim that the Kingdom of Chenla conquered its ruling state, Funan, and that this conquest was completed by Isanavarman. In these accounts, the last King of Funan is named Rudravarman, a fact corroborated by local inscriptions dating to the 7th century. It is possible, however, that rather than a political conquest there was a political continuity from Rudravarman to the family of Isanavarman. What the Chinese call a "conquest" could simply have been a transfer of power, representing the shift from an existing pattern of coastal settlement towards inland settlements which came to be considered more advantageous in terms of the accumulation of wealth. Inscriptions suggest that certain chiefs and kings transferred their interests towards the interior at this time. Such large scale population shifts could have been accompanied by some violence.

By the beginning of the 7th century, the center of political power had definitively shifted from the coastal regions to the interior, where the emerging economy was based more on agriculture than on maritime commerce. The ethnic identity of the population of Chenla was dominated by the Khmer, a fact confirmed by the almost exclusive use of Khmer in surviving inscriptions. Chenla was probably a confederation, or group of communities, governed by "pon" whose power was based on the control of territory and people, drawing wealth from agriculture and land-based inter-community exchanges rather than maritime activity. The shift towards a civilisation based on inland agriculture marks the beginning of the development of the Angkorian state which would dominate vast stretches of interior Southeast Asia from the 9th to the 14th centuries.

The Hydraulic Cities of Angkor

B.P. Groslier has described hydraulic cities as based on a highly productive system of irrigation carefully adapted to the region in which they were established. "Baray" (or large reservoirs) ensured the optimal storage of water for cultivating rice: "from an altitude as high as possible, [they] distributed with the help of gravity the maximum amount of water onto a large surface organised into permanent rice fields".[9] The "baray" filled through the monsoon rains (June to October) and the accompanying flood of the rivers; rice planted during the dry season (that is, with sowing and transplanting in September and October, and harvest in January and February) then made full use of the water stored in the "baray". If the monsoon season brought little rain or was too short, the "baray" along with the Great Lake still allowed for the rice fields to be filled with water when necessary. Thus even if the irrigation system tied to the hydraulic city did not always permit two (or even three) harvests, it still could guarantee at least one harvest of rice per season, thus overcoming unforeseen variations in climate.

Very little is actually known about urban orgnanisation at Angkor. B.P. Groslier describes a mix of urban and rural elements harmonized in a sort of "agrarian city" with rice fields adjacent to the city, if not actually within it. It was not, in fact, until the very end of the Angkorian era that the city was delimited as such by an enclosing wall. I have elaborated on some of these issues in my previous book, *Les Cités Khmères anciennes* (*The Ancient Khmer Cities*).

The decline of the system

Many historians have tried to explain the decline of the civilisation of Angkor. Here I discuss two hypotheses regarding its decline. The first searches for

[9] Groslier, B. P. "La cité hydraulique angkorienne : exploitation ou sur exploitation du sol ?" in *BEFEO*, LXVI. 1979, p.187.

possible reasons for the decline of Angkor in the geological movement of the tectonic plate of the basin of the Great Lake which could, in the end, have disturbed the water supply system of the region. The second hypothesis seeks causes for the decline of Angkor in "vices of the structure" which were inherent in the hydraulic system used at Angkor from the moment it was established, and which in the end caused the general blockage of the system.

1. Geological Movement

The first hypothesis is that proposed by Dr. Heng L. Thung in the SPAFA Journal #9 (January - April 1999). Dr. Thung assumes that the location of Angkor was determined by the availability of a permanent water supply for everyday consumption as well as for irrigation. Any interruption to this supply would have been fatal to Angkor. As Dr. Thung puts it:

> Angkor might have been condemned, even before it was constructed, by a slow geological movement which led to a change in the slope of rivers and their beds, rendering the huge Khmer water reservoirs unusable. Over the centuries, the slow, level and meandering rivers which fed these reservoirs changed their profile and their course. The city depended on reservoirs for its water supply during the dry season which coincided with the retreat of the flood waters of the Lake.

Some contemporary evidence supports this theory. The use of satellite radar imagery has allowed researchers to observe the region of Angkor as a whole and has illuminated different characteristics of the ground. Researchers have discovered signs of a geological movement prior to which rivers flowed more slowly. In the area north of Angkor, the change in the course of the rivers indicates that movements of the earth crust forced these geologically ancient rivers to change their form and to flow much less slowly and with fewer meanders than previously. The increased flow of the rivers in turn led to increased erosion of their beds. Dr. Thung's hypothesis thus suggests that rivers

began to run faster because geological movements caused a greater incline to the terrain as a whole.

Physical evidence for such movements can be found in the landscape of the present. The Siem Reap River was constructed artificially to provide water to the moats of Angkor Wat. The river was approximately two to two-and-a-half meters deep when it was dug, probably during the reign of Rajendravarman (944-968 CE). An ancient stone bridge, with a foundation two-and-a-half meters below the water surface, attests to this probable depth. However, the upper Siem Reap River bed at present lies about six meters below the surface (or four meters lower than its original depth) due to erosion, leveling slowly to the original depth of two meters south of the city of Siem Reap. The intakes to the "baray" were originally two meters below the surface, thus matching the original water level of the man-made Siem Reap River. The sinking of the stream bed, accompanied by lower water levels during the dry season, has rendered the intakes to the reservoirs useless as the water level diminished. Aerial views taken by the Cambodian Geological Department in 1998 have shown that such movements are part of relatively recent geological activities affecting the basin of the Great Lake. Preliminary analysis of these views has revealed that, as the entire region sinks, the northwestern part of the basin sinks less than the southern section. Therefore the Lake basin begins to slant towards the south where large pockets of flooded forests have been created.

Analysis of natural water systems in the region confirm these geological movements. To the northwest, the Sangker River springs from Phnom Tadet in the Cardamom Mountains as does the Mongkol Borei River which joins the Sangker River downstream. Farther west, the Mongkol Borei River is joined by the Sisophon, Svay Chek, and Sreng Rivers, all of which originate in the Dangrek Mountains. It is likely that this remarkable confluence of small rivers

resulted from the retreat of the Lake towards the east. Earlier, the Great Lake certainly spread up through the area of Mongkol Borei and Sisophon, and even today, at high flood levels, the waters of the Great Lake can reach into this area.

2. Vices of the Structure

A second theory explaining the decline of Angkor has been proposed by B.P. Groslier who noted that, "the hydraulic city which appeared at the end of the 9th century on the plain of Siem Reap was the essential motor for development of the region. A remarkable creation, in constant expansion until the end of the 11th century, the hydraulic city seems then to have become blocked and ended in a kind of impasse".[10] Groslier proposes inherent structural problems in the model of the hydraulic city which he enumerates as follows.

A. Deforestation

In methodically extending their rice fields towards Phnom Kulen, the Khmers necessarily deforested large areas of land. The effects of this deforestation, especially on the hills and higher elevations which served as water reservoirs, are well known. Initial rivulets washed away portions of the soil while the remaining soil became compacted. Gullies then formed and large scale erosion of the soil followed. Large areas of bare earth led to a decrease in convection rains once caused by water evaporation from areas of foliage. With less rain, the level of the water table decreased.

B. Siltation

The hydraulic system of Angkor depended on gravity. In a flat country where rivers without a strong current are themselves fed by slow and turbid streams, the waterways inevitably silted up. In the moats, the rate of siltation seems to

[10] Groslier, B.P. "La cité hydraulique angkorienne : exploitation ou sur exploitation du sol?" in *BEFEO*, LXVI. 1979, p.197.

have been about 2-3 millimeters per year. The Western Baray silted at a rate of 0.3 meters per century from the middle of the 11th century to the middle of the 14th century CE; this rate of siltation increased to one meter per century during the post-Angkorian period.

C. Siltation of the Lake

Ongoing natural sedimentation in the Lake necessarily, if insidiously, modified the mouths of the rivers. Today the Siem Reap River flows at least two meters lower than the intended entrances to all known Angkorian waterworks due to erosion. This indicates the degree to which siltation has changed the relation of the Lake to the rivers flowing into it.

D. Decrease in the water table

Linked to the changes described above are modifications in the ground water level which has dropped 0.7 meters. As long as irrigation was assured and the water level remained sufficiently high and constant, mineral exchanges through the soil were minimal and clay remained below the surface. When the river was dry during the hot season, the ground water level decreased and evaporation brought particles of clay to the surface. Little by little, the arable layer of earth filled with iron and thus was rendered fallow and unusable.

E. Malaria

The stagnant waters of the large reservoirs generally became excellent breeding grounds for mosquitoes which then devastated local populations with malaria.

The Angkorian hydraulic city was a system of using space which was remarkably adapted to the terrain of its area. In the end, however, it might have been a system of over-exploitation. Most experts today consider any possible over-exploitation as reversible. I am convinced that the Angkorian system for

the management of water, although it has been left in a state of disuse for more than five centuries, can still be made productive and should be rehabilitated.

The hydraulic system of Angkor was never totally abandoned by local inhabitants, although the system saw less use since the region as a whole became much more sparsely populated in the interceding centuries. At the beginning of the 20th century, the Western Baray - one of the great man-made Angkorian reservoirs measuring 8 kilometers by 1.5 kilometers - was still filled with water in its eastern section and was being used to irrigate the low plains. An effort to restore the Angkorian hydraulic system was set in motion in 1932-33 by the Ecole Française d'Extrême-Orient (EFEO). This restoration effort was primarily motivated by archaeological desires to restore Angkor to its original state. Knowledge of the hydraulic system as a whole was greatly advanced when one of the archaeologists working at Angkor, Goloubew, began to take aerial photographs of the area. The project to restore the hydraulic system of Angkor was pursued in several stages (figure 13). In 1937, the dam on the Siem Reap River known as Prasat Keo at Khnat was rebuilt to regulate the amount of river water flowing into the moat of Angkor Thom. In 1939, a supply canal was cut from the Siem Reap River to the Western Baray. In 1940, silt was removed from the Western Baray and the mouth of the supply canal feeding the Baray was improved. During the 1940s, canals leaving the Western Baray were cleaned and repaired. Between 1953 and 1959, the dam at Prasat Keo was once again reconstructed and a large canal was built draining from the Western Baray. A series of wells were drilled along this drainage canal. By 1959, a road had been built on the crest of the dike surrounding the Western Baray.

All of these efforts, largely undertaken through the initiative of the EFEO, were aimed to restore and reactivate the hydraulic system for archaeological rather than contemporary water use reasons. The irrigation network completed

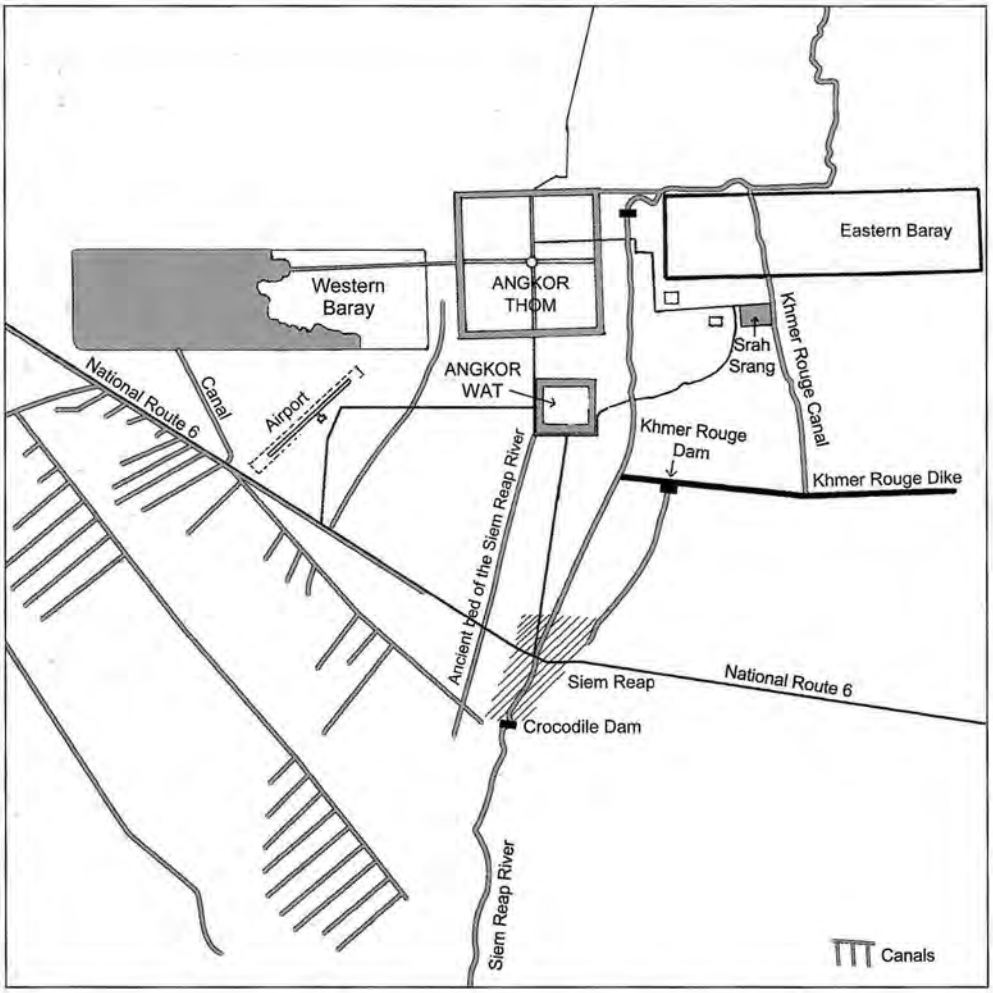


Figure 13: *The Angkor Region with canals and waterways*

in 1959 did, however, provide local residents with a 13,000 square hectare area of dikes, dams, and canals. More than 2,500 farming families made use of this system with an average allotment of land estimated at 4 hectares per family. Today, priority should be given to the restoration and expansion of this irrigation network which remains perfectly functional. Part of the revenues generated by tourism at Angkor should be used to rehabilitate portions of the hydraulic works of Angkor.

The amount of water stored in the Western Baray must be increased. Raising the water level by one meter in the reservoir means that 15 million additional cubic meters of water will be available for use. The Western Baray has the capacity to store 56 million cubic meters of water and could irrigate more than 11,000 hectares of rice fields, allowing for at least two rice harvests per year. In addition to the continued restoration of the hydraulic system of the Western Baray, other necessary projects must address the water supply system of the Siem Reap area as a whole. The Siem Reap River needs to be rehabilitated in its entirety from Kulen to the Great Lake. Protected zones must be established and enforced on both sides of the river. The incline of the river should be modified to make a series of water gates, a process which might mean encasing the river bed in concrete. This succession of levels or locks will allow for both, a higher river level in general as well as higher water levels further up the river. The canal dug during the Khmer Rouge period from the Prasat Keo Dam towards Srah Srang needs to be reconsidered. The Northern Baray should be filled with storage water during the rainy season and then used to maintain the levels of the Siem Reap River during the dry season. The moats of Angkor Thom and Angkor Wat should also be filled completely in order to keep general water levels in the region higher, thus offsetting the effects of the general geological subsiding described earlier. Given the considerable evaporation found in large surfaces of water, it does not seem economical to

build more water reservoirs (as is being done in northern Thailand). Rather, I suggest that existing Angkorian water storage basins such as the Western and Northern Baray as well as Srah Srang be filled in order to dramatically increase the amount of water stored in the Angkor region. During the dry season, water released methodically from these reservoirs will allow the level of the Siem Reap River and the water table as a whole to remain at a higher level than at present.

If the hydraulic system of Angkor should be restored and reutilised, then what actions can be taken to prevent the dangers of geological movement and systemic collapse outlined above? Few immediate measures are at our disposal. We can, however, propose some counter measures to the vices of the system outlined by Groslier. These counter measures include reforestation of the Kulens as well as the preservation of the remaining Forest of the Temples; restoration of the reservoirs, lakes, and ponds; restoration and protection of an adequate ground water level; and anti-erosion measures along the rivers. Measures should also be taken to stop excess siltation in the Great Lake, and navigation channels should be dredged and kept open in it. Most importantly, ambitious development plans which risk destroying the already precarious ecological equilibrium of the region (for example, the project to dam the Great Lake proposed by the Mekong Commission in 1964) should be dropped.

The Great Lake is the largest freshwater lake in Southeast Asia. It covers 250,000 hectares during the dry season and expands to cover 1.25 million hectares (five times its area) during the flood season. The vast saturated area which results from this annual expansion shelters a very high level of biodiversity which includes more than fifty species of fish and 250 species of water fowl as well as a large number of flora of all kinds. The Lake is one of the most productive breeding grounds for fish in the world. However, because of its economic value, there is great pressure to develop and overexploit the

natural resources of the Great Lake. The bogs and flooded forests along the lake shore are being progressively destroyed, primarily due to the conversion of forests into rice fields. Siltation is rapidly increasing due to the deforestation of the entire basin of the Great Lake. The Great Lake is also endangered by the geological movements described above. A shift in the entire basin of the Great Lake could provoke dramatic changes in the environment, accelerating the rate of degradation already noticeable today.[11]

We should think of the Great Lake as part of a hydraulic network which includes the Lake, the Tonle Sap River, the zone of Veal Phok, the sill of Kompong Chhnang, and the zone of the "Four Faces" around Phnom Penh. This interconnected water system is subjected to intense sedimentation which is aggravated and increased through human activities. If no action is taken to remedy silting, the Lake and its hydraulic network will be considerably reduced in volume and flow, a change which will provoke crisis at the end of each dry season. Siltation will make navigation on the Great Lake more and more difficult as the Lake becomes more shallow. Eventually, the Great Lake could be transformed into a series of smaller separate lakes.

A third problem critical to the Great Lake and its hydraulic network concerns the phenomena of warming. Sedimentation might reach such levels that the usual passages used by migrating fish become blocked. The rising of the bottom of the Lake can provoke, during extreme dry seasons, a noticeable rise in the temperature of the water of the Lake, thus threatening the fish. It has already been noted that, given the present rate of sedimentation, the migrations of certain species of fish have been obstructed, limiting their aquatic habitat and reducing their breeding capacity. The number of species of fish and birds found in the Great Lake area in general is declining.

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[11] See Chapter Two in *Angkor: a manual for the Past, Present and Future*. APSARA, 1996.

In response to these threats, the Great Lake has been classified as a Multiple Use Site by a Royal Decree on the Protection of Natural Sites signed in 1993. In October 1997, at the request of the Royal Government of Cambodia, UNESCO inscribed the Great Lake as a Reserve of the Biosphere in the World Network of Biosphere Reserves.

Environment

When planning for the future of the Angkor / Great Lake region in general, it is important to consider the environment of the region today, and then to administer and protect the land, taking into consideration its particular characteristics as well as the constructions and habitations already established on it. Here I sketch a brief portrait of the region of the Great Lake before discussing the future management of the site of Angkor and the town of Siem Reap in more detail.

The Great Lake is surrounded by plains. To the west, in the area of Battambang, the plain extends to an average width of 80 kilometers, while to the east, near Kompong Thom, the plain surrounding the Lake stretches to an average width of 60 kilometers. To the north and south of the Lake, the plain is narrower, reaching only widths of about 30 kilometers (around Siem Reap to the north and near Bakan and Pursat to the south).

The flood plain to the west and south of the Great Lake generally follows the line of Sisophon - Battambang - Pursat - Kompong Chhnang as roughly outlined by National Route 5. Around Moung Russey and Pursat, local flooding extends south of National Route 5, which is submerged every year. To the north of the Lake, the flood plain stretches up to National Route 6 between Sisophon and Kralanh. Between Puok and Kompong Thom (with the notable exception of the area of Stoung), the flood waters of the Lake remain

well to the south of National Route 6, while to the south of Kompong Thom, flood waters reach up to National Route 6. Without the construction of the national highways, which are elevated on dikes, the flood waters would spread much further. The foundations of these highways date to the Angkorian period. We can see on a contemporary map that the arching oval traced by National Routes 5 and 6 around the Great Lake limits the expansion of the Great Lake's waters during the flood season (figure 14).

The plain of the Great Lake is clearly different from the plain of the "Four Faces" around Phnom Penh. The main difference is the density of population which, on the plain of the Great Lake, is still less than 30 to 40 inhabitants per square kilometer. While the zone was once very densely populated during the Angkorian period, the plain of the Great Lake today is, with rare exceptions like Siem Reap, quite underpopulated. Considerable surfaces are covered with forest scrub and "veal"(fields).

The Region of Battambang

The area around Battambang (Srok Mongkol Borei, Battambang, Sangker and part of Moung Russey) is characterised by low plains on which flood waters spread widely, hemmed in only by National Route 5. Brown soil, clay, and deep alluvial deposits are rich in chemicals, notably lime, which come from a limestone massif marked by the hills of Phnom Sampou, Phnom Krapoeu, Phnom Tauch, and Phnom Sisophon. Trees and bushes fill the flooded sections of the area, while savannas and forests line areas of the Lake that do not flood. Huge uncultivated areas remain, although the region also contains the largest area of rice fields presently under cultivation in Cambodia (160,000 hectares).

The region was surely quite heavily populated at the time of Angkor, and ruins from the time are found at Wat Ek, Wat Proul, Prasat Ang, and Sneng. Aerial

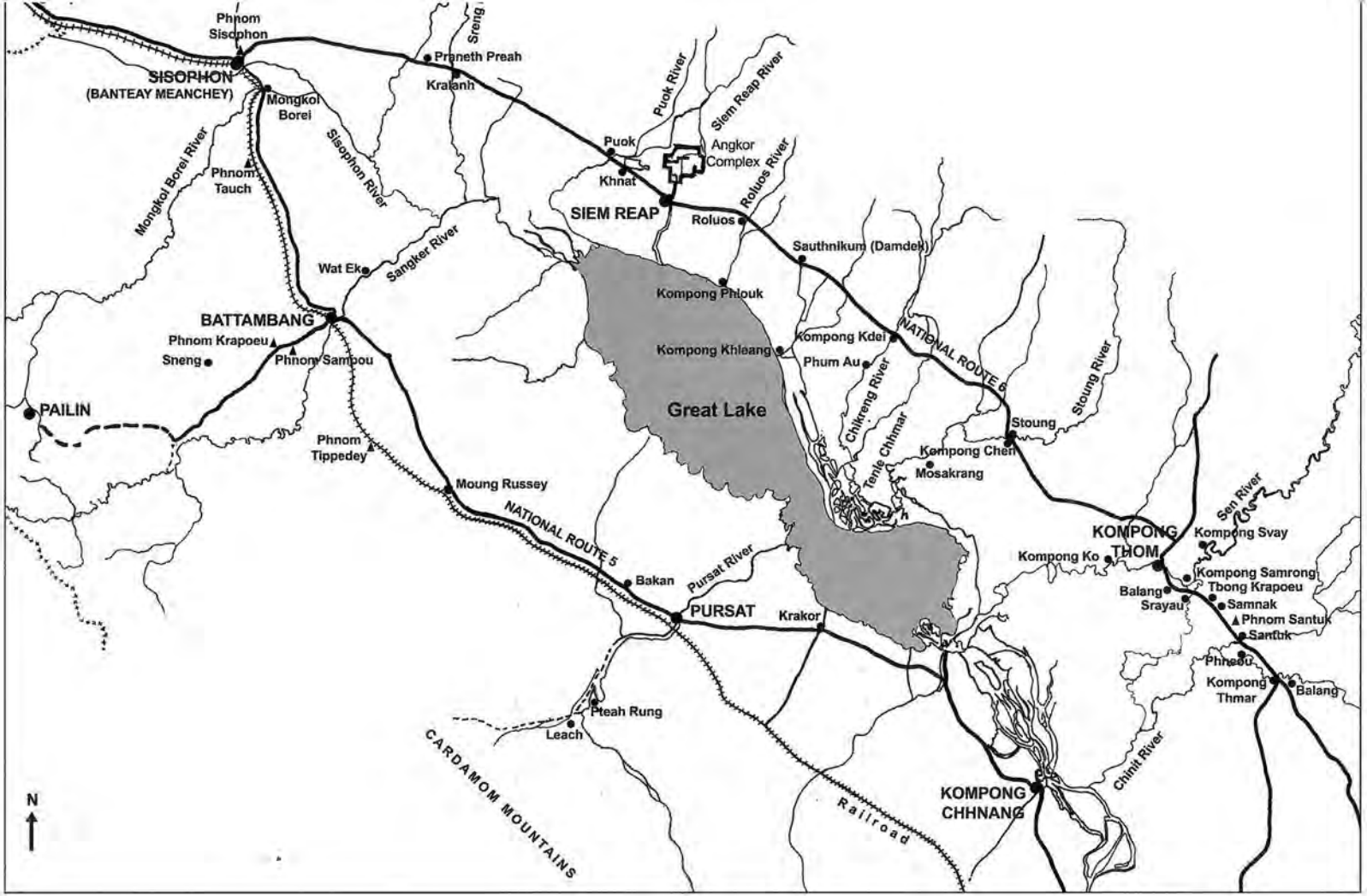

Figure 14: *The Great Lake Region*

photographs show traces of ancient agricultural activity (the reservoir at the northern base of Phnom Tippedey) and it is not inconceivable that Battambang was the granary for Angkor. Most rice fields in the area were abandoned after the fall of Angkor however and the area is described as largely unpopulated in late 19th century accounts, with plains unused and covered with scrub and forests.[12]

The return of Khmer peasants to the great plains between Battambang and Mongkol Borei dates to 1925. Following more than a century of Siamese control, the region of Battambang was returned to the control of the French Protectorate over Cambodia in 1907. The peasants who settled the region of Battambang in the late 1920s and 1930s were migrants from southern areas of Cambodia who came to work for salaries, eventually settling permanently in the area and becoming landowners. A part of the migrants also came from Cochinchina. These "Khmer Krom" began to arrive in 1926, and their movement was encouraged between 1930 and 1934 by Protectorate policies which provided them with new tools and clothing upon their arrival. It is due to this policy of resettlement that areas of Battambang Province today have large populations with family ties to "Kampuchea Krom" (the southern Mekong Delta in present-day Vietnam). The new inhabitants came primarily from the west and south of Cochinchina, especially from the areas around Soc Trang and Tra Vinh.[13]

The recultivation of land in the Battambang area was accomplished in part by the founding of great estates which made use of tenant farmers and salaried labor. The use of salaried labor was frequent since an area of more than five hectares could not be fully exploited using only the labor of a single family unit.

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12 See J.Delvert. *Le Paysan Cambodgien.* L'Harmattan, 1994.

13 See J.Delvert. *Le Paysan Cambodgien.* L'Harmattan, 1994.

In the Battambang region, especially between Mongkol Borei and Battambang, the large estates were generally not owned by local inhabitants, but instead were the property of government officials or businessmen of Chinese origin. Even if land was not actually cultivated, it had almost all been judicially appropriated to owners by the 1920s and 1930s. The region of Battambang was once again turned over to Siamese control during World War II from 1941 to 1946. Battambang returned to Franco-Cambodian control on December 9, 1946.

The Region of Pursat

The region of Pursat has much poorer soil than that of Battambang. The edge of the Great Lake is quite close to the first hills leading to the Cardamom Mountains (37 kilometers from the edge of the Lake), leaving narrow alluvial plains and then elevated sandy terrain relatively close to the shores of the Lake. The region is scored by rivers flowing down from the Cardamom Mountains, and some forests of "tbeng" trees are found as well as large areas of scrub. The Pursat area is ravaged each year by the violent floods of the Pursat River. Rice cultivation using receding flood waters is practiced throughout the region. Cultivation of rice during the dry season is limited. Cultivated land in the region of Pursat (from Bakan to Krakor) does not surpass 40,000 hectares. Cattle raising is an important agricultural activity in this area.

The Pursat River, sometimes called the "Kbal Pram", is one of the bigger rivers in Cambodia. It does not play as important a role in the life of local inhabitants as, for example, the Siem Reap River or the Sangker River. In all the districts which it traverses, the cultivation of rice (primarily rice grown using receding flood waters, although some floating rice cultivation occurs as well) remains the principal activity. The district of Pteah Rung, upstream in a forested area, is an exception. Here vegetable fields cover 360 hectares, while rice fields cover 745 hectares. Orange orchards dot the region and oranges are

such a traditional crop of this area that Cambodians often call the fruit "Pursat Oranges". Orchards are scattered throughout the forests and scrub where the soil is rich in phosphorus and nitrogen and thus suitable for orange trees.

The Region of Kompong Thom

Floodplains extend between the Chinit and Stoung Rivers around Kompong Thom. Near the Lake, these plains are covered with forests and grassy plains. The peasants in the region of Kompong Thom have sometimes cleared the flooded forest in order to settle and cultivate the land (for example at the village of Kompong Ko). They have also settled in parts of the grassy plains, although huge uncultivated areas remain as well. Above the flood plain, higher grassy plains are dotted with termite hills and thickets of bamboo; this area was once probably a forest which has become extremely degraded. Further inland still, there are dense forests.

People have not settled on the flood plains, but rather have built houses along the banks of the rivers (the village of Phneou on the Chinit River; the villages of Kompong Samrong, Balang, and Kompong Ko on the Sen River; the villages of Kompong Chen and Mosakrang on the Stoung River; and the village of Kompong Kdei on the Chikreng River). Houses and small settlements are also found on hillocks and at the foot of hills which do not flood (for example, the villages of Tbong Krapoeu, Samnak, and Santuk). Around their houses, villagers cultivate a quick-growing rice which they call "vossa". Flooded rice is also cultivated on low-lying plains in the region as well. Cultivation of flooded rice has a long tradition here, even though this type of rice has a longer growing season (the rice literally floats on the flood waters but is rooted in the earth below) which requires peasants to sow and transplant the rice in April. Floating rice farmers are thus absent from their homes, living in carts or temporary shelters during the period when this work is required. After

the harvest, the rice stalks (2-3 meters high) are left in the by then dry fields as feed for the cattle. Some weeks before the rains come, the peasants set fire to the harvested fields and the ash serves as fertiliser for the next year's planting. Harvested rice is brought home in carts.

The water buffalo is used as a draft animal in this region. Cows are more numerous than water buffalo however, and the area has favorable conditions for raising livestock. Pastures are abundant, and only a small part of their area is cultivated. Even rice fields are frequently left fallow for one or two years, increasing the extent of available pasture. Especially in the dry season around the lakes of the flooded forests, excellent pastures are found and entire villages move with their livestock to live in these field areas from February to April when they are not growing rice. The villagers also fish in the rivers and lakes during this time. The displacement of rice-growing villages towards the lakeside pastures from February to April of each year is one of the most characteristic social patterns of this region. Villages are almost abandoned during these months with the houses locked and the schools suspended.

The area of Srayau in Kompong Thom Province covers approximately 326 square kilometers. The soil in this area has large amounts of clay. The water table lies at 4 meters above sea level. Most of the eleven villages in this district are found south of National Route 6 on sandy hillocks that do not flood. These hillocks were probably once the ancient banks of the Sen River. Other villages are located along the banks of this river as well. The villages are surrounded by fruit trees while the rest of the land is uncultivated.

The population center of Kompong Svay has grown up in an area which was once fields. To the south, at Santuk, and to the west at Stoung, forests remain

and the exploitation of the forest is an important part of daily life. At Kompong Thmar and Balang, a part of the population lives from wood working and firewood sales as well as from the production of charcoal. Various hard woods as well as different types of bamboo are sent to market by raft down the Chinit River. Around Phnom Santuk, in an area covered with dense forests, clusters of hill villages are found; the people living here have rice and vegetable fields and also collect forest products.

To the west, in the districts of Stoung and Chikreng (districts administratively attached to Siem Reap), populated areas have developed in a dense forest and peasant life is intimately intermingled with the forest. The most evident example of this is in the district of Chikreng where the upper fields have been carved out of the forest by slash and burn techniques. Once these fields, usually circular in form, have been established, they almost always become permanent. They are cultivated for five to six years in succession after which the forest can no longer reconstitute itself.

The district of Chikreng lies along the Chikreng River on the border of Kompong Thom and Siem Reap Provinces towards Sauthnikum (Damdek). Most of the cultivated areas in this region are found along the banks of the river and around Phum Au where a small stream runs. Flooded rice cultivation is practiced and population movements are common in order to fish and tend to livestock from February to April. Some vegetable fields and orchards (mangoes and coconuts) are established along the river. Population density in the area is low (34 inhabitants per square kilometer). Rural life develops within a forest frame since the villages lie between the forests which flood and the dense higher forests which are more or less preserved. The forest dominates even larger population centers such as Kompong Kdei.

4. The Region of Siem Reap

The area of Sauthnikum, Siem Reap, and Puok, between the Chikreng River and the Puok River, is characterised by high sandy plains, found quite close to the Great Lake, which do not flood. The town of Siem Reap lies at an altitude of 20 meters above sea-level, 14 kilometers from the Great Lake. The flood plain leading to the town is quite narrow, at its widest stretching 6 kilometers in from the Great Lake.

Populations are found living on the high sandy plains of this area and in dense forests which cover some of the land. Soil conditions are poor and thus not particularly favorable for agriculture. The most common use of land is for small rice fields (the average size of a rice field in the district of Puok is 0.25 hectare). Fields in this area have scattered trees, bushes and termite hills, and are more-or-less surrounded by forest zones. It is a confused landscape, unorganised in appearance. Forest villages are numerous and their inhabitants live almost exclusively from exploiting the woods by collecting resins, oils, bamboo, and vines, as well as cutting wood for construction, woodworking, and firewood. The forest villages also maintain some higher fields converted from forest into rice paddies.

The slope of the flood plain is quite steep in this area, and therefore water rises quickly during the floods. The cultivation of floating rice is limited, and is not practiced at all south of the town of Siem Reap. Raising livestock is very important in this area and conditions are favorable for it on the fields and in the lakeside forests. These fields and flooded forests are close to the zone of habitation and thus eliminate any need to move animals long distances during the dry season. There is no need to travel to fish either since inhabitants live near fishing villages such as Kompong Khleang and Kompong Phlouk. These fishing villages are an important element of the region.

Large scale rice cultivation ended with the fall of Angkor and the dissolution of centralised power. Village life turned to the forest and to the raising of individual herds of livestock. Two types of post-Angkorian villages developed in this region: the low-lying villages on the cusp of the flooded zones where crops are grown (floating rice, receding water rice, and dry season irrigated rice) and herds of livestock are raised; and the "high" villages near the forests where receding water rice is grown along with vegetables and fruits, while wild fruits are picked and forests are also exploited.

The density of the population in the area of Sauthnikum, Siem Reap and Puok is quite high. The most beautiful and well kept orchards in Cambodia are found along the banks of the river at Sauthnikum (Damdek), the Roluos River, and the Siem Reap River. The settlement of this area seems to have followed ancient patterns of habitation. Because of the relative density of population, dry season rice fields extend along the basin of the Great Lake, irrigated by canals (in Siem Reap), by small reservoirs or "tomnup" (at Roluos), and since 1937 by water from the Western Baray at Khnat. The forest, the dry season rice, the river, and the fairly dense population characterise a region which once lay at the heart of Angkor.

The area to the west of Puok, towards Sisophon and Poipet, is one of the most desolate regions of Cambodia. National Route 6 cuts through the virtually empty area between Puok and Sisophon. Only scattered peasant settlements are found here. The natural conditions of the area do not differ much from the other regions described above, where a mix of fields, flooded forests, and higher dense forests are found. The fields here, particularly the low-lying fields under 20 meters above sea level, generally flood and have a very infertile sandy surface. The flood waters of the Great Lake can reach north of Kralanh, but these flood waters contain little alluvial soil due to deforestation and the

acidity of existing soils; deposits brought by the rivers coming from the Dangrek Mountains contain mostly sand. Only the southern most areas of this region are fertilised by the waters of the Great Lake, but these low-lying areas remain under up to 4 meters of water for long periods of time. Some hills have attracted inhabitants to their base and slopes (such as Praneth Preah and Phnom Sisophon). Besides these recent commercial centers, only the banks of the Sreng and Sisophon Rivers are inhabited.

Planning the Future of Angkor: Zoning the Environment

The landscape described above makes up the region of Angkor. Planning for the future of this region must consider the relationships and interconnections between different elements making up the environment of this area. Zoning regulations passed in 1994 aim primarily to protect the archaeological heritage of the region, although these zoning measures also took into consideration environmental concerns. These concerns should be further addressed by future regulations as well as stricter implementation of existing zoning regulations.

In 1994, the Bureau Arte Bceom engaged in a comprehensive study of the area, collecting soil samples, water samples, and drilling samples, analysing the groundwater table, studying traces of inhabitation, existing vegetation and topology, as well as engaging in archaeological research and the collection of satellite data. The Bceom analysis revealed a series of ecological zones in the area of Angkor which extend in broad bands out from the Great Lake. Each zone is characterised by particular soil compositions, temperature conditions, vegetation, and fauna. The following five distinct ecological zones have been identified by this study (figure 15).

The 1st ecological zone: Phnom Kulen and its surrounding hills

The chain of mountains which ring the plain of Siem Reap to the north are the

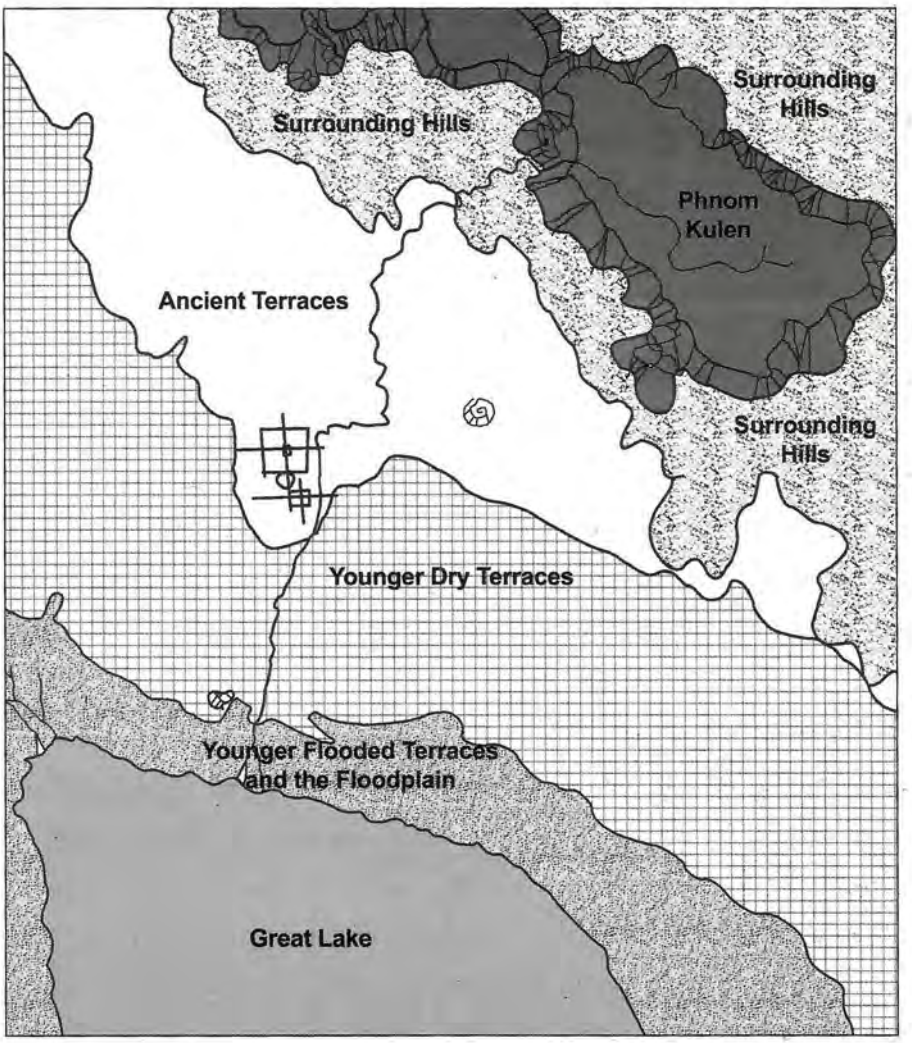

Figure 15: *Ecological Zones of Angkor*

first part of the ecological chain which makes up the region Angkor. These mountains are essential to the equilibrium of the region. Their dense and humid tropical forests are a primary source of nutrients and water for the plains below. The ancient Khmer were highly successful in transforming the plateau of Kulen into a vast water reservoir. They sculpted the beds of the rivers of Kulen with images of Brahmanic deities and linga, thus sanctifying the water which flowed from the mountains down to the plain. The area of Kulen should be given the highest degree of protection possible, while the lower surrounding hills should be afforded some degree of protection as well.

The 2nd ecological zone: The ancient terraces

The complex of Angkor was built in large part on the sandy soil of alluvial terraces composed of pre-glacial sedimentary deposits. These alluvial deposits have compressed to form the foundation on which the temples are constructed, providing a rich source of construction material for temple construction as well (laterites and clays). The complex of Angkor is built on a north-south axis following the Siem Reap River. The relation of water to man-made constructions is the central element of this ecological zone. Today it is once again necessary to rehabilitate the hydraulic system connecting the Western Baray to the Siem Reap River, and to reconsider the role of the canal dug during the Khmer Rouge regime which aimed to connect Srah Srang to this system as well. The Khmer Rouge regime built the so-called crocodile dam as well (figure 13); today this dam does not have a sufficient width nor enough sluices to avoid the river flooding the town if rains are very heavy. As noted above, the Northern Baray located in this ecological zone should be rehabilitated and the Neak Poan group should be restored. In addition to the archaeological interest of restoring water to the Northern Baray of Preah Khan, such a project could ensure approximately nine million cubic meters of

supplemental water. Such a supplemental water supply will help to raise the level of the Siem Reap River when it is at its lowest during the dry season.

3rd ecological unit: The younger dry terraces

Between the zone of the ancient terraces and a band of recent deposits found on the plain near the Lake, there is a band of alluvial deposits dating to the last glacial age. The town of Siem Reap is located in this zone. Portions of these younger terraces are sometimes flooded during the rainy season. As a zone adjacent to higher ground, this area is characterised by the rapid run-off of water from the monsoon rains, in contrast to fully flooded areas which receive sediments gradually through the slow recession and evaporation of still water. The soils in this area consists of sandy clays, muddy clays, and gravel. This area is therefore not very suitable for agricultural use. It is an area characterised by numerous termite mounds and hills. The areas of this zone which do not flood provide the best sites for urban construction and necessary infrastructure.

Within this zone, a Hotel City is being established which will accommodate large hotels of international standards (3 stars and up). A sub-decree of the 13th of October 1995 gave APSARA Authority an area of 560 hectares in which to organise and manage a Hotel City. A more recent sub-decree has enlarged this area to 1004 hectares. The location of the Hotel City does not conflict with protected archaeological zones nor does it take over agricultural or forest zones. Instead, the Hotel City is consciously planned for an area in which the soil does not allow for agricultural development. The new city will be designed to blend seamlessly into the surrounding environment. The network of roads and water systems necessary for development of the Hotel City will be designed following Angkorian models, and will improve the current landscape of the region while creating a coherence between the Hotel City and the Archaeological Park of Angkor.

4th ecological unit: The young flooded terraces

This zone, closer to the Lake, is completely flooded during the annual monsoons. The zone serves as a spill-over storage area for run-off water from the higher terraces, while also accommodating the highest flood waters of the Great Lake. After the lakeside marshes have become filled with both with the waters of the Great Lake and the waters coming from the Mekong River, the excess water floods onto these terraces. The hydraulic system of Angkor is thus included in a great area of interconnected waterways including those found on the plain of the "Four Faces" surrounding Phnom Penh as well as those found in closer proximity on the plain of the Great Lake. During the rainy season, this interconnected water system fills completely, resulting in a state of flooding that can last for up to five months. The water then begins to recede.

Soils in the zone of geologically young terraces near the Lake are rich in nutrients. Rice is planted continuously, and conditions allow for year round harvests. Overuse or misuse of the soil in this region can, however, lead to the gradual impoverishment of the soil and a drop in rice production. The ecosystem of this zone is complex, containing long standing systems of water management utilised by the Khmer to cultivate irrigated rice. This zone should be completely reserved for rice production.

5th ecological zone: The floodplain of the Great Lake

The plain directly adjacent to the Great Lake is flat with only slight elevations around the whole of the Great Lake. The Great Lake is not uniform in its cycles of flooding and its natural bank fluctuates greatly, creating an adjacent zone of varied vegetation with highly diversified species. The bank offers a great number of protective habitats and sources of nutrition. The flooded forests and thickets, as well as the marshes and pastures along the Lake, are the first source of nourishment for the fish of the Great Lake. The fish population of the Great Lake ranks among the densest and most diverse in the world.

This region must be left in its natural state and should be made into a large protected ecological reserve. Such a reserve will become the center for an eco-tourism that will come to compliment cultural tourism at the Archaeological Park of Angkor. The flooded forests of the Great Lake, like the forests around the temples, have suffered almost 70% destruction over the last few decades. The floodplain of the Great Lake must be rehabilitated and managed as an integral part of the larger basin of the Great Lake which is classified as a Reserve of the Biosphere.

Management of the monuments in three Ecological Management Zones

The temples of Angkor lie within the larger ecosystem described above. The region must be administered as a whole, even as the restoration and maintenance of individual temples continues. Since the beginning of the international campaign to preserve the temples of Angkor, I have pondered the options of restoration. Should Angkor be restored to its original state, that is, to the temples as they were when they were first constructed between the 9th and 13th centuries CE? Or should the monuments be restored to retain only those features of the site as it was when it was "re-discovered", that is to say, the state of the temples in the 19th century? Through a third option, should restoration work simply limit itself to simple tasks of maintenance which keep the temples in their present state?

I choose the first option while recognising that the restoration of the temples to the state they were in when they were originally constructed is a task which can only be partially realised over a long period of time. To follow such a restoration policy requires putting in action a comprehensive master plan for long term restoration which allows time to train local conservators, historians, archaeologists and architects. The necessary financial resources for such a project must also be found. The finances which Cambodia lacks at present must be generated by the temples themselves, that is through the development of high-end cultural tourism at the site of Angkor. Only the most famous and

striking temples will be restored to their original state. After their complete restoration, these temples will once again take on their religious function and Angkor will be a place of pilgrimage for the Khmer.

Numerous villages are found in the Archaeological Park of Angkor. Many of the inhabitants of these villages are employed in the work of restoring and maintaining the temples. In 1970, the populations inhabiting the slopes of Phnom Bakheng (then a strategic military post) were forcibly moved to an area north of Phum Thmei, adjoining the village of Siem Reap. In 1973, the Khmer Rouge halted all conservation work at the site of Angkor. During the Khmer Rouge period, the majority of the people living in the region, as long as they were considered "old people" (which is to say long-term resident farmers), were treated relatively well. Those who worked for the Conservation of Angkor, along with their families, were forcibly moved to Roluos in 1975. Like many of the country's population, they were considered "new people" needing "re-education" and they suffered greatly during the Khmer Rouge regime. After the Khmer Rouge regime, these workers along with the other local inhabitants of Angkor returned to their old homes. In 1986, authorities decided once again to move residents from the Park, but they have not been completely successful in these efforts.

I believe that we must try to manage the site of Angkor with its existing level of habitation. The presence of inhabitants is a challenge to site management at the same time that it prods us to ask whether Angkor should be a dead or living patrimony? Should Angkor be preserved as a museum city with no inhabitants? Or should it be kept as a living historical site which includes present-day villages with their inhabitants? I prefer this latter option. It is important if we follow the policy of a living patrimony to give precedence to recruiting inhabitants of villages close to the monuments to work on their maintenance. It is also

important to maintain constant dialogue with the monks of the Buddhist temples found within the Archaeological Park concerning their life and practices on the site.

The present landscape of Angkor is comprised of a dynamic mixture of natural elements, ancient monuments, waterways, and vegetation, all of which are woven into local patterns of use by inhabitants. The ground cover has been and continues to be modified by the activities of everyday living engaged in by local populations. The activities of organisations involved in conserving sites in the Angkor region, as well as the activities and facilities generated by tourism, continue to have a direct impact on ground cover as well.

The region of Angkor should be evaluated and then managed in terms of its existing vegetation, taking into consideration modifications to the ground cover which have already occurred. The least affected areas of the forest are those in which the native cover remains largely intact with a good number of trees of various ages and species as well as a variety of other plants, vines, and shrubs. The most modified areas of the region are those areas with the greatest population density and use: the monument sites, the villages, and the town of Siem Reap. In terms of quality of trees, diversity of species, and variety of ages, there remain only small areas of true forest in the region of Siem Reap, south of Phnom Kulen. The main remaining pockets of forests are found in the interior and around the walls of Angkor Thom in the so-called "Forest of the Temples". In ecological terms, as well as for the picturesque appearance of the site, this relatively limited area of forest is of great importance as it frames the site and defines the general character of the Archaeological Park.

Outside of this sparse remaining "Forest of the Temples", there are areas of modified forests and thickets, seasonal rice fields and pastures, as well as rice

fields which are more intensively cultivated. The landscape surrounding Angkor today is too often the result of disordered and unplanned activities springing up near important roads, waterways, inhabited areas and of course the monuments. The typical pattern of settlement in the region consists of a single row of houses lining each side of a road. Behind these houses, land is cultivated or lies unused.

In order to develop an efficient and practical policy for protecting and improving the environment of the Angkor / Siem Reap Region in general, as well as to institute the best possible land use, it is necessary to delimit zones and management areas which, while always responding to the needs of the monuments, also recognise existing forms of land use and land cover. This approach gives priority to fully protecting zones of high natural or cultural value. It also aims to improve vegetation and landscaping in areas which are presently degraded. Such rehabilitation efforts are necessary in order to protect what still remains of the natural vegetation while fostering areas of new forestation. Through the cultivation of new areas of forest and field, alternative resource areas will be established so that the use of areas of high conservation value will no longer be necessary.

The New Zealand based office of Boffa, Miskell, and Fraser Thomas have proposed three management zones in their report "The Landscape Management Areas". Zone A consists of actual sites of cultural patrimony as well as areas of remaining forests found in the Park. Zone B provides a mixed-use buffer zone of degraded areas of scrub and pasture used for agriculture and habitation. This zone will separate sites of cultural patrimony from increasingly urbanised areas, while preserving remains of ancient habitation and re-establishing certain traditional uses of land. Zone C is a larger zone of agricultural use, comprised primarily of irrigated rice fields and their associated

habitat, which includes the most productive agricultural areas to the south of the Angkor Park. To the north of the Park, Zone C consists of areas of rice fields and scrub mixed with secondary forest which become more dense closer to Phnom Kulen. Zone C contains archaeological sites and remains of ancient habitations as well, and some traditional land use is practiced in the area as well. I detail the management of each of these zones below.

Zone A: The Cultural Patrimony

Zone A includes all the major monuments of Angkor as well as the areas of forest remaining around the temples. Major cultural landscapes identified in zone A include Angkor Wat, Angkor Thom, Preah Khan and Ta Prohm. In addition, the zone contains substantial areas of secondary forest as well as areas of high scrub with scattered trees. Zone A also has small pockets of land used as pasture and rice fields.

The primary management objective for this zone is the protection of the monumental and natural patrimony found within it. Long-term management of the vegetation aims to conserve what remains of the forest while restoring a healthy, diverse, and sustainable cover of semi-dense large-leaf forests to the rest of the zone. It is of the utmost urgency to implement policies protecting the existing forest and to initiate substantial reforestation programs.

A careful study and evaluation of all areas currently under agricultural use within this zone should be undertaken. If present practices of harvesting wood and other local uses of the forests within this central zone of Angkor continue at their present rate, a significant portion of the remaining vegetation cover will be eliminated and the landscape of the central sites of Angkor will be radically altered. Agricultural practices in the zone must be limited to the seasonal growing of rice in the ancient moats, and to the collection of fruits, mushrooms,

medicinal plants and other natural products of the forest. The collection of all kinds of wood must be banned from this zone and, if any cutting or collection is authorised, it must be strictly controlled and overseen. All areas of degraded scrub in zone A must be revitalised and ideally reforested. Practical initiatives to restore the forest to at least a basic cover of trees in the largest possible portion of the zone should be encouraged. Substantial areas of secondary forest and scrub in the interior of zone A have been cut and then replanted with a limited number of species native to the forest (primarily *Dipterocarpus alatus* and *Hopea odorata*). These reforestation programs have been undertaken by the Provincial Department of Water and Forests with the support of FAO (The Food and Agriculture Organisation). Such programs should be evaluated and supported by follow-up action in areas in which the young seedlings have perished.

Zone A covers a very small portion of the Angkor / Siem Reap Region as a whole. It is, however, the central and most important zone both in terms of cultural patrimony and in terms of natural environment. As such, this zone requires the strongest possible protection with careful attention given to maintaining and fostering the long-term quality of the environment. No other area in Cambodia is more significant and more worthy of protection.

Zone A has been carefully delimited to exclude villages and their surrounding environments. No villages to the north, west, or east of Angkor (Phum Angkor Krau, Phum Kuk Chan, Phum Khven, Phum Veal, Phum Peng Ses, Phum Srah Srang, Phum Kravanh) are included within this zone; the only exception is Phum Rohal which is extremely difficult to remove from the zone. Still areas of habitation do presently exist within zone A. In some cases, inhabitants have already been subject to relocation once, but have gradually returned over the years. Because of the international significance of zone A and

the potential for degradation of the natural and cultural patrimony which habitation will cause, I recommend the establishment and enforcement of directives strictly regulating all existing habitations in the interior of this zone and prohibiting new constructions in it. There are a limited number of contemporary temple complexes located within zone A. Although it is out of question to propose that these pagoda complexes be relocated outside of the perimeter of zone A, still it is recommended to establish limits to their expansion and to refuse authorisation for any new pagodas within the zone.

Zone B: A Buffer Zone

This zone of transitional land comprised of mixed scrub, thickets, and agricultural lands, has a considerable cover of degraded vegetation with the potential for regeneration. Unused land is scattered among areas exploited quite intensively for agricultural production (livestock raising and rice cultivation). Management of this zone should aim to protect as well as exploit the resources of the forests while fostering agricultural production sufficient to completely support local communities. Substantial firewood resources must be created in zone B in order to replace those which are no longer available due to the restrictions placed on cutting wood in zone A. Sustainable wood resources can be created in this area over a period of five to ten years. The reforestation projects necessary to establish such resources must be urgently supported in order not only to supply firewood to local populations but also to develop hardwood resources for wood-working.

In order to provide appropriately for the local population, and thus to encourage local populations to stop exploiting existing protected forests, it is necessary to carefully plan such reforestation projects. The species planted must be appropriate, and the areas replanted must be of sufficient size. The location of

replanted areas must be convenient both to inhabitants and to a management team which must be sufficiently trained to oversee and administer these new plantations.

There are a number of villages located in zone B. In general, I foresee no problems with the future expansion of these existing villages into their immediate surroundings. However, these villages do exert pressure on the remaining forests of zone A as well as on the scrub and thickets of zone B, since the villagers harvest forest products and sometimes, through their activity, impede the natural regeneration of existing forests. The growth of population in these villages, as well as the appearance of new villages within the zone, could potentially lead to overpopulation and degradation of the landscape in zone B. For these reasons, I propose that no new villages or areas of inhabitation be authorised within zone B. Instead, settlement should be encouraged in zone C.

Zone C: The Agricultural Zone

Zone C is a zone of intensive agricultural production for which management should have similar aims to those described for zone B. Zone C is the management zone furthest from the primary temples of Angkor and thus is of a lower priority than the first two zones of management and protection. Zone C covers the whole of the region of Siem Reap from south of Phnom Kulen to the Great Lake, with the exception of zones A and B as described above. Agricultural productivity, particularly rice production, can be improved within this zone. It would also be prudent to reforest some sections of this zone and thus to introduce forms of forest-based agriculture. This will not only improve the diversity of the zone but will also secure forest resources for the wider community, thus alleviating pressure on existing forests in zone B and improving the aesthetic character of zone C.

In what precedes, I have sketched a series of five ecological zones followed by a set of three management zones for overseeing these ecological zones. I now discuss the background and current state of administrative institutions being developed to oversee the site of Angkor.

Planning the future of Angkor: Administration and Management

Standing in front of Angkor Wat on November 30, 1991, then Director General of UNESCO Frederico Mayor called on the international community to mobilise itself to protect, preserve, restore, and promote the site of Angkor. In 1992, the site of Angkor was provisionally registered on the World Heritage List and at the same time was declared endangered. The registration of Angkor was conditional and obligated the Royal Government of Cambodia to undertake the following measures within a three year deadline:

- to pass adequate laws of protection for Angkor,
- to create a national institution to oversee the management of Angkor,
- to establish boundaries, zones of management, and buffer zones to protect the monuments.

Because of initiatives by the French and Japanese governments, working in partnership with UNESCO, an International Conference to Safeguard and Develop the Angkor Archaeological Zone took place in Tokyo in October 1993. This conference brought together representatives from 31 countries and 7 international organisations. The conference established a mechanism for management of the site and initiated the campaign to safeguard Angkor by creating an International Coordinating Committee. This International Coordinating Committee (ICC) meets annually with ambassadorial participation, either in Phnom Penh or in Siem Reap. In between these plenary

sessions, a technical committee meets three times a year in sessions attended by representatives of ambassadors.

An urgent action plan for the management of Angkor and its region was presented by the Cambodian delegation at the 1993 Tokyo Conference. Because of the magnitude of the required task and the necessity to coherently integrate a wide range of very diverse and often even conflicting activities, it was seen as necessary to outline seven guidelines for action. These guidelines were:

- Establishment of a institution to manage the site
- Research
- Restoration, preservation and promotion of the temples
- Development of human resources
- Education of local populations
- Development of tourism
- Development of urban areas.

In 1994, the "Zoning and Environmental Management Plan for the Siem Reap / Angkor Region" (ZEMP) was undertaken under the supervision of UNESCO. The ZEMP Report set in motion three initiatives which have proceeded with varying success. Through the first, the Park was successfully de-mined so as to render it completely accessible to local inhabitants, researchers, and tourists. Through the second, a special Cultural Heritage Police was established to root out clandestine excavations and to stop the illegal traffic of antiquities and cultural objects. At present, trafficking has all but ceased at the main sites at Angkor, although looting continues to be a problem

at less visited sites. The third initiative aimed to stop illegal logging in the Park, while at the same time initiating reforestation within the Angkor Archaeological Park. To date, this initiative has had only mixed results.

The conditions set for World Heritage registration were met by Cambodia at the beginning of 1996 when the institutional frame for the management of Angkor was set in place through the passage of a series of laws, decrees, and sub-decrees. Significant legislation passed during this process includes the Royal Decree establishing Protected Cultural Zones in the Siem Reap / Angkor Region and Guidelines for their Management (1994), and the Law for the Protection of Cultural Heritage (1996). National institutions created during this process include the Supreme Council on National Culture (1995) and the Authority for the Protection and Management of Angkor and the Region of Siem Reap, or APSARA (1995).

APSARA was officially created in 1995 but lacked the necessary resources to do more than collect data, identify areas requiring investment, and carry out feasibility studies for development projects spelled out in the Action Plan. Political events surrounding the fighting in July of 1997 further disrupted the early activities of APSARA. General elections for the National Assembly were held in July 1998, and a political crisis ensued through which a new government was only formed in November 1998. During the months of crisis, economic activity in the country decreased dramatically. The national budget was used to cover military expenses, to reintegrate defecting Khmer Rouge into civil society, and to cover the cost of the elections. The tourism and real estate sectors were virtually frozen and much international aid was suspended. Blocked budgets and minimal salaries paid months late further hampered the efforts of APSARA. Severe staff reductions left APSARA with only about twenty employees.

The Royal Decree of January 1999 redressed this situation completely and allowed for the central administration of APSARA to be re-established. The decree granted more power to the President of the Administrative Council of APSARA who also took on the functions of President and Director-General. The power of the Authority as a whole was also reinforced considerably with regards to control of the development of Angkor. As the Decree stated:

> The Royal Government of Cambodia has the obligation to respect and protect the site of Angkor, which has been registered as World Heritage, and to exert itself in order to assure the safeguarding and permanent well-being of this site. Thus all measures or authorisations taken or decided by local and national authorities at all levels which prove to be incompatible with these international obligations, will be considered null and void.

As a result of this Royal Decree, the action plan originally sketched in the ZEMP report was to be rigorously followed, and all authorisations and permits which had been granted without the knowledge of proper APSARA authorities were henceforth considered illegal. Any constructions that did not have official permission from the APSARA Authority were to be destroyed without reimbursement to the offending owner following a 45-day notification period of impending destruction.

During the 1990s, all income from tourism at Angkor was under the control of the Ministry of Tourism. The Royal Government decided at the end of May 1999 to give the APSARA Authority a part of this income, in particular funds gathered through the sale of admission tickets to the monuments. A contract was signed with the Sokha Hotels Group to collect all admission fees to Angkor. In return the Sokha Hotel Group paid an annual rights fee of one million US dollars with an automatic annual increase of 15% for the duration of the five

year contract. The initial one million US dollar fee in 1999 was divided to provide an $US800,000 budget to APSARA, $US150,000 to the Ministry of Tourism, and $US50,000 to the Ministry of Culture.

With increased legal power as well as an operating budget, the APSARA Authority could operate much more effectively. Whereas in 1996, APSARA had only 18 employees and an annual budget of $US123,198, by the year 2000, APSARA had 880 employees and an annual budget of $US2,189,483. Because of the link of the APSARA budget to entrance ticket sales, budget increases for APSARA are closely tied to growth in the number of tourists visiting Angkor.

Since the launching of the Campaign to Safeguard Angkor in 1993, the number of teams of researchers and technicians working at Angkor has increased. The main foreign national and private teams working on site today include:

- France and the EFEO: Angkor Thom, the Royal Terraces, and the Baphoun
- Japan: Angkor Wat (western causeway, northern library); the towers of Suor Prat; the Bayon (master conservation plan, north library); Banteay Kdei (Sophia University)
- Germany: Angkor Wat: (preservation of the Apsaras and bas reliefs); Preah Ko
- China: Chau Say Tevoda
- The World Monuments Fund: Preah Khan
- Italy: Pre Rup
- Switzerland: Banteay Srei

Restoration work is thus still largely done with the help of foreign experts and funding. The overall aim, however, is for work at Angkor to be increasingly nationalised as local human resources develop. Contracts with foreign research teams commit them to training Cambodian nationals and employing them in restoration work as they become qualified. All activities on the monuments are coordinated by the International Coordinating Committee which ensures the coherent organisation of the different restoration projects. Each team has its own techniques, its own concepts, and its own ways of working; in order to coordinate the work of these teams, a Committee of three experts of world renown has been established to advise on developing coherent standards for the site as a whole.

In 1999, the APSARA Authority established the Ta Nei Training Program to train recent University graduates to fit the growing needs of the Authority. Ta Nei I began in December 1999 and ended in March 2000. Among the 20 graduates of this first training program, 16 were recruited to work for APSARA. These graduates form the nucleus of several technical teams operating throughout the Park which include the team for the conservation of Angkor Wat, the team for the conservation of Angkor Thom, the team for maintenance, the team for sociological research in villages inside the park, and the team to inventory cultural heritage. The second Ta Nei Training Program was held from December 2000 to April 2001. As with Ta Nei I, participants included recent University graduates with degrees in archaeology, architecture, engineering, management and tourism. The 25 participants of the second training program were chosen from a pool of more than 80 applicants, and approximately ninety percent of the graduates of the program are now employed by APSARA. Since then, Ta Nei III and now Ta Nei IV are proceeding with this training agenda.

Several collaborative research projects on ancient kilns are ongoing at the site of Angkor. One research project studies ancient kilns in and around the village of Tani through a partnership between APSARA and two Japanese research institutions (the Nara National Cultural Properties Research Institute, and the Sophia University International Angkor Mission). The research on ancient kilns, begun in the mid-1990s, has recently entered a new phase. The excavations of the Tani Kiln A6 have been completed and the base of the floor has been removed. The complete structure of the kiln has thus been rendered visible, allowing researchers to advance their knowledge of the techniques once used to fire ceramics in Angkorian times. Research is also ongoing at the kiln sites of Thnal Mrec and Sasai on Phnom Kulen. Unfortunately both of these sites have already been extensively looted.

The census of 1998 showed that the following number of inhabitants were living within the zone of the Archaeological Park of Angkor (including the areas surrounding Banteay Srei and Roluos): Angkor Tchum 48,476 inhabitants; Angkor Thom 17,750 inhabitants; Banteay Srei 32,271 inhabitants and Prasat Bakong 54,129 inhabitants. These local inhabitants are a central issue to any cultural and tourist policy for the Park. Current policy aims to employ inhabitants both at local sites and at places of exchange between local communities and the exterior. The APSARA Authority has developed three approaches for providing and developing employment opportunities for local residents. For the short term, APSARA is committed to recruiting members of local communities for jobs not requiring long training periods. These jobs will be connected to public works projects, construction, and all kinds of manual labor within the Park and on the archaeological worksites (with the exception of work which requires archaeologists or restoration specialists). On a more long range basis, APSARA is working to

create a stable nucleus of trained employees able to install basic infrastructure such as wells and drains as well as completing reforestation programs in the Park. Trained employees are also needed for tourist services and related work (maintenance of buildings, garbage collection, etc), and the APSARA Authority has established a clear policy giving preference to recruiting local residents for training to become maintenance workers and operators of new services in the Park. These short and medium-term policies are part of a long-term regional strategy to provide employment to local populations. The populations residing in the Park must be the first to benefit from tourism, not only through possibilities of training and employment, but also through the development of new wells, transportation networks, sewer and drainage systems, and thus better living conditions. In addition, markets need to be found for the agricultural products which are produced in surplus, as well as further developing craft industries and thereby ensuring that rural populations do not abandon their land and join the already considerable exodus to urban areas.

The Master Plan for Tourist Development, formalised in 1995, aims to create controlled development of quality tourism in the Angkor / Siem Reap Region in order to allow Cambodia as a whole to develop economically. Quality tourism requires coherent and harmonious development. It is essential that Cambodian authorities completely control the influx of visitors to Siem Reap and Angkor, and thus carefully manage the development and exploitation of the site of Angkor.

Visits to Angkor increased gradually during the early 1990s, following two decades of civil war which virtually closed the site to visitors. The number of visitors coming to Angkor once again dropped sharply after the fighting in 1997 and the political uncertainties of 1998. Since then, the number of

visitors coming to Angkor has increased dramatically, as has the construction of infrastructure necessary to receive them. In 2000, about 180,000 foreign visitors came to Angkor (this is the number of tickets sold; Cambodians do not pay to enter Angkor). According to conservative estimates, a modest increase in tourism will bring 640,000 visitors per year over the next four years. If a more dramatic increase in tourism occurs, one million visitors will be coming to Angkor by the year 2008.

It is imperative that APSARA address the lack of essential infrastructure in and around the site of Angkor, particularly in the town of Siem Reap. Urgently needed essential infrastructure includes roads, drainage systems, electrical systems, water supply systems, adequate transportation systems, sufficient hotel accommodation, as well as the considerable reinforcement of APSARA's own administrative capacity to manage and oversee such large-scale tourism. With the opening of the Siem Reap Airport (conceived only for domestic traffic) to international air traffic through the government's "open skies" policy initiated in 2000, foreign tourist arrivals have increased dramatically. The present airport is already at full capacity and a new airport must be built to accommodate future traffic. In the coming years, land access by road from Thailand will partially alleviate problems of limited access imposed by the present airport and its capacities, although such land access will also bring additional floods of tourists from neighboring countries.

The Town of Siem Reap

The town of Siem Reap will have to provide the bulk of accommodation and services for increasing numbers of tourists. Here I sketch a brief history of the town and make some suggestions regarding the problems involved in its current rapid expansion.

The town of Siem Reap is the provincial capital of Siem Reap Province and therefore serves as an administrative and commercial center as well as being increasingly dominated by tourism to Angkor. The town has developed in a complimentary relation to surrounding villages which are not only the sites of agricultural production but also increasingly are home to artisanal activity and small industries, the products of which are sold in Siem Reap. Siem Reap was once probably only a group of houses which sprung up around the various temple complexes found in the area. These temple complexes (or wats) were centers of religion, education, and social life in traditional Khmer society. Clusters of habitation developed around the wats found strung out along the Siem Reap River from north to south: Wat Enkosei, Wat Enkosa, Wat Po, Wat Po Langka, Wat Bo, Wat Damnak, Wat Svay, Wat Komnock and Wat Atvear (figure 16, 19). These small wat villages faced the river, or began to grow along roads in the area, forming small pockets of habitation in a larger rural landscape of orchards and rice fields. Such settlements developed as clusters or circles around a wat complex, or as winding lines following irrigation canals. The relation of rice fields to village was organic as well, forming patterns which curve around ponds and canals and allow for pockets of habitation in the wider rice fields.

Occupied by the Siamese during the 18th-19th century, the province of Siem Reap was returned to Cambodian authority in 1907 when Cambodia was under the rule of a French Protectorate. It was only after 1907 therefore that colonial power began to shape and develop the town of Siem Reap. French authorities thought of urbanisation as an abstract social ordering, rather than as an organic relation of houses to fields. They took their models of town development from military encampments and imposed the structure of the grid, a form which they found easy to administer and oversee. The older agglomeration of villages centered around wats, strung along the river, were

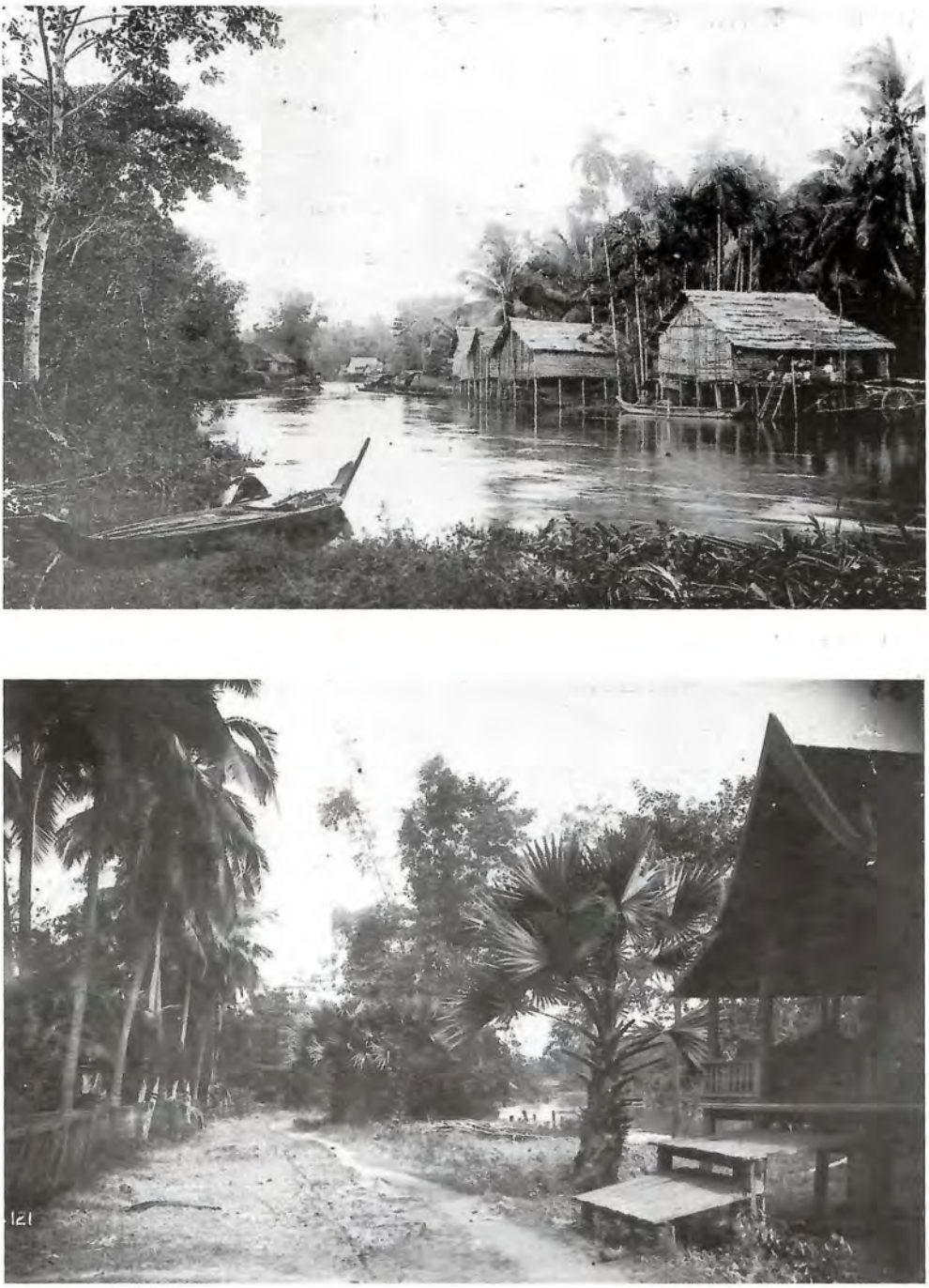

Figure 16: *Siem Reap around 1900*

now reshaped into a centralised town on the west bank of the Siem Reap River. By the 1930s, the urban node of gridded roads and buildings which we find today between the Grand Hotel and the old market had been established. At the center of this town was a quadrangle bordered by arcaded apartments on three sides (figure 17). The administrative quarter of the town stretched along the river to the north, while more informal village habitations were built to the south along the Siem Reap River towards the Great Lake.

Siem Reap was still quite small when Thailand once again returned the town and its province to Cambodia after World War II. After independence, moderate development of the town occurred and the Royal Residence was built. The thrust of post-independence extension followed colonial planning in that public buildings and facilities stretched to the north of the town, while increasing numbers of homes were built south of the town along the Siem Reap River. Public installations such as the stadium, schools, and other sports and cultural facilities were built or at least planned along the northern axis even if they have remained unachieved due to the war. Expansion was cautious and ambitious plans to, for example, host the 2,500 year celebrations of the Buddha in Siem Reap in 1956 were moved to Phnom Penh when planners insisted that sufficient infrastructure was not available in Siem Reap to host the number of expected guests. Several tourist hotels were built during the 1950s and 1960s including La Villa Princière and the Auberges Royales as well as the 200 room hotel of UTA / Air France in front of Angkor Wat. Still, the town of Siem Reap remained quite small and tourism was only a minor industry during the late 1960s.

The civil war of the early 1970s soon engulfed the Siem Reap area. Early in the Lon Nol regime, a dike was built around the town of Siem Reap as a defense against Khmer Rouge forces. This dike enclosed an approximately 25

Figure 17: *Siem Reap today, (above) the "old market" on the left and the arcaded apartments on the right; (below) a detail of the arcaded apartments ringing the "old market", almost all of which are now Internet cafes, souvenir shops, bars, or restaurants catering to tourists*

square kilometer area which had the shape of a polygon. The dike was built by digging out earth from an adjoining area, thus creating both an embankment and an accompanying ditch which sometimes served as a canal. Today this dike no longer exists, although certain broken sections of it were used as foundations for new roads built after the Khmer Rouge regime.

Emptied of its inhabitants by the Khmer Rouge in 1975, the town of Siem Reap was abandoned for almost four years. When Vietnamese troops entered Siem Reap in 1979, they established an important military garrison there. Because of this military installation, former inhabitants of Siem Reap were not allowed to return to the center of the town. Instead, the area around the present-day "old market" housed Vietnamese military officials and experts, as well as Cambodian officials working with the Vietnamese army. Because the central section of the pre-1975 town was thus closed off to the general public, those who had lived in Siem Reap before the war resettled either on the opposite bank of the river in a new area dubbed "Quarter 1", or on the peripheries of the existing town. In 1983, "Quarter 1" was divided into two sections. The section north of National Route 6 was called Sangkat 1, while the section south of National Route 6 was called Sangkat 4.

A fairly miserable market developed in the shade of the trees which bordered National Route 6 in Sangkat 4. As the 1980s proceeded - and particularly after economic liberalisation in 1989 - this market expanded and buildings were gradually built to house it. Today it is a large market with many goods imported from Thailand (figure 18). This market has become known as the "upper market", while another market located to the southwest in Sangkat 2 on an old airfield from the Lon Nol regime is known as the "lower market". The colonial quadrangle in the center of town became the market today known as the "old market" during the UNTAC period. The present-day configuration of Siem Reap

Figure 18: *"Psar leu" or the "upper market" in Siem Reap today*

town, with its extensions towards the east, can be understood as a direct result of the limits and constraints put on the population by the government after 1979.

The land wars

It is hard to underestimate the chaotic conditions which followed the return of large portions of the surviving population to urban areas following the fall of the Khmer Rouge regime in 1979. Sections of cities were occupied by troops, while other areas and buildings were claimed as "victory property" belonging to the political party rather than to the people as a whole. In general, the rapid return of people to the cities required blunt acts of division, seizure, and assignment. It was only in 1989 that a series of laws and legal regulations began to systematise and standardise ownership and property rights in Cambodia, reintroducing procedures which are still in process ten years after the United Nations intervention in Cambodia.

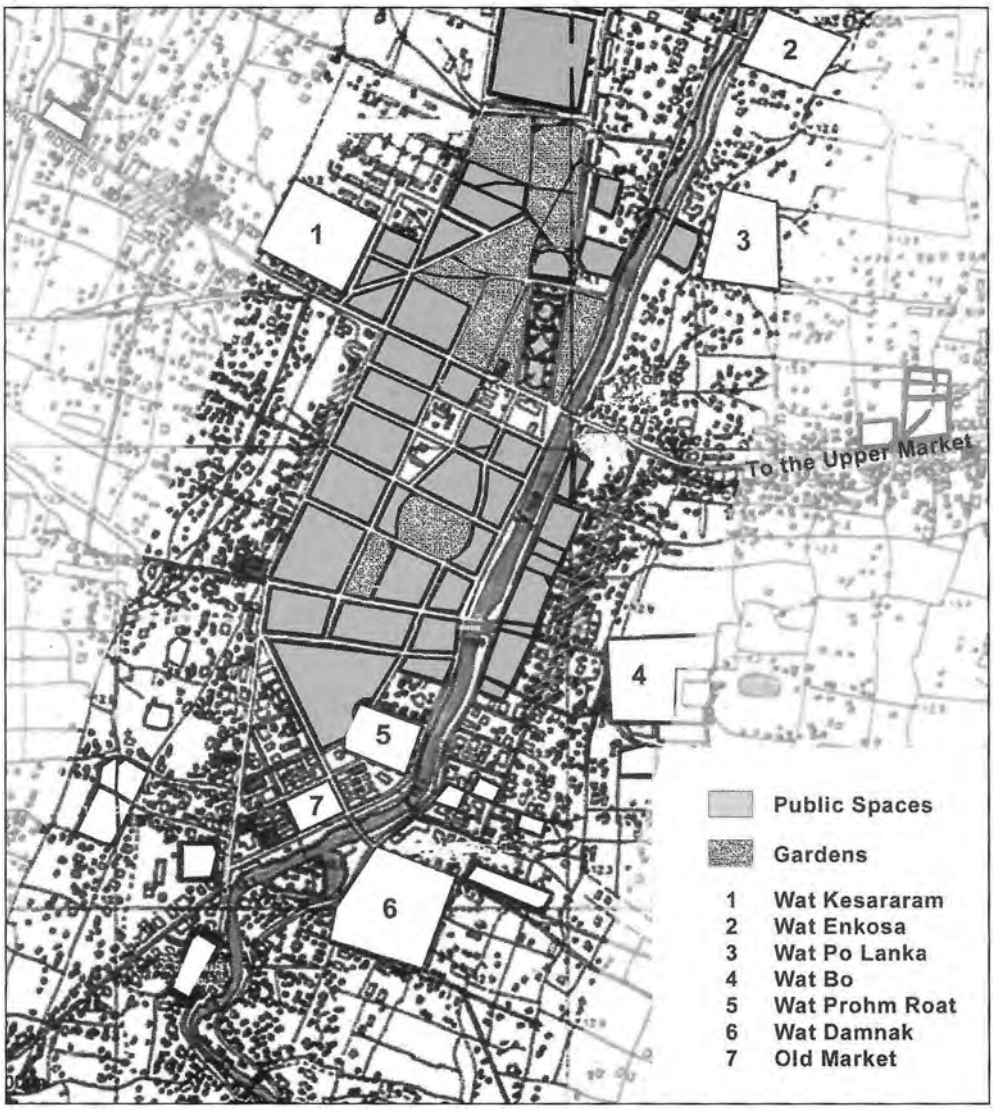

Figure 19: *The town of Siem Reap*

The Decree of April 22, 1989

Article One of this Decree declared that all goods, whether movable or immovable, located within the territory of Cambodia were the collective property of the Cambodian people and that no property rights prior to 1979 would be recognised. Article Two of the Decree gave the rights of property to the actual inhabitants of the property and authorised them to transfer those rights by inheritance or by sale, provided that foreigners did not benefit from such a transfer. Article Three of the Decree established the principal of land taxation. Article Four instituted a procedure for officially establishing land claims through the deposit of a request and the obtaining of a provisionary certificate of occupation.

The Constitution of April 30, 1989

Article 14 of the new Constitution defined the public domain of the State. Article 15 of the new Constitution recognised the rights of possession and use of land by Cambodian citizens living on it. Article 18 categorically prohibited all forced confiscations of the property of citizens. Article 18 also, however, authorised expropriation of certain property if and only if it was necessary for the public good, and if and only if proper indemnity was offered for the seized property.

The Instruction of June 3, 1989

This instruction restated that no pre-1979 land claims were to be honored, and that the State could not undo the redistribution of land which had taken place after January 7, 1979. The instruction also clarified and detailed the procedure for officially procuring ownership rights. In order to make a land claim, the head of a family had to request authorisation for occupancy from the People's Committee of the district, commune, and village according to models provided by the Agricultural Service. Applications for land occupancy documents could be submitted from the day of the instruction (June 3, 1989)

through December 31, 1989. After December 31, 1989, the State would consider all land with no claims laid on it as free and unappropriated.

The "Land Law" of August 11, 1992

This law reintroduced the right of individuals to own property. The first section of the law defined the notion of property and enumerated different types of ownership (proprietary, temporary possession, authorisation to cultivate, concession, ownership for a life time, right of use etc.). The second section of the law regulated the acquisition of property and affirmed the inalienable rights of both the public and private domains. Article 74 stated that peaceful, continuous, well-intentioned inhabitation of a property for more than five years - provided that this habitation was publicly acknowledged without ambiguity - would henceforth transform into legal possession of the property, provided that there were no contestations and that the property had been properly registered. A property which had been unoccupied for three consecutive years automatically became State property.

A fundamental distinction was inscribed between property and possession by this Law. The right of property was stated as a perpetual right, while the right of possession was legally acknowledged but could be lost by the refusal to continuously use the property. The right of possession was thus defined as less absolute and more fragile than the right of property. Although the distinction between property and possession was said to be a provisionary juridical distinction, necessitated by the particularities of the post-Khmer Rouge situation, it now seems that these categories will be necessary for a considerable amount of time in order to solve the complexities of land possession and ownership. In fact, the legal process for transforming temporary possession into property (that is, five years of continuous possession and use, payment of

land taxes, and proper registration of the concerned property) requires an as yet only partially functioning mapping administration as well as a not yet functioning fiscal authority to assess and collect land taxes. The transitional period in which all inhabitants gradually turn their provisional possessions into officially recognised property is likely to take several decades.

The "Law on assignment of properties" of January 29, 1993

This short six article law regulates the division of properties between the State and the Cambodian People's Party (CPP). After January 29, 1993, any building occupied by either the State or the Cambodian People's Party was declared as their respective property. The CPP seemingly benefited from this law since any land or building which it occupied immediately became its property without the intermediate step of possession, taxation and use for a period of five years required for all ordinary Cambodian citizens under the "Land Law". Although this "assignment of properties" law was modified in 1993, following legislative elections sponsored by the United Nations, the legacy of "victory property" still lingers today.

The Constitution of September 21, 1993

Article 44 of the new constitution reaffirmed the right to own private property but stipulated that only Cambodian citizens could own property in Cambodia. The Constitution also reiterated that the expropriation of property could only take place if the property was needed for the public good. Just indemnity had to be paid for the property before it could be taken under this clause.

It is within this legal framework and context that the development of Siem Reap over the last fifteen years has taken place. Over this period, the town of Siem Reap has expanded along two main axes: the north / south axis of the

Siem Reap River from Angkor to the Great Lake, and the east / west axis of National Highway 6 from the "upper market" to the airport. In addition to developments along these two main axes, peripheral urban areas have developed along new dikes, canals, and roads.

The events of the last few decades have deeply affected the population of the Siem Reap area. The population of the town of Siem Reap in 1970 is estimated to have been about 10,000 inhabitants, with small additional increases of population due to tourism. In 1979, the population of the town jumped to 30,000 inhabitants as people poured in from the countryside after the fall of the Khmer Rouge regime. By 1991, 68,800 inhabitants were found living in the larger Siem Reap area. Siem Reap has been subjected to influxes of new inhabitants due to several factors. Surviving members of its original pre-1975 inhabitants generally returned to the town after 1979. In addition, villagers gradually displaced or officially removed from the archaeological sites resettled in the northwestern section of the town. Refugees from the north, northwest, and west of the country poured into Siem Reap as well due to ongoing civil war throughout the 1980s and early 1990s. In the late 1990s, with rapidly increasing tourism, the town has become a magnet drawing landless and jobless people who come to beg, sell souvenirs, or seek construction work.

Several scenarios can be envisioned for the future development of Siem Reap. If tourist development occurs gradually, we can assume a rate of growth based on average annual growth rates of 7.1% recorded from 1975 - 1995. Given 77,000 inhabitants in Siem Reap town in 2000, the town will thus grow to 106,000 inhabitants by 2005 and 146,000 inhabitants by 2010 according to this scenario of limited growth. Such gradual growth rates are unlikely,

however, since over the last two years, annual population growth rates have already increased to 9.1%. Using this present-day growth rate, we can estimate 120,000 inhabitants by the year 2005, and 160,000 inhabitants by the year 2010. Even these growth rates seem low since tourist development may occur much more rapidly and large local population increases will result from the development of many hotels. In a scenario of rapid growth, the population of Siem Reap could grow by 45,000 persons annually due to the number of employees needed to service the tourist industry. This calculation is based on considering the 1,700 hotel rooms available in the year 2000. Each hotel room requires 5 staff personnel to fully service it, and each of these workers is assumed to have an average family of 5 persons to support.

In general, management of growth and tourist development must address two main issues. The existing small town character of Siem Reap must be preserved, while the surrounding area of the town must be developed to house the projected population increases.

The existing town

Protective measures must be put in place to preserve the qualities of the town of Siem Reap itself, including not only its architectural heritage but also its harmonious blend of public spaces, gardens, and buildings. For this reason, a Royal Decree was issued in 1992 which established controls over the banks of the Siem Reap River. A fully protected 50 meter zone was established on each side of the river, while a larger 500 meter zone was placed under a protective administration ensuring careful monitoring of all buildings added to this zone. Unfortunately, this Royal Decree was suspended in 1999. More legislation of this kind must be passed and enforced in order to appropriately manage public spaces and control town areas.

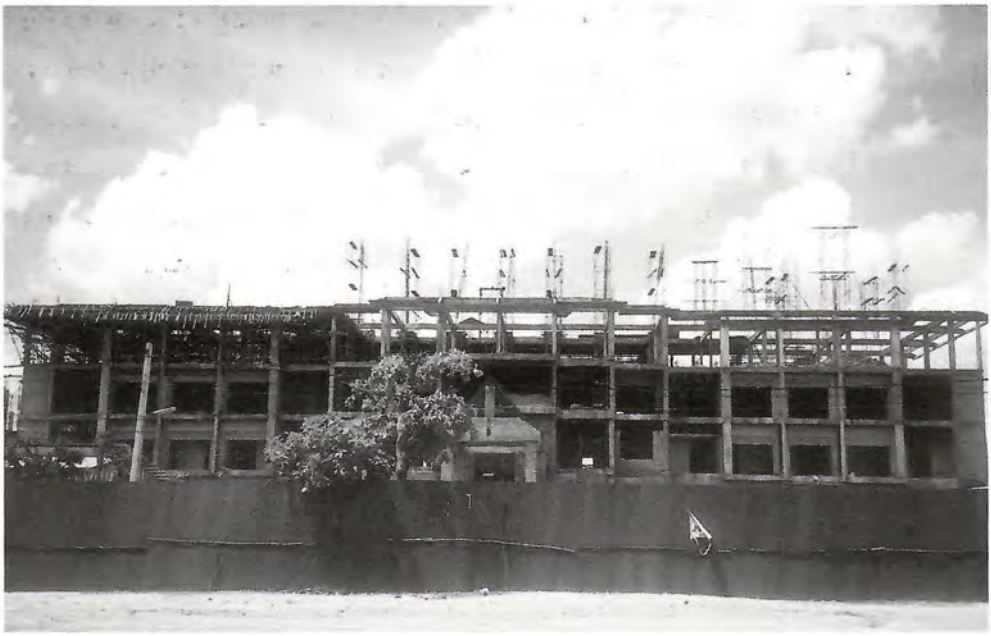

Figure 20: *Siem Reap today, hotels along the road from the airport, an area not officially zoned for hotels. An abandoned work site (above), and a recently completed hotel (below).*

Areas bordering National Highway 6 as well as the zones adjacent to the existing road leading to the temples, are reserved for public buildings, schools, stadiums, and administrative facilities, not hotels (figure 20). A 60 meter free zone is allocated on each side of these roads to allow for infrastructure additions such as canals, sewer, electricity and water. It cannot be over emphasized that the areas on the sides of the road to the temples are reserved for public gardens and public facilities while hotel construction should be limited to the Hotel City area. A managed protective perimeter of 500 meters should also be enforced along the principle axes of the town in order to ensure appropriately designed buildings and to preserve open green spaces. The central sectors of the present town should be kept for administrative and commercial uses. Craft industries should be developed in the town and should include both training and marketing components in order to complement the craft production which has developed in surrounding villages.

The expansion of Siem Reap

The land located to the west of the town of Siem Reap, south of the Western Baray, is prime agricultural land which can be irrigated by the Western Baray. A joint effort by hydrologists, agriculturalists, and local authorities favors an extension in this zone of irrigated fields, accompanied by the improvement of their productive capacities. It is therefore proposed to limit the development of the town of Siem Reap to within the perimeter of the ancient canal found about 1.5 kilometers west of the Siem Reap River. West of this canal, the land should be reserved for agricultural use only.

The land to the east of Siem Reap is largely unsuitable for agricultural use due to limited possibilities for developing an irrigation network. I recommend that urban areas be allowed to expand into this area. Expansion must take place within a quadrangular grid, respecting the East - West axis of the temples and following the slope of the ground as it descends towards the Great Lake (figure 21).

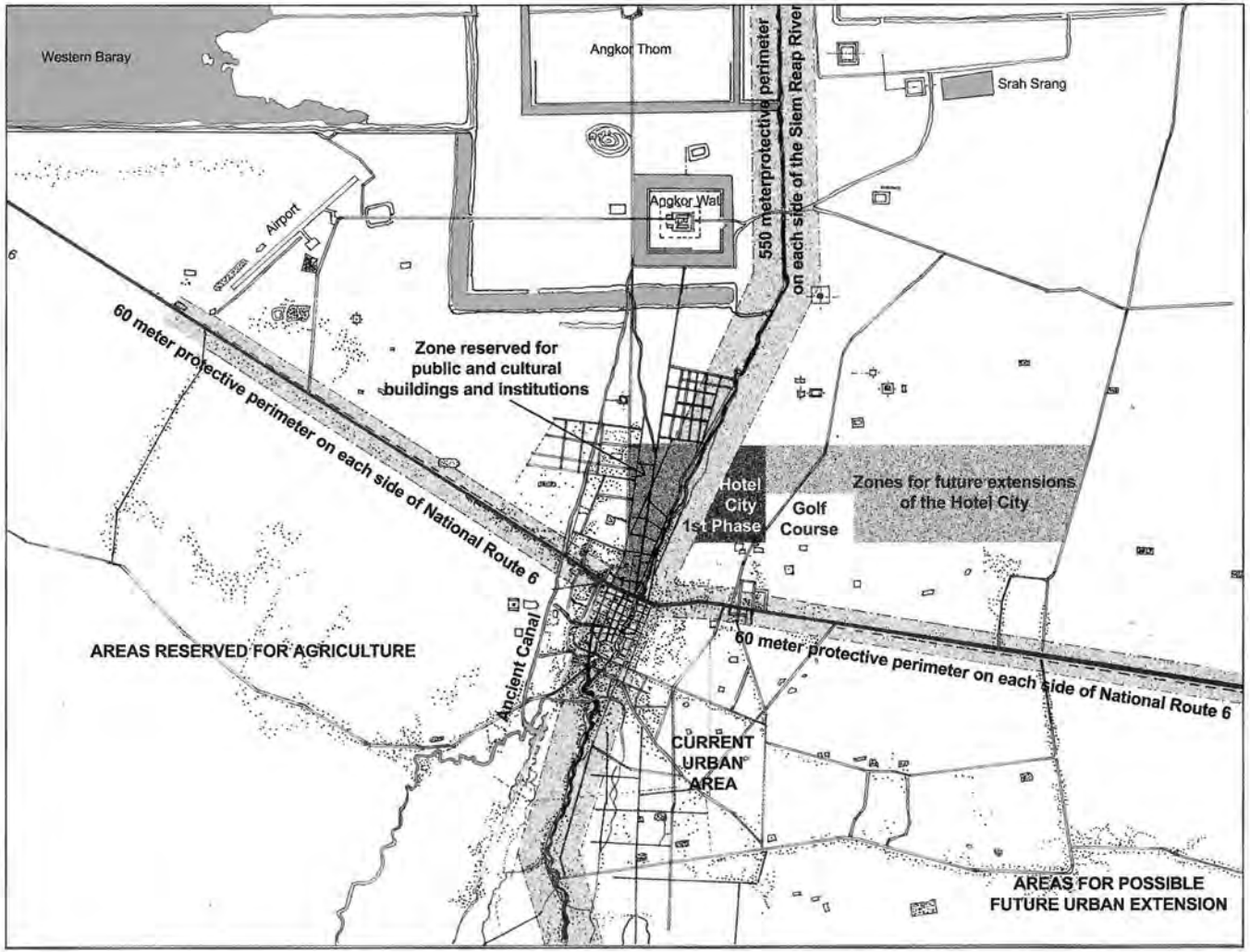

Figure 21: *Proposed zones of protection and development in and around Siem Reap.*

The desire to preserve the current atmosphere of the town of Siem Reap has led to the proposal to establish a separate Hotel City with significant tourist facilities northeast of the town in an area where there are few existing structures. At present this area is covered with scrub, and its geological makeup is not conducive to agricultural use or the development of large forests. The poor soil conditions of the area chosen for the Hotel City make it a suitable region for urbanisation while allowing for small planting projects which will help to protect the Angkorian forests and will set the resulting tourist facilities in a pleasing frame (figure 22).

The area of the Hotel City, close to the present-day town, is near the Siem Reap River as well and lies north of National Route 6. The development of this zone will take as its underlying principle the improvement of the landscape as it is developed. Tree planting will be undertaken and new infrastructure (roads and access bridges) between the Hotel City, the town, and Angkor will be built. The vastness of the area allows us to envision long-term development of hotels conceived around an infrastructure of canals and man-made landscapes which will develop from west to east. Once the airport is moved from its present location to its planned new location near Damdek, the Hotel City will be the closest portion of the town of Siem Reap to the airport.

Much attention must be paid to the relationship of the Hotel City, the town of Siem Reap, and the Archaeological Park of Angkor. It is recommended to physically mark the present limit of the park with a canal running from east to west. This canal will help to collect excess rain water and run-off from the southern area of the temples, and will provide a clear boundary dividing the Park from the land outside of it. Reforestation projects in the protected forest areas of the southern zone of the Archaeological Park of Angkor (that is, to the north of the canal) should be pursued.

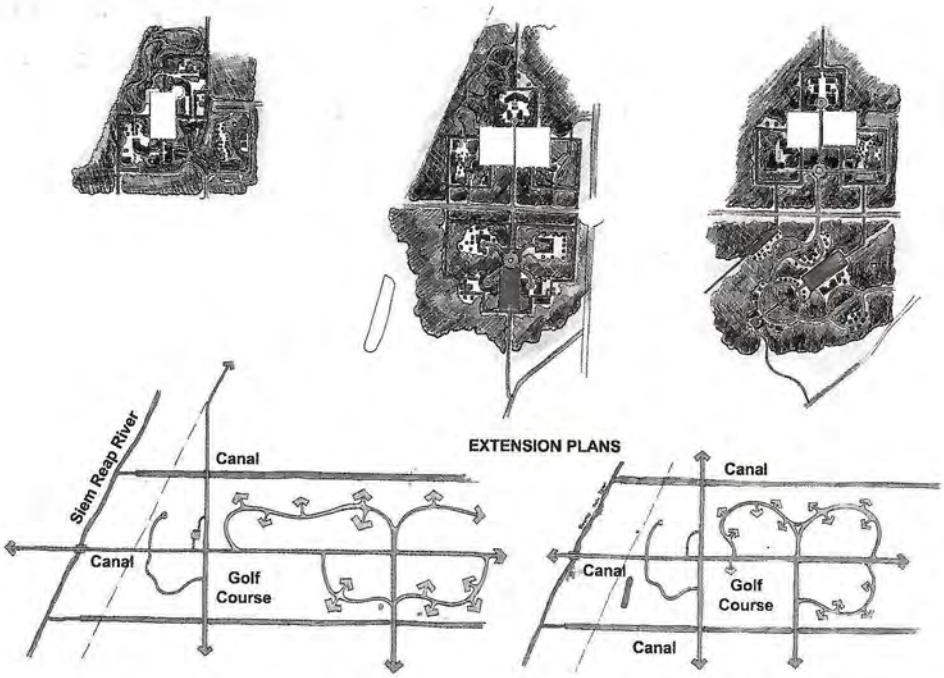

Figure 22: *Plans for the Hotel City (above); (below) a new road in the Hotel City with walled-off hotel space on the right.*

The flow of visitors to the site will be facilitated by the establishment of a new access road to the temples, east of the Siem Reap River. A north-south road will lead from National Route 6 to the central visitor's reception in the heart of the Hotel City. This road will continue towards the Park, entering the Park near Prasat Kravan and using the existing road to approach Angkor Wat, circling around its moat from East to West.

Projected Population Growth in Siem Reap

Year	Population Town of Siem Reap	Population Siem Reap Province
1962	10,281	312,696
1966	11,000	348,000
1979	30,000	492,000
1987	13,000	576,000
1992	43,500	647,000
1998	83,715	696,164
2000	83,000	713,000
2005	120,000	830,000
2010	160,000	924,000

The Water Supply for Siem Reap

The availability of water and the management of water resources has been crucial to settlement of the plain of Angkor. Both Groslier and Thung tell us that the civilisation of Angkor fell when it could no longer adequately provide water for its populations. The foreseen rapid development of the Angkor / Siem Reap Region in the years to come faces similar water supply challenges.

A present consumption of 100 liters per inhabitant per day has been established as the basis for water use calculations in 2002. Average daily use is projected to rise to 120 liters per local inhabitant per day by 2006. In addition,

the average tourist visitor is estimated to consume approximately 500 liters of water per day. The tourist service industry consumes a huge quantity of additional water with the water needs for restaurants, for example, estimated at 100 liters of water per table per day.

A recent Japanese survey, completed in June 2000, has studied potential new water sources which can adequately supply future development. Their report has identified four possible sources of water supply and has evaluated the potential of each of these sources as follows.

The Western Baray

The minimum potential storage capacity of the Western Baray, without raising its dikes, is estimated at 40.7 million cubic meters (34.1 million cubic meters of water from the Siem Reap River plus 6.6 million cubic meters of rain water). If a maximum of 36 million cubic meters of water are used for irrigation purposes, 4.7 million cubic meters of water still remain which can provide the water supply system with about 12,900 cubic meters of water per day throughout the year.

The Siem Reap River

There is not sufficient water at present in the Siem Reap River for it to serve as a reliable supplementary source of water. The river could only become a possible water supply if large quantities of additional water were pumped into the river canal during the dry season from elsewhere (for example from the Northern Baray if it were to be rehabilitated).

The Great Lake

The Great Lake is the largest fresh water lake in Southeast Asia. It has a potential capacity to store more than 1,300 million cubic meters of water, even

when the Lake is at its lowest level. Water supply from the Lake can be considered practically unlimited. From a hydrological point of view however, any water supply provided by the Lake must be secure at the minimum level of the Lake which is calculated at 0.7 meters during the dry season. The tap for a potential Lake water supply must be located at least 4 kilometers out from the banks to allow for this lowest possible water level. The distance of the water supply would thus lie more than 19 kilometers from the center of Siem Reap, and water would have to be pumped over this distance since the area is too flat to transport water by gravity to the town.

Subterranean water sources

The water table of the Siem Reap area can be tapped as a potential supplementary water source. The water table can be accessed by wells and careful pumping plans, provided that such pumping does not adversely affect the environment.

The four potential water supply sources, studied by the Japanese team, were evaluated not only for the cost of developing each particular source, but in terms of the costs of the resulting pipe system needed to distribute the water provided by each potential source. The following criteria were used to determine the most viable of the four sources described above:

- cost of developing the source
- ease of continuous operation and maintenance
- impact on the heritage of Angkor
- consistency and quality of the water supplied
- flexibility of the system
- impact on the environment.

Following the collection and evaluation of information on each possible water source, it was concluded that a system of wells tapping ground water offered the best possibility for increasing the water supply in Siem Reap.

Test wells drilled in the alluvial and diluvial beds identified as WT4 (west of Angkor Wat at the southwest corner of the Western Baray), LTa-2 (in the town of Siem Reap), and LTb-2 (in front of Angkor Wat) all show considerable subterranean water sources. A recent test well, drilled near the area of the airport, was able to provide 444 liters of water per minute. One must consider carefully, however, the fact that excessive pumping of ground water can provoke slumping and sinking of the soil. Such sinking and slumping could effect the stability of the temples as well as changing the overall terrain of the area. Although the Japanese study concluded that ground water tapped by such drilling has the greatest potential to satisfy the growing demand for water in the region of Siem Reap, the study warned of adverse secondary effects such as the sinking and slumping mentioned above as well as possible depletion of the water table. In order to develop and administer the tapping of ground water then, the quantity of water pumped must be carefully considered as well as the locations where such pumping occurs. The ground water table can supply water continuously over a long period of time without adverse side effects if such tapping is carefully planned and well-managed.

The maximum amount of water pumped from any one well will be determined by the maximum sinking of soil which is to be allowed. Computer simulations can accurately determine the maximum possible amount of ground water that can be extracted. The principle objective of such computer simulations is to establish a reasonable plan for pumping continuous supplies of water from certain zones. A continuous water supply is defined as the maximum quantity of water which can be continually extracted from the ground water table

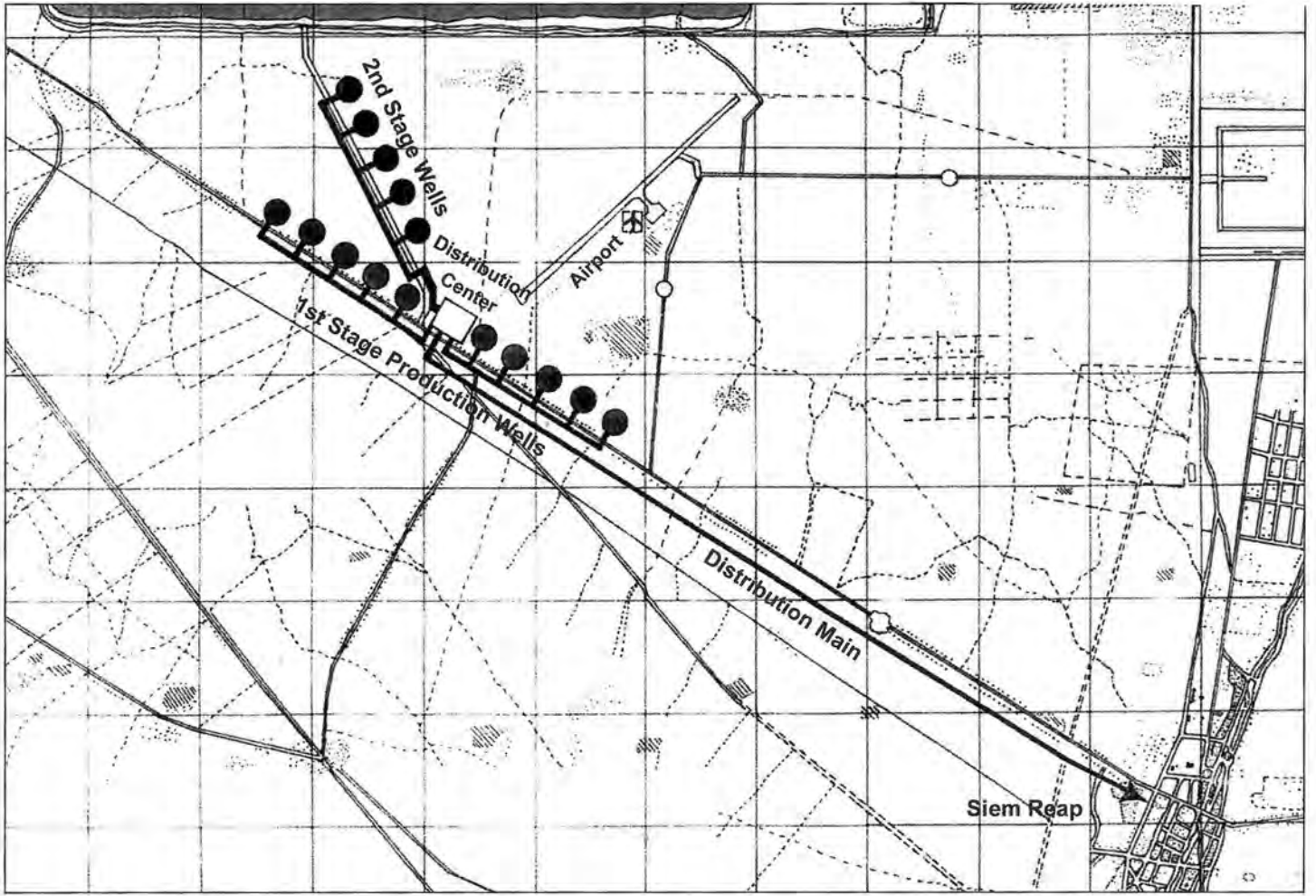

Figure 23: *Proposed Ground Water Wells*

without adverse secondary effects. Careful spatial distribution of pumps over an appropriately sized area will ensure such ecologically sound extraction. Two successful pumping tests have already been carried out in which a considerable continuous volume of water could be pumped while water table levels and ground slumping remained at acceptable levels.

The plan for expanding the water supply for Siem Reap is envisioned in two stages. During the first stage, the present 1,440 cubic meters of water supplied per day will be increased by 8,000 cubic meters to supply a total of 9,440 cubic meters of water per day. Existing water supply systems will be abandoned at the end of this stage, and will be replaced by the newly installed systems. This initial stage of developing the water supply begins with the drilling of ten wells along National Route 6 (figure 23). The productive capacity of each of these new 50 meter deep wells is estimated at 800 cubic meters of water per day. The principal water supply distribution system will initially be installed along National Route 6. Work envisioned during the first stage of the water supply development project includes the drilling of the ten wells, installation of connecting pipes, construction of reception wells, construction of a reservoir for untreated water, installation of equipment for water treatment, construction of a pumping station for water distribution, and laying of pipes for water distribution. A second phase of the project will then add 5 additional wells along the section of road leading from National Route 6 towards the Western Baray, thus increasing the water supply to 12,200 cubic meters per day.

The water supply system for the Hotel City is foreseen as a separate system from that of the town of Siem Reap itself. Water for the new Hotel City will be supplied in one comprehensive system, joined to the northern most section of the town water distribution system. The water supply system for the Hotel City will be installed and paid for by individual hotel investment projects. None of the water system plans described above have been realised to date.

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