

5) Lake Tonle Sap

The lake dominates surface water system in the region. The average water level of the lake is reported as 1 to 2 m in dry season and 8 to 10 m in wet season. This lake is fed not only by streams flowing south from the Kulen mountain range, but also, in wet season, by the Tonle Sap River flowing north from its junction with the Mekong near Phnom Penh. During the rainy season, the level of the Mekong rises above that of the Tonle Sap River such that in addition to following its normal course emptying into the South China Sea, the River overflows backwards into the lake. For this reason, the level of the lake rises by 7 to 8 m, roughly quadrupling the water surface from around 2,500 - 3,000 km² to 10,000 - 13,000 km², thereby displacing the lake shore by 20 to 30 km. During dry season, the flow in the Tonle Sap River is reversed and the lake drains into the Mekong. This phenomenon is extremely rare if not unique in the world. At low water level the lake is about 120 km long and up to 35 km wide. Peak flooding in the lake usually occurs in September or October with the lowest levels in April or May.

There is a relative deep channel emerging from the lake towards the town that is used for navigation and harboring. A large number of floating villages surrounds the shoreline. Even floating school, office and police box are observed.

More detail information about the lake investigated by the Study Team can be found in the Section 3.2.

6) West Baray

The West Baray is another permanent surface water source in the region. This man made reservoir, dating from the 11th century, is a major feature of the Angkor civilization. It is enclosed by a rectangular dike, and about 8 km long and 2 km wide. The water surface now covers around 1,000 ha. It is fed by rain water and river water. From the Siem Reap River a canal, which receives the water through diversion from French Weir through American Weir, enters at the eastern end of the baray.

This baray is serving as a reservoir for irrigating the surrounding rice fields. There is only one outlet from the reservoir. The outlet was reconstructed by France along with the paved embankment in the vicinity of the outlet. A 3 km canal flows south southeast from the baray to irrigate the rice fields south of the National Road No 6. Water is fed into this canal by gravity and passes through 4 ways diversion structure.

It is reported that the depth of the reservoir is 8 m in wet season and 2 m in dry season. More detail information about this baray investigated by the Study Team can be found in Section 3.2.

7) Groundwater

The water level around the area is generally high (closer to the ground surface). In the beginning of dry season it is about 1 to 4 m from the surface. The water level in the beginning of wet season varies between 2 to 4.5 m. High iron content is found in groundwater in many places. More detail information about groundwater investigated by the Study Team can be found in Section 3.4.

8) Climate

The climate is controlled by the tropical monsoon system modified by the local topography, dominated by the lake and the Kulen Mountains. Breezes reinforced over the lake are forced upwards due to the presence of Kulen Mountains and, on cooling, induce showers. Thunder and lighting activity are intense but no quantitative records are available. The annual rainfall varies between 1,100 - 1,800 mm per year, with an average of 1,400 mm (19 year average from 1979 to 1998). The peak rainfall occurs in August / September (240 mm average in September, within that 19 years record). February was the driest month in that 19 years with 4 mm rainfall.

The mean daily temperature varies only slightly between a high of approximately 28.5°C in April to a low of 24.0°C in December. Total annual temperature variation is from 14°C to 40°C. Average relative humidity range from 75% in March to 89% in October.

In wet season, large areas of the plain are flooded as the lake expands. Usually, the floods cause no losses as people have learned to live with this yearly phenomenon. On the contrary, the floods are beneficial to agriculture by leaving fertile silt deposits over the land. Overflow of the river is not very common. The last major flood was reported in 1997 when the entire town was inundated because of bank overflow of the river and lack of drainage.

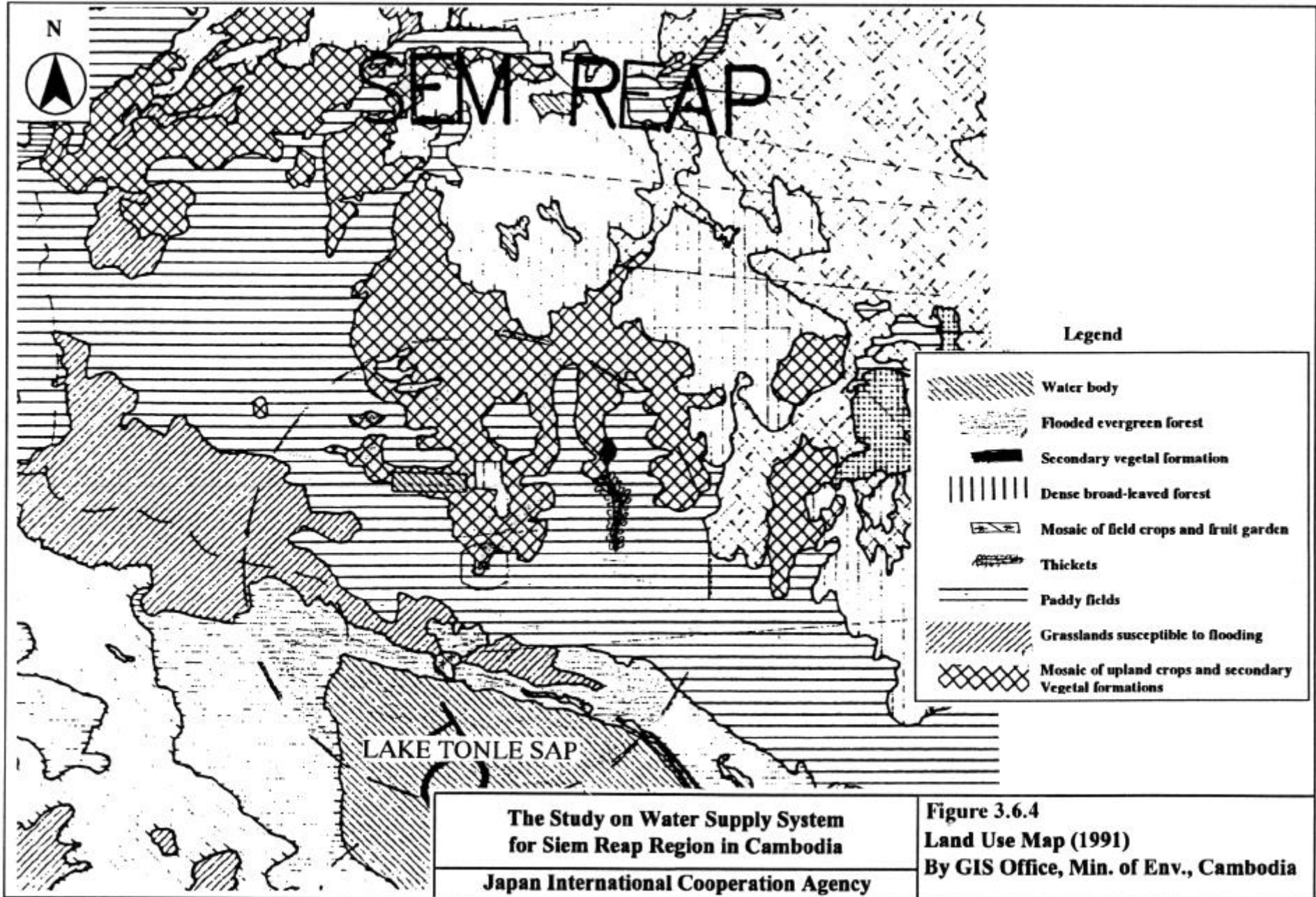
9) Land Use

The Land Use Map prepared by GIS office, Ministry of Environment, Government of Cambodia was based on information of 1991 but published in September 1996 tells about the land use pattern very grossly (Figure 3.6.4). This map divided the region according to 9 types of land use. The northern part is mostly a mosaic of upland crops and secondary vegetal formation. The central part is essentially covered by paddy fields.

The southern part has two major types of land use: grassland susceptible to flooding, and flooded evergreen forest. Northern part of the region is covered with the evergreen forest. A large part of the natural vegetation of the area has been altered by human action; hence much of this forest is of secondary growth. The most obvious general degradation is the result of extensive land clearing for agriculture, and massive logging. Other potentially unsustainable exploitation practices include slash and burning agriculture, fuel wood collection, charcoal making, resin collection, etc.

The land use in the central portion of the region is basically composed of rice cultivation.

The other major land use pattern occurs in the area flooded by the Lake. There are at least two crops in that area. Floating rice grows in the rising water. The main rice crop was cultivated just after the floodwater recedes taking the advantage of nutrient rich deposits left by the receding water. Flooded forest area along the shoreline has a sensitive ecosystem. Some of the area is permanently under water while most of the area remains under water for certain duration per year. This is the breeding ground for fish of the lake and the lower Mekong River.



(2) Ecological Condition

Siem Reap Region is rich in ecological resources. It has a wide variety of flora and fauna.

1) Vegetation

The natural vegetation of the plains is lowland evergreen tropical rain forest. Dipterocarpus alatus is a common species and grows to about 35 to 40 m in height.

The freshwater flooded forests of the lake are renowned as one of the world's most extensive examples of this kind of forest. At the central part of the plain, extending from the inundated zones to the base of the mountains, a wide band of cultivated land is dominating. The principal crop is the rice paddy. The northern area is generally covered with evergreen forest.

Table 3.6.1 gives a list of major plants in the area. According to this list prepared by the Bureau of Forestry and Wildlife, Siem Reap in 1994, the total plant types is 54.

2) Fisheries

Fishes are caught in lake, West Baray, rice fields, ponds, floodwaters, streams, canals, and the rivers. The main species are common carp, Tilapia, and silver carp.

The lake is one of the world's richest and most productive inland fishing area. Harvests are estimated between 50,000 to 1,000,000 tons per year. Calculated on the lake's average area, the average yield is 65kg/ha/year, which is double that of the intensively managed reservoir in Thailand. This high productivity is due to the high nutrient status of the lake's water. However, the lake fishery is threatened by siltation, which is reported as 4 mm per year (ZEMP, 1993). Siltation will decrease the depth and increase the temperature. This increases the risk of mortality from high temperature and deoxidizing to fish.

3) Wildlife

The closest habitats of wildlife are the swamp forests bordering the lake to the south and the forests of the Kulen Mountains to the north. ZEMP team estimated (1993) that there are about 40 large mammal species, and about 400 species of birds in this area. However, the Study Team observes that the wildlife in the province is not well recorded.

**Table 3.6.1 List of Major Plants in Angkor Region
By the Bureau of Forestry and Wildlife, Siem Reap, 1994**

<Scientific name>	<Khmer name>	<Scientific name>	<Khmer name>
Plant of the best quality			
1. <i>Cassia siamea</i>	Angkanh	26. <i>Garcinia schomburghiana</i>	Tromung
2. <i>Diospyros bejaudi</i>	Angkat khmao	27. <i>Eugenia sp.</i>	Pring
3. <i>Afzelia cochinchinensis</i>	Beng	28. <i>Sandoricum indicum</i>	Kamping reach
4. <i>Dalbergia bariensis</i>	Neang nuon	29. <i>Aglaia gigantia</i>	Bangkoeru
5. <i>Melanorrhoea laccifera</i>	Kreul	30. <i>Hydrocarpus anthelmitica</i>	Krabao
6. <i>Pterocarpus pedatus</i>	Thnong	31. <i>Garcinia ferra</i>	Prus
7. <i>Diospyros helferi</i>	Trayoeung	32. <i>Melaleuca leucadendron</i>	Smach
8.	Tatrav	33. <i>Cratoxylon prunifolium</i>	Lngieng
Plant of first quality			
9. <i>Hopea helfera</i>	Koki daek	34. <i>Parinarium anamensis</i>	Thlorc
10. <i>Hopea recopei</i>	Popel	35. <i>Careya sphaeria</i>	Kandaul
11. <i>Lagerstroemia sp.</i>	Sralao	36. <i>Callophyllum sp.</i>	Pha-ong
12. <i>Peltiferum ferrugineum</i>	Trasek	Plant out of classification	
13. <i>Sindora cochinchinensis</i>	Krakoh	37.	Chambak
14. <i>Pentacme siamensis</i>	Reang phnom	38. <i>Popowia diospyrifolia</i>	Rumduol
15. <i>Tectona grandis</i>	Maisak	39.	Samporng
16. <i>Dialium cochinchinensis</i>	Kralanh	40. <i>Schleicher trijuga</i>	Pongror
Plant of second quality			
17. <i>Dipterocarpus alatus</i>	Chheuteal toek	41.	Rokar
18. <i>Anisoptera Glabra</i>	Phdiek	42.	Svay
19. <i>Dipterocarpus intricatus</i>	Trach	43. <i>Combretum cardrengulaire</i>	Sangkae
20. <i>Dipterocarpus obtusifolius</i>	Tbaeng	44. <i>Azadirachta indica</i>	Sdao
21. <i>Shorea vulgaris</i>	Chorchong	45.	Tras
22. <i>Vatica artrotricha</i>	Chrameas	46. <i>Lagerstroemia anisoptera</i>	Trabaek prei
Plant of third quality			
23. <i>Mangifera indica</i>	Svay prei	47. <i>Delonix regia</i>	Kngauk
24. <i>Artocarpus altilus</i>	Khnau prei	48. <i>Ficus religiosa</i>	Po
25. <i>Carallia lucida</i>	Tromeng	49. <i>Tamarindus indica</i>	Ampeoul
		50. <i>Xilopia sp.</i>	Kray
		51. <i>Nephelium cochichinensis</i>	Semoan
		52.	Srakum
		53.	Donkay
		54. <i>Diospyros decandra</i>	Chan

4) Endangered Species

It was not possible to obtain any information about endangered plants in the region. The Study Team recommends a thorough investigation on this regard.

ZEMP team identified (1993) about 17 endangered mammals, and 24 species of endangered birds in the region.

However, a declaration made by the Ministry of Agriculture, Forestry and Fisheries on August 1, 1996, enlisted 100 birds, 35 mammals and 6 reptiles as the endangered species, in whole of Cambodia. Table 3.6.2 shows the list. The Office of the Forestry in Siem Reap identified species found in the province in that table.

The Study Team observed widespread abuse on the endangered species in the region. Hunting and trapping animals and birds is common in the areas by gun, net and fishhook. Many species are sold in the market for food, medicine and decoration. From the sensitive ecosystem of the lake, the Study Team observed the shipment of rare alligator, snake, bird and other endangered species. All these evidences advocate for the better wildlife management to address these heinous activities.

5) Protected Areas

On November 1, 1993 a total of 23 protected areas were declared by the Royal Decree. This is shown in Figure 3.6.5. Four of these are located completely or partially in the Siem Reap Province:

- Angkor Protected Landscape (10,800 ha to be revised to 37,000 ha)
- Kulen Mountains National Park (37,500 ha)
- Kulen Promtep Wildlife Sanctuary (402,500 ha)
- Lake Tonle Sap Multiple Use Management Area (316,250 ha)

**Table 3.6.2 Endangered Species in Whole of Cambodia
By Ministry of Agriculture, Forestry and Fisheries (1/2)**

I - ANIMALS

No.	Name	S.R Area	No.	Name	S.R Area
1	Novibos sauveli	*	19	Felis bengalensis	*
2	Rhinoceros sondaicus		20	Cuon alpinus	*
3	Elephas indicus	*	21	Sus dcrofa et vitatus	*
4	Capricornis sumatresis	*	22	Canis aureus	*
5	Bos gaurus		23	Felis viverrina	*
6	Bos banteng		24	Nytecebus tardigradus	*
7	Bos bublus		25	Hylobates lar	*
8	Panthera tigris	*	26	Manus javanika	*
9	Panthera pardus	*	27	Paradoxurus hermaphroditus	*
10	Ursus thibetanus	*	28	Herpost urvo	*
11	Ursus malayanus	*	29	Semnopithecus polycepholus	*
12	Cervus eldi	*	30	Macaca irus	*
13	Cervus porcinus		31	Macaca cynomolgus	*
14	Felis marmorata		32	Hystrix cristata	*
15	Felis temmincki		33	Sciurus petorista	*
16	Tragulus kanchul	*	34	Lepus cochinsinnensis	*
17	Rusa unicolor	*	35	Canus indicus	*
18	Cervus mutiacus	*			

II - SNAKES

No.	Name	S.R Area
1	Varanus calvator	*
2	Varanus nebulosus	*
3	Python reticulatus	*
4	Python melurus	*
5	Python curtus	*
6	Naja tripudians	*

**Table 3.6.2 Endangered Species in Whole of cambodia
By Ministry of Agriculture, Forestry and Fisheries (2/2)**

No	Name	S.R Area	No	Name	S.R Area
1	Grus antigone	*	51	Copsychus saulasis musicus	*
2	Aquila hastata		52	Hemiproene coronata	*
3	Pavo muticus	*	53	Poricrocotus flammeus	
4	Bubo bubo	*	54	Poricrocotus perigrinus	
5	Reputa ceylonensis	*	55	Pelargopsis gural	*
6	Otozyps calvus	*	56	Haleyon smyrnensis	*
7	Gyps indicus	*	57	Halyon fusea	*
8	Limmoetus nepalensis	*	58	Cerule varia	*
9	Limmoetus philipensis	*	59	Oriolus indiens	*
10	Soilornis rutipectus	*	60	Oriolus melanocephalus	*
11	Spilornis holospilus	*	61	Oriolus ardens	*
12	Astur soioensis	*	62	Leptoptilus dubius	*
13	Astur poliopsis	*	63	Leptoptilus javanicus	*
14	Haliastur indus	*	64	Pseudotanus leucocephalus	*
15	Milvus migrans	*	65	Mycteris cinerea	*
16	Circus spilontus	*	66	Anes tomus oscitans	*
17	Falco peregrinnus	*	67	Threskiornis melanocephalus	*
18	Baza lophotes		68	Pseudibis papillos	
19	Strix flammea	*	69	Thaumatibis gigantea	*
20	Picus javanensis	*	70	Plegadis falcinellus	*
21	Picus pulvorulensis		71	Xenorhynchus asiaticus	*
22	Picus vittatus	*	72	Dissura opiscoous	*
23	Hirundo oolocalia		73	Anhinga melanogaster	
24	Halcyon pulcolla		74	Ardea cinerea	*
25	Corvus lavallanti	*	75	Ardea sumatrana	*
26	Corvus torquatus		76	Egretta alba	*
27	Corvus insolens	*	77	Egretta garzetta	*
28	Palocornis fesciata	*	78	Bubuleus ibis	*
29	Palocornis rosa	*	79	Ardeola bacchus	*
30	Ioriculus vernalis	*	80	Egretta sacra	*
31	Gemrocus nyctemerus	*	81	Butorides striatus	*
32	Gemorocus annamensis	*	82	Gorsachius melanophus	*
33	Gallus gallus		83	Ixobrychus sinensis	*
34	Tropicoperdrix charltons	*	84	Pelecanus philippensis	*
35	Tropicoperdrix merlinivivida	*	85	Pelecanus onocrotalus	*
36	Dichoceros bicorris	*	86	Phalacrocorax carba	*
37	Rhytidoceros undulatus	*	87	Phalacrocorax fusciocollis	*
38	Anthracoceros aldirostris	*	88	Phalacrocorax nige	*
39	Picaserica caudata	*	89	Anas acuta	*
40	Chalcophaps indica	*	90	Dandrocygna javanica	*
41	Alsoconus torringtonioe	*	91	Anas crecca	*
42	Turtur muna	*	92	Nettapus pulchellus	*
43	Turtur sutatensis	*	93	Fulica atra	*
44	Strep topilia	*	94	Gallicrex cinecea	*
45	Eurystomus affinis	*	95	Porphysio edwarsi	*
46	Eurystomus orientalis	*	96	Gallinula pervifrons	*
47	Eulabes jagricollis	*	97	Sarcogranus indicus	*
48	Gracupica nigricollis	*	98	Scolopax russticola	*
49	Microhieras fringgillarius	*	99	Capella gallinago	
50	Garrulax perspicillatus	*	100	Amuornis phoenicurus	*

(3) Laws and Regulations

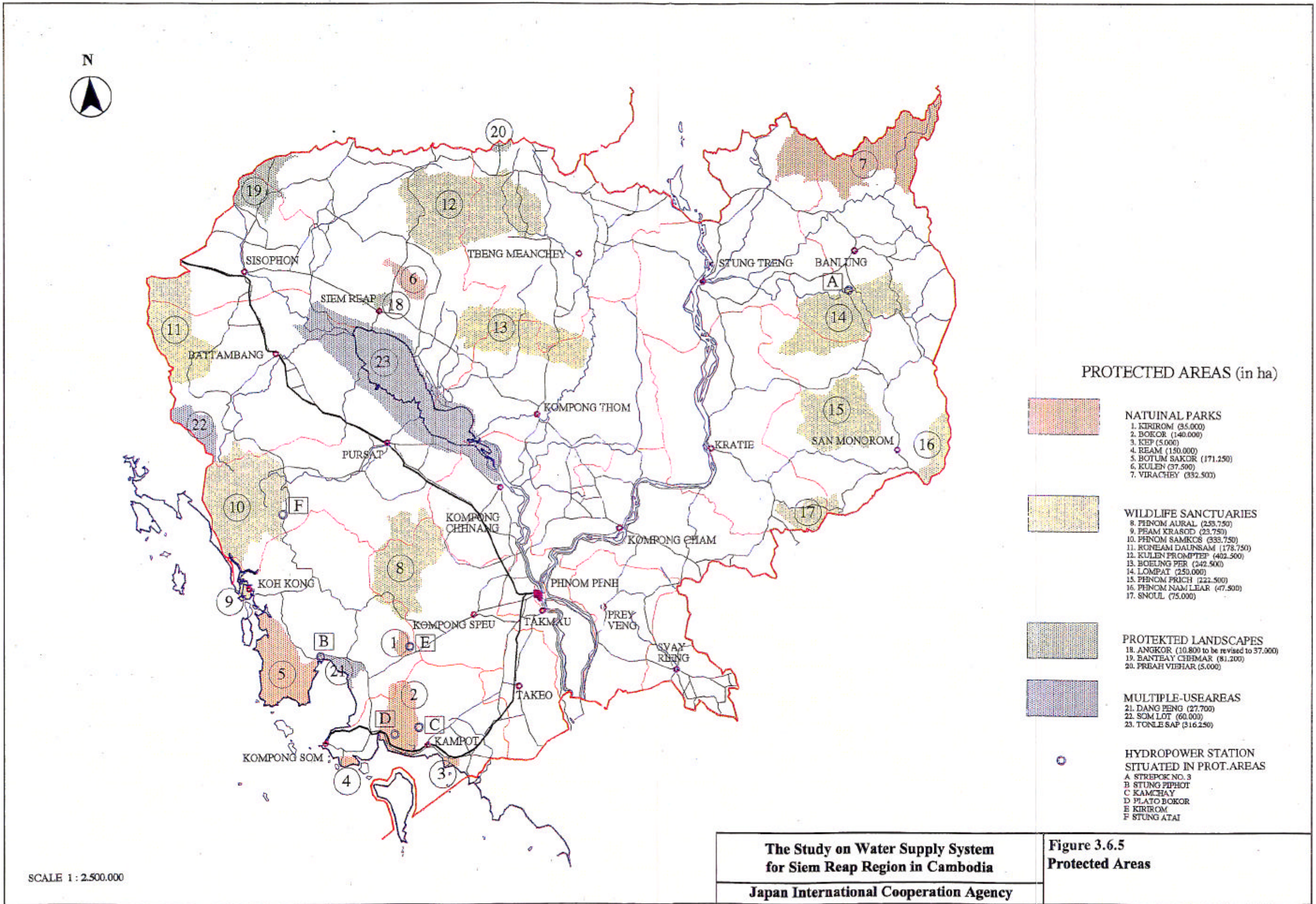
1) Environmental Protection

A “Law on Environmental Protection and Natural Resource Management” was promulgated on 24 December 1996. The main objectives are to protect and promote environmental quality and public health through the prevention, reduction, and control of pollution; to assess the environmental impact of all development projects; and to ensure the rational and sustainable conservation, development, management, and use of natural resources. The law provides the scope for national and regional environmental plans for environmental protection and sustainable natural resources management. The law defines the scope of environment, the importance of environmental degradation, the authority to supervise natural resources, and the regulation for punishment. The regulations concerning the punishment can be made more specific as it appears that enforcement would be extremely difficult with the law with its present documentation.

2) Environmental Impact Assessment (EIA)

At present (September 1999), there is no specific law on EIA.

The “Law on Environmental Protection and Natural Resource Management”, however, specifies that an EIA have to be done on every project and activity, private and public, and have to be reviewed and evaluated by the Ministry of Environment. This law also states that there will be a sub-decree on EIA, which will determine the procedures of EIA; and nature and size of proposed projects and activities subject to EIA. The law does not mention which guideline has to be followed in the interim period until the sub-decree on EIA is prepared. The Study Team observes that quick incorporation of the issue of EIA with specific guidelines is essential in order to achieve the objectives of the law.



PROTECTED AREAS (in ha)

- NATURAL PARKS**
 - 1. KIRIROM (35.000)
 - 2. BOKOR (140.000)
 - 3. KEP (5.000)
 - 4. REAM (150.000)
 - 5. BOTUM SAKOR (171.250)
 - 6. KULEN (37.500)
 - 7. VIRACHEY (332.500)

- WILDLIFE SANCTUARIES**
 - 8. PHNOM AURAL (253.750)
 - 9. PEAM KRASOD (23.750)
 - 10. PHNOM SAMKOS (333.750)
 - 11. RONEAM DAUNSAM (178.750)
 - 12. KULEN PROMPTER (402.500)
 - 13. BOEUNG PER (242.500)
 - 14. LOMPAT (250.000)
 - 15. PHNOM PRICH (221.500)
 - 16. PHNOM NAM LEAR (47.500)
 - 17. SNOUL (75.000)

- PROTECTED LANDSCAPES**
 - 18. ANGKOR (10.800 to be revised to 37.000)
 - 19. BANTEAY CHHMAR (81.200)
 - 20. PREAH VIHAR (5.000)

- MULTIPLE-USE AREAS**
 - 21. DANG PENG (27.700)
 - 22. SOM LOT (60.000)
 - 23. TONLE SAP (316.250)

- HYDROPOWER STATION SITUATED IN PROT. AREAS**
 - A STREPOK NO. 3
 - B STUNG PIPHOT
 - C KAMCHAY
 - D PLATO BOKOR
 - E KIRIROM
 - F STUNG ATAI

**The Study on Water Supply System
for Siem Reap Region in Cambodia**

Japan International Cooperation Agency

**Figure 3.6.5
Protected Areas**

SCALE 1 : 2.500.000

3) Water Pollution Control

In April 1999, a law was enacted regarding water pollution control. This is known as “Sub-Decree on Water Pollution Control”. The main purpose of this law is to regulate, prevent and reduce the water pollution of the public water areas so that the protection of human health and the conservation of bio-diversity should be ensured. This law defines the public water areas, source of pollution and types of pollution. It also states that an effluent discharge permit will be required for any kind of disposal into public water bodies. Under this law, monitoring on the discharge and/or transportation of effluent from any sources of pollution is the responsibility of the Ministry of Environment in addition to the monitoring of the water pollution level of all public water bodies. This law also provides for the penalty in case of violation of the law. This law also stipulates various standards.

The effluent standard for discharging into public water areas is given in Table 3.6.3. For the protected areas like Lake Tonle Sap and the Siem Reap River (according to the plan, this will become a protected area in future), the standard is strict. But it is rather lax for general public water areas. The acceptable BOD load is 80 mg/l. It would be difficult to keep the ambient water quality with this discharge standard especially in large cities or industrial areas. A review is recommended by the Study Team. Table 3.6.4 shows the list of pollution sources for which permission is required before discharging and transporting. Table 3.6.5 shows the ambient water quality for bio-diversity conservation and Table 3.6.6 gives the ambient water quality for public health protection.

Right now, there is no standard for drinking water in Cambodia. WHO guideline is generally followed.

**Table 3.6.3 Effluent Standard for Pollution Sources
Discharging Wastewater to Public Water Areas or Sewer (1/2)**

N°	Parameters	Unit	Allowable limits for pollutant substance discharging to	
			Protected public water area	Public water area and sewer
1	Temperature	°C	< 45	< 45
2	pH		6 - 9	5 - 9
3	BOD ₅ (5 days at 20 °C)	mg/l	< 30	< 80
4	COD	mg/l	< 50	< 100
5	Total Suspended Solids	mg/l	< 50	< 80
6	Total Dissolved Solids	mg/l	< 1000	< 2000
7	Grease and Oil	mg/l	< 5.0	< 15
8	Detergents	mg/l	< 5.0	< 15
9	Phenols	mg/l	< 0.1	< 1.2
10	Nitrate (NO ₃)	mg/l	< 10	< 20
11	Chlorine (free)	mg/l	< 1.0	< 2.0
12	Chloride (ion)	mg/l	< 500	< 700
13	Sulphate (as SO ₄)	mg/l	< 300	< 500
14	Sulphide (as Sulphur)	mg/l	< 0.2	< 1.0
15	Phosphate (PO ₄)	mg/l	< 3.0	< 6.0
16	Cyanide (CN)	mg/l	< 0.2	< 1.5
17	Barium (Ba)	mg/l	< 4.0	< 7.0
18	Arsenic (As)	mg/l	< 0.10	< 1.0
19	Tin (Sn)	mg/l	< 2.0	< 8.0
20	Iron (Fe)	mg/l	< 1.0	< 20
21	Boron (B)	mg/l	< 1.0	< 5.0
22	Manganese (Mn)	mg/l	< 1.0	< 5.0
23	Cadmium (Cd)	mg/l	< 0.1	< 0.5
24	Chromium (Cr)	mg/l	< 0.2	< 1.0

**Table 3.6.3 Effluent Standard for Pollution Sources
Discharging Wastewater to Public Water Areas or Sewer (2/2)**

N ^o	Parameters	Unit	Allowable limits for pollutant substance discharging to	
			Protected public water area	Public water area and sewer
25	Chromium (Cr ⁺⁶)	mg/l	< 0.05	< 0.5
26	Copper (Cu)	mg/l	< 0.2	< 1.0
27	Lead (Pb)	mg/l	< 0.1	< 1.0
28	Mercury (Hg)	mg/l	< 0.002	< 0.05
29	Nickel (Ni)	mg/l	< 0.2	< 1.0
30	Selenium (Se)	mg/l	< 0.05	< 0.5
31	Silver (Ag)	mg/l	< 0.1	< 0.5
32	Zinc (Zn)	mg/l	< 1.0	< 3.0
33	Molybdenum (Mo)	mg/l	< 0.1	< 1.0
34	Ammonia (NH ₃)	mg/l	< 5.0	< 7.0
35	DO	mg/l	> 2.0	> 1.0
36	Polychlorinated Byphenyl	mg/l	< 0.003	< 0.003
37	Calcium	mg/l	< 150	< 200
38	Magnesium	mg/l	< 150	< 200
39	Carbon tetrachloride	mg/l	< 3	< 3
40	Hexachloro benzene	mg/l	< 2	< 2
41	DDT	mg/l	< 1.3	< 1.3
42	Endrin	mg/l	< 0.01	< 0.01
43	Dieldrin	mg/l	< 0.01	< 0.01
44	Aldrin	mg/l	< 0.01	< 0.01
45	Isodrin	mg/l	< 0.01	< 0.01
46	Perchloro ethylene	mg/l	< 2.5	< 2.5
47	Hexachloro butadiene	mg/l	< 3	< 3
48	Chloroform	mg/l	< 1	< 1
49	1,2 Dichloro ethylene	mg/l	< 2.5	< 2.5
50	Trichloro ethylene	mg/l	< 1	< 1
s	Trichloro benzene	mg/l	< 2	< 2
52	Hexachloro cyclohexene	mg/l	<2	< 2

Remark: The Ministry of Environment and the Ministry of Agriculture, Forestry and Fishery shall collaborate to set up the standard of pesticides which discharged from pollution sources.

**Table 3.6.4 Type of Pollution Sources Required Having
a Permission from Ministry of Environment before
Discharging or Transporting Their Wastewater (1/2)**

N^o	Type of pollution sources	Category
1	Canned food and meat manufacturing	I
2	Canned vegetable and fruit manufacturing	I
3	Aquatic production processing	I
4	Frozen manufacturing	I
5	Flour manufacturing	I
6	Sugar manufacturing	I
7	Pure drinking water manufacturing	I
8	Brick manufacturing	I
9	Soft drink manufacturing and brewery	I
10	Wine and alcohol manufacturing	I
11	Feed mill manufacturing	I
12	Oil and fat manufacturing	I
13	Yeast manufacturing	I
14	Cake and sweet manufacturing	I
15	Cigarette manufacturing	I
16	Garment manufacturing without chemical washin	I
17	Hotel	I
18	Restaurant	I
19	Animal farm	I
20	Slaughter - house	I
21	Garage and car cleaning	I
22	Business center	I
23	Hospital and clinic	I
24	Plastic manufacturing	I
25	Sewage treatment plant	I
26	Gelatin and Glue manufacturing	I
27	Natural resin manufacturing	I
28	Glass manufacturing	I
29	Cement manufacturing	I
30	Macadam quarrying	I
31	Gravel quarrying	I
32	Wood processing	I
33	Fertilizer manufacturing	I
34	Mixed concrete manufacturing	I
35	Ship carrying liquid substances	II
36	Acetylene derivative manufacturing	II
37	Leather manufacturing	II
38	Soap and detergent manufacturing	II

Table 3.6.4 Type of Pollution Sources Required Having a Permission from Ministry of Environment before Discharging or Transporting Their Wastewater (2/2)

N^o	Type of pollution sources	Category
39	Oil store house and filling station	II
40	Landfill site	II
41	Textile or synthetic textile	II
42	Garment manufacturing with using chemical wash	II
43	Pulp and paper manufacturing	II
44	Printing house	II
45	Mining and coal washing	II
46	Battery manufacturing	II
47	Inorganic pigment manufacturing	II
48	Electronic manufacturing	II
49	Coal tar product manufacturing	II
50	Film product manufacturing	II
51	Chemical organic substance manufacturing	II
52	Pharmaceutical manufacturing	II
53	Solvent (for cleaning) manufacturing	II
54	Pesticide manufacturing	II
55	Oil refining factory	II
56	Iron and steel industry	II
57	Non-ferrous metals manufacturing	II
58	Metal product manufacturing	II
59	Plating factory	II
60	Incinerator or waste recycling plant	II
61	Night soil treatment plant	II
62	Waste oil treatment plant	II
63	Industrial waste treatment plant	II
64	Laboratory and Research center	II
65	Power plant	II
66	Wood processing manufacturing	II
67	Shrimp farm	II

- Note:** a- The sources of pollution of category I that are subject to the prior permit from the Ministry of Environment when the amount of their effluent exceed ten cubic meter per day (10 m³/day) but not including the amount of water volume used for cooling the engine.
- b- The sources of pollution of category II that shall be necessarily required to apply for the permission from the Ministry of Environment.

**Table 3.6.5 Water Quality Standard in
Public Water Areas for Bio-diversity Conservation**

1. River

No	Parameter	Unit	Standard Value
1	pH		6.5 - 8.5
2	BOD ₅	mg/l	1 - 10
3	Suspended Solid	mg/l	25 - 100
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform	MPN/100ml	< 5000

2. Lakes and Reservoirs

No	Parameter	Unit	Standard Value
1	pH		6.5 - 8.5
2	COD	mg/l	1 - 8
3	Suspended Solid	mg/l	1 - 15
4	Dissolved Oxygen	mg/l	2.0 - 7.5
5	Coliform	MPN/100ml	< 1000
6	Total Nitrogen	mg/l	0.1 - 0.6
7	Total Phosphorus	mg/l	0.005 - 0.05

3. Coastal water

No	Parameter	Unit	Standard Value
1	pH		7.0 - 8.3
2	COD	mg/l	2 - 8
3	Dissolved Oxygen	mg/l	2 - 7.5
4	Coliform	MPN/100ml	< 1000
5	Oil content	mg/l	0
6	Total Nitrogen	mg/l	0.2 - 1.0
7	Total Phosphorus	mg/l	0.02 - 0.09

MPN : Most Probable Number

**Table 3.6.6 Water Quality Satandard
in Public Water Areas for Public Health Protection**

No	Parameter	Unit	Standard Value
1	Carbon tetrachloride	µg/l	< 12
2	Hexachloro-benzene	µg/l	< 0.03
3	DDT	µg/l	< 10
4	Endrin	µg/l	< 0.01
5	Diedrin	µg/l	< 0.01
6	Aldrin	µg/l	< 0.005
7	Isodrin	µg/l	< 0.005
8	Perchloroethylene	µg/l	< 10
9	Hexachlorobutadiene	µg/l	< 0.1
10	Chloroform	µg/l	< 12
11	1,2 Trichloroethylene	µg/l	< 10
12	Trichloroethylene	µg/l	< 10
13	Trichlorobenzene	µg/l	< 0.4
14	Hexachloroethylene	µg/l	< 0.05
15	Benzene	µg/l	< 10
16	Tetrachloroethylene	µg/l	< 10
17	Cadmium	µg/l	< 1
18	Total mercury	µg/l	< 0.5
19	Organic mercury	µg/l	0
20	Lead	µg/l	< 10
21	Chromium, valent 6	µg/l	< 50
22	Arsenic	µg/l	< 10
23	Selenium	µg/l	< 10
24	Polychlorobiohenyl	µg/l	0
25	Cyanide	µg/l	< 0.005

4) Water Supply and Sanitation Policy

In 1987, a Sub-Decree for 'The Provision and Use of Potable Water' was enacted. The purpose of this decree was to ensure the control of water supply by the State. It provides that the provision of potable water is to be a state monopoly to be carried out by means of municipal and provincial administrations or some other designated bodies. However, at present (September 1999) there is no comprehensive policy for water supply. With the assistance from the Asian Development Bank (ADB), the process for the preparation of such policy was started. A draft policy is proposed already by ADB (Institutional Support to the Water Supply Sector, March 1998). A national level committee will work for the preparation of this policy along with some experts provided by the ADB. Concurrently with this project, the World Bank (WB) is proposing a component within their Cambodian Urban Water Supply Development Project, to address 'Policy Framework'. The GOC also welcomed the idea of ADB and WB collaborating on this policy together. WB is also proposing to fund a Water Policy Consultant to assist the Government in preparing the sector policy.

Although the country is rich in surface and groundwater resources, a significant portion of the population may find it difficult to afford the cost of having good quality water supplied to their homes. Thus, a highly organized operational procedure is essential to get maximum benefit from water supply services. The main problems for the provincial towns are:

- acute shortage of skilled manpower to develop and operate the provincial water supplies,
- clear demarcation of electricity and water operations, which are under the same administration in many towns, and
- absence of adequate accounting and financial systems to ensure accountability for revenue and expenditure.

According to ADB proposed draft policy on water supply, the mission statement is as follows:

1. Maintain a continuous supply of safe water at reasonable cost to all registered customers.
2. Develop water sources, treatment and supplies in the provincial urban areas in accordance with Government priorities, with the ultimate aim of achieving 100% coverage in longer terms.
3. Progressively develop wastewater drainage, treatment and disposal facilities consistent with the maintenance of a healthy environment in provincial urban areas.

4. Aim to achieve short, medium and long term financial viability by making a net profit as a contribution to future rehabilitation and development costs.
5. Employ adequately skilled staff who are respected, valued and rewarded appropriately.
6. Treat customers courteously and promptly, with a strong commitment to quality of service and social aspirations of the community.
7. Respect and conserve the environment.

To make the investment priorities, this proposed Policy Statement underscores the following criteria:

- Willingness and ability to pay in relation to cost
- Scope and condition of present system
- Preset access to water in adequate quantity and quality
- Incidence of water related diseases

No information is available about a separate sanitation policy. However, some basic principals are outlined in ADB proposed Water Supply Draft Policy anticipating that introduction of piped water supply will lead to increased flow of wastewater. The policy proposed to avoid flush toilet to reduce the amount of wastewater. The preferred option will be pour flush pit latrine, with its limited wastewater implications, or alternatively, some forms of ventilated improved pit (VIP) latrine.

5) Water Resources Management

DFID (UK) assisted 'Management Support Program to the Water Sector' tentatively proposed about the possible institutional structures that could be appropriate for regulating and developing the water sector in Cambodia. In Cambodia, at present, both regulatory and executing functions are combined in one institution for each subsector (irrigation, water supply, hydropower, industrial water supply) of the water sector without any coordinating or controlling mechanism applied to the sector. DFID observes that this approach sometimes presents numerous drawbacks, in that water resources planning is not facilitated, competing institutions are in conflict, and it is a cause of overlapping functions and responsibilities.

In this regard, DFID tentatively proposed for one regulatory institution coordinating the functions of several executing agencies, which can be both governmental and private. DFID observes that by this way, the most effective and economical use of the country's total water resources can be attained. However, this proposal is now at very draft and early state.

6) Water Right

At present, there is no regulation about water use right for the West Baray, Siem Reap River, Lake Tonle Sap or groundwater abstraction. There is no plan to make one in near future. This is particularly important for the river. Over abstraction of river water at the Crocodile Weir is one of the reasons of low water flow of the river downstream of the weir in dry season.

7) Fishing Right

There is currently no fishing right for the river and West Barry.

Fishing right for the lake is existing with negligible practice. According to the law, the lake is divided into 3 zones. Fishing is illegal along the shoreline within the flooded forest. The 2nd zone consists of the area of continental shelf (relatively deep-water zone bordering the flooded forest area). This zone is permitted only for hatching. Further deep-water zone is the public fishing area. However, the Study Team observed large scale fishing activity within the zones 1 and 2. Sample hearing survey by the Study Team also indicated that most of the people are not aware of the law itself.

8) Solid Waste Management

A 'Sub-Decree on Solid Waste Management' was enacted in April 1999, which covers both household and hazardous wastes. This also includes monitoring of the waste management and penalties for defaulters. The purpose of this sub-decree is to regulate the solid waste management with proper technical manner and safe way in order to ensure the protection of human health and the conservation of bio-diversity. The collection, transport, storage, recycling, minimizing and dumping of the waste in the provinces and cities are the responsibility of the authorities of provinces and cities. The Ministry of Environment should monitor the implementation of solid water management and disposal in the provinces and cities.

9) Law on Wood Export

Considering the importance of the forestry, and recent over logging, the Government of Cambodia banned export and bidding for export for wood effecting from April 30, 1995. The log already cut at that time was also banned for export which was used for domestic purposes.

10) Law on Endangered Species

This is described in the Section 3.6.3 (2).

11) Law on Protected Areas

This is described in the Section 3.6.3 (2)

12) Law for the Supervision on Forestry

A law regarding the supervision of forestry was promulgated on June 25, 1988. This law defined the type of forests, their demarcations, criteria for the business of wood and wood products, the protected forestry, hunting rule and the scope of punishment for violating the regulations. However, the Study Team observed that there is no information in the Office of Forestry in Siem Reap on the enforcement of this law in the past 11 years.

(4) Water Quality

In this section a summary of the water quality investigation results of the surface and groundwater carried out by the Study Team is presented. Details can be found in Section 3.5.

1) Groundwater

The survey conducted for groundwater shows that nitrate, nitrite, chloride, calcium, manganese and magnesium are almost negligible. Hardness is also very low in most places except southern area and central part of the Town. The major concern is iron concentration. In most places, iron content is higher than WHO standard of 0.3 mg/l. It is indicated that the area along the former river course near the West Baray seems to have low iron content while the eastern part of the town have high iron content. General bacteria were found in most open wells. Waters from tube wells are not contaminated. In most cases, pH values indicate that the well water is in acidic and aeration can be a suitable way to increase pH. It also indicates that water in some wells is contaminated by human or animal feces, which may cause harm if drunk without some measures (like boiling).

2) Surface Water

There are three major surface water sources in the vicinity of the town. These are the river, the lake, and West Baray. Ranges of iron concentrations of these waters are 0.2 to 0.9 mg/l for Baray, 0.3 to 1.5 mg/l for the River and 0.5 to 7.0 mg/l for the Lake. This indicates that water of the Baray is less polluted among these three while that of the Lake is most polluted.

3) Bottled Water

Water quality test was carried out by the Study Team for 4 types of bottle water available in the area. Out of these, three were locally bottled brands while one was imported brand. Result indicates that the locally bottled drinking waters were poor in quality. Continued consumption of such water may not be recommended. In one case, excess residual chlorine was found, indicating poor treatment procedure. This also caused the water to be in acidic range. All the local brands showed low EC values, and low Ca, Mg, and hardness.

(5) Water and Sanitary Infrastructure

Sanitary infrastructure of a locality is composed of water supply system, wastewater disposal system, solid waste disposal system, primary health care and hygiene education system to ensure public health.

1) Water Supply

The piped water supply system in the town was restarted in July 1999 after a 4-year suspension. Still, most of the people get their water from open dug well, tube well or surface water source. Most of the tube wells are shallow. Hotel and other big enterprises have their own deep tube well.

Urban Water Supply:

Most of the households in the town area have wells. Some of the wells are open dug wells and some are tube wells. In most cases, one well serves 1 family. Some of these wells have the problem of iron. Some of the persons mentioned that they boil the water before drinking while others consume the water without any treatment. Only a few people are connected with public water supply. This service is also suffering from iron problem. Most people boil the tap water before drinking.

Rural Water Supply:

Areas adjacent to the town center are covered by rural water supply system. The rural water supply is under the authority of Ministry of Rural Development. They carry out the program with direct assistance of UNDP / CARERE and with the support of AISF (French NGO) and UNICEF. The people outside this program have to deal with various obstacles. In many cases they dug an open well without lining or elevated well boundary. The average depth is 3 to 5 m. The Study Team found that the water quality of some of the wells are unpleasant. Above all, many people are using the water from pond, river or the lake for their domestic purposes including drinking.

Bottled Water:

A large section of the people depends on the bottled water for their drinking water demand. There are 4 local bottling companies whose total production capacity is 4,511 liters per day (1997). Average price is about 400 Riels per liter. A survey by the Study Team suggests that there are some points to worry about the hygiene condition that prevails in the bottling companies. It was learned that there is no periodic check for the water quality. The source of water in these cases is the ground water. In one of the bottling companies visited by the Study Team, it was found that there is no post chlorination. The material in different filter beds is changed only once in 8 to 12 months.

Deep Wells:

Deep wells are used by hotels, hospitals and some organizations. There is no data available on the total number of deep wells operating in the Town. A brief survey conducted by the Study Team revealed that hotels usually treat the water up to some extent, while the hospital uses the water without any treatment. Most of cases, the treatment involved filtration, ion exchange (for iron removal) and disinfection.

Previous Water Works:

The first waterworks of Siem Reap was constructed in the 1930s by France. In 1960s USA constructed another system which was in operation until March 1995. It was suspended due to reduced water availability, decreased water quality caused by lack of wastewater treatment facility, and poor condition of waterworks facility developed from the difficulties to reconstruct the old filter bed. The production rate was 300 m³/day and the treatment involved alum coagulation, sand filtration and disinfection by electrostatic chlorine generation. The intake was from the river. In 1994, there were 170 connections including 17 offices, one hospital and 2 schools. The supply was intermittent and there were no water meters.

Present Water Works:

An emergency water supply project funded by CFD is now operating. It uses the existing water supply network but uses groundwater as the source. Two new deep wells are constructed. Total 414 connections are provided all equipped with water meters. This includes 335 house connections, 6 hotels, 15 guesthouses, 23 restaurants, 30 offices, 3 schools, and 2 pagodas.

Institution and Management of Urban Water Supply:

For the urban water supply, the responsible authority is the Ministry of Industry, Mines and Energy. A provincial office of this Ministry in Siem Reap assumes all the responsibilities. However, a separate waterworks has

been established under this provincial office to operate the water supply system in the town.

2) Water Management

Water management is uncoordinated and wasteful, resulting in low efficiency. One of the reasons is the lack of comprehensive planning. Absence of water right law further complicates the matter. Absence of water storing structure except West Baray, and special rainfall pattern forces the dry-season flow in the rivers insufficient to meet the demand. The dry weather flow at the river is less than 1 m³/s which is already too low to flush out pollution and avoid eutrophication. Absence of any wastewater treatment facility also contributes to the poor water quality of the river. The growth in population of the town requires a greater quantity of water to maintain required river quality. Water from the West Baray is utilized for irrigation purpose in this region. Another irrigation scheme uses water from the Crocodile Weir to irrigate southern part of Siem Reap. There is no deep well operating in the area for the purpose of irrigation only.

3) Wastewater Disposal

There was a piped waste collection system in the central core of the Town. However, the service is now not working properly. There is no wastewater treatment plant at the town or nearby regions. There is no sewage project currently under consideration. According to the District Office, 30% of the household is covered by the septic tank system, while only 10% use pit latrines. The remaining uses open defecation. There is a drainage system for the disposal of rainwater in the Town. The storm drainage system consists of cisterns placed in many places connected to 3 canals which discharge into rivers or rice fields. Details of the wastewater disposal and drainage are described in Section 4.8.

4) Solid Waste Disposal

There is only limited solid waste collection system in the town. The provincial government made a 10-year contract with a contractor for solid waste collection (from February 1998). The contractor collects the solid waste everyday from the pre-registered household by using vehicles. As there is no landfill site in and around Siem Reap, usually the garbage is thrown in the low land sites of private parties who want to fill their site for future construction. In August 1999, the total number of pre-registered household for solid waste collection is only 506, which translates a cover ratio of less than 5%. After giving contract money to the provincial

government, the contractor is allowed to collect a fee from the pre-registered household. The monthly fee varies from 4,500 Riel for simple households to 76,000 Riel for hotels, with 7 variations. A site investigation of a landfill site by the Study Team denotes that huge amount of organic matter is the principal constitute of the landfill material. This may cause high strength leachate that may lead to ground water pollution.

5) Public Health

The Siem Reap Province has a serious public health situation. The most serious illness, all of which occur at high levels, are malaria, tuberculosis, sexually transmitted diseases including AIDS, diarrhea, acute respiratory infections and dengue fever. Cambodia has one of the highest rate of tuberculosis infection rate in the world. Few of the public clinics can deliver even a basic health service.

Present situation

The Province of Siem Reap has 1 provincial hospital, 14 district health centers, and 75 dispensary. In addition, there are two children's hospital constructed and operated by NGOs. The total number of staff working in the Public Health Service (as of Dec. 1996) is 855. Out of which there are 31 medical doctors, 5 pharmacists, 0 dentists, 56 medical assistants, 9 pharmaceutical assistants, 2 dental assistants, 225 primary nurses, 152 primary midwives, 213 junior nurses, 69 junior midwives, and other technical and administrative staffs.

From the 1996 record provided by the Office of Health Service in Siem Reap, it is gathered that water borne disease occurrence is significant in the province. The statistics of health service is compiled and presented below.

Major Water Related Diseases Diagnosed in Siem Reap Province, 1996

Kind of water related diseases	Number of new cases
Malaria	14,496
Diarrhoea	17,508
Typhoid	17,676
Skin disease	5,676
Sub Total (water related diseases)	55,356
Total (of above and others)	139,752

Source: Based on information provided to the JICA Study Team by Provincial Office of Health Service

This shows that about 40% of the total cases are water-related diseases. Considering a population of 650,000, it means one in every 11.7 persons is suffering from water related diseases.

Situation in Hospital, 1996

Kind of water related diseases	people admitted	people died
Malaria	3,072	84
Diarrhea	558	12
Cholera	48	0
Dengue	264	24
Respiratory	2,004	48
Sub total (water related diseases)	5,946	168
Total (of above and others)	15,168	264

Source: Based on information provided to the JICA Study Team by Provincial Office of Health Service

This shows that about 40% of the total admittance and 64% of the total death are due to water related diseases.

A quick visit by the Study Team to the provincial hospital revealed that the hospital is functioning well although there is acute shortage of equipment and skilled personnel. Built in the 1960s, this has 340 beds with 100% occupancy rate throughout the year. Among 200 staffs, there are only 15 medical doctors and 15 medical assistants. There are 2 wells with electric pumps and elevated tanks. The water is used without any treatment though problem of iron is reported. There is no water available at night, which is very inconvenient for the patients.

Future Strategy

Under the UNICEF collaboration, the Department of Health has taken up an ambitious program to be implemented within 1996 - 2000. Under present 3 tiers' policy, there is 1 dispensary in most of the commune and 1 health center for each district. Under the new 2 tier system, there will be 4 referral hospital located regionally with the level of present provincial hospital, and 57 health centers located in the center of an area with about 8,000 to 12,000 people. The health center is defined as to serve MPA (Minimum Package of Activities) which includes simple curative, preventive and referral service, among others. The center will consist of headed by a qualified nurse. The referral hospital will be able to serve CPA (Complementary Package of Activities).

Health Education

The present situation in the health education is not well organized. There are some topics related to hygiene and health care in the textbook of the school curriculum. Health Office also promotes the aspects of public health by poster, video, audio, and group discussion from time to time. However, because of the lack of financial support, water borne diseases are less focused than, for example AIDS, the campaign of which is well supported. Under the proposed UNICEF supported health program, provisions are kept for community participation in the health centers through the Health Center Management Committee (HCMC) and Feed Back Committee (FBC). It is proposed that through this program, health messages will reach four corners which include hygiene, proper water use, nutrition, vaccination, birth spacing, and use of health centers.

6) Fire Protection System

The fire service is under the jurisdiction of the provincial police force. There are four fire engines serving the town and another one serving the airport. Out of these engines, one was out of order when the Study Team visited. It is reported that they do not have ladders to reach above the first floor of buildings. The fire fighters are taken from the police department and are not specially trained. Water source for fire protection is often short supply especially in dry season.

(6) Social Environment

Siem Reap has a unique and sensitive social environment. There are different social groups visible in the area. However, the social texture is fragile because of increasing pressure from tourism sector. More details on social investigation can be found in Section 3.6.2.

(7) Environmental Management

1) Ecology

The signal of continued environmental degradation is visible all around Siem Reap. Encroachment of agricultural land into secondary forest, and massive logging for firewood and other purposes are threatening the natural balance. To overcome this problem, a long-term intensive program is needed. However, this must take note about the acceptance by the local people, as no legislation is sufficient to ensure sustainable use of natural resources without people's participation. Environmental values will also have to be promoted through meaningful education.

Unsustainable fish catching from the lake will ultimately damage the future potential of this industry. Fish hatching plants can be planned scientifically and fisher community can be brought under effective awareness program. The problem of increased siltation has to be addressed otherwise it will result in high animal mortality in dry years and reduced annual migration from the Mekong River to the lake.

To ensure the bio-diversity of the wildlife, a strict practice of present law is highly recommended. Further encroachment upon the flooded forest around the lake should be prevented to stabilize the land use patterns.

2) Water Management

Minimum water flows in the river have to be increased to ensure dilution of pollution, domestic and agricultural water use, and tourist attractiveness. This can be achieved by constructing new dams on the river near Kulen Mountains, and by rehabilitating some of the ancient water structures. As an immediate step, clear law about the water abstractions from river has to be introduced and practiced. This will prevent the excessive water use.

The present weir and diversion structures can be altered with little afford to become multipurpose structure which can also be used as a flood control and drainage structure. Pollution of the river should be stopped by immediately prohibiting sewage disposal into the river and by constructing sewerage system in near future.

The present solid waste disposal system is essential to improve. Suitable landfill site has to be identified and present collection and transfer system could be reorganized.