7.2 Sector Approaches

7.2.1 Objectives and Approaches

The objectives of water source and water supply development are:

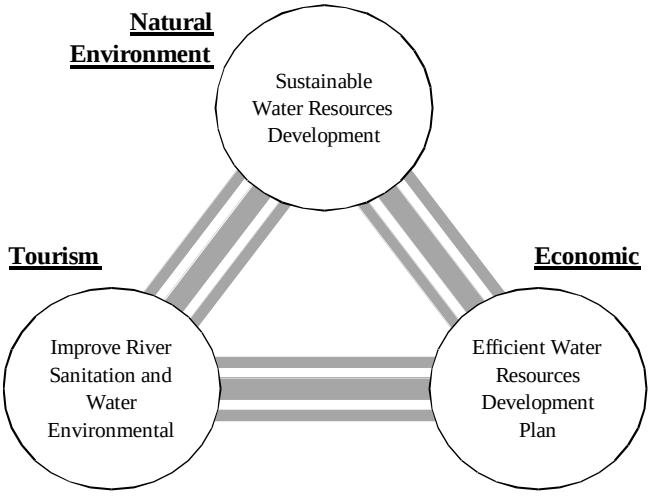
1. Development of water resources for water supply, agriculture and environment,
2. Increasing capacity and coverage ratio of public water supply service,
3. Managing and conserving groundwater.

The approaches shown below are proposed to tackle the issues described in the section above, in consideration of three important point of view to achieve an integrated sustainable development in the Siem Reap / Angkor Town, which are (i) Natural Environment, (ii) Economy, and (iii) Tourism.

The issue on concentration of groundwater abstraction is stretch as a part of water resources management issue.

Objectives	Sector Approaches	Necessary Actions
1 Developing water resources for agriculture, water supply and environment 2 Increasing capacity and coverage ratio of public water supply service 3 Managing and conserving groundwater	Water Resources 1 Water resources development in consideration of sustainability 2 Efficient water resources development plan 3 Improve river sanitation and water environment of Angkor heritage	1 Prepare and execute law on water resources conservation 2 Conduct integrated study on water resources management 3 Establish organization to manage the water resources 4 Develop surface water resources
	Water Supply 1 Provide sufficient water to people and businesses 2 Efficient water supply management and narrowing gap between peak and off-peak demands 3 Improve water supply services to enlarge cover ratio through customer satisfaction	1 Improve Unaccounted for Water (UFW) 2 Increase capacity of water supply system 3 Strengthen Siem Reap Water Supply Authority

(1) Development Approach for Water Resources Sector



Water Resources Development in consideration of Sustainability

Baray is the Angkor supreme wisdom on water management (retaining) system that is suitable with geographical condition to develop abundant water environment. It is necessary to improve existing baray and develop new baray to maximize utilization of surface water resources.

Development of groundwater resource is to be considered its potential and capacity. To do so, it is necessary to grasp and monitor the present groundwater abstraction condition.

In order to ensure the sustainability of water resources, management system of both surface water and groundwater utilization in consideration of sustainability is to be developed.

Efficient Water Resources Development Plan

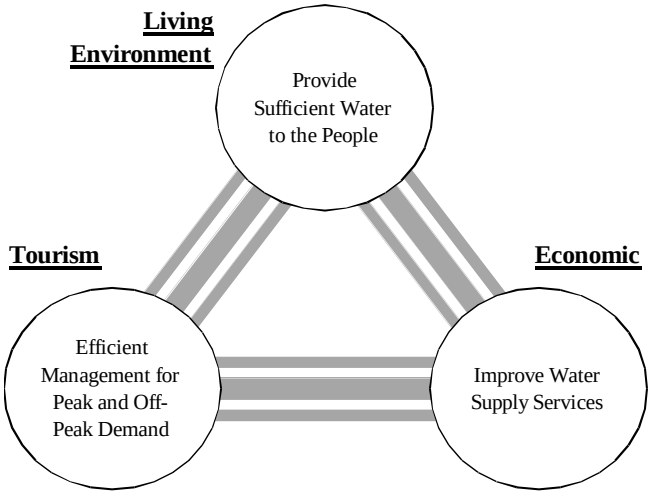
To optimize the efficiency of water resource, it is necessary to prepare development plan for entire river basin, as well as groundwater catchment area. Furthermore, the development plan should be synthesized of surface water and groundwater resources, with consideration of total demand and water allocation balance of agriculture, water supply and environmental uses.

Improve River Sanitation and Water Environmental of Angkor Heritage

Not only limited to sanitary issues, but moreover to keep tourism value of Siem Reap River and water retaining Angkor heritages, such as Sras Srang, improvement of water environment is necessary.

Preliminary, river environmental flow during dry season should be secured and regulation on wastewater discharge to the river should be established and implemented.

(2) Development Approach for Water Supply Sector



Provide Sufficient Water to the People and Businesses

To improve living environment as well as sanitary condition, sufficient water necessary to be provided to the people by the public service. The low coverage ratio not only made a bad impact to the people's life, but also created concentration of groundwater

abstraction in the limited dense populated area of the Town, which may affects the sustainability of groundwater resource.

To secure living environment and sustainability of groundwater uses, it is necessary to provide sufficient water to the people for their living and business activities as soon as possible. Preliminary, it is necessary to promote new customer/connection to supply new production capacity of 8,000 m^3/day.

Efficient Water Supply Management for Narrowing Gap between Peak and Off-Peak Demands

The number of visitor during peak and off-peak tourism season has a difference more than 2.5 times. This figure also directly means the difference on water supply demand.

Concerning financial problem, efficiency and proper asset management, it is difficult for Siem Reap Water Supply Authority (SRWSA) to develop their system to meet maximum demand, which only operate during peak tourism season.

The water supply management from supply side and demand side is necessary to be implemented to cope well this problem. Operation management to minimize water production losses during peak season, public awareness on implementation of water reuse/recycle and water saving is necessary to be conducted.

Improve Water Supply Services to Enlarge Cover Ratio through Customer Satisfaction

Improvement of the services, such as sufficient customer records and billing system, decrease Non Revenue Water (NRW), optimize organization performance and implement risk management system, will increase benefit both for SRWSA and customer. Also, satisfying customers will increase number of customer and enlarge the business market.

To realize the sustainability of the services, efficient cost performance and financial load balance among SRWSA and customer sides are necessary by improvement of water supply services.

7.2.2 Planning Framework

(1) Water Supply

1) Target Year

Target year of the water supply development plan is set in line with the Town Master Plan, which is 2020 as a long term target year and 2012 as a mid-term target year.

2) Service Area

Water supply service area should be covered overall urban area which was determined by the land use plan. Determined urban area consists of 27 villages among total of 76 villages as listed below.

Table III.7.7 Water Supply Service Area

Commune	Village	Commune	Village	Commune	Village
Svay Dangkum	Phnhea Chey (urban)	Sla Kram	Sla Kram	Sala Kamraeuk	Voat Bour
	Thmei (urban)		Boeng Doun Pa		Voat Svay
	Svay Dangkum (urban)		Dak Pou (urban)		Voat Damnak
	Sala Kansaeng		Banteay Chas		Sala Kamraeuk
	Kruos (urban)		Mondol Bei		Chonlong
	Vihear Chen				Ta Vien
	Stueng Thmei (urban)	Kouk Chak	Trapeang Seh (urban)		Trapeang Traeng
	Mondol Muoy		Veal (urban)		
	Mondol Pir		Teaksen Tboung (urban)	Srangae	Kaksekam
	Ta Phul				Thnal

note: (urban) means service area limited to urban area of the village

3) Service Population

There are huge differences on target water supply service area as well as service population defined by this Study and previous Study on Water Supply System for Siem Reap Region in Cambodia (JICA, 2000). The estimated inhabitant population is more than 1.5 times and tourist population is 3 times compared to previous study.

Table III.7.8 Comparison of Service Population

Year	Inhabitant Population			Average Tourist Population		
	Water Supply MP (JICA, 2000)	Town MP (this Study)	difference	Water Supply MP (JICA, 2000)	Town MP (this Study)	difference
2004	34,969	68,583	196.13%	3,101	5,531	178.36%
2005	37,028	70,445	190.25%	3,394	6,514	191.93%
2006	39,244	72,891	185.74%	3,686	8,125	220.43%
2007	44,832	75,433	168.26%	3,979	9,361	235.26%
2008	47,701	78,076	163.68%	4,271	10,787	252.56%
2009	50,540	80,824	159.92%	4,564	12,435	272.46%
2010	53,151	83,674	157.43%	4,856	14,340	295.30%
2011	n.a.	86,628	n.a.	5,149	15,555	302.10%
2012	n.a.	89,688	n.a.	5,441	16,874	310.13%
2013	n.a.	92,851	n.a.	5,734	17,719	309.02%

The inhabitant population was projected based on the 2004 population figure. The tourist population also estimated based on the latest figure and the trend of increased ratio. Therefore, the development of Siem Reap / Angkor Town is much faster than assumption by the previous Study on Water Supply System for Siem Reap Region in Cambodia (JICA, 2000).

Number of tourist population is different every month. The highest is in December as the best season for tourism and the lowest is in June due to the unsuitable weather for sightseeing. The foreign tourist population has a difference for 2.6 times between peak and off-peak at the present, and it will be reduced to 2 times difference by 2020. For the local tourist population, the difference is nearly fixed by 3.5 times. Considering total urban population (inhabitant and tourist), the different between peak and off-peak is only 1.15 times in 2012 and 1.13 times in 2020.

Table III.7.9 Estimated Service Population

Year	Siem Reap District Inhabitant			Tourist Population by Month						Peak and Off-Peak Difference	
	Urban	Rural	TOTAL	peak season (Dec.)		off-peak season (Jun.)		average			
				Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
2004	68,583	70,983	139,566	6,687	1,813	2,513	520	4,306	1,225	266%	349%
2005	70,445	71,680	142,125	8,025	1,994	3,016	573	5,167	1,347	266%	348%
2006	72,891	72,916	145,807	10,317	2,193	3,877	630	6,643	1,482	266%	348%
2007	75,433	74,185	149,618	12,007	2,413	4,512	693	7,731	1,630	266%	348%
2008	78,076	75,488	153,564	13,474	2,654	5,570	761	8,994	1,793	242%	349%
2009	80,824	76,824	157,648	15,676	2,920	6,479	838	10,463	1,972	242%	348%
2010	83,674	78,190	161,864	18,233	3,212	7,536	922	12,171	2,169	242%	348%
2011	86,628	79,582	166,210	19,917	3,347	8,232	960	13,294	2,261	242%	349%
2012	89,688	80,999	170,687	21,751	3,487	8,991	1,001	14,519	2,355	242%	348%
2013	92,851	82,435	175,286	21,921	3,633	10,068	1,043	15,265	2,454	218%	348%
2014	96,120	83,891	180,011	23,049	3,786	10,585	1,087	16,050	2,558	218%	348%
2015	99,493	85,362	184,855	23,766	3,946	10,915	1,132	16,549	2,665	218%	349%
2016	102,977	86,850	189,827	24,502	4,111	11,253	1,179	17,061	2,777	218%	349%
2017	106,571	88,352	194,923	24,010	4,283	12,405	1,230	17,585	2,893	194%	348%
2018	110,254	89,847	200,101	24,748	4,463	12,786	1,281	18,126	3,015	194%	348%
2019	114,014	91,325	205,339	25,506	4,651	13,178	1,335	18,681	3,142	194%	348%
2020	113,182	97,464	210,646	26,284	4,846	13,580	1,391	19,251	3,274	194%	348%

Source: JICA Study Team.

Based on the type of accommodation, the estimated tourism population was classified in to 2 groups for foreign tourist and 3 groups for local tourist. "Others Stay" for local tourist is consists of temple, relative's and friend's place. The detailed figures are shown in the table below.

Table III.7.10 Allocation of Estimated Service Population by the Accommodation

Year	Peak Season (month of December)					Off-Peak Season (month of June)				
	Foreign Tourist		Local Tourist			Foreign Tourist		Local Tourist		
	Hotel Stay	Guesthouse Stay	Hotel Stay	Guesthouse Stay	Others Stay	Hotel Stay	Guesthouse Stay	Hotel Stay	Guesthouse Stay	Others Stay
2004	4,681	2,006	181	1,269	363	1,759	754	52	364	104
2005	5,668	2,357	212	1,396	386	2,130	886	61	401	111
2006	7,351	2,966	247	1,535	411	2,762	1,115	71	441	118
2007	8,630	3,377	287	1,689	437	3,243	1,269	82	485	126
2008	9,769	3,705	332	1,858	464	4,038	1,532	95	533	133
2009	11,463	4,213	383	2,044	493	4,738	1,741	110	587	141
2010	13,447	4,786	442	2,248	522	5,558	1,978	127	645	150
2011	14,813	5,104	481	2,343	523	6,123	2,109	138	672	150
2012	16,313	5,438	523	2,441	523	6,743	2,248	150	701	150
2013	16,578	5,343	568	2,543	522	7,614	2,454	163	730	150
2014	17,575	5,474	615	2,650	521	8,071	2,514	177	761	149
2015	18,270	5,496	666	2,762	518	8,391	2,524	191	793	148
2016	18,989	5,513	719	2,878	514	8,721	2,532	206	826	147
2017	18,758	5,252	776	2,998	509	9,691	2,714	223	861	146
2018	19,489	5,259	837	3,124	502	10,069	2,717	240	897	144
2019	20,245	5,261	901	3,256	494	10,460	2,718	259	934	142
2020	21,027	5,257	969	3,392	485	10,864	2,716	278	974	139

Source: JICA Study Team.

4) Estimated Demand for Water Supply Demand Estimation

Water demand is simply estimated by three categories, which are domestic demand, tourism demand, and other use (for public and commercial facilities). There is no industrial activity which requires huge amount of water in the Siem Reap urban area as well as in the district. Therefore, the water demand for small industrial activities such as craftwork is included as a part of "other use".

Unit Water Demand

Unit water demand as a calculation basis for water demand estimation is mainly based on the Basic Design Study on the Project for Improvement of Water Supply System in Siem Reap Town (JICA, 2003). Some adjusted based on the survey result and fact findings through this Study was made as described below:

a. By 2020, domestic unit water demand planned to be reached 150 Lpcd, as an average consumption of Asian 50 cities stated in "Second Water Utilities Data Book (ADB, 1997)".
b. Tourist/hotel unit water demand was adjusted based on the Japanese Standard of Architecture Facilities Design Standard of 250-300 Lpcd.
c. Public and commercial demand was fixed on 5% of total demand.
d. Unaccounted for Water (UFW) was adjusted by figure estimated from actual figure of 35% in 2004.

Table III.7.11 Unit Water Demand and Design Criteria

Year	Domestic	Foreign Tourist		Local Tourist			Public & Commercial (% of total demand)	Daily Peak Ratio	UFW
		Hotel Stay	Guesthouse Stay	Hotel Stay	Guesthouse Stay	Others Stay			
2004	100	250	180	180	100	100	5%	1.2	35%
2005	105	250	180	180	105	105	5%	1.2	35%
2006	110	250	180	180	110	110	5%	1.2	40%
2007	115	270	190	190	115	115	5%	1.2	30%
2008	120	270	190	190	120	120	5%	1.2	15%
2009	125	270	190	190	125	125	5%	1.2	15%
2010	130	280	200	200	130	130	5%	1.2	15%
2011	130	280	200	200	130	130	5%	1.2	15%
2012	130	300	200	200	130	130	5%	1.2	15%
2013	135	300	210	210	135	135	5%	1.2	15%
2014	135	300	210	210	135	135	5%	1.2	15%
2015	140	320	220	220	140	140	5%	1.2	12%
2016	140	320	220	220	140	140	5%	1.2	12%
2017	145	320	230	230	145	145	5%	1.2	12%
2018	145	340	230	230	145	145	5%	1.2	12%
2019	150	340	240	240	150	150	5%	1.2	12%
2020	150	340	240	240	150	150	5%	1.2	12%

Water Demand

Projected water demand for the Siem Reap / Angkor Town for peak and off-peak seasons are shown in table below. The difference of water demand is 1.27 times (4,051 m^3/day) in 2012 and 1.22 times (4,878 m^3/day) in 2020.

Table III.7.12 Water Demand Projection for Peak Season (m^3/day)

Year	Domestic	Foreign Tourist		Local Tourist			Public & Commercial	**Urban Water Demand**
		Hotel Stay	Guesthouse Stay	Hotel Stay	Guesthouse Stay	Others Stay		
2004	6,858.30	1,170.25	361.08	32.58	126.90	36.30	429.27	**9,014.68**
2005	7,396.73	1,417.00	424.26	38.16	146.58	40.53	473.16	**9,936.42**
2006	8,018.01	1,837.75	533.88	44.46	168.85	45.21	532.41	**11,180.57**
2007	8,674.80	2,330.10	641.63	54.53	194.24	50.26	597.28	**12,542.82**
2008	9,369.12	2,637.63	703.95	63.08	222.96	55.68	652.62	**13,705.04**
2009	10,103.00	3,095.01	800.47	72.77	255.50	61.63	719.42	**15,107.79**
2010	10,877.62	3,765.16	957.20	88.40	292.24	67.86	802.42	**16,850.90**
2011	11,261.64	4,147.64	1,020.80	96.20	304.59	67.99	844.94	**17,743.80**
2012	11,659.44	4,893.90	1,087.60	104.60	317.33	67.99	906.54	**19,037.40**
2013	12,534.89	4,973.40	1,122.03	119.28	343.31	70.47	958.17	**20,121.54**
2014	12,976.20	5,272.50	1,149.54	129.15	357.75	70.34	997.77	**20,953.25**
2015	13,929.02	5,846.40	1,209.12	146.52	386.68	72.52	1,079.51	**22,669.77**
2016	14,416.78	6,076.48	1,212.86	158.18	402.92	71.96	1,116.96	**23,456.14**
2017	15,452.80	6,002.56	1,207.96	178.48	434.71	73.81	1,167.52	**24,517.83**
2018	15,986.83	6,626.26	1,209.57	192.51	452.98	72.79	1,227.05	**25,767.99**
2019	17,102.10	6,883.30	1,262.64	216.24	488.40	74.10	1,301.34	**27,328.12**
2020	16,977.30	7,149.18	1,261.68	232.56	508.80	72.75	1,310.11	**27,512.38**

Table III.7.13 Water Demand Projection for Off-Peak Season (m^3/day)

Year	Domestic	Foreign Tourist		Local Tourist			Public & Commercial	**Urban Water Demand**
		Hotel Stay	Guesthouse Stay	Hotel Stay	Guesthouse Stay	Others Stay		
2004	6,858.30	439.75	135.72	9.36	36.40	10.40	374.50	**7,864.43**
2005	7,396.73	532.50	159.48	10.98	42.11	11.66	407.67	**8,561.12**
2006	8,018.01	690.50	200.70	12.78	48.51	12.98	449.17	**9,432.65**
2007	8,674.80	875.61	241.11	15.58	55.78	14.49	493.87	**10,371.23**
2008	9,369.12	1,090.26	291.08	18.05	63.96	15.96	542.42	**11,390.85**
2009	10,103.00	1,279.26	330.79	20.90	73.38	17.63	591.25	**12,416.20**
2010	10,877.62	1,556.24	395.60	25.40	83.85	19.50	647.91	**13,606.12**
2011	11,261.64	1,714.44	421.80	27.60	87.36	19.50	676.62	**14,208.96**
2012	11,659.44	2,022.90	449.60	30.00	91.13	19.50	713.63	**14,986.20**
2013	12,534.89	2,284.20	515.34	34.23	98.55	20.25	774.37	**16,261.83**
2014	12,976.20	2,421.30	527.94	37.17	102.74	20.12	804.27	**16,889.73**
2015	13,929.02	2,685.12	555.28	42.02	111.02	20.72	867.16	**18,210.34**
2016	14,416.78	2,790.72	557.04	45.32	115.64	20.58	897.30	**18,843.38**
2017	15,452.80	3,101.12	624.22	51.29	124.85	21.17	968.77	**20,344.21**
2018	15,986.83	3,423.46	624.91	55.20	130.07	20.88	1,012.07	**21,253.41**
2019	17,102.10	3,556.40	652.32	62.16	140.10	21.30	1,076.72	**22,611.10**
2020	16,977.30	3,693.76	651.84	66.72	146.10	20.85	1,077.83	**22,634.40**

The water demand allocation by village level for year 2012 and 2020 are as shown in figure below. As a trend, the demand is increase to the south of the national road no.6.

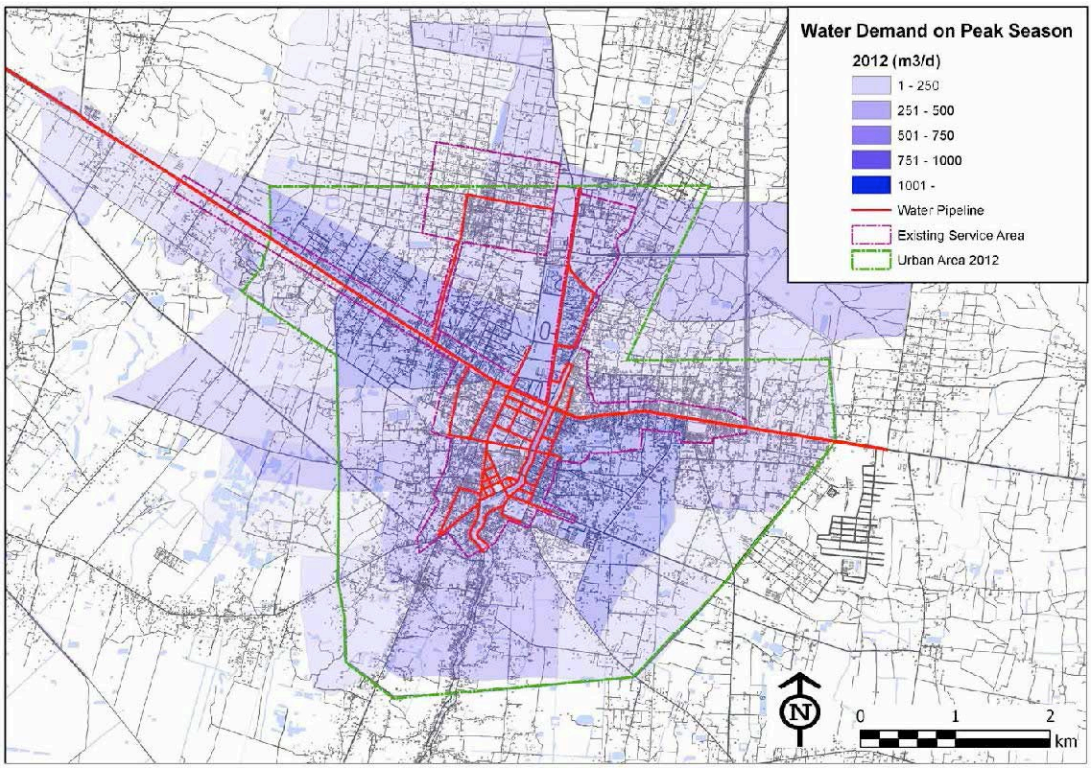


Figure III.7.19 Water Demand by Village in 2012

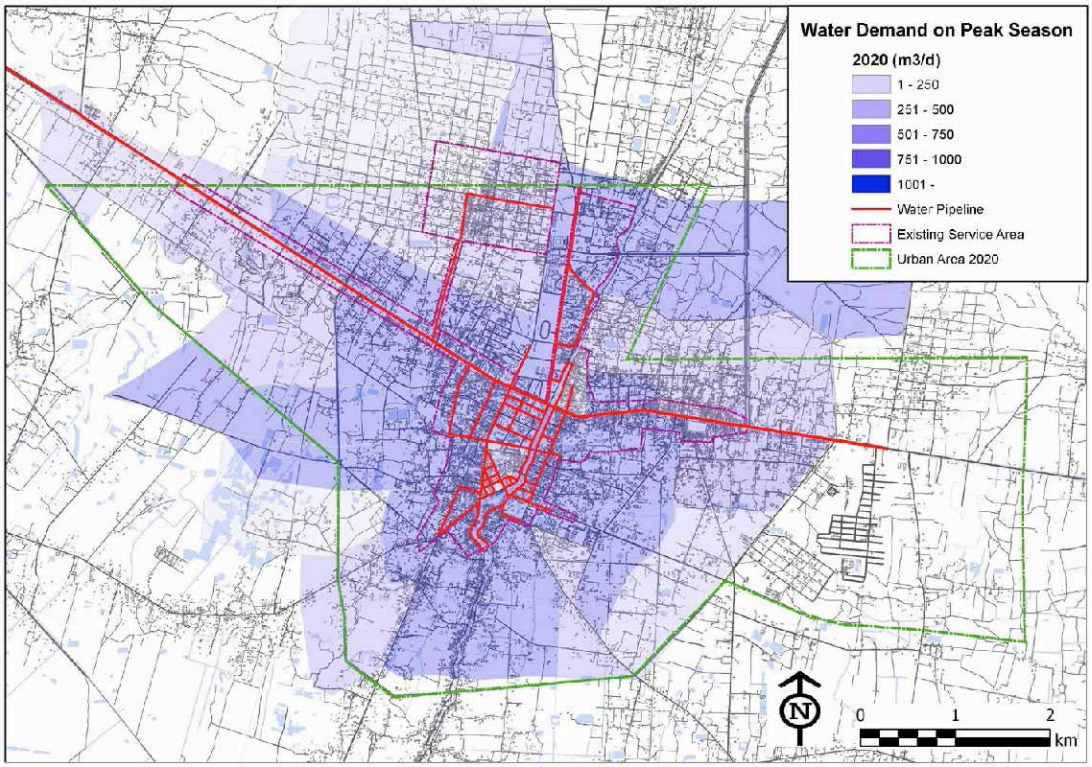


Figure III.7.20 Water Demand by Village in 2020

Required Water Supply System Capacity

Concerning daily peak ratio of 1.2 and various UFW shown in Table III.7.13 above, the total required supply water capacity is estimated as below. There is huge difference between required water supply system capacities for peak and off-peak demand, which is 5,591 m^3/day in 2012 and 6,556 m^3/day in 2020, respectively.

Table III.7.14 Required Capacity of Water Supply System (m^3/day)

Year	Required Water Supply Capacity			Year	Required Water Supply Capacity		
	Peak Season	Off-Peak Season	balance		Peak Season	Off-Peak Season	balance
2004	**14,604**	**12,740**	**1,863**				
2005	16,097	13,869	2,228	2013	27,768	22,441	5,326
2006	18,783	15,847	2,936	2014	28,915	23,308	5,608
2007	19,567	16,179	3,388	2015	30,740	24,693	6,047
2008	18,913	15,719	3,194	2016	31,525	25,326	6,200
2009	20,849	17,134	3,714	2017	32,952	27,343	5,609
2010	23,254	18,776	4,478	2018	34,632	28,565	6,068
2011	24,486	19,608	4,878	2019	36,729	30,389	6,340
2012	**26,272**	**20,681**	**5,591**	**2020**	**36,977**	**30,421**	**6,556**

(2) Other Demands

1) Irrigation Demand

There are two major irrigation systems at Siem Reap River basin, namely West Baray System and Crocodile Weir System, and one irrigation system in Roluos River basin, so called North East Baray System.

Due to the lack of management system on operation, maintenance and monitoring/recording of those systems, there is no data on supplied capacity for irrigation. Therefore, only estimation figure is available, which is done by the Study on Water Supply System for Siem Reap Region (JICA, 2000) based on measurement result during its study period.

West Baray Irrigation System

The Baray supplies water for irrigation during the dry season, generally from the end of November until May. The water supply through Canal B which has flow capacity of 9 m^3/s. According to the periodical flow measured by the Study on Water Supply System for Siem Reap Region, the intake amount is approximately 2 m^3/s in average for irrigation of 6,354 ha.

The annual supplied irrigation water is 32.0 million m^3 on average, which accounts for 66% of the total Baray's effective capacity.

Crocodile Weir Irrigation System

Water from the weir supplied through two irrigation canals, namely Vichear Chin Canal on the right bank of Siem Reap River and Chreav Canal on the left bank. According to the periodical flow measure by the Study on Water Supply System for Siem Reap Region, the intake amount is approximately 1 m^3/s for irrigation of 2,409 ha in average. However, it is physically impossible for the Siem Reap River to keep water flow of 1 m^3/s during the driest season judging from the real condition in 2005 and previous flow

pattern.

The irrigation water required annually should be 16.0 million m^3 in average.

North East Baray Irrigation System

There is no record for this System. According to a hearing survey to the government officer in charge, the irrigated area by North East Baray System is about 3,000 ha as a maximum. Based on the average irrigation demand of two systems above, the irrigation water demand can be estimated approximately 1.1 m^3/s.

The annual required irrigation water is 17.6 million m^3 on average.

2) River Environmental Flow

The minimum river flow required for self-treatment of the Siem Reap River should be considered. At least for three weeks on February 2005, there was no flow in the River at the junction of National Road No.6. Water was corroded and stunk, which brought the sanitary deterioration and bad image on the landscape of the River.

Japanese standard has a high requirement for environmental flow. At least 1 m^3/sec is required for every 100 km^2 catchments area, which means 6.7 m^3/sec is required for the Siem Reap River.

7.2.3 Water Resources Development Plan

The water resources should be developed with consideration of both advantage and disadvantage. One of the most important manners is to clarify the development potential and the feasibility of each alternative of water resource, with consideration of its utilization such as irrigation, water supply and river environmental flow.

Based on the available collected information, it was preliminary evaluated the development potential of alternative water resources. The result of the evaluation was summarized in the table below.

Table III.7.15 Comparison of Development of Potential Alternative Water Resources

	Alternative		Advantage		Disadvantage	Development Potential	Project Realization
1	Siem Reap River (at Kulen Mountain)	1	Very good water quality. [spring water, no contamination]	1 2 3	Very low quantity (0.052m^3/s) in dry season. Difficult operation/management due to huge difference water volume (about 50 times) between dry and rainy seasons. The project may desecrate the hallowed Angkor heritage.	low	difficult
2	Siem Reap River (at Siem Reap district)	1	Closed to supply area.	1 2	Bad quality water (total coliform and Fe), especially in dry season. No water flow during dry season.	very low	difficult
3	West Baray	1 2	Estimated enough surplus water (9 mil. m^3/year) after rehabilitation works. Sufficient enough water quality for water supply source.	1 2	Uncertainty of the construction works. Unknown factor on water right convesrion to water supply purpose.	high	for irrigation: high, for water supply: difficult.
4	North East Baray	1 2	During dray season, still retain approximately 218,000 m^3. Continuous recharge during dry season for 0.54m^3/sec.	1 2	Uncertainty of the exact potential figure, which necessary to conduct the study. Unknown factor on water right convesrion to water supply purpose.	enough	for irrigation: high, for water supply: difficult.
5	Tonle Sap Lake	1	Sufficient water quantity during dry season.	1 2 3 4	Bad quality water (total coliform and SS), especially in dry season. Big difference in water quality between dry and wet seasons. Huge difference on location of waterside line during dry and rainy seasons (max. 8m height, appr. 16km distance). Construction and water treatment cost very high.	low	difficult
6	City Groundwater	1	Sufficient water quality.	1 2	Dense well development. Continuity on groundwater disorder development, which is un-control today.	low	low
7	Tonle Sap Groundwate	1 2	Estimated sufficient water quantity. Sufficient water quality.	1 2	Necessary to conduct actual potential test based on planning capacity. Intake well location bit far from the City.	very high	for water supply: high, for irrigation: difficult.

It is very difficult to consider Siem Reap River water as a water source for any purpose, due to the lack of capacity and bad quality during dry season.

West Baray has a huge potential of water development capacity (estimated 73.31 million m^3) which can be used not only for irrigation purpose, but also for water supply and river environmental flow. The detailed design for West Baray rehabilitation had been conducted under cooperation of Government of India and it is scheduled to complete the construction work in the early 2008. However, utilization for water supply will take more time due to the unsettled water use right, including water law and related sub-decree. According to MOWRAM officer, it should be discussed among related government agencies after the confirmation of capacity of surplus water, which means at least necessary to monitor West Baray water balance for one year. Therefore, it is difficult to consider West Baray as a water source for water supply at this moment.

By preliminary estimation, North East Baray has an enough water development capacity with the estimated 17 million m^3 as maximum. It may be able to cover a part of irrigation water, river environmental flow, and baray maintenance water as a fishpond.

Due to water right related issues mentioned above, at the present it is difficult to consider North East Baray as a water source for water supply. However, it is necessary to conduct appropriate survey to ensure the exact development capacity, including water flow and water level measurement, determine actual water balance of the Roluos River basin.

Tonle Sap Lake has a huge amount of water with minimum storage of 1,300 million m^3 for entire year. However, due to the bad water quality and difficulties on the construction work of water intake structures, the development potential as a water supply source is low and it is not practical for irrigation water caused by high operation and maintenance cost for pumps.

Present utilization of groundwater resources is concentrated in the limited town center area and may not keep the suitable distance for sustainable use of groundwater resource, especially for high capacity well of large hotels. Therefore it is not recommended to develop more in the limited town area.

From the result of ADB's Study and survey conducted by SAWAC, groundwater potential surrounding Tonle Sap Lake can be assumed very high both from quantity and quality point of view. Transmissivity of Tonle Sap is 1,000 m^2/day, which is very high compared to the city area of 22 m^2/day. The storage coefficient of 5×10^{-5} also more then 2 times compared to the city area of 2×10^{-5}. However, it is necessary to conduct a groundwater investigation, including well abstraction test for actual required development capacity.

Preliminary demarcation on water resource utilization based on the evaluation above is summarizing as figure below.

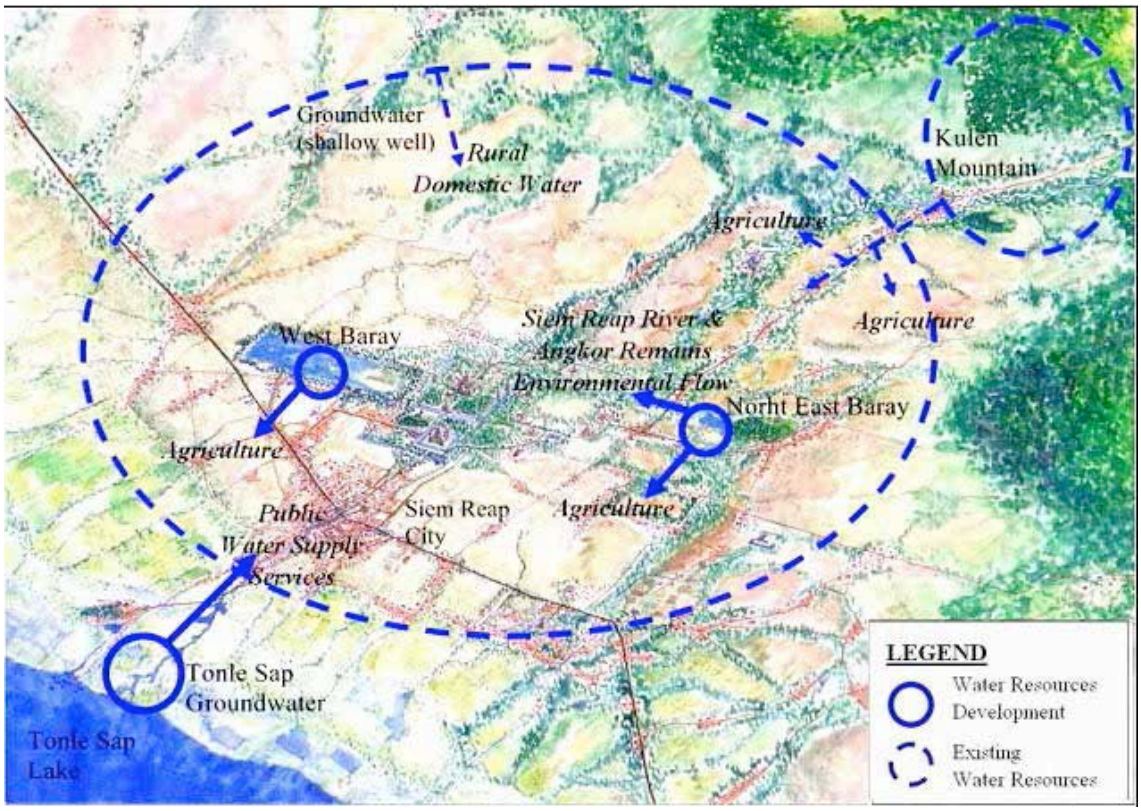


Figure III.7.21 Potential Utilization of Water Resources

To have most efficient sustainable water resources development plan, it is necessary to conduct not only the surveys mentioned above. Moreover, the Study on Integrated Water Resources Management for the related river basins and groundwater catchment area is necessary to be conducted initially, and the implementation of physical development and improvement will come after.

7.2.4 Water Supply Development Plan

Public water supply services will concentrate its services to the urban area. The area which could not be covered by the public service will be supplied by private individual wells. Moreover, since public water supply services still cannot cover all urban water demands, the individual well plays an important role also in urban water supply.

However, the groundwater consumption is necessary to monitor and control properly for its sustainability. As a first step, the Government shall form and work in force Provincial Degree to obligate commercial wells, as a huge capacity well prior to be monitored, to register and install the water meter. As soon as public water supply service is ready for its capacity to supply major number of commercial users, Ministerial Sub-Decree on groundwater charge for commercial well is recommended.

The groundwater charge aims to; (i) reduce groundwater abstraction in the town center, (ii) promote transition of groundwater user to public water supply, and (iii) increase government budget for water resources management works.

It is necessary that sufficient water is provided by the public water supply to the people as soon as possible. However, due consideration on the required time sequence of water treatment plant construction and service connections, the system development can not be held at once. Also due consideration on initial cost impact to avoid over-investment, which makes financial difficulties, the Stage Wise development is recommended.

The new water treatment plan with capacity of 8,000 m^3/day was constructed and it can be fully operated from early 2006. However, to supply those capacities, it was assumed additional 4,000 service connections are required. To have additional new 4,000 service contracts and its connections construction, it will take a time at least up to the end of year 2008.

Therefore, the next development stage only can be started soon after the distribution connections of present capacities can be ensured. Also to turn one's present experience to have an advantage on operation, maintenance and management, preliminary the development capacity proposed for 8,000 m^3/day. Due consideration of life period and performance of present New French System, it will be terminated as soon after the next development stage was completed.

Concerning required development period, only two time developments can be implemented during the Study target year of 2020. As a result, the service coverage ratio will reach nearly 80% based on off-peak season required capacity or 65% based on peak season total demand required capacity.

Proposed time schedule and capacity of stage wise development are summarized in the figure below. The service coverage ratio was based on the off-peak demand.

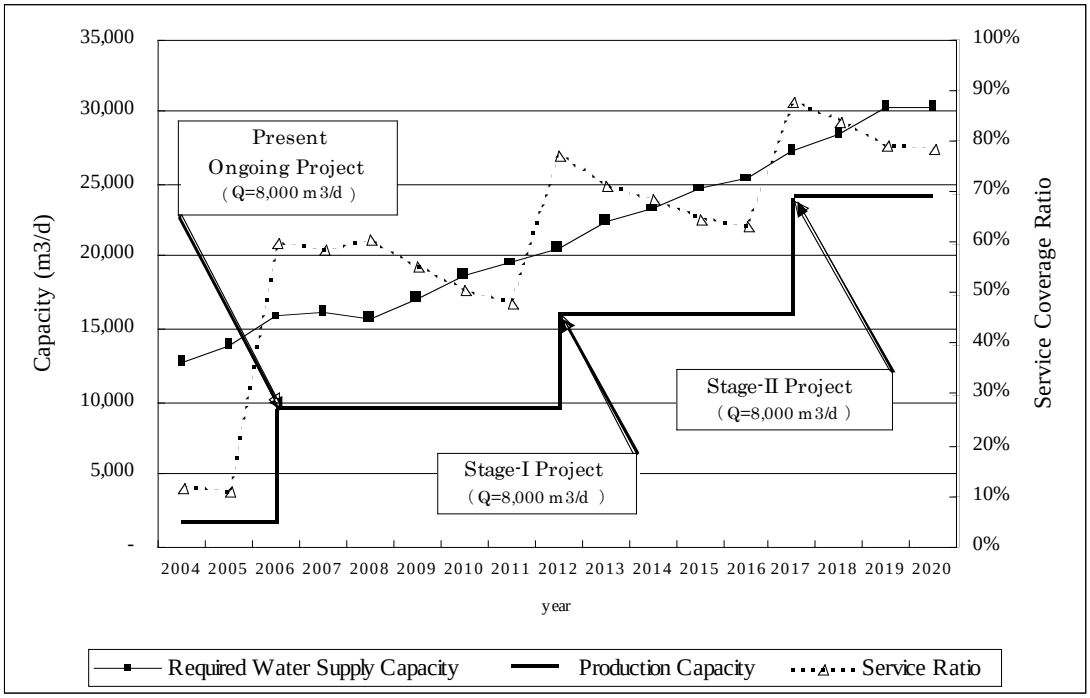


Figure III.7.22 Proposed Time Schedule and Stage Wise Development of Water Supply

The location of proposed new water treatment system is in the Southern part of Siem Reap / Angkor Town, near to Tonle Sap Lake basin where the groundwater intake well proposed to be constructed.

In the future, the present new water treatment plant will supply to block Q1 and Q2, the western part of the town. The proposed water treatment plant will supply to block Q3 and Q4, the eastern part of the town, where almost projected future water demand plan to be allocated.

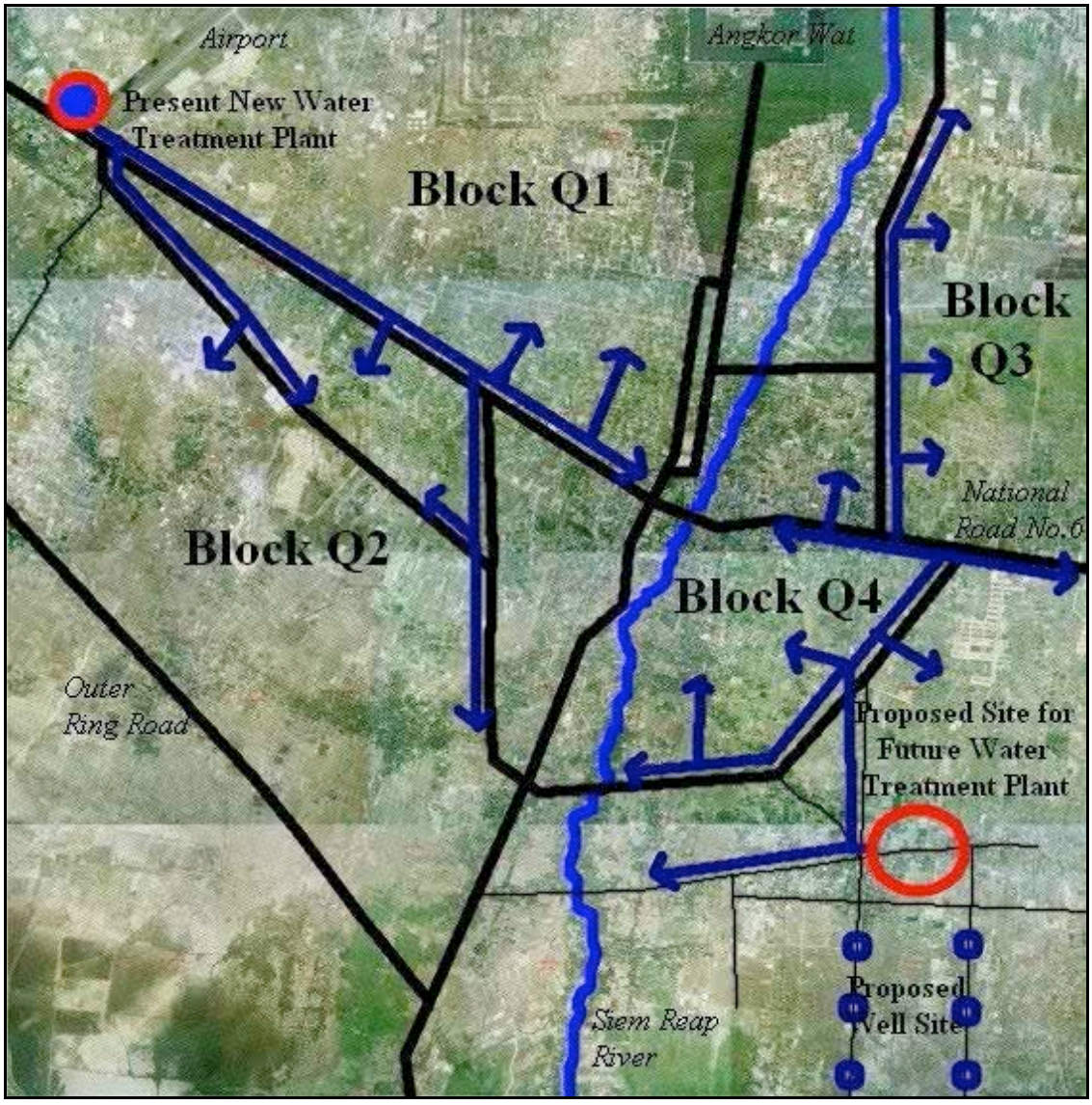


Figure III.7.23 Proposed Schematic Development Plan of Water Supply System

To promote the number of distribution connection as well as number of the service contract, tariff adjustment is necessary to be conducted. Preliminary, it is plan to be considered during development of additional 4,000 connections under supervision of MIME and Phnom Penh Water Supply Authority. To reduce the financial load of the inhabitant, the implementation of the tariff block system with consideration of load mitigation by tourist side was proposed.

In order to save the water and utilize the water resources and water supply assets as maximum as possible, the demand side management program is also recommended to minimize water utilization by the end user. This program is proposed in environmental management section of this Study as a part of public awareness campaign.

7.3 Projects and Programs

Necessary projects to improve water related issues can be categorized into three major groups below.

1. Groundwater Conservation
2. Water Supply Development
3. Water Resources Development

It should be noted that, water issues directly related to agriculture is not included in this chapter as well as in this Study.

Preservation of surface water resources and improvement of water environment will be clarified by proposed priority project named The Strategic Study on Integrated Water Resources Management for Siem Reap River and Roluos River. This study will grasp present water resources problems, includes agriculture sector, and proposed the integrated river basin management program for its utilization and preservation.

7.3.1 Projects/Programs Implementation Sequence and Priority

This study was not covered an investigation necessary to grasp total present water resources system, both for surface water and groundwater. Also there is no relevant study tackled integrated water resources issue, which should cover agriculture, water supply and environmental sectors.

The Strategic Study on Integrated Water Resources Management for Siem Reap River and Roluos River is proposed as first priority project, before implementation of physical improvement. An integrated management and development plan is necessary to keep sustainability of water resources, which covers surface water and groundwater as a source, and agriculture, water supply and environment as a demand.

The proposed study will include every necessary survey, such as river profile, water flow and water level, groundwater vein (distribution) and potential, irrigation water demand, to grasp the total present water resources condition. As an output of the study; (i) establishment of surface water level and water flow measurement system, (ii) integrated water resources management plan, includes draft water use right for both river basin, (iii) master plan on water resources development, and (iv) feasibility study on priority projects, should be presented.

North East Baray is recommended as further project for water resources development, and water supply system using Tonle Sap groundwater is recommended as further project for water supply development. Which both of this project will be implemented soon after proposed study mentioned above.

North East Baray is preliminary proposed to be developed mainly for irrigation purpose, concerning balance of potential capacity and irrigation demand. It is recommended also to utilize surplus water for Siem Reap River and Roluos River environmental flow, as well as to restore water required by Angkor heritages such as Sras Srang.

Tonle Sap groundwater is proposed as further source for public water supply development, due to the high potential initially verified by relevant study. Concerning the utilization of surface water source for water supply, uncertain factor of the water use right of surface water should be clarify by necessary law and decrees. Soon after execution of the necessary law and decrees, possibility to utilize water from West Baray and/or North East Baray for water supply will be studied. It is assumed it will be considered in the second stage of water supply development.

As a priority improvement on public water supply system, replacement of old pipes with over 25 years is recommended. The old pipes not only increases water loses, moreover it may deteriorate water quality.

The implementation sequence of proposed projects/programs is as shown in figure below. Concerning the sequence and proposed implementation time, the projects and program below are selected as a priority.

1. [W-1] Provincial Regulation on Registration of Commercial Well
2. [W-3] Replacement of Old Pipeline
3. [W-4] The Strategic Study on Integrated Water Resources Management for Siem Reap River Basin and Roluos River Basin

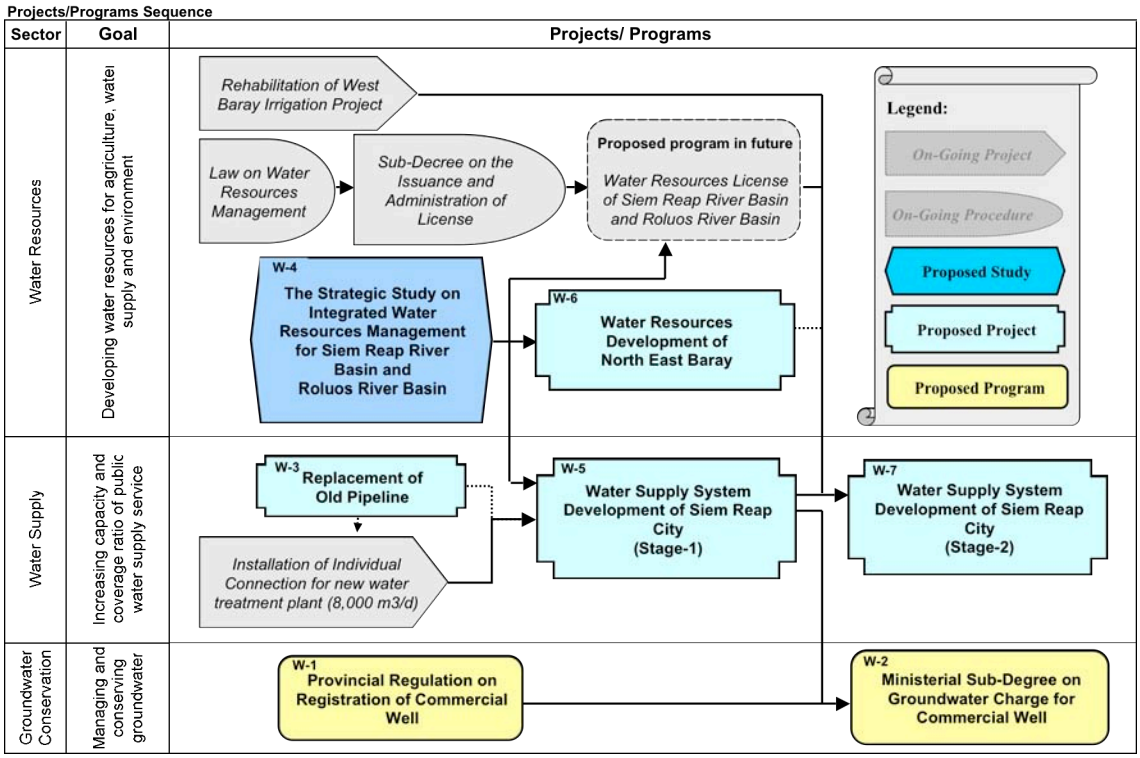


Figure III.7.24 Proposed Projects/Programs Implementation Sequence

7.3.2 Preliminary Project Cost Estimates and Implementation Schedule

Necessary proposed projects/programs including the preliminary cost estimate and tentative implementation schedule are summarized in the Appendix of this chapter.

7.4 Proposed Institutional Arrangement

7.4.1 Present Surface Water Management Organization

Daily operation and maintenance of water structures and meteorology equipment in the Siem Reap City is under control of Department of Water Resources and Meteorology (DOWRAM) of Siem Reap Province, which consist of 48 staff in total. DOWRAM is line department of Ministry of Water Resources and Meteorology (MOWRAM), who implement and manage all project related to surface water resources. The organization structures are shown in the figure below.

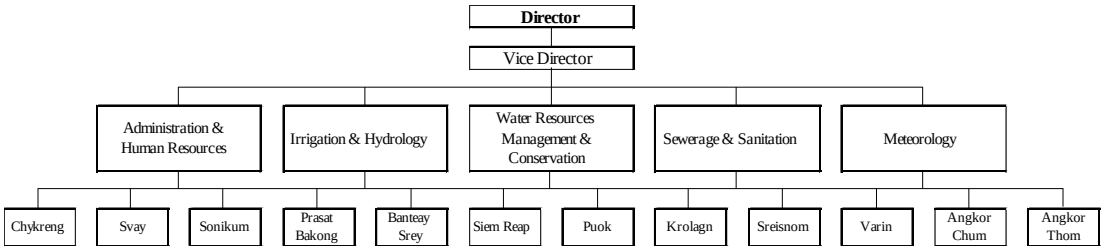


Figure III.7.25 Organization Chart of Provincial Department of Water Resources and Meteorology

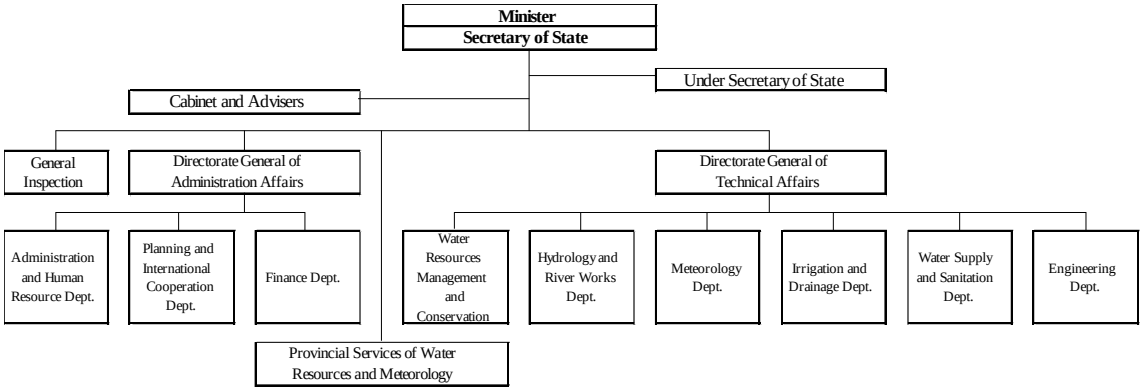


Figure III.7.26 Organization Chart of Ministry of Water Resources and Meteorology

Capacity of DOWRAM is limited to record a measurement result by existing meteorology stations, and operate French Gate and Crocodile Gate. There is no gate operation record and no consideration on water allocation management. Therefore, nobodies understanding the actual capacity of surface water resources and water consumption.

7.4.2 Present Groundwater and Water Supply Management Organization

Department of Industry, Mines and Energy (DIME) of Siem Reap province is

responsible to operate and maintenance the facilities related to groundwater and existing public water supply, under controlled and supervised by the Ministry of Industry, Mines and Energy (MIME).

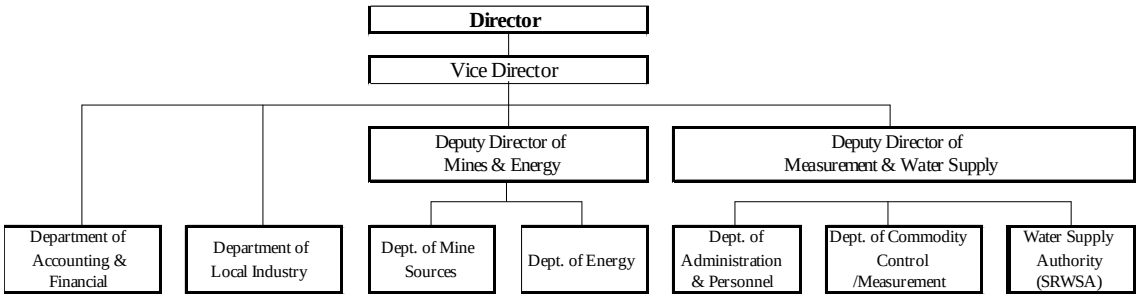


Figure III.7.27 Organization Chart of Department of Industry, Mine and Energy of Siem Reap Province

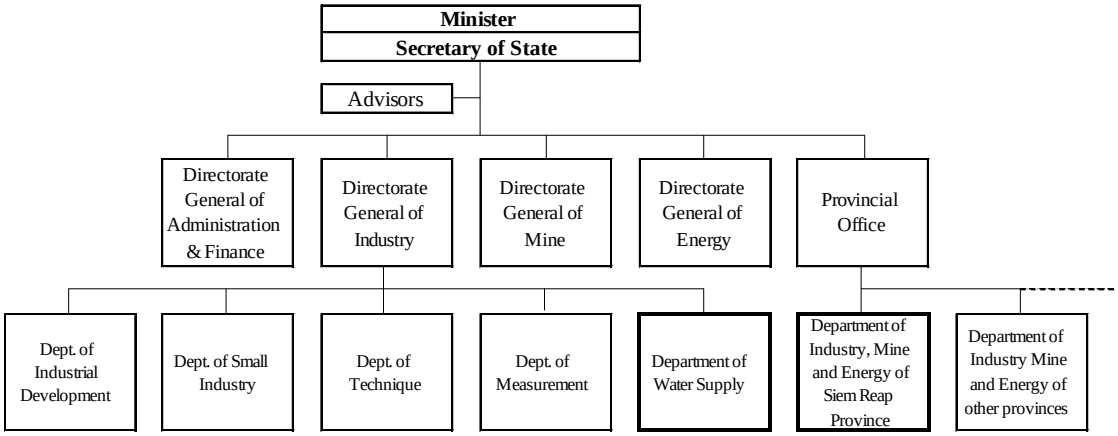


Figure III.7.28 Organization Chart of Ministry of Industry, Mine and Energy

Water supply system of Siem Reap City and groundwater monitoring wells is under responsibility of Siem Reap Water Supply Authority (SRWSA), as one of the department under DIME and directly supervise by Department of Water Supply of MIME.

In 2005, SRWSA was consisted of 12 staffs and it was increased nearly 3 times to operate and manage the new system with capacity of 8,000 m^3/day. The capacity building program of SRWSA is conducting by Phnom Penh Water Supply Authority, under supervision by MIME. The new management structure is still under consideration during this Study period.

Groundwater monitoring data from existing 7 monitoring wells are recorded since 2003 by SRWSA. However, they lacks of expert to analyze and utilize those recording result. Practically, the groundwater monitoring works is not really match with SRWSA task, which is to supply sufficient water to the people.

Also at the present, there is no any system to record and monitor exact groundwater abstraction capacity. Within their present capacity, DIME starts conducting individual well survey to grasp total number of existing well by village in Siem Reap province since last 2004.

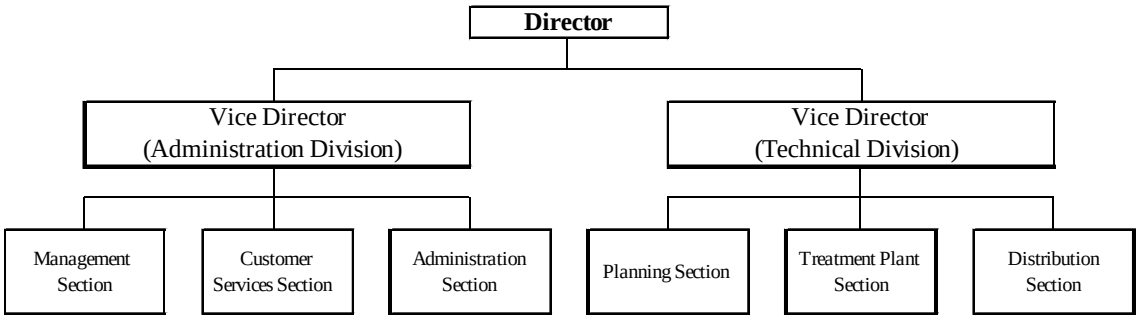


Figure III.7.29 Organization Chart of Siem Reap Water Supply Authority (2005)

7.4.3 Proposed New Organization

(1) Background

To improve water related issues and keep the sustainability of the water resources development, it is necessary to manage and operate synthetically. The targets and tasks of the management works will cover surface water, groundwater, irrigation, water supply and environment, which are crossover the task of several ministries.

Inline with the implementation of the proposed priority project of The Strategic Study on Integrated Water Resources Management for Siem Reap River Basin and Roluos River Basin, the Project Coordination Committee will be established. The committee plans to be formatted by present water resources related organization below:

1. Ministry of Water Resources and Meteorology
2. Ministry of Industry, Mines and Energy
3. Ministry of Agriculture, Forestry and Fishery
4. Ministry of Rural Development
5. Ministry of Environment
6. Ministry of Land Management, Urban Planning and Construction
7. Provincial Government
8. APSARA Authority

It is proposed to formally promote the above committee as an organization to operate and manage the water resources development for Siem Reap and Roluos River Basin, base on the formulated integrated water resources management plan and water resources development master plan by the proposed priority study mentioned above.

(2) Organization Duties

The functions and duties of the proposed new organization are listed below:

- Determine water allocation plan and water use right of the Siem Reap province groundwater, Siem Reap river basin and Roluos river basins to serve agriculture, urban water supply and environmental preservation in a sustainable manner with national and international characteristics in parallel with the policy program of the Royal Government of Cambodia.
- Record and monitor surface water and groundwater utilization inline with the water allocation plan as well as water use right, includes registration of groundwater commercial well and monitoring sanitation environment condition of the rivers.
- Evaluate and study of surface water and groundwater water balance, and define

development potential in order to create a technical specification and planning basis.
- Manage and monitor every water resources development activities.
- Compose and propose law, letters, and other regulations relevant to management of the water resources as well as monitor implementation.

(3) Organization Structure

The proposed organization will be divided into two divisions shown below. However, the planning section of each division will have inter-link to keep the prospective balance and sustainability of water resources development at planning (initial) stage.

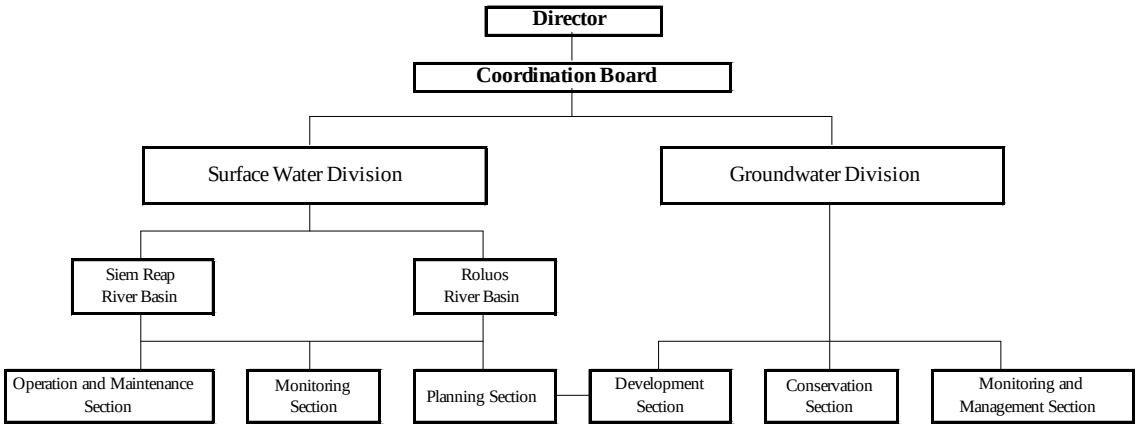


Figure III.7.30 Proposed Organization Structure

Director and member of the coordination board will be taken over by the related present post in the ministries. Those positions function on request bases, when decision making of the development or conservation is required.

The member of the sections will be assigned to the related department of the Siem Reap province, inline with the present task and job description.

(4) Detailed Task of the Sections

The task of proposed sections is described below.

Surface Water Division

1. Operation and Maintenance Section
   Operate, record and maintenance the water related structures, such as a gate and canal, based on the operation manual.
2. Monitoring Section
   Record and monitor water level, water flow and water allocations in the field. Water allocations record will be evaluated in comparison with water use right and capacity of water resources.
3. Planning Section
   Preliminary study and planning of the system to meet the requirement from water resources user and keep appropriate water allocation balance. The study on water allocation balance and development plan should be worked together with development section.

Groundwater Division

4. Development Section
   Preliminary study and planning of the new groundwater development to meet the requirement from water resources user and keep appropriate groundwater abstraction plan. The study on groundwater abstraction capacity and development plan should be worked together with conservation section and planning section of surface water division.
5. Monitoring and Management Section
   Record, and monitor data of groundwater monitoring wells. Also conduction annual individual well survey, register and monitor commercial well development and groundwater abstraction capacity.
6. Conservation Section
   Evaluate data recorded by Monitoring and Management Section, and prepare groundwater conservation plan as well as development countermeasure to keep its sustainability.

7.5 Priority Projects and Programs

7.5.1 Provincial Regulation on Registration of Commercial Well (W-1)

(1) Program Background

All supplies water for Siem Reap / Angkor Town, which consists of public water supply, commercial uses (e.g. hotel, guest house, restaurant and shops), private/domestic use and public uses, are covered by groundwater resource.

Inline with the development of the Town, number of well in the area also increasing. However, there is no any data can grasp the actual consumption of groundwater, which is necessary to monitor, evaluate and control for its sustainability.

To ensure the sustainability of groundwater utilization, registration and installation of water meter especially for the huge capacity well of commercial uses are necessary to be enforced. The commercial well should be registered will consists of hotel, guesthouse and restaurant. The registration items are; (i) outline of the commercial activity, (ii) well diameter, (iii) well depths, (iv) pump type and capacity, (v) pump depth, and (vi) water meter type.

(2) Program Outline

Program Purpose

The Regulation aims to:

1) Grasp and monitoring the condition of groundwater consumption.
2) Manage groundwater utilization.

Target Area/Location

Siem Reap Province.

Prospective Beneficiaries

All groundwater users.

Program Components/Activities

The procedures to set up the Regulation are as follows.

1) Prepare provincial regulation to obligate commercial (hotel, guesthouse and restaurant) wells to register and install the water meter.
2) Empower Department of Industry, Mines and Energy (DIME) of Siem Reap Province for commercial well administration works.
3) Enforce the regulation and monitor/control the registration progress.

Program Output

Registration of Commercial Wells.

Program Input

To establish the Provincial Regulation, taskforce/working group chaired by Provincial Government with cooperation of Ministry of Industry, Mines and Energy (MIME) is necessary. Moreover, it is recommended to involve ODA long-term experts as an advisor.

Environmental and Social Impact
Improving monitoring/management system of groundwater by public/user participation may lead the user to think about sustainability and risk on groundwater.

(3) Institutional Arrangement and Implementation Schedule

Implementation Organization

The Regulation will be establish and announce by Provincial Government.

Operation and Maintenance Organization

Implementation (registration and administration works) will be conducted by Department of Industry, Mines and Energy (DIME).

Implementation Schedule

The implementation should be commenced as soon as possible, desirably from early 2006 as shown below.

1) Prepare provincial regulation — January 2006 until December 2006
2) Empowerment of organization — August 2006 until December 2006
3) Implement the regulation — from January 2007

(4) Financial Arrangement

Preliminary Cost Estimation

No special cost required.

Expected Funding Sources

The Government of Cambodia.

7.5.2 Replacement of Old Pipeline (W-3)

(1) Project Background

There is remains old pipeline in the present distribution network system, with approximate length of 6.5km. Those old pipeline causing water leakage and decrease water quality.

To reduce water leakage and improve supply water quality, it is necessary to replace that old pipeline as soon as possible.

(2) Project Outline

Project Purpose

The Project aims to:

1) Reduce water leakage.
2) Improve supply water quality.

Target Area/Location

Siem Reap District.

Prospective Beneficiaries

All customer of public water supply service.

Project Components/Activities

The Project will compose of replacement (construction) works of old pipeline with total length approximately 6.5km. The installation will include necessary accessories, such as valves, chambers and supporting structures.

Project Output

The Project will come up with the new distribution pipeline.

Project Input

Necessary project inputs are:

1) Materials, which may consists of pipes, valves and chambers.
2) Installation works and materials for concrete structures and back filling.

Environmental and Social Impact

Expected social impact is to reduce the negative health impacts associated with water supply.

(3) Institutional Arrangement and Implementation Schedule

Implementation Organization

Ministry of Industry, Mines & Energy (MIME), Department of Portable Water Supply.

Operation and Maintenance Organization

Siem Reap Water Supply Authority (SRWSA).

Implementation Schedule

The Project will be implemented as soon as required procedures between MIME and

World Bank is settled. It is assumed to be implemented by schedule as follow:

1) Procurement of material April 2006 until June 2006
2) Construction/installation works July 2006 until March 2007

(4) Financial Arrangement

Preliminary Cost Estimation

Item		Amount ('000 USD)
1.	Direct cost	375.0
2.	Soft component	
3.	Physical contingency	37.5
4.	Price escalation	37.5
5.	Engineering service	
TOTAL		450.0

Preliminary project cost estimation is estimated based on the following conditions and assumptions.

1. Import duties are included in the direct cost.
2. For construction type project, physical contingency and price escalation are assumed to be 10 % each of the direct cost.
3. Value added tax is not included in the direct cost.

Expected Funding Sources

Material will be funded by World Bank loan and installation/construction works funded by SRWSA/MIME.

7.5.3 The Strategic Study on Integrated Water Resources Management for Siem Reap River Basin and Roluos River Basin (W-4)

(1) Project Background

Siem Reap / Angkor Town, which is the center of tourism activity of Cambodia, is facing shortage of surface water resources during dry season, especially for agriculture and river environmental flow. The shortage of surface water resources can be realized visually.

Water level data is available for Siem Reap River, West Baray and Tonle Sap Lake. However, water flow data is available only for limited period and area, which are recorded by several ODA projects. Due to water level of Siem Reap River and West Baray are controlled by the gate, almost no continuous record for the capacity of the river and baray. Lack of information/data related to present surface water resources also makes difficulties to provide the countermeasures to the problems.

The gate operation record is not available. Lack of water resource management system also wastes valuable water during dry season.

In addition of that, lack of public water supply service causing concentration on groundwater abstraction in the dense urban area. Over density of groundwater intake well will affect to recovery of the groundwater, which may land subsidence problem.

To maximize efficiency of water resources, it is necessary to conduct the strategic study on integrated water resources management, which should cover both of surface water and groundwater resources to meet demands on agriculture, water supply and environmental uses.

The study aims to grasp capacity of water resources, establish monitoring and management system for its sustainability, prepare development master plan and define the task of every related agency. The related agency may consists of; (i) Ministry of Water Resources and Meteorology, (ii) Ministry of Industry, Mines and Energy, (iii) Ministry of Agriculture, Forestry and Fishery, (iv) Ministry of Rural Development, (v) Ministry of Environment, (vi) Ministry of Land Management, Urban Planning and Construction, (vii) Provincial Government, and (viii) APSARA Authority.

(2) Project Outline

Project Purpose

The Project aims to:

1) Establish surface water measurement/monitoring system for Siem Reap and Roluos River Basins.
2) Grasp groundwater distribution condition and its potential.
3) Define water resource capacity/potential, both for surface water and groundwater.
4) Formulate an integrated water resources management plan.
5) Prepare water resources development master plan.

Target Area/Location

Target areas of the Project are Siem Reap River Basin and Roluos River Basin with total estimated land of 842 km^2 and 551 km^2, respectively.

Prospective Beneficiaries

Prospective beneficiaries of the Project will be residents, commercials and agriculture activities in the river basins.

Project Components/Activities

The Project will compose of the followings.

1) Establish and set-up surface water monitoring/measurement system.
2) Conduct hydraulic calculation for the river basins.
3) Conduct groundwater investigation and prepare vein (groundwater distribution) map.
4) Formulate an integrated water resources management plan.
5) Prepare water resources development master plan.
6) Prepare draft water allocation plan and water use right for Siem Reap River Basin and Roluos River Basin.
7) Conduct a feasibility study on the priority projects.

Project Output

The Project output will consists of the followings.

1) Surface water level and water flow measurement system.
2) Integrated water resources management plan.
3) Master plan on water resources development.
4) Feasibility study on priority projects.

Project Input

Required project inputs are consists of followings.

1) 20 expertise with total man/months of 120.
2) Surface water measurement equipment.
3) Topographic survey.
4) Geological and groundwater investigations.
5) Groundwater abstraction test.

Environmental and Social Impact

Expected environmental and social impacts are as follows:

1) Increases amount of water utilization by sufficient water resources management.
2) Improve agriculture activities and production during dry season.
3) Reduce the negative health impacts associated with shortage of water supply.
4) Improve river sanitation problem and provide amenity on Angkor Remains.

(3) Institutional Arrangement and Implementation Schedule

Implementation Organization

The Project will be implemented by Ministry of Water Resources and Meteorology (MOWRAM).

Operation and Maintenance Organization

Operation and maintenance organization for surface water monitoring/measurement system will be handled by Department of Water Resources and Meteorology (DOWRAM).

Implementation Schedule

The Project needs to be commenced as soon as possible, desirably from 2007. Detailed implementation schedule is as shown below:

1) Measurement system preparation	January 2007 until June 2007
2) Management plan & Master plan	March 2007 until December 2008
3) Feasibility study	October 2008 until June 2009

(4) Financial Arrangement

Preliminary Cost Estimation

Item		Amount ('000 USD)
1.	Direct cost	6,620
2.	Soft component	
3.	Physical contingency	
4.	Price escalation	662
5.	Engineering service	
TOTAL		7,282

Preliminary project cost estimation is estimated based on the following conditions and assumptions.

1. For program and procurement type project, only price escalation of 10% is considered.
2. Value added tax is not included in the direct cost.

Expected Funding Sources

Grant

JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

Project Long List

Sector: Water Resources and Water Supply

No	Project Title	Project Site	Project Outline	Present Related Action	Project Component	Assumed Fund	Estimated Cost ('000 USD)	Implementation Agency	Implementation Period 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Water Environmental Preservation									
W-1	Provincial Regulation on Registration of Commercial Well	Siem Reap Province	Obliges commercial (hotel, guest house and restaurant) well to register and install the water meter.	nil	Provincial Regulation	Gov. of Cambodia	none	Provincial Government	regulation; implementation and monitoring
W-2	Ministerial Sub-Decree on Groundwater Charge for Commercial Well	Siem Reap Province	Synchronous with the availability of water supply service, obliges commercial (hotel, guest house and restaurant) well to pay groundwater charge.	nil	Ministerial Sub-Decree	Gov. of Cambodia	none	Ministry of Economic and Finance	sub-decree; implementation and monitoring
Water Resources and Water Supply Development									
W-3	Replacement of Old Pipeline	Siem Reap District	Replacement of old pipeline which was installed during 1975-79 with total length approximately 6.5km located in the central of the city.	Study on the Project for Improvement of Water Supply System in Siem Reap Town (JICA)	Construction	SRWSA and Loan	450	Ministry of Industry, Mines & Energy (MIME)	tender &
W-4	The Strategic Study on Integrated Water Resources Management for Siem Reap River Basin and Roluos River Basin	Siem Reap Province	Preparation of integrated water resources management plan, includes installation of equipment for river water measurement, integrated water resources management plan, water resources development plan, institutional program and feasibility study on priority projects.	West Baray Improvement Project (Gov. of India) Rural Water Supply Project for Siem Reap Province (ADB) The Study on Water Supply System for Siem Reap Region (JICA) Preliminary water flow and capacity estimation (APSARA)	Strategic Master Plan Study, Feasibility Study	Grant	7,282	Ministry of Water Resources and Meteorology (MOWRAM)	MP; FS
W-5	Water Supply System Development of Siem Reap City (Stage-1)	Siem Reap District	Design and construction of Tonle Sap groundwater intake pumping station, transmission pipeline, water treatment plant and expansion of distribution pipeline.	Rural Water Supply Project for Siem Reap Province (ADB) The Study on Water Supply System for Siem Reap Region (JICA) Study on the Project for Improvement of Water Supply System in Siem Reap Town (JICA)	Basic Design, Detailed Design and Construction	Grant	13,716	Ministry of Industry, Mines & Energy (MIME)	BD; DD; construcu on
W-6	Water Resources Development of North East Baray	Siem Reap Province	Design and construction of North East Baray, which consists of existing dyke improvement, dredging, installation of gates and river improvement.	Preliminary water flow and capacity estimation (APSARA)	Detailed Design and Construction	Grant	8,320	Ministry of Water Resources and Meteorology (MOWRAM)	DD; constructi
W-7	Water Supply System Development of Siem Reap City (Stage-2)	Siem Reap District	Feasibility and comparison study of West Baray surface water (case-1) and Tonle Sap groundwater (case-2) as a source of Siem Reap water supply. Design and construction for expansion of water supply system based on the result of feasibility study.	West Baray Improvement Project (Gov. of India) Rural Water Supply Project for Siem Reap Province (ADB) The Study on Water Supply System for Siem Reap Region (JICA) Study on the Project for Improvement of Water Supply System in Siem Reap Town (JICA)	Feasibility Study, Detailed Design and Construction	SRWSA and/or Loan	case-1: 11,830 case-2: 12,310	Ministry of Industry, Mines & Energy (MIME)	FS; DD; constructu on

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Project Brief

Sector: Water Resources and Water Supply

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
W-1	Provincial Regulation on Registration of Commercial Well	All groundwater users	National Budgedt	None (thousand US$)	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap Province	Provincial Government				

Background:
1) All water supply for Siem Reap town covered by groundwater
2) Lack of information related to groundwater utilization
3) No monitoring and management system on groundwater utilization

Project Purpose:
1) Grasp and monitoring the condition of groundwater utilization
2) Manage groundwater utilization

Project and Program Outline/Components:
1) Prepare provincial regulation to obligete commercial (hotel, guest house and restaurant) wells to register and install the water meter
2) Empower Department of Industry, Mines and Energy (DIME) of Siem Reap Province for commercial well administration works
3) Enforce the regulation and monitor/control the registration progress

Project Output:
1) Provincial Regulation

Environmental and Social Impact:
1) Improve monitoring/management system of groundwater utilization

Related Projects:
nil

Implementation Schedule:

1) Prepare provincial regulation	Jan-06	Dec-06
2) Empowerment of organization	Aug-06	Dec-06
3) Implement the regulation	Jan-07	

Project Cost: ('000 USD)

1) Direct costs	
2) Capacity building	
3) Physical conti.	
4) Price Escalation	
5) Engineering service	
sub-total	
6) Land acquisition	
TOTAL	-

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Project Brief

Sector: Water Resources and Water Supply

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
W-2	Ministerial Sub-Decree on Groundwater Charge for Commercial Well	All groundwater users	National Budgedt	None (thousand US$)	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap Province	Ministry of Economic and Finance				

Background:
1) All water supply for Siem Reap town covered by groundwater
2) Lack of management system on groundwater utilization
3) To promote utilization of public water supply service

Project Purpose:
1) Manage groundwater utilization
2) Improve sustainability of groundwater utilization
3) Increase the budget for groundwater management, as well as for environmental conservation activities

Project and Program Outline/Components:
1) Prepare ministerial sub-decree to charge groundwater for commercial (hotel, guest house, restaurant and pub/bar) uses
2) Empower/establishment of the organization for commercial well administration
3) Enforce the sub-decree
4) Monitor/control the registration progress and tariff collection

Project Output:
1) Ministerial Sub-Decree
2) Organization for commercial well administration

Environmental and Social Impact:
1) Improves management and sustainability of groundwater utilization

Related Projects:
nil

Implementation Schedule:

1) Prepare ministerial sub-decree	Jan-12	Dec-12
2) Establish the organization	Jun-12	Dec-12
2) Implement the regulation	Jan-13	

Project Cost: ('000 USED)

1) Direct costs	
2) Capacity building	
3) Physical conti.	
4) Price Escalation	
5) Engineering service	
sub-total	
6) Land acquisition	
TOTAL	-

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Project Brief

Sector: Water Resources and Water Supply

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost	Project Priority
W-3	Replacement of Old Pipeline	All public water supply service customer	SRWSA and Loan	450 (thousand US$)	**Priority**

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap District	Ministry of Industry, Mines & Energy (MIME)	Portable Water Supply	Meng Saktheara		

Background:

There remains old pipeline in the present distribution network system, with approximate length of 6.5km. The old pipeline causes water leakage and decrease water quality.

To reduce water leakage and improve supply water quality, it is necessary to replace the old pipeline as soon as possible.

Project Purpose:

1) Reduce water leakage
2) Improve water supply quality

Project and Program Outline/Components:

Replacement works (construction) of old pipeline with total length approximately 6.5km together with necessary accessories, such as valves, chambers and supporting structures.

Project Output:

New distribution pipeline.

Environmental and Social Impact:

1) Reduce the negative health impacts associated with water supply

Related Projects:

1) Study on the Project for Improvement of Water Supply System in Siem Reap Town (JICA)

Implementation Schedule:

1) Procurement works	Apr-06	Jun-06
2) Construction works	Jul-06	Mar-07

Project Cost: ('000 USD)

1) Direct costs	375
2) Capacity building	
3) Physical conti.	38
4) Price Escalation	38
5) Engineering service	
sub-total	450
6) Land acquisition	
TOTAL	450

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Project Brief

Sector: Water Resources and Water Supply

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost	**Project Priority**
W-4	The Strategic Study on Integrated Water Resources Managemen for Siem Reap River Basin and Roluos River Basir	Residents, commercials and agriculture activities in the river basins	International (Grant)	7,282 (thousand US$)	**Priority**

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap and Roluos River Basins	Ministry of Water Resources and Meteorology	Secretary of State			

Background:
Water shortage especially during dry season for agriculture, water supply and environmental uses become serious problem. Moreover, lack of present water resources related information/data makes difficulties to provides its countermeasures.
To improve management and sustainability of water resources, it is necessary to conduct a strategic study on integrated water resources management. The strategic study should cover both of surface water and groundwater resources to meet demands on agriculture, water supply and environmental uses.

Project Purpose:
1) Establish surface water measurement/monitoring system for Siem Reap and Roluos River Basins
2) Grasp groundwater distribution condition and its potential
3) Define water resource capacity/potential, both for surface water and groundwater
4) Formulate an integrated water resources management plan
5) Prepare water resources development master plan

Project and Program Outline/Components:
1) Establish and set-up surface water monitoring/measurement system
2) Conduct hydraulic calculation for the river basins
3) Conduct groundwater investigation and prepare vein (groundwater distribution) map
4) Formulate an integrated water resources management plan
5) Prepare water resources development master plan
6) Prepare draft water use right for Siem Reap River Basin and Roluos River Basin
7) Conduct a feasibility study on the priority projects

Project Output:
1) Surface water level and water flow measurement system
2) Integrated water resources management plan
3) Master plan on water resources development
4) Feasibility study on priority projects

Environmental and Social Impact:
1) Increase amount of water utilization by sufficient water resources management
2) Improve agriculture activities and production during dry season
3) Reduce the negative health impacts associated with shortage of water supply
4) Improve river sanitation problem and provide amenity on Angkor Remains

Related Projects:
1) West Baray Improvement Project (Gov. of India)
2) Rural Water Supply Project for Siem Reap Province (ADB)
3) The Study on Water Supply System for Siem Reap Region (JICA)
4) Preliminary water flow and capacity estimation (APSARA)

Implementation Schedule:

1) Measurement system preparation	Jan-07	Jun-07
2) Management plan & Master plan	Mar-07	Dec-08
3) Feasibility study	Oct-08	Jun-09

Project Cost: ('000 USD)

1) Direct costs	6,620
2) Capacity building	
3) Physical conti.	
4) Price Escalation	662
5) Engineering service	
sub-total	7,282
6) Land acquisition	
TOTAL	7,282

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Project Brief

Sector: Water Resources and Water Supply

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
W-5	Water Supply System Development of Siem Reap City (Stage-1)	All people in Siem Reap town	International (Grant)	13,716 (thousand US$)	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap District	Ministry of Industry, Mines & Energy (MIME)	Portable Water Supply			

Background:

In early year 2006, new water treatment plant with capacity of 8,000 m3/day is available to start operation, however construction of individual connection to distribute water all those capacity, which is estimate about 4,000 connections, may takes time at least until the end of 2008.

Coverage ratio of Siem Reap public water supply service estimated nearly 70% in 2008, which will be decreased year by year inline with expansion of population, tourist and other urban activities.

To meet the water demand for sustainable urban development, further water supply development is necessary.

Project Purpose:

1) Find an appropriate arrangement of groundwater intake well
2) Develop new water treatment plant
3) Expand and improve water supply distribution system
4) Empower Siem Reap Water Supply Authority (SRWSA)

Project and Program Outline/Components:

1) Conduct topographic survey, geological and groundwater investigation
2) Conduct groundwater abstraction test
3) Prepare basic design and detailed design of the expansion water supply system
4) Conduct and supervise construction works for the expansion of water supply system
5) Empowerment of SRWSA

Project Output:

1) Basic design and detailed design of the expansion water supply system
2) Groundwater intake pumping station and transmission pipeline with capacity of 8,800 m3/day
3) New water treatment plant with capacity of 8,000 m3/day
4) Expansion of water supply distribution network

Environmental and Social Impact:

1) Reduce the negative health impacts associated with water supply
2) Increase the quantity of supply water to the people

Related Projects:

1) Rural Water Supply Project for Siem Reap Province (ADB)
2) The Study on Water Supply System for Siem Reap Region (JICA)
3) Study on the Project for Improvement of Water Supply System in Siem Reap Town (JICA)

Implementation Schedule:

1) Basic design	Jun-09	Mar-10
2) Detailed design	Apr-10	Dec-10
3) Construction and supervision	Jan-11	Dec-12

Project Cost: ('000 USD)

1) Direct costs	10,320
2) Capacity building	
3) Physical conti.	1,032
4) Price Escalation	1,032
5) Engineering service	1,032
sub-total	13,416
6) Land acquisition (3 Ha)	300
TOTAL	13,716

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Project Brief

Sector: Water Resources and Water Supply

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
W-6	Water Resources Development of North East Baray	Residents, commercials and agriculture activities in the river basin	International Grant	8,320 (thousand US$)	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap Province	Ministry of Water Resources and Meteorology	Water Resources Management & Conservation			

Background:

Water shortage for agriculture and river environmental flow especially during dry season becomes serious problem.

At the present, Roluos river was intercepted by old dyke crossing at the foot of Bok Mountain, and formed a reservoir named North East Baray.

Expansion of capacity of North East Baray by improvement of the dyke, dredging, installation of gates and some river improvement can increase water availability during dry season, both for Siem Reap River Basin and Roluos River Basin.

Project Purpose:

1) Increase water resource for agriculture and river environmental flow during dry season
2) Improve water resource management system

Project and Program Outline/Components:

1) Conduct topographic survey and geological investigation
2) Prepare detailed design for the improvement of North East Baray
3) Conduct and supervise construction works for the baray
4) Empowerment of Department of Water Resources and Meteorology of Siem Reap Province (DOWRAM)

Project Output:

1) Detailed design of the North East Baray improvement works
2) Expanded North East Baray with necessary water control facilities
3) North East Baray water resources management system

Environmental and Social Impact:

1) Increase water resource capacity during dry season
2) Improve agriculture activities and production during dry season
3) Improve river sanitation problem and provide amenity on Angkor Remains

Related Projects:

1) Preliminary water flow and capacity estimation (APSARA)

Implementation Schedule:

1) Detailed design	Jan-10	Dec-10
2) Construction and supervision	Jan-11	Jun-13

Project Cost: ('000 USD)

1) Direct costs	6,400
2) Capacity building	
3) Physical conti.	640
4) Price Escalation	640
5) Engineering service	640
sub-total	8,320
6) Land acquisition	
TOTAL	8,320

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Project Brief

Sector: Water Resources and Water Supply

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
W-7	Water Supply System Development of Siem Reap City (Stage-2)	Residents, commercials and agriculture activities in the river basin	SRWSA and/or Loan	(case-1) 11,830,000 (case-2) 12,310,000	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap District	Ministry of Industry, Mines & Energy (MIME)	Portable Water Supply			

Background:

Siem Reap/Angkor town was rapidly growth due to its high tourism potential of Angkor Remains.
Rapid population growth was assumed to be continued until 2020 with annual growth rate of 2.6% to 2.7%.
To cover urban water demand, expansion of water supply system is necessary to be conducted as soon as water production/treatment capacity meet shortage to distribution capacity.

Project and Program Outline/Components:

1) Prepare feasibility study, incl. comparison study for West Baray surface water (Case-1) and Tonle Sap groundwater (Case-2)
2) Conduct topographic survey and geological investment
3) Case-2: Conduct groundwater abstraction test
4) Prepare detailed design of the expansion water supply system
5) Conduct and supervise construction works for the expansion of water supply system
6) Empowerment of SRWSA

Project Purpose:

1) Find an appropriate arrangement of water resource
2) Increase capacity of supply water treatment plant
3) Expand and improve water supply distribution system
4) Empowerment of Siem Reap Water Supply Authority (SRWSA)

Project Output:

1) Feasibility study and detailed design of the expansion water supply system
2) Case-1: West Baray intake facilities and transmission pipeline with capacity of 8,800 m3/day
   Case-2: Groundwater intake pumping station and transmission pipeline with capacity of 8,800 m3/day
3) New water treatment plant with capacity of 8,000 m3/day
4) Expansion of water supply distribution network

Environmental and Social Impact:

1) Reduce the negative health impacts associated with water supply
2) Increase the quantity of supply water to the people

Implementation Schedule:

1) Feasibility study	Jan-14	Dec-14
2) Detailed design	Jan-15	Dec-15
3) Construction and supervision	Jan-16	Dec-17

Project Cost: ('000 USD)

	case-1	case-2
1) Direct costs	8,600	9,200
2) Feasibility study	350	350
3) Physical conti.	860	920
4) Price Escalation	860	920
5) Engineering service	860	920
sub-total	11,530	12,310
6) Land acquisition (1 Ha)	300	
TOTAL	11,830	12,310

Related Projects:

1) West Baray Improvement Project (Gov. of India)
2) Rural Water Supply Project for Siem Reap Province (ADB)
3) The Study on Water Supply System for Siem Reap Region (JICA)
4) Study on the Project for Improvement of Water Supply System in Siem Reap Town (JICA)

Chapter 8 Solid Waste Management

8.1 Current Situation

8.1.1 National Institutional System

(1) Legal System

1) Law on Environmental Protection and Natural Resource Management

The Law on Environmental Protection and Natural Resource Management, which was enacted in 1996, is the supreme legal instrument for environmental management. It codifies the following frameworks for environmental protection and natural resource management:

- Formulation of national and regional environmental plans;
- Execution of environmental impact assessments for new investment projects;
- Natural resource management;
- Protection of the environment from public nuisance;
- Monitoring, record-keeping and inspections;
- Establishment of an environmental endowment fund; and
- Penalties against violation.

Based on this law, the following Sub-decrees were prepared:

a) Sub-decree on the Environmental Impact Assessment Process (enacted in August 1999);
b) Sub-decree on Water Pollution Control (enacted in April 1999);
c) Sub-decree on Solid Waste Management (enacted in April 1999); and
d) Sub-decree on Air and Noise Pollution Control (drafted in July 2000).

2) Sub-Decree on Solid Waste Management

The Sub-decree on Solid Waste Management (SWM) was enacted in April 1999 and established the legal basis for SWM together with the Sub-decree on Water Pollution Control. The Sub-decree on SWM regulates SWM in a proper technical and safe manner to protect human health and the environment. It divides solid waste into two categories, i.e. non-hazardous waste and hazardous waste. The other important contents of the sub-decree are described below.

General and common aspects:

e) The Ministry of Environment (MOE) shall establish guidelines on non-hazardous waste management and hazardous waste management;
f) Disposal of solid waste in public areas or unauthorized areas is strictly prohibited;
g) Exportation of solid waste from Cambodia requires approval from the MOE, the Ministry of Trade and the importing country;
h) Importation of solid waste is strictly prohibited; and
i) Penalty: Violators of the Sub-decree shall be fined and punished in accordance with the Law on Environmental Protection and Natural Resource Management.

For non-Hazardous Waste Management

a) Provincial and municipal authorities shall establish non-hazardous waste management plans for the short, medium and long-terms;

b) Provincial and municipal authorities shall be responsible for non-hazardous waste management services according to guidelines issued by the MOE;
c) The MOE shall monitor the implementation of non-hazardous waste disposal (storage, collection, transport, recycling, treatment and final disposal (landfill)); and
d) Investment in the construction of non-hazardous waste disposal facilities is subject to prior approval by the MOE.

For Hazardous Waste Management

a) The MOE shall issue Ministerial Declarations (*Prakas*) on standards for the quantity of toxins or hazardous substances in hazardous waste;
b) The owner of hazardous waste shall be responsible for its temporary storage and shall submit quarterly reports on it to the MOE;
c) The owner of hazardous waste other than domestic sources shall be responsible for its disposal;
d) The disposal of hazardous waste from domestic sources (households, markets, etc.) is the competence of the local authorities;
e) The transportation or construction of a storage place or landfill for hazardous waste from factories and manufacturing sites shall be subject to permit from the MOE;
f) The owner or responsible person of a storage place or landfill for hazardous waste HW shall submit quarterly reports on it to the MOE;
g) Investment in treatment or incineration at hazardous waste disposal facilities shall be subject to prior approval by the MOE;
h) The monitoring of packing, storage and disposal of hazardous waste is the responsibility of the MOE; and
i) The MOE shall take samples of hazardous waste and analyze them in its laboratory.

Issues

The Study Team identified the following issues on the Sub-decree on SWM:

j) It is generally without specific descriptions, and detailed regulations and guidelines have not been well prepared yet.
k) No local authority has established a non-hazardous waste management plan for the short, medium and long-terms.
l) Though the classification of non-hazardous waste and hazardous waste is reasonable as a broad one, a more detailed classification is necessary for proper SWM, especially for identification of the body (producer) responsible for the disposal of the solid waste.
m) There is a list of hazardous waste, but it is neither clear nor sufficient. In addition, there is no information for the identification method of hazardous waste.
n) Though the disposal of HW from domestic sources is the competence of the local authorities, the domestic sources in the Sub-decree included clinics and hospitals. This might need to be examined.

3) MOE Declarations

In order to supplement the Sub-decree on SWM, the MOE has issued the following Ministerial Declarations (*Prakas*):

o) Declaration on the Provision of Duties to carry out the Sub-decree on Water Pollution Control and Sub-decree on SWM for Urban and Provincial Environmental Departments, June 2, 1999;
p) Declaration on Industrial HWM, May 26, 2000;
q) Declaration on the Proceeding of the Department of Environmental Pollution Control, July 27, 2000; and
r) Declaration on Industrial Sludge Management, October 9, 2000.

4) Guidelines[1]

According to the Cambodia Waste Management Program for 2002 – 2006 published by the Department of Environmental Pollution Control (DEPC) of the MOE, the following guidelines have been prepared pursuant to the 1996 Environmental Law and the Sub-decree on SWM:

s) Guideline for hospital/clinic waste management;
t) Guideline for industrial waste recycling and disposal; and
u) Guideline for toxic and hazardous waste movement.

5) Enforcement

Chapter 5 in the sub-decree on SWM states that violators of the sub-decree shall be fined and punished according to the Law on Environmental Protection and Natural Resources Management. However, enforcement of the law and the sub-decree appear to be insufficient. For example, waste is clearly being disposed of haphazardly in public and private areas, temporary storage of waste in collection areas is below standards, and the dumping of waste at most disposal sites causes obvious air and water pollution and exposes the waste pickers to great risks and health hazards.

(2) Administration and Organization

In general, administrative powers and responsibilities concerning urban environmental management in Cambodia are divided imperfectly between line ministries, municipalities and provincial governments. All maintenance, rehabilitation and development works within provincial urban areas are handled by the branch offices of the line ministries.

Although household (non-hazardous) solid waste management has been placed under the jurisdiction of local authorities (municipalities and provincial governments), SWM is under the jurisdiction of several governmental organizations. Some organizations are directly involved in SWM and others are indirectly involved. The MOE is the main responsible body at the national level. The roles and functions of those organizations are presented below.

[1] The information in this section is cited from the "Cambodia Waste Management Program for 2002 – 2006 ".

1) Ministry of Environment

The MOE is the main responsible body at the national level for the administration of SWM. The MOE is responsible for establishing proper guidelines for SWM, approving and issuing operating and discharge permits for the necessary facilities, new or old, such as storage and transfer stations, recycling and treatment plants and final disposal sites. The MOE is also responsible for monitoring and enforcing compliance with the environmental law and the operating and discharge permits.

The organization chart of MOE is presented in Figure 8.1. DEPC is the main responsible department for the administration of SWM. The Department of EIA Review and the Provincial Municipal Department of Environment are also responsible for some parts of SWM administration.

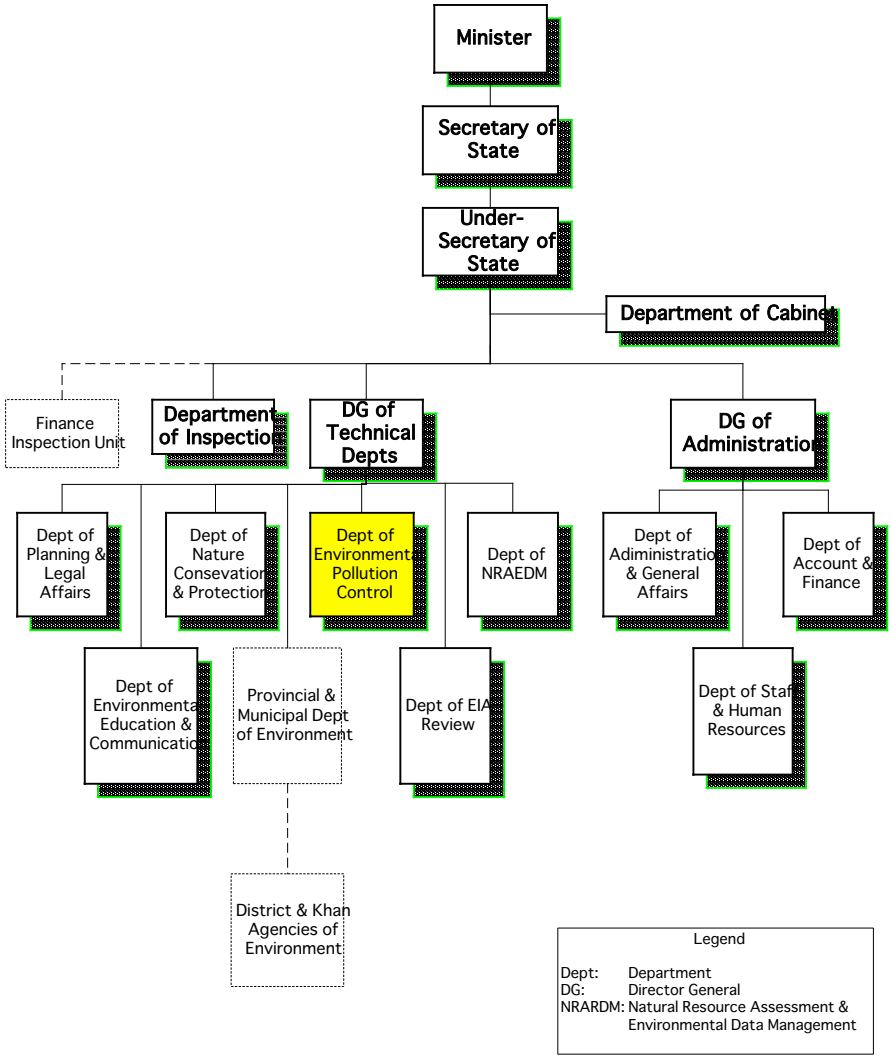


Figure III. 8.1 Organization Chart of Ministry of Environment

DEPC has 76 personnel and consists of seven offices as shown in Figure 8.2. The Office of Solid Waste and Hazardous Substance Management, which has 14 personnel, is the main office for SWM administration.

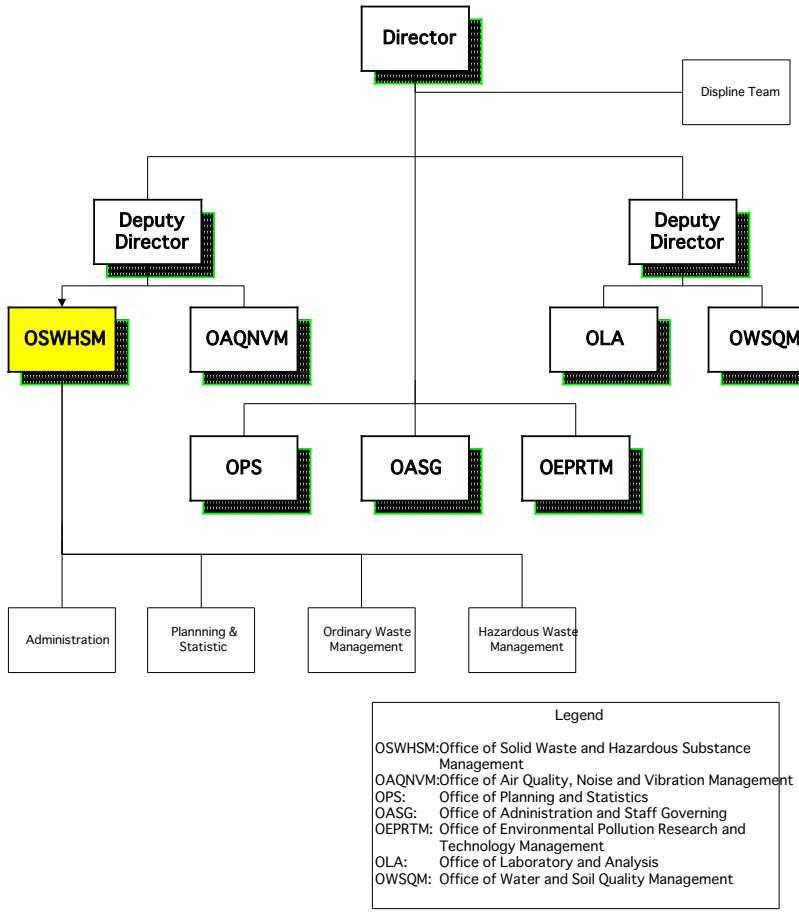


Figure III. 8.2Organization Chart of Department of Environmental Pollution Control

2) Ministry of Health

The Ministry of Health is responsible for the administration of health aspects including SWM in all medical institutions at the national level. As indicated in Figure III.8.3, the Department of Hospital is in charge of SWM in all medical institutions and the department organizes a waste management committee.

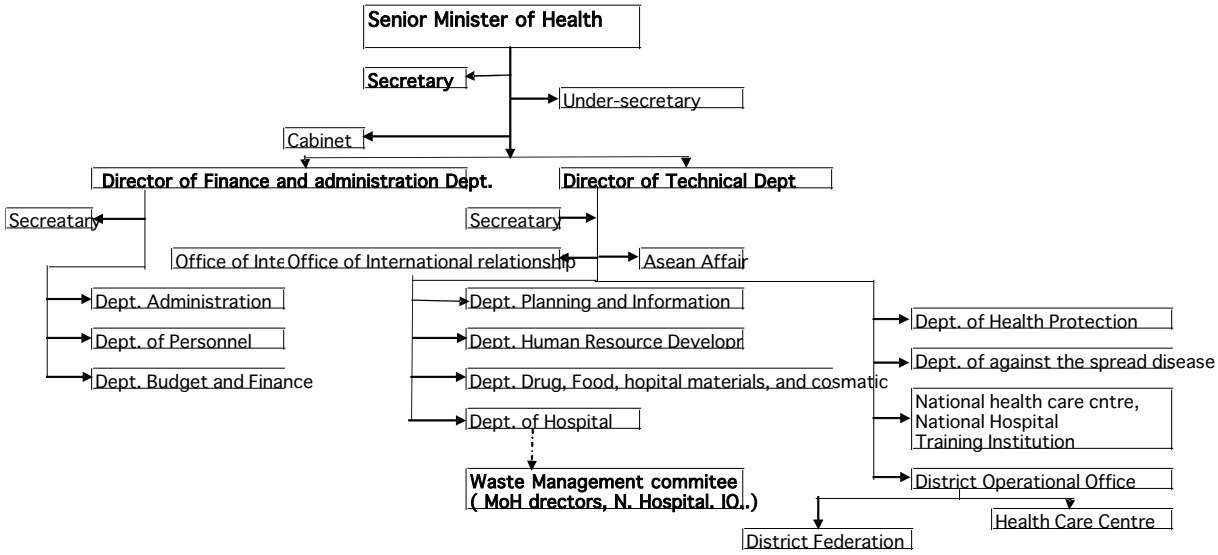


Figure III. 8.3 Organization Chart of Ministry of Health

8.1.2 Overview of SWM in the Study Area

The administrative responsibility of SWM works in the study area is actually obscure. However, the present administrative system of SWM in the study area can be divided into two areas: Siem Reap town and the Angkor heritage area.

(1) Within Siem Reap Town

- MICC, a private company, executes all the SWM works and no local authorities are actively involved in it. The implementation of SWM works is legally under the responsibility of the Siem Reap provincial government or the Siem Reap District office.
- The tree cutting works in public spaces and cleaning of some public space are sometimes executed by the Department of Urban Planning and Development of APSARA.

(2) Within the Angkor Heritage Area

- The implementation of SWM works for monuments and tourist places in the Angkor heritage area is under the responsibility of the APSARA Authority.

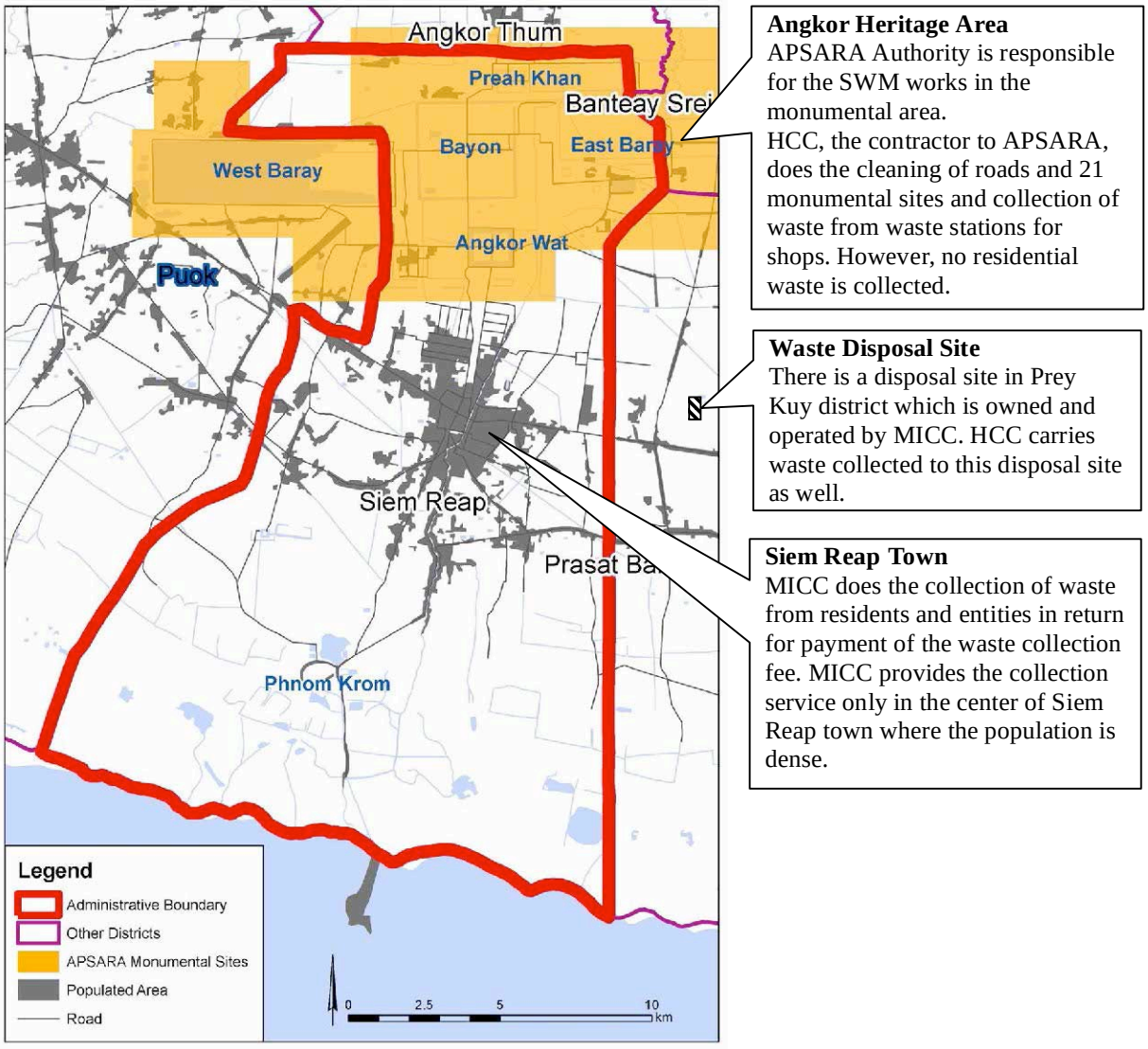


Figure III.8.4 Overview of Solid Waste Management System

8.1.3 Siem Reap District Excluding the Angkor Heritage Area (Zone1)

(1) Implementation System

The Ministry of Economics and Finance selected a private company for SWM services without a tender and made a contract with MICC for SWM services in Siem Reap district excluding the Angkor Heritage area on 13 December, 1999. The contract period is for 20 years, from January 1, 2000 to January 1, 2019. This contract has given MICC the monopoly rights to collect the service fee from waste dischargers within the specified area. According to the contract, MICC is obliged to clean, collect, transport and dispose of waste within the specified area, although the contract does not clearly specify MICC's duties except financial matters. The contract mainly stipulates the financial obligations of MICC. According to "Public Private Partnership for Environmental Facilities: A Self-Help Guide for Local Governments", EPA July 1991, this contract is classified as a "Franchise Contract" in which the government grants a company an exclusive monopoly to provide solid waste services within a specific zone, or zones within the municipality.

The financial duties of MICC stipulated in the contract are as follows:

- To invest more than 191,151 USD in the equipment and facilities used for the implementation of the SWM works during the contract 20 years.
- To pay 6% in turnover and profit taxes of the total amount to be paid every year.
- To pay to provincial office the amount of 3.5 million riel per year.

However, the study could not confirm records of even one of the above mentioned duties.

This contract has the following problems:

- The local authorities, including both the Siem Reap provincial government and Siem Reap district office, do not have any power in the contract, even though they are legally responsible for the SWM works.
- It does not specify the responsible organization for supervision.
- It does not stipulate the areas of public spaces to be cleaned and who is to pay for these works.
- It does not stipulate the service quality, such as the waste collection frequency.
- The contractor is not required to submit a financial report.
- No market competition for 20 years.

Therefore, no local authorities have any supervisory function, neither a responsible body nor a person in charge of the supervision of MICC's performance.

(2) Financial System

Except for 2 million riel per month, which the Siem Reap Provincial government started to pay MICC for the sweeping work in the newly specified public space, the only financial source for SWM works is the fee collected from waste dischargers by MICC. MICC allocates this revenue not only for the collection, transportation and disposal of waste discharged by residents and entities but also for public waste management work, such as street sweeping work and river cleaning work. Cleaning parks is the responsibility of neighboring hotels in return for being granted the monopoly right to use the park. Therefore, no local authorities spend any money on SWM works except

for the 2 million riel per month by Siem Reap Provincial government.
The contract stipulates the waste collection fees and MICC collects it accordance with the fee tariff by mobilizing ten fee collectors for visiting customers; however this work is very difficult because many people refuse for paying it.

Table III.8.1 Waste Collection Fee Tariff Table Included in the Contract

TYPE LOCATION	VALUE DEFINTE	PERIOD
A. Local Flat		
1- Ground Flat	USD 1.00	Per Month
2- First Floor to up	USD 0.80	Per Month
B. House of Exploitation		Per Month
1- Ground Flat	USD 3.00	Per Month
2- Over two flat	USD 5.00	Per Month
3- The place clean car and motorbike	USD 5.00	Per Month
4- Restaurant Small	USD 20.00	Per Month
5- Restaurant Big	USD 50.00	Per Month
6- Medium Restaurant & Hotel	USD 90.00	Per Month
7- Restaurant & Hotel Big	More than USD 200.00	Per Month
8- Night Club	USD 50.00	Per Month
9- Bank	USD 30.00	Per Month
10- Small Souvenir Shop	USD 15.00	Per Month
11-Big Souvenir Shop	USD 30.00	Per Month
12- Handicraft industry Services	USD 50.00	Per Month
13- House Whole Big	USD 50.00	Per Month
14- Modern Market	USD 50.00	Per Month
15- Store out Market and out Mobile		Per Month
a. Small	100 Riel	Per day
b. Mobile	100 Riel	Per day
c. Medium	200 Riel	Per day
d. Big	300 Riel	Per day
e. Store Sell the rise china noodle and fruits	1000 Riel	Per day
16. Market		
a. Phsar Loeu	USD 500.00	Per Month
b. Phsar Chas	USD 200.00	Per Month
c. Phsar Kroam	USD 100.00	Per Month
17 The other small market will be pay the same store out market		
C. Residence		
18. Residence for local staying	USD 5.00	Per Month
19. Residence for rent to foreigner	USD 10.00	Per Month
20. Guest House	USD 20.00	Per Month
21. Company Office	USD 20.00	Per Month
22. Company Branch	USD 20.00	Per Month
23. Clinic	USD 20.00	Per Month
24. Private School	USD 30.00	Per Month
25. Modern Karaoke	USD 45.00	Per Month
26. Factory	USD 100.00	Per Month
27. Night Club	USD 50.00	Per Month
28. NGO Office	USD 20.00	Per Month
29. Parking	USD 100.00	Per Month
30. Fuel Station	USD 20.00	Per Month

The present waste collection fee system has the following problems:

a) There are many people who do not want to pay or who cannot afford to pay the collection fee.
b) The collection fee system does not have enforceability.
c) The cost to collect the waste collection fee is expensive, in particular for households because MICC has no efficient measure to collect fees.
d) The fee collection system encourages people who don't want to pay for it to dispose of their waste in open spaces illegally.
e) It is difficult to obtain cooperation from the public in SWM works because they are customers.
f) The present waste collection fee tariff system does not encourage dischargers to reduce the waste discharge amount because it does not correspond to the

waste discharge amount.

g) There is no safety net for poor people who cannot afford to pay the waste collection fee. Poor people who cannot manage their garbage have to illegally dispose of it.
h) There is no reward for MICC to clean public spaces.

(3) Equipment and Staff for Solid Waste Management Works

The current waste management resources input by MICC is summarized in Table 8.2. The current resource input for SWM works, vehicle fleet in particular, seems quite insufficient for Siem Reap town in terms of quantity and quality, considering the population and economic condition in Siem Reap.

Table III. 8.2 Waste Management Equipment and Manpower as of Jan. 2005

Category	Vehicles/ equipment	No	Use (Capacity)
Equipment	2 ton trucks	7	SWM collection, road and drain cleaning (5.2m^3)
	4 ton trucks	1	SWM collection, road and drain cleaning (9.8m^3)
	Boats	2	Cleaning Siem Reap river
	Motorbikes	8	Supervision
	D4D Bulldozer	1	Final disposal site operations
Manpower	Clerks	6	Administration, accounting, etc.
	Fee collectors	10	Collection of garbage collection fee
	Drivers	10	Driving waste collection trucks
	Garbage collectors	40	Collection and Loading waste
	Street sweepers	36	Cleaning streets
	Mechanic	3	Repairing trucks and a bulldozer
	Record keepers at the disposal site	2	Recording the trucks bringing garbage into the landfill site
	Bulldozer operators	2	Spreading and compacting waste
	Others	8	
	Total	117	
Facilities	Main office	1	
	Workshop	1	In front of the new power station

4) Three Rs (Reduce, Reuse and Recycle)

According to the questionnaire survey, 89% of residences separate recyclable materials such as empty bottles, empty plastic pet bottles, empty cans, cardboard, etc. for sale to recyclable buyers. Even portable gas containers are commonly returned to the shops for refill from large cylinders containing propane gas, and refilled gas in a used cylinder.

43% of hotels, guest houses and restaurants separate some of the kitchen waste for pig farmers who come to collect it for feeding pigs, and all hotels, guest houses and restaurants separate recyclable materials such as empty bottles, empty plastic pet bottles, empty cans, cardboard, etc. for sale to recyclable buyers. Although the recycling activities for recyclable materials in the waste are considerably active, the waste discharge rates are still quite high for deluxe hotels in particular.

As for empty bottles, empty pet bottles, empty cans and metal goods, which are not separately discharged from generation sources like residences, mobile recyclers separate and collect them from waste discharged and they are sold to either middleman shops or end users such as fish source factories.

In markets, carton boxes are commonly stored separately for sale to recyclable buyers or

middle men.

In hospitals, the empty drip containers and tubes are commonly stored separately for sale to recyclable buyers or middle men.

Most mobile recyclers individually do the collection of recyclable materials and their ages vary from children to old people. Some children do the collection to help with the household income and some to earn their allowances by themselves. Most children recyclers collect materials in polysacks on foot, while some of the adult recyclers who live mainly from resource recovery collect materials using bicycles or motorbikes.

There are at least seven middleman shops for recyclables in Siem Reap town as of Dec. 2005. Most of the middleman shops deal with a variety of materials and they commonly peletize low quality plastic materials. Some of the large middleman shops even receive materials collected from districts other than Siem Reap. Metal materials are exported to Thailand and cardboard and plastic materials are transported to Phnom Penh and sold to trading companies for recyclable materials.

Table III. 8.3 Summary of Existing Middleman Shops in Siem Reap

Name of middleman shop	Mau Chai	Num Nay	Patt Cham	Seng Mong Heng	Song Vutha	Vai Siep	Total
Buying per day (Riel)	400,000	150,000	N.A.	1,000,000 - 4,000,000	3,000,000	500,000	5,000,000 - 8,000,000
Number of employees	8	5	2	12	21	6	54 persons
Material dealt							
Cardboard	X	X	X	X	X	X	–
Paper				X			–
Plastic (Mix)	X	X	X	X	X	X	–
Plastic pet bottle	X	X	X	X	X	X	–
Soft pet bottle	X	X	X	X	X	X	–
Hard plastic pet bottle	X	X	X	X	X	X	–
Aluminum can	X	X	X	X	X	X	–
Steel can	X	X	X	X	X	X	–
Ferrous metal				X	X		–
Non-Ferrous metal				X	X		–
Bottle	X	X	X	X	X	X	–
Treatment							
Palletizing	X	X			X	X	–

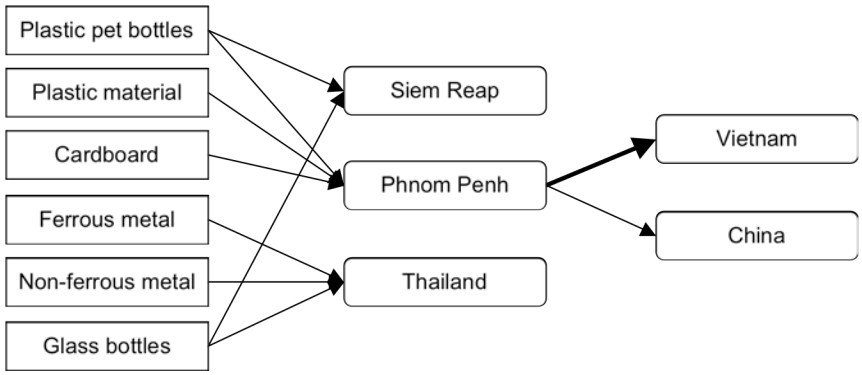


Figure III. 8.5 Stream of Recyclable Materials

Table III. 8.4 Purchasing and Selling Prices of Reusable Materials as of December 2004

Unit: riel

Material		Unit	Purchase prices (riel)	purchasing price				selling price
				Song Vutha	Man Chay	Kum Nay	Seng Mong Heng	
Plastic pet bottle		1 kg (=40 bottles)	800 to 1,000 1 bottle=20-25	800	900	900	1,000	1,300
Soft plascit pet bottle		1kg (=35 bottles)	900 to 1,500 1 bottle=25-400	1100	900	1,500	1,300	1,500-1,600
Hard plastic pet bottle		1 bottle	100 Spoiled one=800-1,000 Colored one: 500 for 1kg	100/bottle	900/kg	100/bottle	100/bottle	150-200
Coloured plastic pet bottle	PET Bottle witho	1 kg	800 to 1,000	800	900	900	1,000	1,300
Plascti container		1 kg	800 to 1,000	800	900	900	1,000	1,300
Plastic container		1 kg	900 to 1,300	-	-	-	1,300	1,500-1,600
Plastic container		1 kg	800 to 1,000	800	900	900	1,000	1,300
Plastic good		1 kg	500 to 1000	500	800	900	1,000	1,300
Plastic good		1 kg	500 to 900	800	900	No	500	900
Plastic straw		1 kg	800 to 1000	800	No	No	1,000	1,300
Rubber		1 kg	500	500	-	-	500	700-800
Aluminum can		1 can	50 to 65	50/can	65/can	65/can	65/can	66.5
Steel can		1kg	300	100/8can	-	-	300/kg	400
Pesticide can		1 bottle	50	50/can	-	-	No	-
Beer bottle		1 bottle	60 to 85	70	85	60	85	90
Fish source bottle		1 bottle	100 to 150	100	140	150	150	170
dbeRbgxüg		1 bottle	30	30	-	-	30	40
dbTwkRtl		1 bottle	130 to 150	150	130	130	150	170
Cardboard		1 kg	250 to 300	300	-	-	250-280	350
Paper		1 kg	100	-	-	-	100	-
steel	steel	1 kg	500 to 600	600	-	-	500-600	600-700
aluminum	aluminum	1 kg	4,200	-	-	-	4,200	4,600
copper	copper	1 kg	8,500	-	-	-	8,500	9,500

Source: N. Murata, JOCV, Department of Environment of Siem Reap

Waste collection workers of MICC sort recyclable materials as they collect waste to earn money; however, the amount recovered by them is quite small. This implies that many of the recyclables are collected at the generation sources before waste is collected by MICC.

Therefore, the amount of recyclables in waste that reaches the landfill seems quite small and this prediction is supported by the existence of few waste pickers working at the landfill site.

Consequently, Siem Reap town is judged to be a recycling-oriented society where the 3Rs are actively conducted. However, it should be reminded that it greatly relies on the many existing poor.

5) Condition of the Cleanliness

Only the roads shown in Figure III.8.6 are swept with the 36 street sweepers of MICC, while public places and many open places that remain dirty and this causes aesthetic problems. Scattered garbage is often seen in land reserved for road widening along main roads, vacant lands, rivers and streams. Because any public spaces other than the six streets specified by the contract and the Siem Reap River in the town are not cleaned by any organizations, the amount of illegally dumped waste and uncollected waste continues to accumulate in the town. In particular, the many scattered thin plastic bags in the town looks very ugly and this is supported by the questionnaire survey result where 44% of the people who are not satisfied with the present SWM works have raised dirtiness of the town due to waste scattering for the reason. However, it is not so serious to cause sanitary problems.

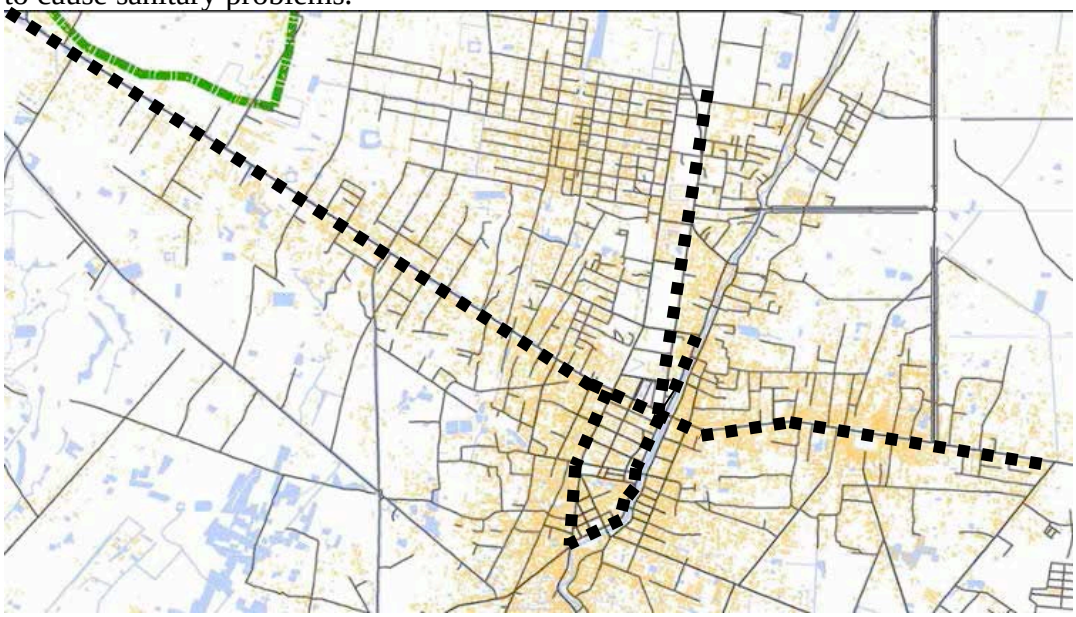


Figure III.8.6 Map of the Roads Which Are Daily Swept

6) Tree and Grass Cutting

The Department of Urban Planning and Development employs 10 workers every day for mainly trimming trees and cutting grass in public places. It has also been carrying out the improvement of landscape of the Siem Reap River and public places to make the town more attractive.

7) Discharge and Storage

Dischargers commonly use bamboo baskets, plastic bags, carton boxes, and trash boxes made of waste tires for storage but some people also discharge garbage onto roads directly. The garbage discharged is often left on the roads for several hours until being collected by MICC. A few stray animals and birds scavenge though the garbage, causing it to scatter and creating aesthetic problems.

8) Collection and Transportation

MICC collects waste from 3am to 3pm. Waste is collected in mixed condition and the collection workers always separate the recyclables for selling informally. Non-residential waste is collected by the door to door collection method and the residential waste is collected by the curb side collection method. The frequency of waste collection should be daily in the town center and every two days in the other area according to the MICC site manager; however, it is actually very irregular and less frequent. For example, Siem Reap Referral Hospital always burns their domestic waste in spite of paying USD 80 per month to MICC for the 3 times waste collection per week contract because MICC comes to collect waste often only fortnightly.

The estimated transportation capacity of MICC's fleet as of December 2004 is approximately 123 m^3 per day according to Table III.8.5. All the collection vehicles are very old open dump trucks and are frequently under repair. The side plates of the carriers of trucks have been made higher so that more waste can be accommodated and the carriers have also been improved to make it easier to load more waste onto them. MICC's trucks always very much overload waste for transportation. However, the waste on collection trucks is covered with a sheet to prevent waste from scattering during the transportation. According to General Manager of MICC, MICC has doubled the number of waste collection trucks from four to eight since 2000 and it implies that the waste discharge amount has been rapidly increasing since 2000.

Table III. 8.5 Estimation of Transportation Capacity

Items	Estimated loading capacity for waste	Average no. of trips per day	No. of units	No. of trips per day	Transport capacity of truck per day	Efficiency	Estimated Transport Capacity
Unit	m^3	trips/truck/ day	Nos.	Trips/day	m^3/truck/day		m^3/day
Small trucks	5.2	4	7	28	20.8	0.7	102
Medium trucks	9.9	3	1	3	29.7	0.7	21
Total	-	-	8	31	-	-	123

Notes: The efficiency was estimated in 0.7 due to occasional service hours required.

9) Processing and Treatment

There are neither processing plants nor treatment plants for municipal waste in large scale. However, four middleman shops for recyclable materials palletize low quality used plastic. As for healthcare waste, there are small capacity incinerators.

10) Healthcare Waste

Domestic waste discharged from medical institutions is collected by MICC subject to the individual waste collection contract.

Syringes are put into specially designed yellow carton boxes for syringes provided by

UNICEF and then carried to Creav Health Center by dischargers for burning in an incinerator made of metal. Medical institutions pay Creav Health Center 500 riel per box of syringes for the incineration fee. Hospitals commonly burn infectious waste such as used bandages and absorbent cottons in their small incinerators.

However, it is also common practice for most medical institutions to sell used drip containers and tubes. We confirmed that some of the middleman shops for recyclables often deal with used syringes and injection cases which they are not supposed to.

11) Industrial Waste

There is a very small amount of industrial waste because there are no large industries in Siem Reap. There are a considerable number of small fish source factories in Siem Reap; however, they do not generate any waste because they use up all materials.

8.1.4 Angkor Heritage Area

(1) Implementation System

The Department of Monument and Archaeology in the APSARA Authority is responsible for SWM works for garbage generated by tourists, the tourist industry and nature such as trees in the Angkor heritage area. However, no authorities are responsible for the waste generated by residents. All the SWM works have been contracted out to the private company, HCC, which was awarded a contract in August 2003 through an open tender held by the APSARA Authority. HCC collects waste generated by tourists but not by local residents.

HCC carries out the SWM works for the Angkor heritage area based on the existing contract. The contract agreement was made between APSARA Authority and HCC, and the contract period is for 4 years from 11 October 2003 to 11 October 2006. The contract is the lump sum based contract and the payment is made monthly. The lump sum contract amount is USD 19,540 per month including the disposal cost. The financial source is APSARA Authority's budget which is obtained from the entrance fee. The scope of work covered by the contract is as follows.

- To clean the specified area and to collect, transport and dispose of waste/trash.
- 21 specified temples except the inside of these temples have to be cleaned.

The responsible person of each temple appointed by the Department of Monument and Archaeology supervises HCC's work performance. The Study Team evaluates this contract as very reasonable and well prepared; and in addition both HCC's work and APSARA's supervision are very well performed.

(2) Equipment and Staff for Solid Waste Management Works

HCC, which was established in 1997, carries out the works related to solid waste in Phnom Penh and Siem Reap as follows:

- Phnom Penh: Cleaning of Phnom Penh Airport and shopping mall buildings
- Siem Reap: Cleaning of Angkor Heritage area and Siem Reap Airport

HCC has about 430 employees in Cambodia and 50% of these work in Siem Reap. The current waste management resource input is summarized in Table 8.6.

Table III. 8.6 Waste Management Equipment and Manpower

Category	Vehicles/ equipment	No	Use (Capacity)
Equipment	Compactor truck (4 to 8 tons)	4	SWM collection, road cleaning
	2 ton trucks	1	SWM collection, road cleaning
	Bicycle for recycle	A few	Collection of recyclable materials
Manpower	Clerks	1	Administration
	Management/Supervisor	7	Supervision
	Drivers	6	Driving waste collection trucks
	Street sweepers/garbage collector	130 to 150	Cleaning streets, collection waste
	Mechanic	3	Repairing trucks
	Cleaning Siem Reap Airport	50	Cleaning the airport
	Movable cleaning team	1	Cleaning subject to the request
Facilities	Main office	1	
	Stores for keeping cleaning tools	21	at every temple
	Small trash bins	206	
	Garbage station (3mx2m)	39	
	Notice board	86	

(3) Three Rs (Reduce, Reuse and Recycle)

There are many child recyclable collectors, especially around the restaurants near the famous temples, and they collect mainly empty cans and empty plastic pet bottles.
Although HCC has arranged for their workers to use bicycles which have two sacks for collecting recyclables, HCC has granted them the benefit from resource recovery.

(4) Condition of Cleanliness

We can find 130 to 150 street sweepers throughout the Angkor heritage area and they keep the area very clean. There is a sufficient number of litter bins placed in proper locations. However, some tourists who have bad manners (most are local tourist according to HCC) throw garbage onto the roads and thin plastic bags are scattered in some places.

(5) Discharge and Storage

Thirty-nine garbage stations have been properly installed near food stalls and shops so that they can dispose of their waste. The garbage stations are appropriately designed and they are functioning quite well.

Garbage station

(6) Collection and Transportation

HCC uses compactor trucks made in Korea for the collection and transportation of waste. All of the equipment is still in good condition and there is no problem with scattered waste as the vehicles are closed type trucks. HCC currently collects about 930 m^3 of waste per month by about 150 trips per month. The collection and transportation capacity is quite satisfactory for executing their duties.

(7) Others

There are neither processing plants nor treatment plants. However, fallen leaves collected are often burned on site.
Neither healthcare waste nor industrial waste is generated in the Angkor heritage area.

HCC contracted out the final disposal work to MICC because HCC has no landfill site. HCC pays MICC USD 1,800 per month in tipping fees.

8.1.5 Final Disposal

MICC owns the disposal site in Prey Kuy district next to Siem Reap district and has been operating it since 2001. It is the only landfill site and receives all waste from Siem Reap town, the Angkor heritage area and the Siem Reap Airport. The landfill site is located approximately 8 km from Siem Reap town, and it has an area of 2.6 hectares. The access road to the disposal site from National Road No.6 is difficult to pass, especially during the rainy season as it is a clay road. The land of the disposal site and its surroundings is used as a paddy field and the population near the disposal site is small. Most of the residents have recently moved to the area to do a recycling business. According to MICC, the number of residents living near the landfill site has been rapidly increasing.

Picture of Prey Kuy Disposal Site shown with a dotted line.

There is a small control house at the entrance of the disposal site and a very old bulldozer, a D4D, is used for landfill operation at the site. MICC does not cover waste with soil, nor has it installed a gas ventilation system or a leachate treatment system. In fact, the Prey Kuy disposal site officially has not been approved by Ministry of Environment and Department of Environment in Siem Reap often instructs MICC to improve the environmental protection measures. MICC has constructed the embankment and plant trees surrounding the landfill site; however, they are not sufficient as environmental protection measures. Therefore, the landfill site currently has a negative environmental impact on the surrounding area, such as offensive odor, many flies, waste scattering, water contamination by leachate, and smoke from burning waste. It has caused many people complain to the commune office about the landfill operation, especially for the waste scattering, many flies and smoke. The commune office has in turn complained to the Department of Environment in Siem Reap and Siem Reap Provincial government; however, relevant governmental organizations have failed to force MICC to rectify the problems.

View from the Entrance of the Prey Kuy Disposal Site

The number of waste pickers working in the landfill is only about ten people. This fact implies that there are few recyclable materials contained in the waste in the disposal site due to the fact that the 3Rs are actively conducted at the generation sources.

8.1.6 Basic Data on Solid Waste Management

(1) Waste Discharge Rates

Table 8.7 shows the waste discharge rates obtained by the survey conducted in the study. However, it should be noted that the number of samplings for the discharge rate survey was not sufficient to obtain enough reliability due to the limited number of survey samples. A further detailed study is required for the formulation of the SWM master plan; however, these data can be useful for considering the strategic plan.

Table III. 8.7 Summary of Waste Discharge Rates

Category 1	Category 2	Category 3	*	Unit	Average Rates	Determined Rates
Residential wastes	High income	-	15	g/person/day	527	**490** g/person/day
	Middle income	-	15	g/person/day	504	
	Low income	-	15	g/person/day	433	
	Average		15	g/person/day	488	
Non-Residential waste	Hotel	Deluxe	1	g/guest/day	1,920	**1,250** g/guest/day
	Hotel	Standard	2	g/guest/day	920	
	Guest house	Deluxe	1	g/guest/day	640	**1,010** g/guest/day
	Guest house	Standard	2	g/guest/day	1,200	
	Restaurant	Large	1	g/chair/day	170	
			1	g/guest/day	400	
	Restaurant	Medium	1	g/chair/day	770	**620** g/chair/day
			1	g/guest/day	940	**540** g/guest/day
	Restaurant	Small	1	g/chair/day	920	
			1	g/guest/day	290	

Note: * shows the number of sampling points.

(2) Waste Amounts

1) Waste Generation Amounts

Table 8.8 shows the tentatively estimated waste generation amount as of Jan. 2005 estimated based on the determined waste discharge rates and statistic data. The total waste generation amount estimated is about 88 ton per day.

Table III. 8.8 Summary of Estimated Waste Generation Amount as of January 2005

Generation Source	Unit	Generation Ratio	Number of Generation Sources	Generation amount (ton/day)
Household Waste	g/person/day	490*	121,317	59.4
Commercial Waste (Restaurant)	g/table/day	1,860*	1,346	2.5
Commercial Waste (Shops)	g/shop/day	4,500**	455	2.0
Market Waste	g/stall/day	1,700**	1,000	1.7
School Waste	g/student/day	18**	50,000	0.9
Street Sweeping Waste	g/km/day	47,235**	10	0.5
Hotel Waste	g/guest/day	1,250*	4,803	6.0
Guesthouse Waste	g/guest/day	1,010*	1,705	1.7
Office Waste	g/office/day	2,946**	368	1.1
Heritage area	g/guest/day			9.0
Airport	–			3.0
Total				87.9

Source:
* shows the survey data obtained from this JICA study.
** refers the data from the Study on Solid Waste Management in the Municipality of Phnom Penh, 2005

2) Waste Collection Amounts

The transportation capacity of MICC's fleet as of December 2004 is approximately 123 m^3 per day as shown in Table III.8.5, while HCC uses the three compactor trucks with 4 m^3 capacity and collects about 30 m^3 of waste per day from Angkor Heritage Area and the Siem Reap Airport. In total, approximately 150 m^3 of waste is collected daily in the study area. This is equivalent to approximately 60 ton per day based on the assumed unit weight of 0.4 tons/m^3.

3) Waste Disposal Amounts

There is no record of the final disposal amount of waste. It is estimated to be slightly less than the collection amount, as the resource recovery by MICC's and HCC's collection workers is not active.

4) Recycle Amount

Table III.8.3 shows that the daily recycle amount in terms of money is from 5 million riel to 8 million riel. Assuming the average price per recyclable material is 650 riel per kg, the amount of recyclables collected per day is from 7,692 kg to 12,308 kg. The present total recycle amount is, therefore, estimated to be 10 tons/day, which is 11% of the generation amount.

The number of waste pickers working in the Prey Kuy disposal site is about 20 people. Assuming they each collect 50kg of recyclables per day, they collect 1 ton of recyclables from waste in the disposal site.

The collection workers collect recyclables during the waste collection work. Assuming the amount of recyclables collected by collection workers is 30kg per trip, the amount of recyclables collected is about 1 ton per day by 30 trips per day.

5) Waste Stream

Although this study had few resources to determine the waste stream precisely, a very rough estimate of the waste stream is shown below. The estimated amount of illegally dumped waste is 20 tons per day at maximum.

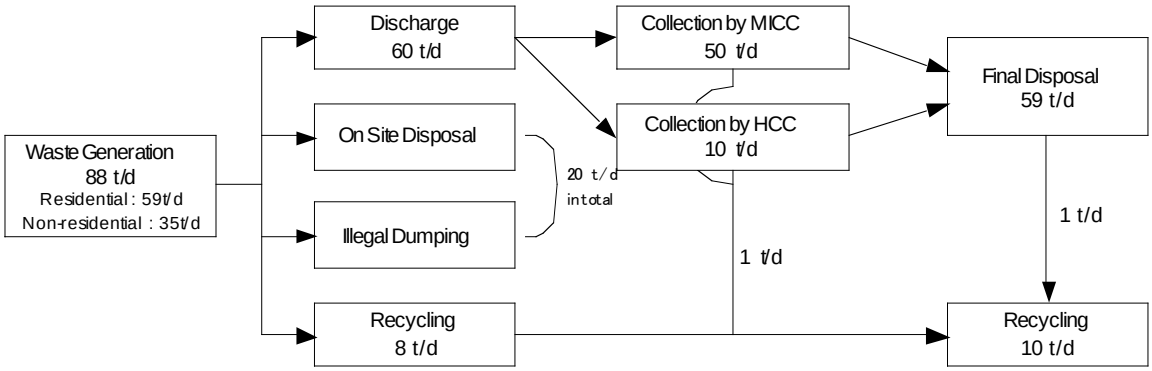


Figure III. 8.7 Waste Stream As of 2005

(3) Waste Composition

Table III. 8.9 Physical Composition of Waste in Siem Reap

Unit: %

Component	Residential Wastes			Non-Residential Wastes		
	High Income	Middle Income	Low Income	Hotels	Guest Houses	Restaurants
Kitchen waste	54%	48%	51%	75%	63%	63%
Grass and wood	14%	21%	18%	2%	8%	3%
Paper	7%	3%	4%	7%	10%	14%
Textile	1%	0%	4%	0%	1%	0%
Plastic (Non-recyclable)	7%	8%	8%	4%	7%	5%
Plastic (Recyclable)	3%	1%	1%	2%	1%	0%
Metal	2%	4%	2%	1%	1%	1%
Rubber and leather	0%	1%	2%	0%	0%	0%
Glass	3%	2%	1%	6%	6%	8%
Ceramics and stone	1%	2%	1%	2%	1%	1%
Others	9%	9%	8%	1%	2%	4%
Total	100%	100%	100%	100%	100%	100%
Bulk Density (kg/l)	0.191	0.190	0.153	0.273	0.203	0.247

Figure III.8.8 shows that the percentage of compostable materials in the waste is about 70%. It should be reminded that 70% is the maximum percentage of waste which can be composted because the actual percentage of waste to be composted depends on various factors such as public cooperation in separate collection, the adopted technology for composting, etc. However, the result of physical composition analysis implies that the waste in Siem Reap at present is suitable for composting in terms of waste quality.

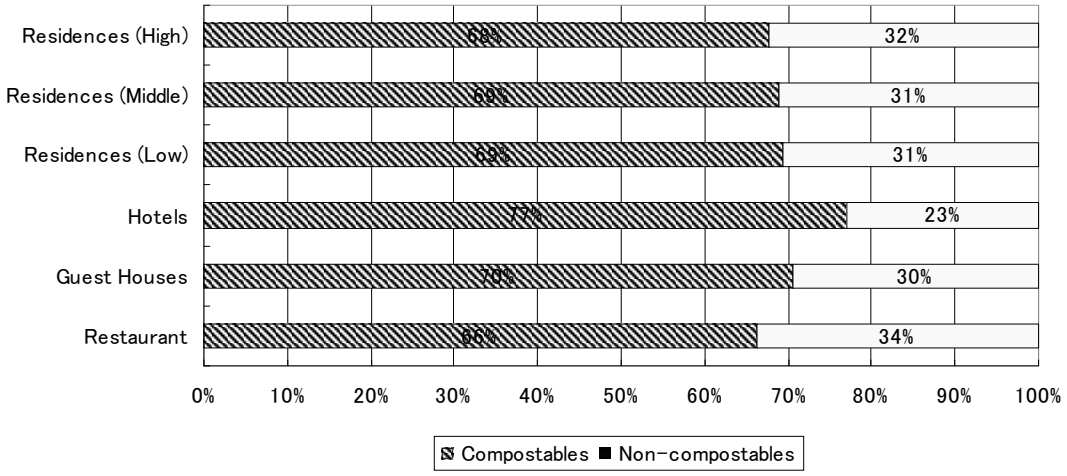


Figure III.8.8 Ratios of Compostable Waste

Figure III.8.9 shows that the percentage of inorganic recyclable materials in the waste ranges from 11% to 23%. These percentages are much lower than those of the wastes in developed countries, which range from 40% to 60% in general. In addition, Table 8.9 shows that the percentage of recyclable plastic ranges from only 1% to 3%.
These data imply the following:

- Possibility of the existence of active 3 R (Reduce, Reuse, Recycle) activities at the waste generation sources.
- Difficulty of the introduction of a new recycling system.

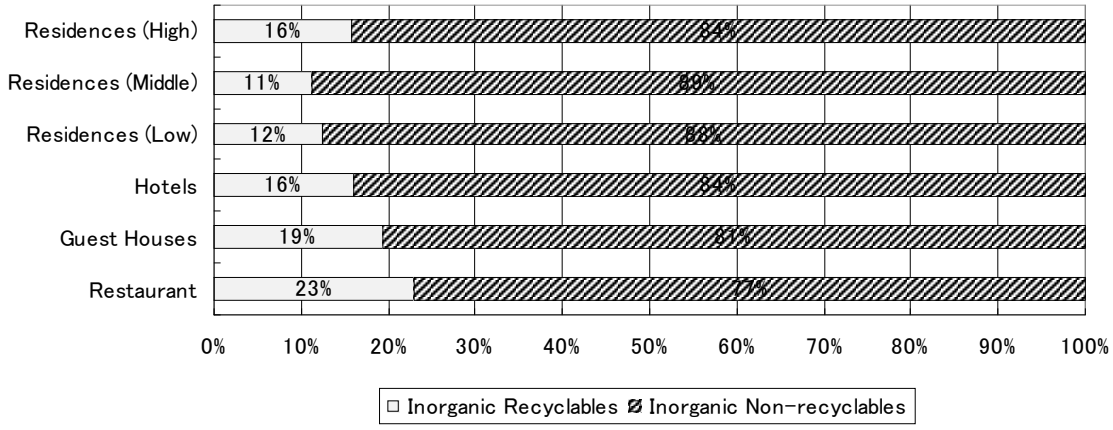


Figure III. 8.9 Ratios of In-organic Reusable Waste

8.1.7 Relevant Studies and Projects Recently Undertaken

a) The Environmental Management System (EMS) section of the APSARA Authority is leading the Angkor environmental program with the assistance by the team consisting of institutions in Japan. Environmental education, EMS guidance, EMS training support and technical assistance for environmental surveys has been provided by the Sophia Asia Centre for Research and Human Development, the Quality Assurance Institute Inc. (JQAI), the Japan Quality Assurance Organization (JQA) and the International Standards Research Institute, Inc. (ISRI).

b) JICA executed "The Study on Solid Waste Management in the Municipality of Phnom Penh". A staff member from the Department of Environment in Siem Reap participated in the SWM technical transfer seminar executed by the Study. In addition, the Study Team visited Siem Reap town to quickly appraise the condition of SWM there.

c) Department of Environment in Siem Reap is leading a few small projects related solid waste.

8.1.8 Prospects

(1) Waste Generation Amount Forecast

The waste generation amount forecast based on the following assumptions.

a) The forecast growth rates of the waste generation factors are 55% of the forecast economic growth rate.

b) Forecast economic growth rate is referred to the scenario developed by the Cambodia Development Research Institute in the ADB Study on Enhancing Governance for Sustainable Development in October 2000.
   - From 2005 to 2010: 8.4%/year
   - From 2010 to 2020: 6.8%/year

The waste generation amount without 3Rs measures taken is forecast as follows.

Table III.8.10 Waste Generation Rates Forecast

Generation Source	Unit	2005	2010	2015	2020
Residential waste	g/person/day	490	614	750	887
Hotel Waste	g/guest/day	1,250	1,475	1,822	2,168
Guesthouse Waste	g/guest/day	1,010	1,705	1,728	1,752
Other waste	g/person/day	171	205	251	297

Table III.8.11 Waste Generation Sources Forecast

Generation Source	Unit	2005	2010	2015	2020
Residential waste	Person	121,317	162,000	186,500	211,000
Hotel Waste	Guests	4,803	14,563	15,797	17,030
Guesthouse Waste	Guests	1,705	4,638	5,060	5,482
Other waste	Person	121,317	162,000	186,500	211,000

Table III.8.12 Waste Generation Amount Forecast

Generation Source	Unit	2005	2010	2015	2020
Residential waste	t/d	59	99	140	187
Hotel Waste	t/d	6	21	29	37
Guesthouse Waste	t/d	2	8	9	10
Other waste	t/d	21	33	47	63
Total	-	88	162	224	296

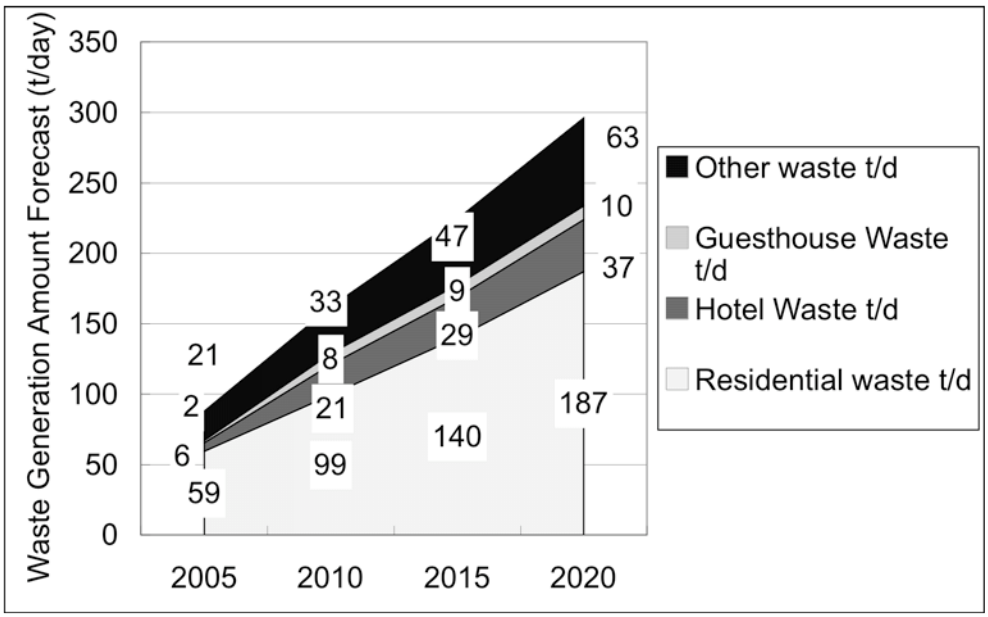


Figure III.8.10 Waste Generation Amount Forecast without 3Rs Measures

The forecast shows the waste generation amount in 2020 will be more than triple of that in 2005 from 88 t/d in 2005 to 296 t/d in 2020.

The total waste generation amount from 2006 until 2020 will be about 783,300 ton.

(2) Waste Properties Forecast

The future waste properties are forecasted as follows:

a) The modernization of way of life lead by the economic growth will greatly increase packaging waste, such as plastic, paper and cans, and decrease kitchen waste. Because these wastes cannot decompose naturally, they will have greater

negative impacts on the environment unless they are properly treated.

b) The increase of packaging waste will lighten the unit weight of waste. This will decrease the waste transportation efficiency of an open truck and increase the necessity of using compactor trucks. It will result in an increase of the collection and transportation cost, which occupy the majority of the SWM expenditure.

c) The amount of grass and wood will not change because there are factors of both increase and decrease. The decrease factor is that the number of trees will slightly decrease and the increase factor is the increase of leaves collected by street sweeping due to the increase of paved road.

(3) Lifespan of the Prey Kuy Disposal Site

The total area of Prey Kuy Disposal site is 3.15 hectors and the available area for the disposal site is about 94% of the total area. The assumed density of waste disposed is 0.7 ton/m^3.

Assuming 10 meters for the waste landfill height, the disposal capacity is 233,560 m^3.
Assuming 15 meters for the waste landfill height, the disposal capacity is 305,600 m^3.
The waste amount disposed already between 2001 and 2005 is estimated at about 88,000 m^3 and then the remained capacity is 145,560 m^3 for 10 meters landfill height and 217,600 m^3 for 15 meters height.

Table III.8.13 simulates the remained lifespan of the Prey Kuy disposal site.

Table III.8.13 Forecast Waste Disposal Amount

	Waste generation amount	Accumulated waste generation amount	Accumulated waste collection amount	
			when 70% collection rate	when 90% collection rate
	m^3/y	m^3	m^3	m^3
2006	35,914	35,914	25,140	32,323
2007	41,084	76,998	53,899	69,298
2008	46,255	123,253	86,277	110,928
2009	51,425	174,679	122,275	157,211
2010	56,596	231,274	161,892	208,147
2011	61,277	292,552	204,786	263,297
2012	65,959	358,510	250,957	322,659
2013	70,640	429,150	300,405	386,235
2014	75,321	504,472	353,130	454,025
2015	80,003	584,475	409,132	526,027
2016	84,684	669,159	468,411	602,243
2017	89,366	758,524	530,967	682,672
2018	94,047	852,571	596,800	767,314
2019	98,728	951,300	665,910	856,170
2020	103,410	1,054,709	738,296	949,238

It implies the followings.

- When 70% of total generation waste is disposed, it will be exhausted in 2010 at the 10 meters landfill height and in 2012 at 15 meters landfill height.
- When 90% of total generation waste is disposed, it will be exhausted in 2009 at the 10 meters landfill height and in 2011 at 15 meters landfill height.

(4) Forecast Problems Ahead

It is expected that the many problems related to solid waste will become serious and

new ones will arise in future in the present SWM system.

1) Serious Negative Environmental Impacts on the Surroundings of the Disposal Site

The disposal operation at the Prey Kuy site has negative environmental impacts on the surrounding area such as offensive odor, flies, mosquitoes, rats, smoke, water contamination, ugly view, etc. The number of complaints about the disposal operation is increasing, although MICC is making efforts to improve the problems in response to the strong direction by the Department of Environment.

In developing countries, a sanitary landfill operation is generally very difficult to achieve by the private sector only due to the following reasons:

- Ignorance of the operation quality gives the operator more profits.
- The customers do not pay an adequate fee for the sanitary landfill operation because they care only about the waste collection service and not the disposal operation quality.
- It requires expensive heavy equipment and operation skills.
- The local authority cannot terminate the disposal operation company as it is often a monopoly even though their performance is very poor.

The increase of the waste generation amount in future will lead to the increase of the waste disposal amount, which will increase the negative environmental impacts unless the sanitary landfill operation is carried out. However, the sanitary landfill operation will unlikely be carried out because the Prey Kuy disposal site is associated with all of the above four reasons. The surroundings will be polluted and then neighborhoods will receive more serious nuisance. Moreover, the smoke will be visible from faraway places by more citizens and more tourists.

Consequently, it will increase the neighbors' opposition to the landfill operation and will cause the citizens to have a strong bias against disposal sites, which will make it difficult for both the private sector and local authorities to acquire land for new disposal site development.

Because the capacity of the Prey Kuy disposal site will be exhausted by around 2009, acquiring new land for landfill development will be very difficult unless the present landfill operation is well improved.

2) Deterioration of the Aesthetic view

In the present SWM system, the waste discharged from people who do not pay the fee is not collected, even though there are many people who do not want or cannot afford to pay it. As a result, a lot of waste is scattered in the town. In addition, MICC will reach their financial capacity limit to do the street and river cleaning works, which it is doing voluntarily without any payment by the local authority. If it reaches the limit, the waste scattered along roads will increase.

Therefore, with the rapid increase of the waste generation amount, the amount of waste heaps and scattered waste in town will greatly increase, which will greatly deteriorate the aesthetic view of the town.

In addition, the public facilities providing people with amenities are not cleaned in the present SWM system even though they are constructed.

3) Deterioration of Infrastructure

Six main streets and the Siem Reap River are cleaned everyday by MICC under a gentleman's agreement as a part of the existing contract without any payment to MICC for these works by local authorities. This means that there is little possibility of the expansion of the cleaning works unless a payment is made.

The street sweeping work prevents dust and prevents drainage from clogging with waste. Without the execution of proper street sweeping work, pedestrians will suffer from dust; motorbikes, bicycles and pedestrians will have difficulties passing due to the dust sediment on roads; flooding will often occur due to drainage clogged with waste; and finally the lifespan of roads will shorten due to frequent flooding. Other infrastructure such as pedestrian, parks, gardens, public toilets, fountains and ponds will suffer the same. Lack of proper cleaning of infrastructure will lead to a rapidly deterioration of their functions and a shortening of their lifespans.

4) Social Problems Due to the Increase of Waste Pickers in Town

Recycling in Siem Reap is very active because of the existence of many waste pickers in town. Such waste pickers often scavenge through trash bins and discharged waste for recyclables, which scatters the waste. Young waste pickers sometimes wait for customers sitting in open coffee shops to finish soft drinks and take the empty aluminum cans immediately after drinking them.

The development of Siem Reap will widen the economic gap between Siem Reap and other areas and it will increase the migration of especially poor people from other areas to Siem Reap. This will result in an increase of waste pickers in town because waste picking is one of the easiest businesses for poor people to start without investment or experience.

The increase of waste pickers will therefore result in an increase of waste scattered in town and cause more nuisance to tourists and possibly security problems.

5) Serious Negative Impacts to the Tourists

Without full improvement measures taken, Siem Reap town will get dirtier, the infrastructure will lose its function quickly, the social problems caused by waste pickers will cause tourists more nuisance, and the environmental deterioration caused by the poor landfill operation will create a bad image on Siem Reap. All of these will give a very bad impression to tourists especially coming from developed countries who grew up in very clean conditions.

The tourists will only be able to relax within the premises of qualified accommodations where sufficient sanitation is ensured. They will also be discouraged by the various nuisances caused by the unhygienic conditions in town. It will have a serious negative impact on the tourist industry.

8.1.9 Issues

There are two core problems with the current SWM. One is that Siem Reap town looks dirty due to the existence of many waste heaps and dust in many places, and the other is that the waste disposal operation has a negative impact on the environment.

(1) Analysis of Problem of "Dirty Condition in Siem Reap Town"

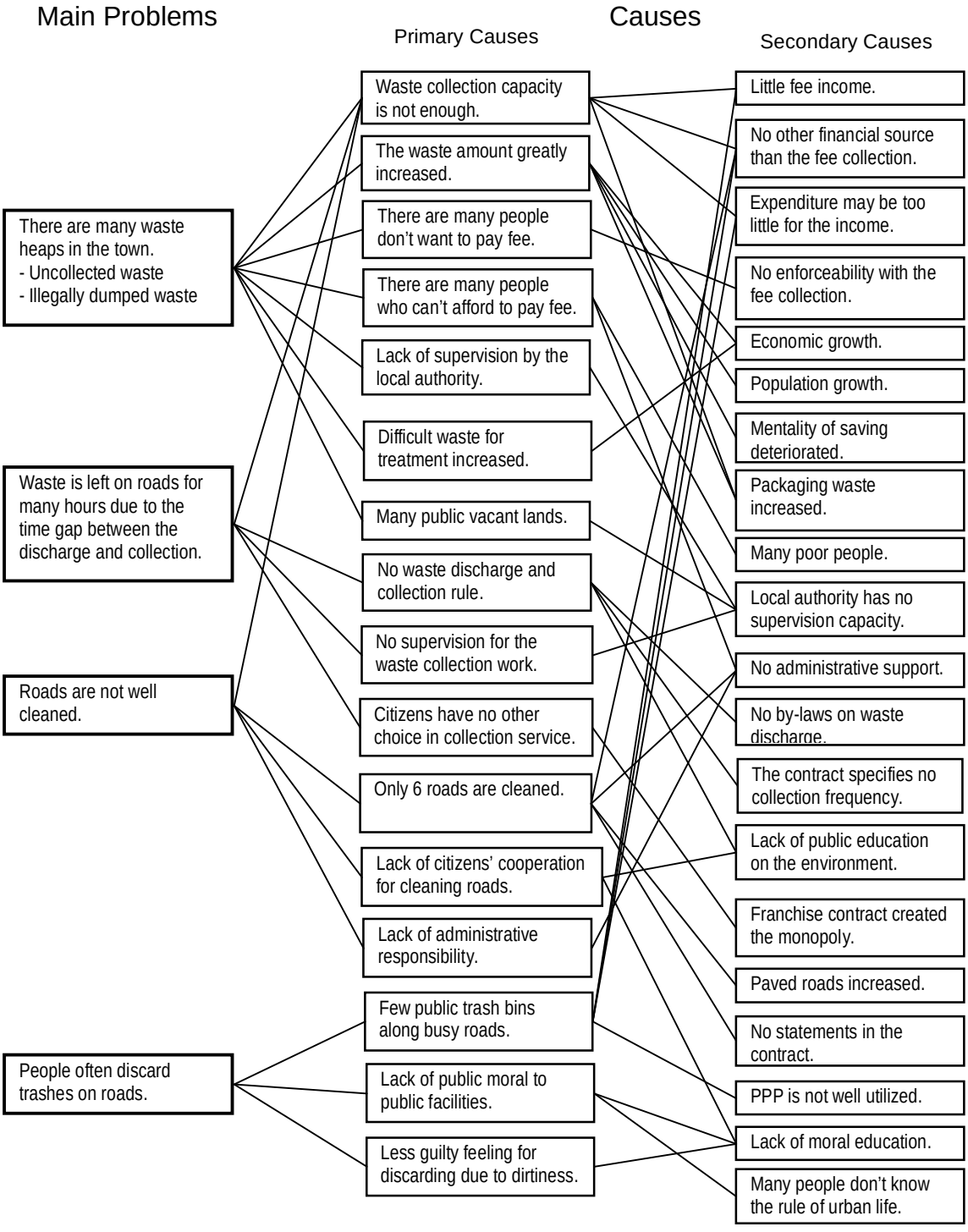


Figure III.8.11 Cause Analysis of the Dirty Condition in the Town

This core problem has brought about the following direct effects:

a) Many people are unsatisfied with the present SWM.
b) Waste often clogs drainage and it causes flooding and shortens the life of roads.
c) The soil sediment on roads causes difficulties for motorbikes, bicycles and pedestrians.
d) The unhygienic condition of the town such as dust, vermin, offensive odor, scattered waste, and ugly view discourages tourists.

(2) Analysis of Problem of "Negative Environmental Impacts by Waste Disposal Operation"

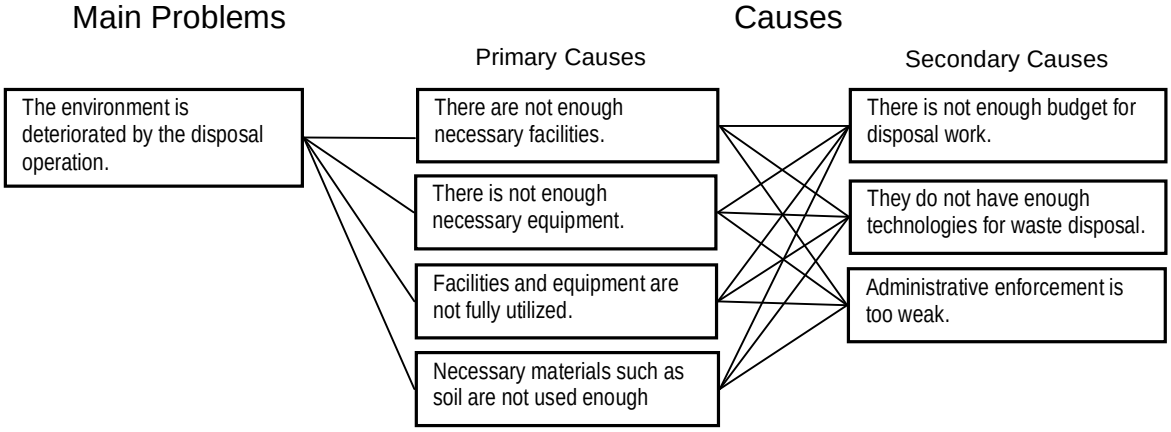


Figure III.8.12 Cause Analysis of Negative Environmental Impacts by Waste Disposal Operation

This core problem has brought about the following direct effects:

a) The environment in the surrounding area is deteriorated by the polluting of groundwater, smoke, many vermin, and offensive odor.
b) The poor disposal operation causes a nuisance to residents in the surrounding area.
c) Residents in the surrounding area complain about the unsanitary conditions.
d) It damages the image of Siem Reap.

(3) Identification of Main Issues

1) Assessment of the Current Condition

Amount and Composition Changed Increased

The waste generation amount is rapidly increasing due to two main factors, population growth and economic growth. In addition, the rapid urbanization and the population concentration are reducing the possibility of properly disposing of waste within the premises of the generation sources by reducing the available land and it has been the another factor to increase the waste discharge amount. The other currently observed factor to increase the waste discharge amount is the change of the waste composition such as the increase of packaging waste, for example plastic pet bottles and plastic bags. The recent socio-economic development has resulted all of these changes and it is

expected to bring even further changes. The trend of socio-economic changes is heavily against the SWM and its magnitude in Siem Reap in terms of SWM has reached the equal level as or even more than that in Phnom Penh.

Change of Lifestyle

The Cambodian people's traditional way of life, which minimizes the consumption of natural resources, is very environmental friendly. Reduce/Reuse/Recycle activities, which remain rooted in their way of life, are still very active in Siem Reap. However, the recent rapid economic development, which leads to a mass-production, mass-consumption and mass-disposal society, is deteriorating their traditional way of life and their mentality to save. This current condition does not allow us to appreciate the existing recycle activities because it is also proof of the fact that people discharge a large amount of recyclable waste. Such a change in people's attitude from 'recycle-oriented' to 'throwaway' has been increasing the load on SWM.

Lack of Responsible Local Authority

Despite facing such adverse conditions, the administration has taken no measures to cope with this problem since 1999 when the Ministry of Economics and Finance made a franchise contract with MICC. In fact, this contract has deprived the local authority, which is obliged to be responsible for SWM, of its authority to execute SWM. Therefore, no local authorities in Siem Reap, neither the Provincial government nor the Siem Reap district government, have the capacity to execute SWM due to a lack of both human resources and equipment. The current capacity for SWM of local authorities in Siem Reap is, therefore, far behind that of Phnom Penh municipality, which owns Phnom Penh Waste Management authority for the execution of SWM.

High Fee Collection Cost and No Cooperation for Collecting

The present fee collection system, in which MICC directly collects the fee from waste dischargers, lacks enforceability, and the fee collection cost is, therefore, very costly. It is most likely that the fee collection cost accounts for quite a large ratio of the total expense, and this could be the biggest obstruction for MICC to expand the service coverage area and to improve the service quality. However, there is no cooperation among the waste collection companies, clients, local authorities, citizens, and entities because the disclosure of financial data creates reciprocal distrust and jealousy among them.

Limitation of Franchise Contract for Solid Waste Management

The main purpose of introducing the franchise contract with the private company was to establish a self-financing SWM system by the private sector because local authorities had no internal financial sources, in other word no money collection capacity. Considering the fact that MICC has managed to carry out the SWM work only by the revenue from their fee collection, the primary purpose to establish an autonomous SWM system has been achieved in return for compromising service quality and ignoring environmental protection. However, due to the adverse socio-economic condition, MICC has failed to operate the disposal work in a sanitary manner and has encountered more difficult problems in the collection work. In the near future, it is expected that the increase in the required SWM work load and service quality will exceed MICC's capacity, which will make the problems very significant and serious.

2) Classification of Causes

The existing causes which are partially shown in Figure III.8.11 and 8.12 are classified into the following three categories in terms of the Solid Waste Management.

External Causes (which cannot be managed by Solid Waste Management)

1. Rapid population growth by migration and urbanization
2. Rapid growth of tourist industry and economic growth
3. Increase in infrastructure such as paved roads
4. Existence of many poor people

External/Internal Causes (which can partially be managed by Solid Waste Management)

1. Accelerated and uncontrolled generation of municipal wastes
2. Negligence and lack of interest and understanding by national and local authorities to SWM problems
3. Lack of financial basis
4. Insufficient public education and limited public participation
5. Great increase in waste that is difficult to treat or decompose
6. Incomplete and/or obsolete legislation and insufficient enforcement

Internal Causes (which should be managed by SWM)

1. Absence of local administration capacity of SWM system
2. Lack of short-term, medium-term, and long-term SWM planning
3. Lack of resources such as equipment and human resources

The SWM plan shall focus on the above "external/internal causes" and "internal causes".

3) Identification of Main Issues

The causes, excluding the external causes which cannot be dealt with by SWM, can be attributed to the following root causes:

a) Lack of people's awareness of waste issues
b) Insufficient capacity of the responsible authority for doing SWM
c) Poor financial system
d) Administration's over-reliance on the private sector in SWM

Rectification of the abovementioned root causes should be the main issues in the SWM master plan.

In order to improve SWM for cities in developing countries, one of the main issues is often to improve the efficiency of the local authority's existing resources, especially human resources, because they generally employ too many people as SWM is often politically used as a job opportunity for many jobless people. This causes labor-related problems and low efficiency of equipment utilization. However, in the case of Siem Reap, this approach cannot be effective because all SWM work is carried out by private companies which aim at the maximization of the profits. In other words, there is little room to rectify the existing problems by technical efficiency improvement measures. In fact, most of the problems require institutional improvement measures. This is the reason why the efficiency improvement of a common issue has not been selected for Siem Reap.

8.2 Sector Objective

8.2.1 Vision

The objective of the SWM works shall be to make the town "LOVELY" for everybody. In order to create a lovely town that the citizens can be proud of, it must be clean and beautiful. Such a town must be attractive for tourists as well.

(1) Siem Reap Town Area

The SWM works for Siem Reap town shall focus on not only waste collection but also beautification of the town. The scope of SWM works should cover the planting and trimming of flowers and trees in various public spaces to make them attractive for people. Keeping the town beautiful is the only efficient way to stop people from discarding trash in public places.

In addition, the development of Siem Reap town has to be associated with the improvement of infrastructure such as roads, parks, drainage, etc. This will make the town not only functional but also attractive for everybody. However, if these facilities are not properly cleaned, there will be an increase of scattered waste and a decline in sanitary conditions in the town. In other words, the improvement of infrastructure will increase the area which requires periodical cleaning. Focusing on the role of infrastructure to make the town attractive for everybody, the objective of SWM should not only be "sanitation" and "environmental protection" but also "proper maintenance of infrastructure" and more positively "beautification of the town".

(2) Angkor Heritage Area

The Angkor Heritage Area will aim to be **the top runner in environmental management in Asia**. Besides environmental protection, this will increase the value of the Angkor Heritage and will help to establish its prestige in the world.

In addition, the Angkor Heritage should be **a model of environmental management** in Cambodia and provide visitors with the opportunity to learn the importance of environmental protection. It will help raise the awareness of Cambodian visitors on environmental protection through the application of stringent waste rules such as prohibiting the use of plastic bags by visitors and shops in the Angkor Heritage area. Before school children visit the Angkor Heritage site, they have to learn the environmental rules applied at the site and how to behave there. The actual visit to the site will allow them to practice environmentally friendly behavior. All general visitors will receive a simple environmental lecture at the entrance gate.

8.2.2 Roles of Solid Waste Management be Works

There are generally three main objectives of SWM works as described below:

a) To maintain the town in a hygiene condition. This can be achieved by collecting and transporting garbage away from the living area immediately after it is generated.
b) To minimize the negative environmental impacts generated through the SWM works. In general, the poor waste disposal operation generates serious negative

environmental impacts, and the greater the amount of disposed waste, the more serious the impact. This objective can be achieved by the operation of a sanitary landfill and minimization of the waste discharge amount.

c) To properly maintain infrastructure to maximize their functions and to lengthen their lifespan. This objective can be achieved by street cleaning, river cleaning, drainage cleaning, trimming trees along roads, arranging plants and flowers in floor beds on footpaths and in traffic islands, cleaning public toilets, cutting open drains, cleaning tombs, etc.

Only through the appropriate execution of all these works will it be possible to make the town beautiful. However, at present many places in town are left dirty because the SWM system concentrates on only the first objective, "hygiene". In order to make the town beautiful, SWM should target not only sanitation but also environmental protection and the maintenance of infrastructure.

8.2.3 Targets

The targets to materialize the vision are proposed in Table III.8.14.

Table III.8.14 Proposed SWM Targets

Item	Target index
a) Waste collection coverage	Residents in urban area: 100% Residents in marginal area: subject to the necessity Business entities: 100%
b) Final disposal system	Sanitary landfill Requiring daily soil cover, leachate collection, leachate treatment, gas ventilation, net fence to prevent waste scattering, security facilities, etc.
c) Waste discharge amount	Discharge rate of residential waste: Less than 600 g/person/day Discharge rate of total waste: Less than 1,200 g/person/day
d) Recycle target	The percentage of in-organic recyclables in the waste disposed is less than 20%. This target is achieved by 3Rs measures taken.
e) SWM cost	The target SWM unit cost: 30 USD per ton of waste

Figure III.8.13 shows the waste generation amount target which has taken the proposed SWM targets shown in Table III.8.14 into account. In 2020, the waste generation target amount is less than the waste generation forecast by 23%, 66 ton/day.

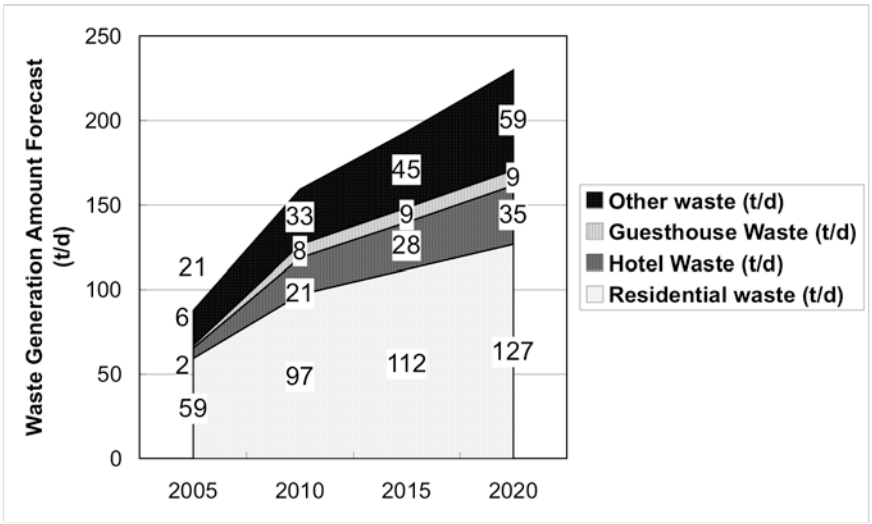


Figure III.8.13 Waste Generation Amount Target with 3Rs Measures

8.2.4 Issues and Approaches

In order to materialize the vision and targets, the proposed approaches to achieve the main issues are outlined.

(1) Strengthening People's Awareness of the Environment

The socio-economic conditions resulting from the on-going rapid economic development is encouraging people to consume more and damaging the traditional way of life which minimizes the consumption of natural resources. Thus, the recycle-oriented society is rapidly deteriorating and people are quickly losing their mentality to save. Stopping the progress of this trend by enhancing public awareness is the most urgent issue. One of pilot projects conducted during the study, therefore, targeted this subject and the project should be continued and expanded.

The approach shall be the same as that used for the pilot project.

1) From Target Sites to Wider Areas

Targeting specific sites first and gradually widening and increasing the target areas. The project should firstly target schools and then widen the target areas gradually to the surroundings of the schools and to neighboring communities, and finally to the all of Siem Reap town.

2) Targeting Various Age Groups by Different Approaches

The environmental education should target the whole population at the same time to make it effective. The project, therefore, should be split into several programs according to the target groups.

3) Utilization of Social Capital

In order to maximize the sustainability of the project, the available social capital such as existing organizations and temples shall be fully utilized for the execution of the project.

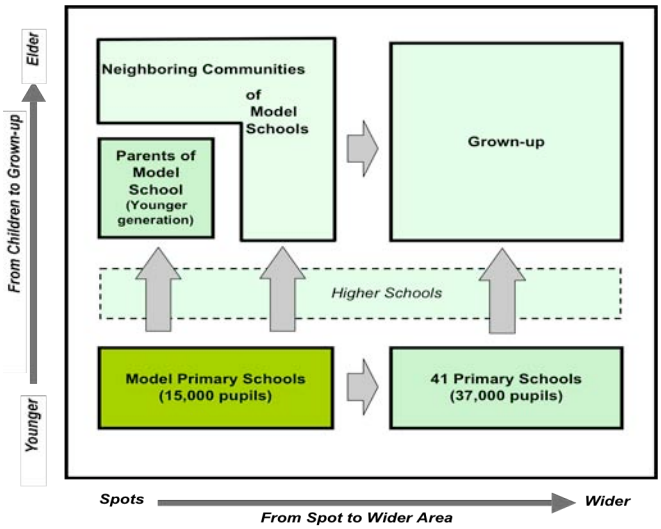


Figure III.8.14 Approach for the Expansion of Target Groups

The target subjects for education are as follows:

- The necessary way of urban life.

- To foster the mind to love and take pride in Siem Reap town.
- To enhance people's sense of moral obligation to public facilities.

(2) Establishment of a Sound Solid Waste Management System

The core problem is that no local authorities in Siem Reap have either the capacity to be responsible or the actual authority for SWM, which they should have in accordance with Cambodian law. Considering the potential of local authorities in Siem Reap and in line with the policy of other sectors in this study, the Study Team proposes that the Provincial government of Siem Reap shall be the responsible administrative organization of SWM. In the Provincial government, the department of public works, which will be established, shall be the responsible and executing organization. This institutional building shall be the first priority in SWM improvement.

After building the abovementioned organization and recruiting staff, their capacity will be developed with the donor's technical assistance. The capacity development focuses mainly on two issues: one is the planning capacity and the other is the management capacity such as the execution and supervision capacity.

The planning capacity will be developed through the formulation of the SWM master plan as on-the-job training by the donor's assistance. The process of formulating the master plan should involve various stakeholders and should not avoid the politically important issues, such as reviewing the existing contract with MICC and the waste collection fee system, etc., in order to empower the plan.
The master plan should target the following main issues.

- Determination of the roles of the provincial government and private sector
- Revision of the contract with MICC
- Improvement of the financial sources and making the financial data transparent

As for the management capacity, which includes monitoring, evaluation, taking actions, etc., this will be developed with the donor's technical assistance through the execution of daily practical work and the plan proposed by the master plan. For example, after preparing the by-law for waste, the responsible organization will inform citizens of their duties designated in the by-law and learn how to do it on site. In addition, it will learn how to involve citizens and how to obtain public cooperation.

(3) Establishment of a Sound Financial System.

This issue, which may be included in the former issue, is separately dealt because it is very important and related to other sectors such as water, wastewater, power, etc., which suffer from the same financial problem.

The requirements of the fee collection system for waste of which the dischargers can be identified are proposed as follows:

- Strong enforceability of the fee collection system.
- Minimization of the fee collection costs.
- Cross subsidy mechanism (the affluent pay for the less well off).
- Transparency and accountability.

The potential options to satisfy the above requirements to be carefully examined are as

follows:

- Shouldered by the tax
- Joint billing with other user charges such as electricity. (This method is used in a wide area in Phnom Penh and quite popular in Central American countries.)
- Establishing a user charge company to bill jointly with other utilities charges. (This method is also popular in Central American countries, Eastern European countries and Central Asian countries)

As for public waste such as road waste and park waste of which the dischargers cannot be identified, financial sources other than the fee collection from dischargers will be considered.

(4) Strengthening of Public Private Partnership

Strengthening the managerial capacity and the financial capacity is essential for the improvement of the SWM system. However, at present the provincial government does not have either of them, while MICC has both to some extent. In view of this, the current situation in Siem Reap cannot be compared with that in Phnom Penh, which has the department of public works and transport as the responsible organization and Phnom Penh Waste Authority as the executing organization within the municipality and, in addition, has received technical assistance from NORAD and JICA for several years in total.

Looking at the current capacity of the Provincial government of Siem Reap, it is not realistic for the provincial government to take over the major role in the implementation of SWM. The practical approach is to fully utilize the private sector's capacity. In fact, the private sector has been growing recently. For example, MICC is somehow carrying out all the SWM works for Siem Reap and HCC is doing a good job with the SWM work in the Angkor monumental sites.

In principle, the private sector's capacity should be fully utilized and the Provincial government should do only the following works:

- Planning and coordination works
- Supervision work to ensure the private sector provides services that meet the required quality standards.
- The works which are too difficult for the private sector to do, waste disposal, revenue collection and the acquisition of budget for public area cleansing work.

In addition, the Provincial government will work for coordination with other organizations, NGOs and citizens. As shown in the pilot project, it is possible to get a sponsor for street trash bins in return for granting the right for advertisement to the sponsor. Such cooperation from other organizations should be promoted and coordinated by the Provincial government because Siem Reap has various effective sites and opportunities even for international advertisement because of the many international tourists.

8.3 Projects/Programs

8.3.1 Proposed Solid Waste Management System

(1) Concept of the Proposed Solid Waste Management System

Measures relying heavily on treatment and processing technologies have to be avoided as they often fail due to the expensive investment, operation and maintenance costs required. Many nations, after conducting trial and error activities, have found that measures to minimize the waste generation amount are the best means of coping with SWM problems. This would place top priority on the creation of a society capable of minimizing natural resource utilization and the mitigation of adverse environmental impacts by reducing the waste generation amount, using recycled materials, and ensuring appropriate treatment and disposal. In other words, the measures taken at the upper waste stream, at the generation source, should be given priority as they widely contribute to the reduction of SWM costs. The measures taken downstream, for example at SWM facility sites, should be given less priority.

The priority ranking of SWM measures is proposed below.

1. Firstly, to reduce the waste generation amount as much as possible by exercising waste generation control and waste reduction measures at the production process and at waste generation sources.
2. Secondly, to recycle as many recyclables contained in the discharged waste as possible.
3. Thirdly, as there will always be waste to discharge even with the successful implementation of waste reduction and recycling measures, processing and treatment techniques should be adopted for better environmental protection.
4. Lastly, the appropriate disposal of waste and residue resulting from processing and treatment operations should be ensured.

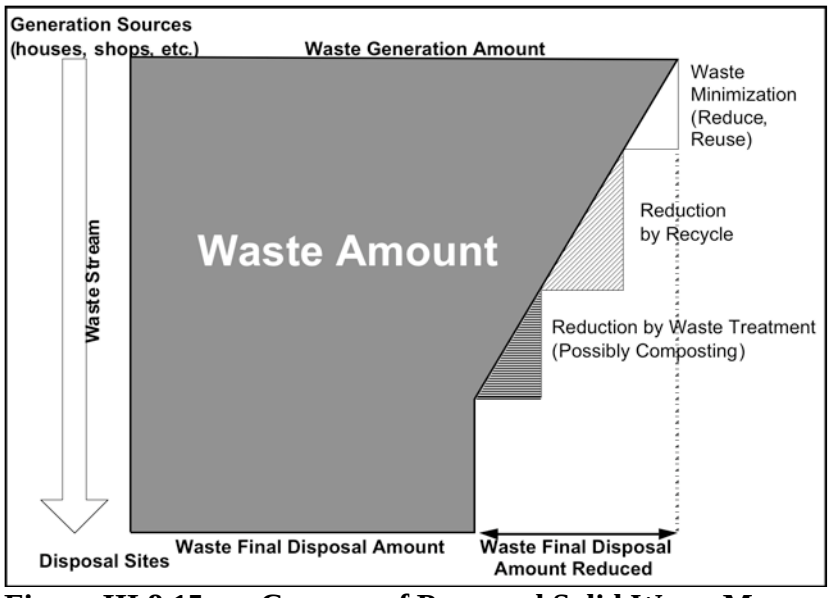


Figure III.8.15 Concept of Proposed Solid Waste Management System

(2) Outline of Technical System

Table III.8.15 Proposed for Solid Waste Management Technical System

Category	Proposed Technical System
Discharge and Storage	1) Discharge • Separate discharging of recyclable and non-recyclable wastes 2) Type of storage • Urbanized areas: Plastic sacks and plastic containers with lids • Marginal areas: Communal containers 3) Collection frequency • Urbanized areas: Three times a week • Marginal areas: Twice a week 4) Collection method • Mixed collection as long as the private resource recovery is active. If it gets weak, separate collection will be introduced. 5) Type of collection method • Most areas: Curbside collection • Marginal areas: Point collection with communal containers 6) Collection time • Most areas: Day collection • Some of business entities: Night collection 7) Type of collection vehicles • Urbanized areas: Compactor trucks • Marginal areas: Detachable container trucks or dump trucks 8) Transportation system • Direct transport by collection trucks
Primary Collection	Primary collection may be introduced only areas that the collection trucks cannot access. Hand cart and pedal cart systems will be used.
Secondary Collection and Haulage	Most areas: 8 m^3 or 4 m^3 compactor trucks Marginal areas: 5.5 m^3 hoist trucks or 6 m^3 dump trucks
Street Sweeping	Manual sweeping
Processing and Treatment	• On-site composting is encouraged. • Centralized composting may be applied only for garden waste.
Recycling	• 3 Rs (Reduce, Reuse, and Recycling) activities are encouraged through educational programs.
Final Disposal	1) Existing disposal site will be improved This will have periodical soil covering, gas ventilation, a net fence to prevent waste scattering, and a security facility. 2) New disposal site This will have a periodical soil cover system, an impermeable layer to prevent leachate from seeping into the ground, a leachate collection system, a leachate treatment system, a gas ventilation system, a net fence to prevent waste scattering, and a security facility.

(3) Outline of Institutional System

The administrative system for SWM is shown below.

- The Department of Public Works and Transportation in the Provincial government is responsible for the implementation of SWM work and supervision of the contractors to ensure they perform in accordance with the contract.
- The Department of Environment in the Provincial government is responsible for ensuring the SWM works comply with the environmental requirements.

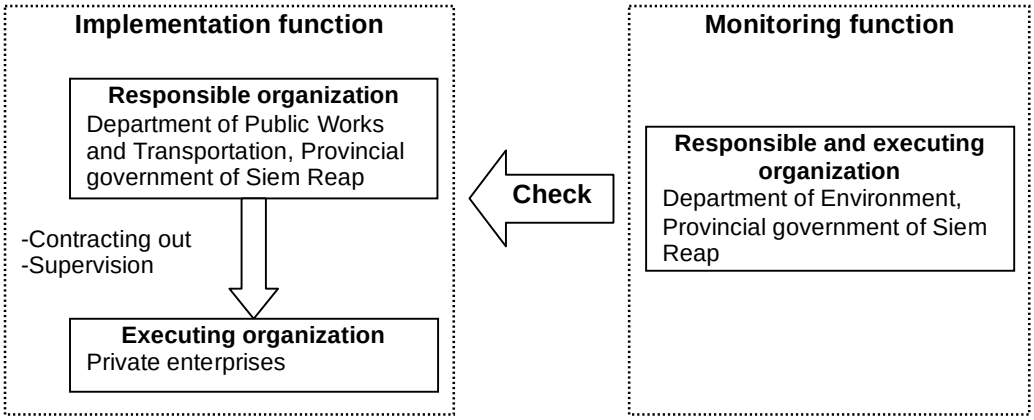


Figure III.8.16 Proposed Administration System for Solid Waste Management

Table III.8.16 Summary of Execution System of Each Component

	Financial source	Waste collection	Waste disposal
Residential waste	Provincial government is responsible for financial source. (including the option of contracting out the fee collection)	Contracting out to private companies	Provincial government owns it and contracts out the operation work.
Non-residential waste	Private company is responsible for financial source.	Private company	Ditto
Public waste (road, river, park, etc.)	Provincial government is responsible for financial source.	Contracting out to private companies	Ditto

8.3.2 Proposed Projects/Programs

The master plan aims to:

A. Strengthen people's awareness of the environment
B. Establish a sound SWM system
C. Establish a sound financial system
D. Strengthen Public Private Partnership

The proposed measures to be taken, in order to attain the objectives, are summarized below.

Table III.8.17 Proposed Projects/Programs

No.	Proposed Projects/Programs	Effect			
		A	B	C	D
1	Enhancing People's Awareness on the Environment				
1.1	Enhancing school children's awareness	X			X
1.2	Enhancing adults' awareness	X	X		X
1.3	Implementation of the beautification programs	X			X
2	Sound SWM System Development				
2.1	Formulation of the SWM master plan				
	a) Waste stream and composition survey		X		
	b) Selection of the land for a new landfill site. Design of the new landfill site and EIA.		X		X
	c) Collection and transportation system		X		
	d) Revising the existing contract with MICC		X		X
	e) Financial system plan		X	X	X
	f) Preparation of action plan		X	X	X
2.2	Development of counterparts' administration capacity				
	a) Tendering, contracting, supervision for the waste collection work		X	X	X
	b) Publicity, public cooperation, education of 3Rs	X	X		X
	c) Supervision of large waste dischargers such as hotels and restaurants to reduce the waste discharge amount	X	X		X
	d) Beautification work such as gardening, tree trimming, etc.	X	X		X
3	Strengthening of the Waste Collection System				
3.1	Procurement of compactor trucks		X		
3.2	Soft component assistance to make effective use of this equipment		X		X
4	Sanitary Landfill Development				
4.1	Consensus building to develop a new disposal site including EIA.	X	X		X
4.2	Acquisition of land for landfill development.		X		
4.3	Construction of the new landfill site.		X		
4.4	Procurement of the landfill equipment.		X		
4.5	On-the-job training of the sanitary landfill operation.		X		
4.6	Establishment and implementation of a monitoring committee to ensure proper operation of the sanitary landfill.	X	X		X

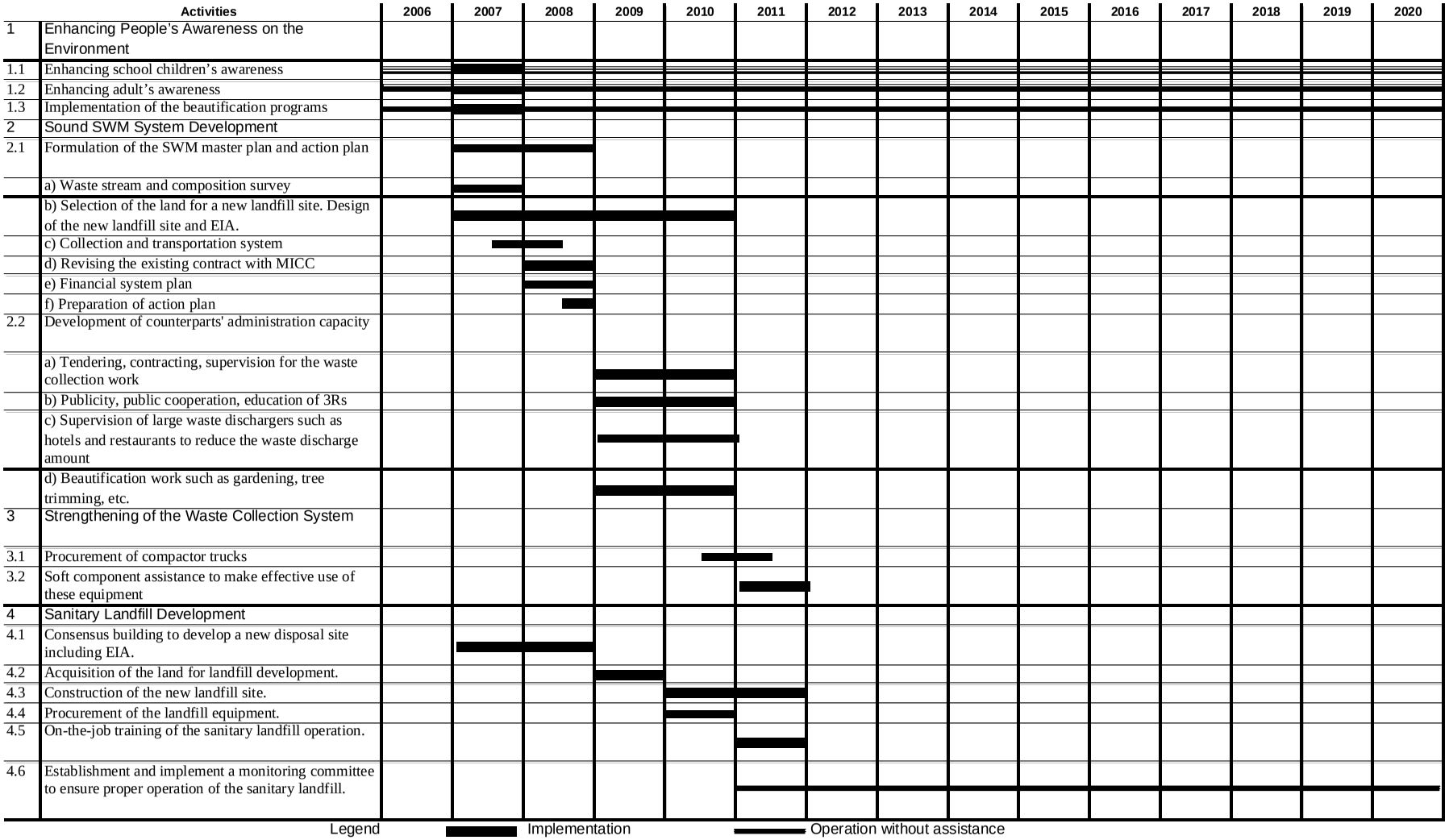


Figure III.8.17 Implementation Program for the SWM Project/Program

8.4 Proposed Institutional Arrangements

The proposed SWM institutional system is described in 8.3.1. The approach to realize this system is as follows:

1) The responsible organization is established in the Provincial government and its capacity is strengthened with the donor's technical assistance.

2) As one of the decentralization measures, the Ministry of Economics and Finance will grants its rights designated in the contract with MICC to the Provincial government.

3) The Provincial government will seek and obtain the financial sources for the implementation of some of the SWM works. After the financial source for a specific work is arranged, the contract of that work is revised. For example, after obtaining the financial source for public waste such as cleaning roads, rivers, and parks, the Provincial government will negotiate with MICC to exclude such works from the present contract and make a new agreement based on the work quantity.

4) Because there is a valid contract for SWM works in Siem Reap made between the Ministry of Economics and Finance and MICC until 2019, both a revision and an amendment of the contract is completely subject to both parties. As for the Ministry of Economics and Finance, the implementation of decentralization should be utilized as an opportunity to transfer its rights to the Provincial Government. As for MICC, the revision and amendment of the contract should create benefits to both parties of the contract to obtain the agreement of both MICC and Siem Reap citizens. The revision and amendment, therefore, will target only the works which give benefits to mainly the public, for example public waste collection and waste disposal.

5) The collection of waste fees for residential waste should be controlled by the Provincial Government, even though it is a matter for individuals, so that the cross subsidy mechanism can work to provide a safety net for poor people.

6) In return for assisting MICC by revising the contract, the Provincial government should request MICC to disclose its accounting data, its revenue in particular, to make the financial condition of SWM transparent.

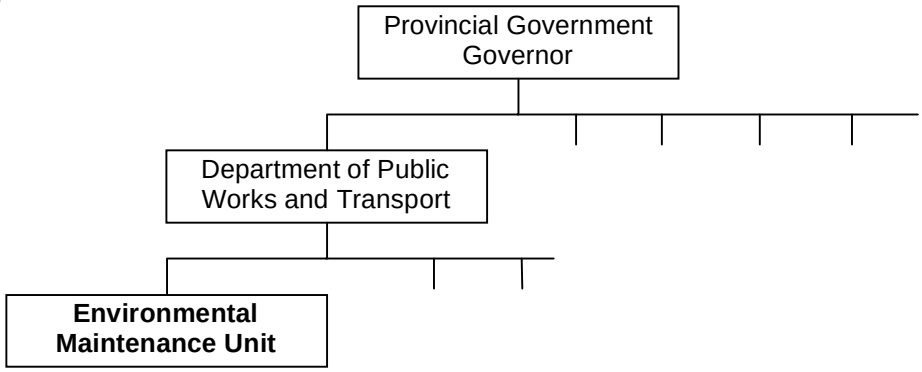
The particularly important issues in the institutional system which is briefly described in 8.3.1 are as follows. These are described below in more detailed.

1) Establishment of the responsible organization for SWM administration
2) Establishment of the financial source
3) Revision of the existing franchise contract for SWM works
4) Acquisition of the new land for landfill development

(1) Responsible Organization for Solid Waste Management Administration

The Department of Public Works and Transport established in the Provincial Government will be the responsible organization for the implementation of SWM.

Because this organization deals with not only SWM works but also public works, it is recommended to establish a small unit for SWM, i.e. an "Environmental Maintenance Unit". The organizational chart and the scope of works of the unit are outlined in Figure III.8.18.



Tasks
- SWM works
- Beautification work
- Cleaning of infrastructure
- Promotion of public and private partnership
- Public education

Staff
- Unit chief: 1 person
- Supervisor: 2 persons (one each for eastern side and western side of Siem Reap

Figure III.8.17 Organizations for Solid Waste Management Administration

The Environmental Maintenance Unit is minimized by contracting out all execution work to the private sector. The unit, therefore, concentrates on the following works:

- Planning, tendering, contracting, supervising, and evaluation of payment to ensure the contractor performs in accordance with the contract.
- Watching for the illegal dumping of waste
- Supervising business entities to carry out waste minimization
- Promotion of 3Rs to citizens
- Coordination with stakeholders

(2) Establishment of the Financial Source

The appropriate financial sources should be in accordance with the generation source. The proposed concept is as follows:

Waste type by source	Proposed financial source
Residential waste	Considering the following factors, the minimization of the fee collection cost with strong enforceability is the top priority requirement. • Everybody discharges nearly the same amount of waste. • There are many dischargers. • There are rich and poor people. • People do not want to pay, if possible. The potential systems are as follows:

	• Tax • Contracting out the fee collection work to the private sector • Joint billing with other user charges. The selection of the best financial system requires consensus building among stakeholders.
Business waste (large discharger)	The characters of this waste are as follows: • There are not many dischargers. • The waste discharge amount differs greatly depending on the dischargers. • They can afford to pay for the fee because they can include it in their business expenditure. Considering the above factors, the waste collection company should collect the fee directly based on the discharge amount.
Business waste (small discharger)	To collect the exact fee from these dischargers in accordance with the discharge amount is too difficult because there are too many of them. In this point, it is similar to residential waste. The appropriate fee collection system for this waste should be linked with that for residential waste.
Public waste (roads, rivers, parks)	There are a few choices for the financial sources of this waste as follows: • APSARA's gate fee. • Hotel tax. • Citizens' tax

(3) Revision of the Contract for Solid Waste Management Works

The present contract should be rectified as follows:

a) To change the signer from the Ministry of Economics and Finance to the Provincial Government of Siem Reap. If the Ministry of Economics and Finance does not agree to this, at least the supervision right should be given to the Provincial Government.
b) To clearly specify the scope of work such as the service coverage area.
c) To specify the required waste collection frequency.
d) To specify the requirements for the waste disposal operation.
e) To specify the organization name for supervision and supervisor's rights.
f) To specify the penalties.
g) To require the contractor to submit a report to the client. The report should include information on the amount of waste collected, the number of trips, the fee collection amount, etc.

(4) Acquisition of the New Land for Landfill Development

The following procedure is proposed for a new landfill development.

a) The development committee for Siem Reap to be proposed by the local administration plan will deal with the site selection of the land for a new landfill site.
b) The committee will select more than five candidate sites.
c) The department of public works and transport will carry out the preliminary investigation for these sites including the topographical survey, geological survey, land use survey and preliminary design. By using the preliminary investigation

data, the department assesses the suitability of each site from the environmental, technical, financial point of views.

d) The department will publicize the assessment results and explain to stakeholders. After hearing their opinions, stakeholders will select a site from candidate sites.
e) The development committee will arrange the financial sources for the land acquisition, the construction, the procurement of equipment will be arranged.
f) The department of public works and transport will carry out the environmental impact assessment.
g) The department of public works and transport will carry out the public hearing and reflect public opinion to the development plan.
h) The department of public works and transport will finalize the plan and the EIA report and submit it to the department of environment for approval.
i) After obtaining the approval, the development committee acquires the land and the department of public works and transport will commence the construction.
j) The department of public works and transport will proceed these works with donor's assistance if necessary.

JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

Project Long List

Sector: Solid Waste Management

No	Project Title	Project Site	Project Outline	Present Related Action	Project Component	Assumed Fund	Estimated Cost (1000 USD)	Implementation Agency	Implementation Period														
									06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
SW-1	Sound SWM System Development	Siem Reap District	In the Provincial government, the department of public works should be established to be a responsible and executing organization of SWM. This institutional building and capacity development will be done.	No action has been taken.	Formulation of the SWM master plan. Development of the administration capacity.	International	1000	Provincial Government															
SW-2	Strengthening of the Waste Collection System	Siem Reap District	The waste collection capacity is strengthened by procuring new equipment and establishing the efficient collection system.	No action has been taken.	Procurement of collection equipment and the establishment of the efficient collection system.	International	300	Provincial Government															
SW-3	Sanitary Landfill Development	Siem Reap District	Establishment of the new sanitary landfill. The preparation works such as the selection of the new site, EIA, consensus building, acquisition of the land will be carried out as a part of SW-1 project.	No action has been taken.	Construction of the new landfill site. Procurement of landfill equipment. Technical transfer by OJT.	International	200	Provincial Government															

JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

Project Brief

Sector: Solid Waste Management

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
SW-1	Sound SWM System Development	Residents, tourists, hotels and commercial businesses	International	1,000 (thousand US$)	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap District	Provincial Government	Public Works & Transport (to be established)			

Background:
The core problem is that any local authorities in Siem Reap have neither the capacity to be responsible nor the actual authorities for SWM administration which they should have in accordance with the Cambodian law. Considering the potential of local authorities in Siem Reap and in line with the policy of other sector in this study, the Provincial government of Siem Reap has to be an administrative responsible organization of SWM. In the Provincial government, the department of public works, which will be established, should be a responsible and executing organization. This institutional building and capacity development has to be the first priority in SWM improvement.

Project Purpose:
The objective of the project is as follows.
1. To assist counterparts to formulate the SWM master plan
2. To assist counterparts to execute the SWM administration
3. To develop counterparts' capacity of the SWM administration through the abovementioned pr

Project and Program Outline/Components:
1. Formulation of the SWM master plan
The study team will assist the counterparts to carry out the following tasks. This work shall involve various stakeholders to empower the plan.
1.1 Waste stream and composition survey
1.2 Selection of the land for a new landfill site. Design of the new landfill site and EIA.
1.3 Collection and transportation system
1.4 Revising the existing contract with MICC
1.5 Financial system plan
1.6 Preparation of Action plan

2. Development of counterparts' administration capacity
The study team will assist the counterparts to execute the following works.
2.1 Tendering, contracting, supervision for the waste collection work
2.2 Publicity, public cooperation, education of 3Rs
2.3 Supervision of large waste dischargers such as hotels and restaurants to reduce the waste discharge amount
2.4 Beautification work such as gardening, tree trimming, etc.

Project Output:
1. SWM master plan, SWM action plan, SWM by-laws
2. Development of counterparts' capacities
3. Actual improvement of the SWM system

Environmental and Social Impact:
1. Improvement of the sanitary condition in the town
2. Reduction of negative impacts to the environment

Related Projects:
1. Solid waste management study for Phnom Phen Municipality by JICA

Implementation Schedule:
1. Capacity development 2007-2010

Project Cost: ('000 USD)

Capacity development	1,000
TOTAL	1,000

JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

Project Brief

Sector: Solid Waste Management

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
SW-2	Strengthening of the Waste Collection System	Residents, tourists, hotels and commercial businesses	International	3,000 (thousand US$)	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap District	Provincial Government	Public Works & Transport (to be established)			

Background:
All waste collection works are carried out by MICC by their own revenue obtained by fee collection. However, the current collection coverage rate is estimated only around 70% and 30% of waste is illegally disposed of somewhere other than the disposal site. In addition, the existing waste collection equipment are all very old and unsuitable for the urbanized area because they scatter waste on roads during transportation due to open tipe. Anothre negative factor is the unsuitable waste quality for dump trucks. It requires a compaction truck for economic operation because the current waste is very light. The waste collection improvement is highly required to clean the town by increasing the collection coverage ratio.To keep Siem Reap town hygienic and beautiful, the urbanized area requires a waste collection coverage rate of 100% at present because the current urbanization condition does not allow people to properly dispose of their waste within their premises.
To achieve a 100% waste collection coverage, a universal waste collection service has to be introduced notwithstanding the payment of a waste collection fee.
In addition, public cooperation in the waste collection work should be maximized in order to minimize the waste collection cost.

Project Purpose:
The objective of the project is the increase of the waste collection capacity to collect more waste discharged.

Project and Program Outline/Components:
1. Procurement of compactor trucks, 8 m3, 5 units
2. Soft component assistance to make these equipment effectively use is carried out by the Sound SWM system development project.
The Provincial government procure and own the waste collection equipment. It rend these to the contractor for doing the work. The rental charge will be deducted from the payment and deposited in the fund for renewal.

Project Output:
1. Procurement of compactor trucks, 8 m3, 5 units
2. Increase of the waste collection amount and the serviced population

Environmental and Social Impact:
1. Sanitary condition in the Siem Reap town is improved.
2. Waste scattered by a collection truck during the transportation is decreased by the introduction of closed type trucks.

Related Projects:
1. Solid waste management study for Phnom Phen Municipality by JICA

Implementation Schedule:
1. Procurement 2010-2011

Project Cost: ('000 USD)

Procurement	300
TOTAL	300

JICA - Study on Integrated Master Plan for Sustainable Development of Siem Reap/Angkor Town

Project Brief

Sector: Solid Waste Management

ID No.	Project Title	Beneficiaries and/or Target Group	Assumed Fund	Estimated Cost (USD)	**Project Priority**
SW-3	Sanitary Landfill Development	Residents, tourists, hotels and commercial businesses	International	2,000 (thousand US$)	

Project Site	Implementation Agency	Department	Contact Person	Telephone	E-mail
Siem Reap District	Provincial Government	Public Works & Transport (to be established)			

Background:

The present Prey Kuy disposal site gives great negative impacts to the surrounding environment because of lack of environmental protection measures taken. Neighborhoods suffer from nuisance such as offensive odor, smoke, vermin, scattered waste, etc. The impacted area and people will increase and expand unless the improvement measures are taken. It will finally cause people's health risks and give nuisance to tourists. The improvement of disposal operation is therefore very important and has to be done as soon as possible. However, it is too difficult to be done by the private sector due to the limited financial and technical capacity. The establishmend of the sanitary landfill has to be implemented by the Provincial government's initiative.

Project Purpose:

1. Reduction of the negativeimpacts by waste disposal operation to the environment

Project and Program Outline/Components:

1. Consensus building to develop a new disposal site including EIA. This work is covered by the Sound SWM development project.
2. Acquisition of the land for landfill development.
3. Construction of the new landfill site.
4. Procurement of the landfill equipment.
   - 13 ton Bulldozer: 1 unit
   - 0.4 m3 Excavator: 1 unit
   - 6 ton dump truck: 1 unit
5. On-the-job training of the sanitary landfill operation.
6. Establishment and implement the monitoring committee to ensure the sanitary landfill operation.

Project Output:

1. Sanitary landfill facility
2. Landfill equipment
3. Transfer of the sanitary landfill operation technology

Environmental and Social Impact:

1. Reduction of the negative impacts to the environment
2. Improve the sanitary condition to the surrounding.

Related Projects:

1. Solid waste management study for Phnom Phen Municipality by JICA

Implementation Schedule:

1. Procurement	2010
2. Construction	2010-11
3. On-the-job trainig	2011

Project Cost: ('000 USD)

1. Procurement	320
2. Construction	1,250
3. On-the-job training	180
4. Acquisition of land	250
TOTAL	2,000