SFD Report

Battambang
Cambodia

Final Report

This SFD Report - Initial - was prepared by
WaterAid

Date of production: September 22, 2018
Last update: September 29, 2018

SFD Report Battambang, Cambodia, 2018
Produced by:
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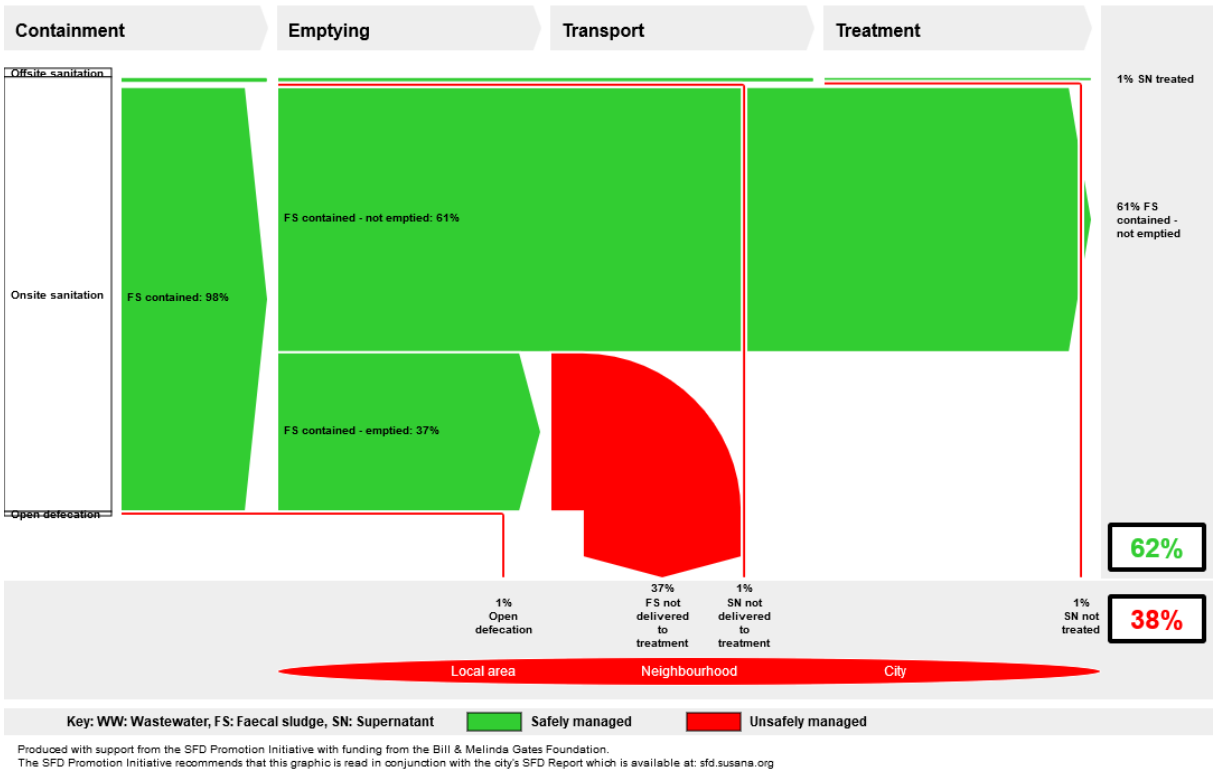
This Executive Summary and SFD Report are available from:
www.sfd.susana.org

1. The SFD Graphic

Battambang, Battambang, Cambodia
Version: Reviewed
SFD Level: 1 - Initial SFD

Date prepared: 22 Sep 2018
Prepared by: WaterAid



Produced with support from the SFD Promotion Initiative with funding from the Bill & Melinda Gates Foundation.
The SFD Promotion Initiative recommends that this graphic is read in conjunction with the city's SFD Report which is available at: sfd.susana.org

2. Diagram information

SFD Level:

Initial

Produced by:

WaterAid Cambodia with support from the Royal Government of Cambodia Ministry of Public Works and Transport, Department of Sewerage Management and Construction.

Status:

Final

Date of production: 22/09/2018

3. General city information

Battambang is the capital city of Battambang province in north western Cambodia. The city is considered the commercial hub for Cambodia's northwest, connecting the region with Phnom Penh via National Road 5, and Thailand via National Road 57. Geographically, Battambang is situated in the Tonle Sap floodplain on the Sangkae River, a small tributary that feeds into the Tonle Sap lake.

Defined by Battambang' Land Use Master Plan the municipality covers an area of 293 km^2, consisting of urban, peri-urban and rural areas. Within the urban boundary, it is estimated that population today exceeds 150,000, and the population for the entire municipality, including its peri-urban and rural areas is approximately 197,000 (ADB, 2012). The city does not have a significant amount of seasonal or diurnal variation in population.

4. Service outcomes

Nearly 99 percent of households in Battambang have access to a pour flush or a cistern flush toilet. The one percent of households without access to a toilet are assumed to practice open defecation. Among those who have access to a toilet, 10 percent have a lined tank with an open bottom connected to the city's combined stormwater and wastewater sewer network, which is regulated and maintained by the Department of Public Works and Transport (DPWT). Under normal conditions, however, little to no faecal sludge is discharged into the combined sewerage network. Therefore, the majority of the wastewater in the sewerage network is stormwater, mixed with greywater and a very small amount of supernatant.

The combined stormwater and wastewater sewer network leads to a wastewater treatment plant (WWTP), also managed by the DPWT, that is currently operating at a very limited capacity. The plant was designed to have a capacity of 1,000 m^3/day and serve 15,000 people over 89 ha of the core city area on the west side of the Sangker River. However, due to general degradation of the systems it is currently operating at a limited capacity of 450 m^3/day. Therefore an estimated 55 percent of the wastewater is discharged untreated into the Sangkae River. Of the 45 percent of wastewater that is treated is discharged into canals and used to irrigate nearby rice fields.

Given that there is virtually no feacal sludge entering the combined stormwater and wastewater systems, and no evidence that pump trucks empty their contents into the swerage system or at the WWTP, it can be concluded that under current normal operating conditions the WWTP does not receive any fecal sludge. It is possible that there may be exceptional circumstances in which feacal sludge enterst the sewerage system; such as overflowing containment tanks during periods of heavy rains and flooding, or due to a deviate pump truck discharing its contents into the seweage system. If any faecal cludge were to reach the WWTP, it would be captured in the plant's settling ponds along with the organic and inorganic solid waste that made it into the sewerage system. According to plant operators, the settling ponds have been cleaned out less than a handful of times in the history of the plant; circa 1995, 2003 and 2006. This low frequency of cleaning reaffirms the conclusion that little to no faecal sludge is reaching the WWTP. During those occurrences, the extracted contents were manually removed and transported to a nearby field. (DPWT, 2018)

The remaining 89 percent of the population that is not on the sewer network, or open defecating, utilises onsite sanitation systems. These systems range from large industrial septic tanks to unlined soakaway pits. Faecal sludge contained within these systems are either left in the system to undergo natural decomposition, or extracted by various means and disposed of in dugout pits, nearby waterways, or farms.

The main challenge with most of the onsite sanitation technologies used in Cambodia is the risks that they potential pose to contaminating the groundwater. This is particularly a concern in Battambang, where only 30 percent of the population has access to piped water services. Unfortunately, there is currently very little specific data available about Battambang's soil and hydro-geological characteristics. However according to the Battambang Department of Environment (DoE) the risk to groundwater contamination from onsite sanitation is low due mostly clay soil and a low groundwater table (DoE, 2018).

5. Service delivery context

The draft "Water and Sanitation Law of the Kingdom of Cambodia" was released in 2004 and the "National Policy on Water Supply and Sanitation" was adopted by the Council of Ministers (CoM) in 2003. The policies lay out the vision for the sector, and specifies the role of different agencies. To date, neither the draft Water and Sanitation Law nor the National Policy defines the minimum technical or operating standards for household sanitation. Furthermore, the policy on decentralization has not been fully implemented in practice and urban water supply and sanitation remain, essentially, under central government control with minimal involvement from local levels (WaterAid, 2015a).

Clarity around the roles and responsibilities for wastewater management has historically been a challenge in Cambodia. In December 2017, a Royal Government of Cambodia (RGC) sub-decree was issued by the Prime Minister's office on *Sewerage and Wastewater Treatment and Management.* The sub-decree officially identified the responsible ministries and their specific roles in the sector.

With exception of the maintenance of the city's sewerage pipe network – which is the responsibility of the DPWT – the responsibilities

and associated costs for sanitation service delivery fall to building owners. Those along the sewerage pipeline bare the connection costs and pay a monthly service fee within their water bill. Those outside the network are responsible for the design, installation, maintenance and any associated costs of their sanitation facilities. Wastewater removal services are available through the DPWT and private family owned pump truck companies. The cost for using these services is typically between 30-50 $US.

For private emptying service providers, there are currently no systems in place that require an official registration or license. Although there are environmental laws stipulating that wastewater must be disposed at a minimum distance of 500 meters away from any dwelling, the law is not currently being enforced. There are no additional safety standards in place, and there are no faecal sludge treatment, disposal or reuse standards in place for pump truck opperators or for the WWTP (DPWT, 2018).

6. Overview of stakeholders

According to the December 2017 RGC sub-decree, responsibility for urban sanitation lies primarily with three ministries and their associated provincial departments:

- The Ministry of Public Works and Transport (MPWT) is responsible for urban drainage, sewerage, septage and the operation of waste water treatment plants. It's provincial departments, DPWT, undertakes related functions at sub-national levels.
- The Ministry of the Environment (MoE) is responsible for setting standards, monitoring and regulation for effluents discharging into water bodies, including from wastewater treatment plans. It's provincial departments, DoE, undertakes related functions at sub-national levels.
- The Ministry of Interior (MoI) is responsible for supporting coordination between the MPWT and MOE, as well as to ensure that operations and monitoring are sufficiently carried out.
- Other key stakeholders are summarized in Table 1.

Tab. 1: Summary of Key Stakeholders

Key Stakeholders	Institutions / Organizations /
Public Institutions	Battambang Municipality; Ministry of Industry and Handicrafts; Ministry of Education, Youth and Sport; Ministry of Health; Ministry of Land Management and Urban Planning.
Private Sector	Pump truck owners / operators
Development Partners, Donors	Asia Development Bank, JICA

9. Process of SFD development

This initial SFD was developed in three stages:

- Stage 1, consisted of a desk review of existing data sources.
- Stage 2, included developing the initial SFD graphic and drafting the report.
- Stage 3, involved verification of the information contained in the SFD graphic and report with key stakeholders.

10. Credibility of data

In the process of conducting Stage 1, a considerable amount of information was obtained regarding Battambang's sewerage and WWTP system. On the other hand, very little information was available describing onsite sanitation coverage and technology used. Only one source was found, and without verification the data provided may not be very reliable. However, during Stage 3, the data presented within this report was verified by key informants and stakeholders.

11. List of data sources

- ADB, 2012. "Water Supply and Sanitation Sector Assessment, Strategy and Road Map." Asian Development Bank.
- DoE, 2018. Personal interview with SFD preparation team. August 23, 2018.
- DPWT, 2018. Personal interview with SFD preparation team. August 23, 2018.
- RGC, 2017. "Sub-decree on Sewerage and Wastewater Treatment and Management." Issued by the Prime Minister's Office on December, 2017
- WaterAid, 2015a. "A Sector Review of the Water Supply, Sanitation and Hygiene (WASH) Situation and Issues

for the Urban Poor & Vulnerable Groups, Cambodia."

SFD Battambang, Cambodia, 2018

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Abbreviations

ADB	Asian Development Bank
CoM	Council of Ministers
DoE	(Provincial) Department of Environment
DLMUP	Department of Land Management and Urban Planning
DPWT	Department of Public Works and Transport
D&D	Decentralization and Deconcentration
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agricultural Organization
JICA	Japan International Cooperation Agency
MIH	Ministry of Industry and Handicrafts
MLMUPC	Ministry of Land Management Urban Planning and Construction
MoE	Ministry of Environment
MoEYS	Ministry of Education, Youth and Sport
MoI	Ministry of Interior
MPWT	Ministry of Public Works and Transport
O&M	Operation and Maintenance
PSI	Population Services International
RGC	Royal Government of Cambodia
SFD	Shit Flow Diagram
SNCDD	Secretariat of the National Committee for Democratic Development
WWTP	Wastewater Treatment Plant

1 City context

Battambang is the capital city of Battambang province in north western Cambodia. The city is considered the commercial hub for Cambodia's northwest, connecting the region with Phnom Penh via National Road 5, and Thailand via National Road 57. Geographically, Battambang is situated in the Tonle Sap floodplain on the Sangkae River, a small tributary that feeds into the Tonle Sap lake (Figure 1). The city has relatively flat terrain, with the northern part of the city having a gentle increase in elevation from 16m to 22m above sea level.

Battambang municipality covers an area of 293km^2, consisting of urban, peri-urban and rural areas (Figure 2). A readjustment of 2008 census data, made in 2011[1], estimated that Battambang's urban population at that time was near 144,300 (WaterAid, 2015a). Using a national average urban population growth rates of 1.5 percent per annum, it is estimated that the urban population today exceeds 150,000, and the population for the entire municipality, including its peri-urban and rural areas is approximately 197,000 (ADB, 2012). The city does not have a significant amount of seasonal or diurnal variation in population. Any variation would likely be attributed to the approximately 13,000 students and staff who attend the five lychees and six colleges located in the town (MoEYS, 2015).[2] The population of the city could change by as much as nine percent depending on if classes are in or out of session.

Like most of Cambodia, Battambang has a moist tropical climate with temperatures ranging between 19 and 34 degrees Celsius on average (Weatherbase, 2018). The main wet season, the southwest monsoon, occurs between June and October. Average annual rainfall is around 1,500 mm varying considerably from year to year. Figures 3 and 4 present the average monthly temperature and rainfall respectively. The large amount of rainfall provides Battambang with plentiful amounts of surface water. On the other hand, groundwater is limited by the hydrogeology of the area which is described as predominantly alluvium. The alluvium soil is generally composed of layers of sand, silt, clay and mixtures of these constituents. The clay portions have a low permeability and have very low hydraulic conductivity. On the other hand, the sandy beds and lenses of the alluvium can have very high water-producing yields. In terms of quality, groundwater from alluvium is generally believed to be of good quality and suitable for most purposes including drinking water. (ESCAP, 2002)

[1] The Royal Government's Ministry of Planning undertook a Reclassification of Urban Areas in Cambodia in 2011, the second in less than a decade. Which resulted in a revision of the 2008 National Census urbanized percentage of the population from 20% to 27% (WaterAid, 2015a).

[2] Lychee student enrolment = 9,863; Lychee staff = 532; College student enrolment = 2,518; College staff = 274 (MoEYS, 2015)

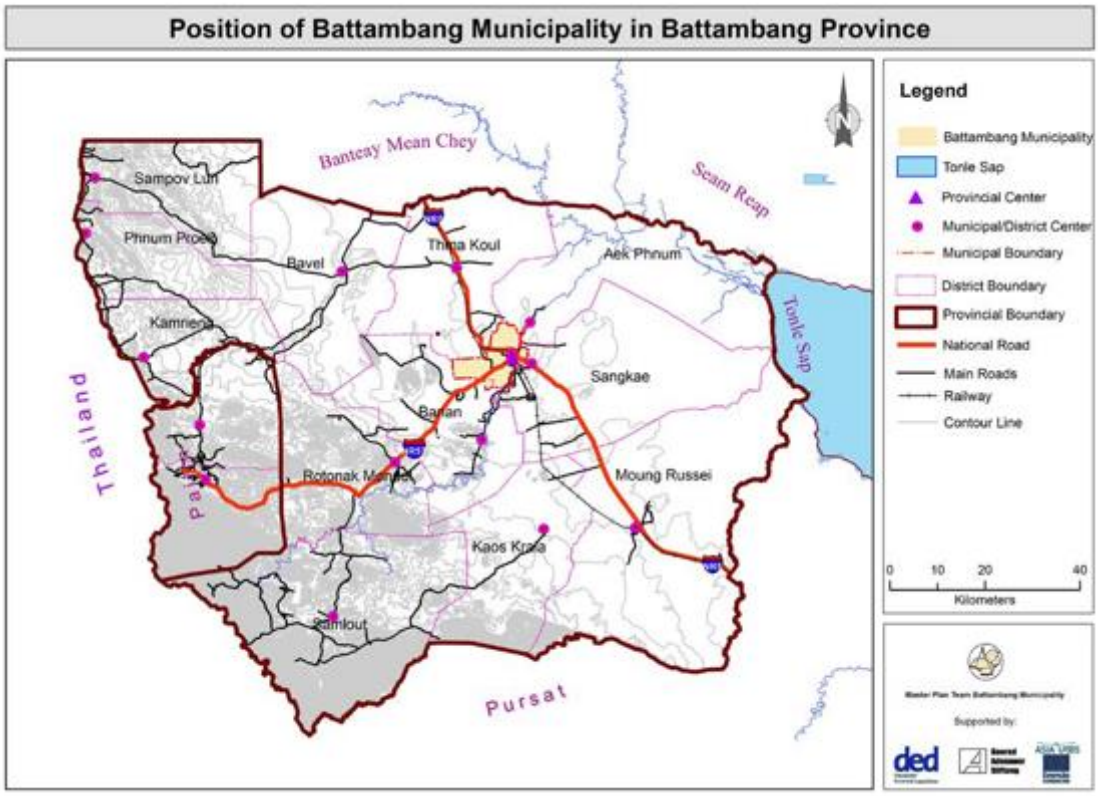


Figure 1: Position of Battambang Municipality in Battambang Province (MLM, 2016)

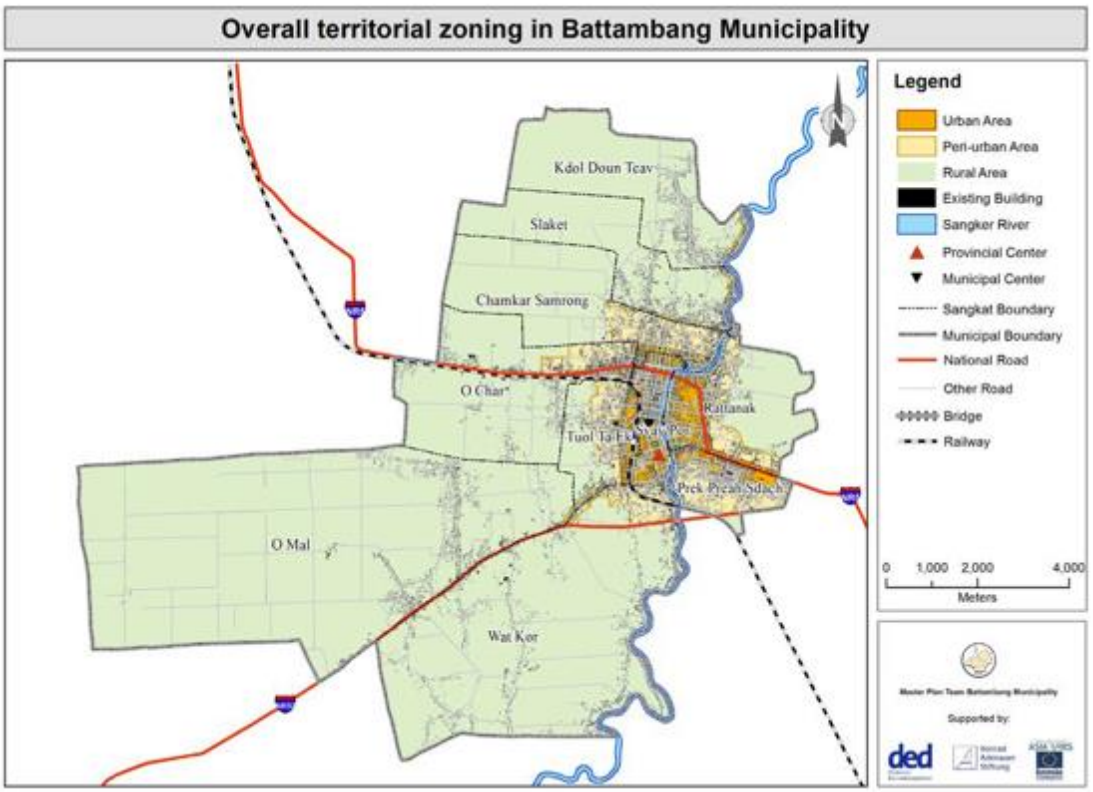


Figure 2: Overall territorial zoning in Battambang Municipality (MLM, 2016)

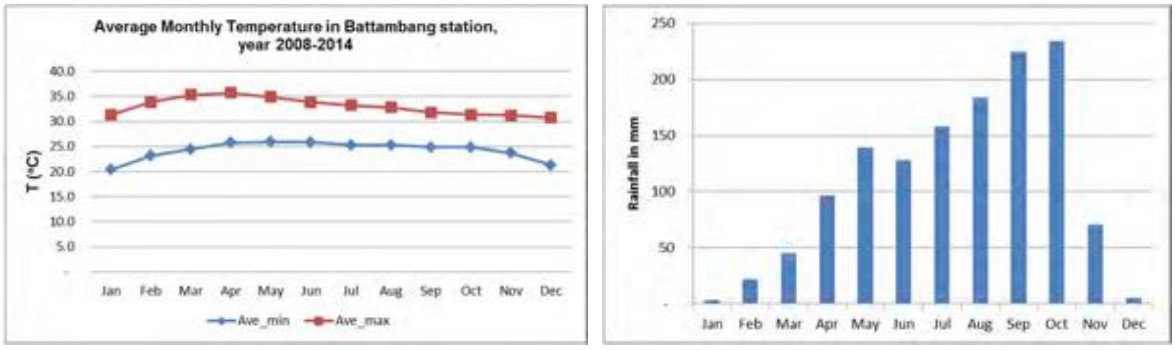


Figure 3: Average monthly temperature and average monthly rainfall (Egis, 2017)

2 Service Outcomes

2.1 Overview

Policy and Institutional Arrangements
The draft "Water and Sanitation Law of the Kingdom of Cambodia" was released in 2004 and the "National Policy on Water Supply and Sanitation" was adopted by the Council of Ministers in 2003. The policies lay out the vision for the sector and specify the role of different agencies. It should be noted that neither of these policies define the minimum technical or operating standards for household sanitation. (WaterAid, 2015a)

As specified by the Royal Government of Cambodia (RGC) in a sub-decree issued in December of 2017, the responsibility for urban sanitation service delivery lies primarily with three ministries: i) The Ministry of Public Works and Transport, ii) The Ministry of Environment, and iii) The Ministry of Interior (RGC, 2017). Their roles are briefly described as follows:

- **The Ministry of Public Works and Transport (MPWT)** is responsible for urban drainage, sewerage, septage and the operation of waste water treatment plants.
- **The Ministry of Environment (MoE)** is responsible for setting standards, monitoring and regulation for effluents discharging into water bodies as defined by the sub-decree on water pollution control issued in 1999.
- **The Ministry of Interior (MoI)** is responsible for supporting coordination between the MPWT and MOE, as well as to ensure that operations and monitoring are sufficiently carried out.

The provincial departments for each of these ministries are responsible for carrying out their mandate at the sub-national level. Additional information on the related policies and the roles and responsibilities of related institutions can be found in Section 3.

Services
A sample survey conducted on behalf of the MPWT in 2017 found that 99 percent of households in Battambang have access to a pour flush or a flush toilet (MPWT, 2017). The

one percent of households without access to a toilet are assumed to practice open defecation (see Table 1).

Table 1: Access to toilet and type of toilet (MPWT, 2017)

Toilet Type	% HH w/ Access
Pour flush toilet	86
Cistern Flush toilet	12
Pit Latrine	0
No toilet	1

As indicated in the SFD Selection Grid (Figure 6), the present study identified seven containment technologies commonly used in Battambang. Described in general, 10 percent of the city's population uses a lined tank with an open bottom that is connected to a combined storm water and wastewater sewer network. Faecal sludge is stored within the tank and extracted, if needed, using primarily pump trucks. Many of these systems include a soak-away pit in-between the tank and the sewerage network; therefore, very little supernatant and even less faecal sludge enters the combined sewerage network from these systems under normal conditions. Connection to the combined sewer lines is also regulated by the DPWT which also maintains the system. However, service expansion and enforcement has been limited due to financial and human resources. Despite that ten percent of the water supply fee paid by households and businesses is allocated to sewerage operation and maintenance (O&M), DPWT reports that only a small proportion of the fee reaches the department. Much of it is diverted to other provincial and municipal departments (DPWT, 2018).

Battambang has a wastewater treatment plant (WWTP), which is also managed by the DPWT. Given that most wastewater passes through a tank with an open bottom, followed in many cases by a soak pit, before entering the combined sewer, it is assumed that little to no faecal sludge is being conveyed and treated at the WWTP. Influent to the plant is therefore mainly storm water with some supernatant. Furthermore, the plant is currently operating at a very limited capacity. Approximately 55 percent of the wastewater in the combined sewer network is discharged untreated into the Sangkae River. The remaining 45 percent that is treated is eventually discharged into canals and used to irrigate nearby rice fields (EGIS, 2017). Any faecal sludge that makes it to the WWTP remains in the settlement ponds. Only a few times in the WWTP's history have the settlement ponds been drained and cleaned out.

The 89 percent of the population that is not connected to the sewer network, or open defecating, uses onsite sanitation facilities ranging from large industrial septic tanks to unlined soakaway pits. Examples of some of these containment technologies are shown in Figure 5. The cost and responsibility of installing, operating and maintaining the onsite facilities rests with the building owner. Faecal sludge contained within these on-site systems are either left in the system to undergo natural decomposition, or extracted. All of the septage and sludge extracted from these systems are disposed of in either dugout pits, directly into nearby waterways or transported and discharged into nearby farm fields. None of the extracted faecal sludge and supernatant from the onsite system is transported for treatment at the WWTP (DPWT, 2018).

Photo 1: Offsite sewerage line to WWTP (source: Khmer Times, credit: Unknow)	Photo 2: Large industrial septic tank system (source: MPWT 2018, credit: Mr. Lun Heng)
	
Photo 3: Square brick septic tank (source: MPWT 2018, credit: Mr. Lun Heng)	**Photo 4: Concrete ringed pit (source: MPWT 2018, credit: Mr. Lun Heng)**
	

Figure 4: Photo examples of sanitation containment technologies common to Cambodia and Battambang

List A: Where does the toilet discharge to? (i.e. what type of containment technology, if any?)	List B: What is the containment technology connected to? (i.e. where does the outlet or overflow discharge to, if anything?)									
	to centralised combined sewer	to centralised foul/separate sewer	to decentralised combined sewer	to decentralised foul/separate sewer	to soakpit	to open drain or storm sewer	to water body	to open ground	to 'don't know where'	no outlet or overflow
No onsite container. Toilet discharges directly to destination given in List B					Significant risk of GW pollution Low risk of GW pollution					Not Applicable
Septic tank					Significant risk of GW pollution T1A2C5					
Fully lined tank (sealed)	T1A3C1				Significant risk of GW pollution T1A3C5					
Lined tank with impermeable walls and open bottom	Significant risk of GW pollution T1A4C1	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution Low risk of GW pollution	Significant risk of GW pollution T1A4C5					Significant risk of GW pollution T1A4C10
Lined pit with semi-permeable walls and open bottom	Not Applicable									Significant risk of GW pollution Low risk of GW pollution
Unlined pit										Significant risk of GW pollution T1A6C10
Pit (all types), never emptied but abandoned when full and covered with soil										Significant risk of GW pollution Low risk of GW pollution
Pit (all types), never emptied, abandoned when full but NOT adequately covered with soil										
User interface failed, damaged, collapsed or flooded										
Containment (septic tank or tank or pit latrine) failed, damaged, collapsed or flooded										
No toilet. Open defecation	Not Applicable							T1B11 C7 TO C9		Not Applicable

Figure 5: SFD Selection Grid

For each of the technologies identified in the SFD Selection Grid, additional information is provided in Table 2, including a short description of the typical situation in which the technology was found to be used and the estimated percent contribution of each technology to the city's total excreta.

Table 2: Containment technology description and estimated contribution to total excreta

SFD Variable Reference #	Description	Use Description	Estimated % Contribution to Total Excreta
T1A2C5	Septic tank connected to soak pit.	Large businesses, industrial areas and institutions (e.g. hotels, large schools, offices)	1%
T1A3C1	Fully lined tank (sealed) connected to a centralized combined sewer.	Medium to small businesses, public bathrooms and institutions (e.g. restaurants, guest houses, schools)	1%
T1A3C5	Fully lined tank (sealed) connected to a soak pit.	Medium to small businesses, public bathrooms and institutions (e.g. restaurants, guest houses, schools)	2%
T1A4C1	Lined tank with impermeable walls and open bottom, connected to centralized combined sewer	Households and small businesses	10%
T1A5C10	Lined tank with, impermeable walls and open bottom, connected to a soak pit	Households and small businesses	70%
T1A4C10	Lined tank with impermeable walls and open bottom, no outlet or overflow	Households	5%
T1A6C10	Unlined pit, no outlet or overflow.	Households	10%
T1B11 C7 to C9	Open Defecation	Households	1%

2.2 SFD Matrix

This section describes each of the seven identified technologies and their related service provisions throughout the sanitation service chain (Figure 7). The information has been organized into two sections: i) Offsite sanitation provision, and ii) Onsite sanitation provision.

Battambang, Battambang, Cambodia, 22 Sep 2018. SFD Level: 1 - Initial SFD
Population: 150000
Proportion of tanks: septic tanks: 60%, fully lined tanks: 60%, lined, open bottom tanks: 90%

System label	Pop	F3	F4	F5	S4d	S5d
System description	Proportion of population using this type of system	Proportion of this type of system from which faecal sludge is emptied	Proportion of faecal sludge emptied, which is delivered to treatment plants	Proportion of faecal sludge delivered to treatment plants, which is treated	Proportion of supernatant in sewer system, which is delivered to treatment plants	Proportion of supernatant in sewer system that is delivered to treatment plants, which is treated
T1A2C5 Septic tank connected to soak pit	1.0	100.0	0.0	0.0		
T1A3C1 Fully lined tank (sealed) connected to a centralised combined sewer	1.0	100.0	0.0	0.0	93.0	45.0
T1A3C5 Fully lined tank (sealed) connected to a soak pit	2.0	100.0	0.0	0.0		
T1A4C1 Lined tank with impermeable walls and open bottom, connected to centralised combined sewer	10.0	40.0	0.0	0.0	93.0	45.0
T1A4C5 Lined tank with impermeable walls and open bottom, connected to a soak pit	70.0	40.0	0.0	0.0		
T1A4C10 Lined tank with impermeable walls and open bottom, no outlet or overflow	5.0	40.0	0.0	0.0		
T1A6C10 Unlined pit, no outlet or overflow	10.0	40.0	0.0	0.0		
T1B11 C7 TO C9 Open defecation	1.0					

Figure 6: SFD Matrix

2.2.1 Offsite Sanitation Service Provision

Containment and Transport - As previously noted, approximately 10 percent of the city's population located in Svay Pao Sangkat, on the western side of the Sangker River, have a lined tank with an open bottom connected to a combined sewerage network. Many of these systems include a soak-away pit in-between the tank and the sewerage network. According to staff from the DPWT, the purpose of the connection to the sewerage network is for overflow, which occurs at times during the rainy season. Under normal conditions, however, very little wastewater makes it into the sewer network. (DPWT, 2018)

Most of the sewerage network was installed in the 1970s, although some portions date back to French colonial times (cica1900-1950) and are still in use. The system consists of concrete pipes from 800 mm to 1,500 mm in diameter. Although there is currently no detailed information on the condition of the pipe network, the DPWT estimates that there is currently a seven percent loss due to cracks and breaks in the line (DPWT, 2018). Therefore, only 93 percent of the wastewater that enters the sewer network reaches the WWTP (see Figure 7, column S4d).

Due to limited operating capacity of the WWTP (see 'Treatment' below), approximately 55 percent of the daily wastewater flow that reaches the WWTP is diverted to the Sangker River without any form of treatment. Fortunately, almost all the discharge points are situated downstream from the intake for the city's water supply. Furthermore, there are six large waste disposal sites along the river and five locations where wastewater discharges to the river. Of these eleven locations, four are in Sangkat Svay Pao, the central business district of the city. There are two outlets where overload flows are conducted to the river but both are often blocked with solid waste (WaterAid, 2015b).

Treatment – Constructed between 1993 and 1994, Battambang's existing lagoon-based WWTP is located north of the city in Chamkar Samraong Sangka. The plant was designed to have a capacity of 1,000 m^3/day and serve 15,000 people over 89 ha of the core city area on the west side of the Sangker River. However, due to general degradation of the systems it is currently operating at a limited capacity of 450 m^3/day, or 45 percent (see Figure 7, column S5d). Photos of the WWTP as it appeared during the SFD preparation team's field visit on August 23, 2018 are shown in Figure 8.

Photo 5: Settling ponds

Photo 6: Defunct sludge removal cart

Photo 7: Pumps in WWTP pump house

Figure 7: Photos of existing WWTP site. (WaterAid, 2018, Credit: J. Dumpert)

Use – After treatment, the effluent is discharged into canals and used to irrigate nearby rice fields (ADB, 2017). What little faecal sludge reaches the WWTP is left in the settling ponds. According to the plant operators, the settling ponds have been cleaned out less than a handful of times in the history of the plant; circa 1995, 2003 and 2006. This low frequency of cleaning reaffirms the assumption that little to no faecal sludge is reaching the WWTP. During those occurrences, the extracted contents included a significant amount of solid waste (organic and

inorganic) which were manually removed and transported to a nearby field - see photos in Figure 9 (DPWT, 2018).

Photo 8 – Manual extraction of sludge from settling ponds. (source: Dr. Bunrith, credit: Unknown)	Photo 9 – Sludge disposal in neighbouring field. (source: Dr. Bunrith, credit: Unknown)
	

Figure 8: Photos of the cleaning of the Battambang WWTP sludge beds, circa 1995

2.2.2 Onsite Sanitation Service Provision

Containment - As previously noted, approximately 89 percent of the population use some type of onsite sanitation facility. Table 3 lists the type and percentage of onsite sanitation currently in use in Battambang as reported in the MPWT's 2017 household survey. For the purposes of the SFD matrix proportion of population estimates (see Figure 7, column 'Pop'), the indicative values in Table 3 were adjusted to take into account non-household systems (e.g. businesses, institutions, hotels, hospitals) and the percent of the population connected to the combined sewer network.

Table 3: Type of Household Containment currently in use in Battambang

Containment Technology	SFD Equivalent	Originally Reported Percent Distribution
Septic Tank	T1A2C5, T1A3C1, T1A3C5	1%
Ring Tank	T1A4C1, T1A4C5, T1A4C10	87.8%
Soak Away Tank	T1A6C10	11.2%

As shown in the SFD Matrix (Figure 7), most of the population (75 percent) use a concrete cylindrical tank with impermeable walls and an open bottom connected to a soak pit (70 percent) or it has no outlet (5 percent). This type of containment technology is favoured by most households and small business because it allows the supernatant to percolate into the surrounding soil via the open bottom and soak pit where applicable. According to staff at the DPWT, it often takes many years for these types of facilities to become full, and some never become full due to natural decomposition. Furthermore, an estimated 10 percent of the population use an unlined pit, which allows for full percolation. However, these tanks are prone to collapsing, particularly during the wet season. Nevertheless, due to the ability of all unsealed options to remove supernatant, it is assumed that when full, 90 percent of the contents is faecal sludge and 10 percent is supernatant.

Similar to the lined tanks used by households, many of the sealed tanks and septic tanks that are used predominantly by businesses and institutions (SFD Matrix - assigned to 4 percent of the population) are designed to allow supernatant to percolate into the surrounding soil using soak pits. A small number of these systems are also connected to the combined sewer system. Due to their sealed design, these technologies would be expected to have a significant proportion of supernatant in the tank. Consequently, it has been assumed that when full, the contents of both the septic tank and sealed tank would be 60 percent faecal sludge.

Risk of Groundwater Contamination – The main challenge with some onsite sanitation technologies used in Cambodia are the risks that they potentially pose to contaminating the groundwater. This is particularly a concern in Battambang as only 30 percent of the population has access to piped water services (JICA, 2013). Unfortunately, there is currently very little specific data available about Battambang's soil and hydro-geological characteristics. As described in Section 1, Battambang is situated in a region that has both clay and sandy soil types. The clay portions have a low permeability and have very low hydraulic conductivity. Furthermore, according to an interviews with the Battambang Department of Environment (DoE) the risk to groundwater contamination from onsite sanitation is low due mostly clay soil and a low groundwater table (DoE, 2018). Given the available information, this SFD study assumes a low risk to groundwater contamination.

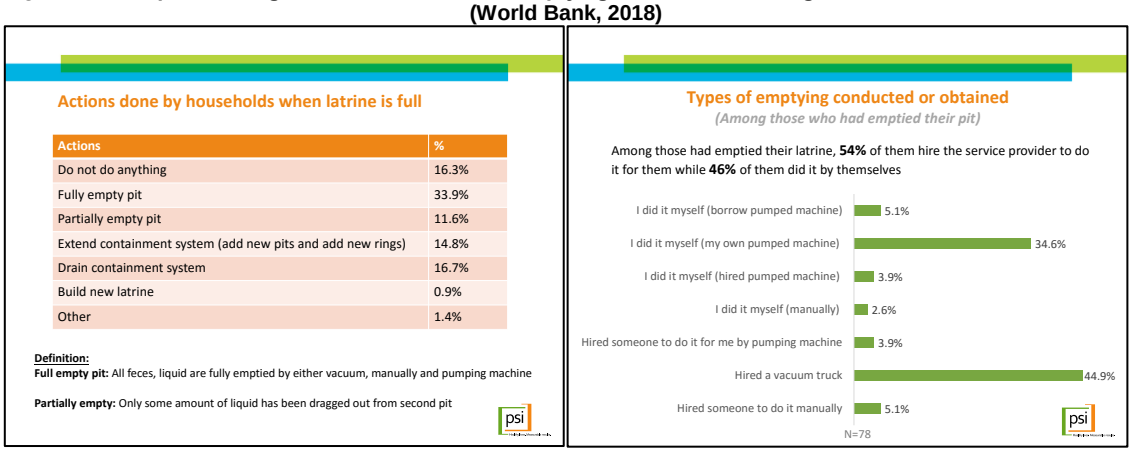
Emptying and Transport – As previously noted, for many of the onsite sanitation technologies it takes a long time to fill up with faecal sludge (3-5 years). Some properly designed systems may never require emptying. However, according to DPWT staff it is very common in Battambang, particularly during the wet season, for onsite sanitation systems to fill up due to storm water infiltration. This can be caused by tanks not being waterproofed properly, or due to damage and deterioration of the tank walls.

To determine common emptying practices would require conducting interviews with Battambang building owners, however this was beyond the scope of this Initial SFD. Nevertheless, using findings from a recent study commissioned by the World Bank on common pit emptying practices of rural Cambodian households (see Figure 10), one can extrapolate a number of insights that are likely applicable to Battambang's urban context:

- One third of the households in the study were likely to attempt to empty the entire container (emptying both faecal sludge and supernatant). However, many households (28.3%) either partially empty or drain the containment system; removing mostly supernatant mixed with storm water. Therefore, this SFD study assumes that the proportion of Battambang households who fully empty or partially empty their system is similar; estimated at 40 percent. It is also assumed that 100 percent of institutions and businesses empty their tanks routinely and do so fully.

- Nearly half of the households in the rural study hired a vacuum truck or someone to manually empty their pit. Given that emptying services are likely more accessible in Battambang, it is assumed that the proportion of building owners using these services would be higher (70 to 80 percent).

Figure 9: Excerpt of findings, from 'Household Pit Emptying and Reuse of Sludge Practices in Rural Cambodia' (World Bank, 2018)



Actions done by households when latrine is full

Actions	%
Do not do anything	16.3%
Fully empty pit	33.9%
Partially empty pit	11.6%
Extend containment system (add new pits and add new rings)	14.8%
Drain containment system	16.7%
Build new latrine	0.9%
Other	1.4%

Definition:
Full empty pit: All feces, liquid are fully emptied by either vacuum, manually and pumping machine

Partially empty: Only some amount of liquid has been dragged out from second pit

These insights have helped to inform the estimates made on the proportion of faecal sludge emptied (see Figure 7, column F3). Table 4 lists the estimates and assumptions made for this variable.

Table 4: Emptying and transport estimates and assumptions made

System	F3 – Estimated % of FS Emptied	F3 - Assumptions Made
T1A2C5	100	Pump trucks are used to fully extract faecal sludge from these business and institutional systems
T1A3C1	100	
T1A3C5	100	
T1A4C1	40	For small business and domestic systems when if emptied a pump trucks may be used but may have difficulty accessing tanks with the industrial equipment. Domestic pumps, buckets and shovels may also be used.
T1A4C5	40	
T1A4C10	40	
T1A6C10	40	Domestic pit, where if emptied is likely to be manually emptied using a shovel and bucket.

Treatment – In all onsite sanitation cases, when faecal sludge and septage is removed from the tanks, none of it is transported to the WWTP for treatment. Instead, the extracted material is disposed of in nearby waterways or farms. However, in many cases the faecal sludge and septage remains in the tank where it undergoes natural decomposition, and therefore is considered safely managed.

2.3 Discussion of resulting SFD graphic

Based on the data and assumptions above, the SFD graphic illustrates that 62 percent of Battambang's wastewater is safely managed (Figure 11).

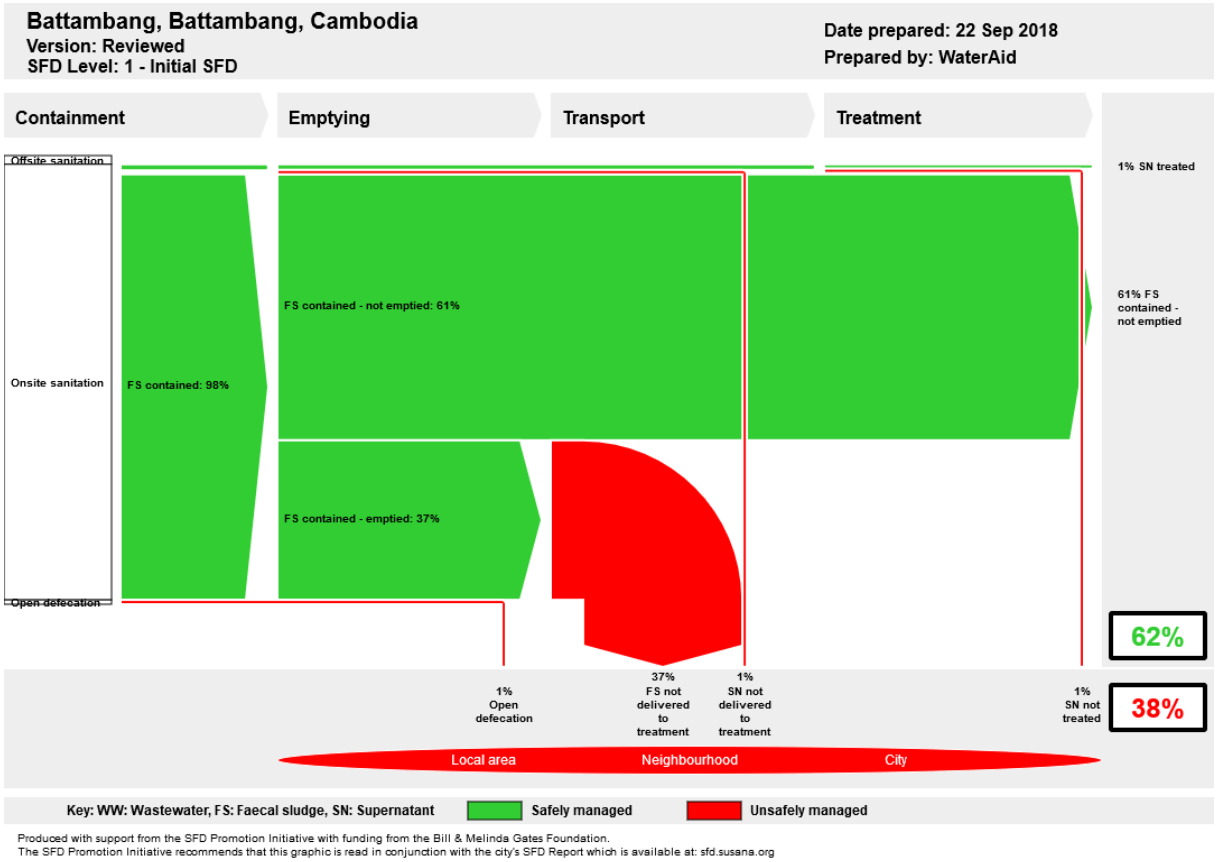


Figure 10: SFD graphic for Battambang, Cambodia

Most of Battambang uses onsite sanitation systems (98 percent). However, there is a small percentage (approximately 10 percent) of onsite tanks that are connected to the city's combined sewerage system. Given that the tanks likely contain most, if not all, of the faecal sludge it is assumed that only supernatant would actually be discharged into the sewerage system. As shown in Figure 11, a fraction of the supernatant is lost along the way to the WWTP due to breaks or cracks within the pipes. Once at the WWTP, another portion of supernatant is lost due to inefficiencies, and finally some of the supernatant is treated.

For faecal sludge management it is estimated that more than half (61 percent on Figure 11) remains within the tank or pit where it is considered safely managed based on the assumption that there is a low risk to groundwater contamination. On the other hand, an estimated 37 percent of the onsite systems are emptied of their faecal sludge; in which case the sludge is transported and unsafely disposed of into nearby waterways or farms. None of the sludge removed is taken to the WWTP for treatment.

3 Service delivery context

3.1 Policy, legislation and regulation

3.1.1 Policy

The draft Water and Sanitation Law of the Kingdom of Cambodia was released in 2004 and the National Policy on Water Supply and Sanitation was adopted by the Council of Ministers (CoM) in 2003. The policies lay out the vision for the sector, and specifies the role of different agencies. To date, neither the draft Water and Sanitation Law nor the National Policy defines the minimum technical or operating standards for household sanitation. Furthermore, the policy on decentralization has not been fully implemented in practice and urban water supply and sanitation remain, essentially, under central government control with minimal involvement from local levels (ESCAP, 2015).

For properties larger than 500 square meters and with more than two floors, the Department of Land Management and Urban Planning (DLMUP) is responsible for providing building permits. This is also relevant for small businesses. In Article 312 of the Sub-Decree #86 on Construction Permit the minimum requirements for “disposal of sewage waters” are set out (IRC/WaterAid. 2016):

- In the absence of a sewer system, building owners shall make provisions to treat and evacuate sewage through a septic tank and a sub-terrain filtering system. In urban areas building owners shall make provisions to connect their septic tank to the sewer system.
- The construction permit application shall include the blue print of the septic tank and the connection to the sewer system.

Effluent standards and compliance
Environmental standards for rivers, lakes and so on are set in the Sub-Decree on Water Pollution Control (April 1999) by the MoE, which is responsible for the conservation of water resources and environmental issues. The Sub-Decree aims to minimise and phase out activities which cause pollution in order to sustain good water quality that is suitable for human usage by improving wastewater management. The Sub-Decree includes:

- Effluent standard for pollution sources discharging wastewater to public water areas or sewers; and
- Type of pollution sources requiring permission from the MoE before discharging or transporting their wastewater. The list includes sewage treatment plant and night soil treatment plants but not sludge emptying and transportation services.

3.1.2 Institutional roles

The roles and responsibilities for wastewater management has historically been a significant challenged in Cambodia. As recently as December of 2017, a sub-decree title *Sewerage and Wastewater Treatment and Management* was signed and released by the Prime Minister’s

office to try and help address the challenge. The objectives of the sub-decree, as presented in the document itself, are to[3]:

- Prepare and justify the roles and responsibilities of the ministries and sub-national government to ensure quality sewerage and wastewater management.
- Delegate executive roles of sewerage management to municipalities, districts and khans (communes).
- Identify necessary mechanisms to improve sewerage management.
- Increase public awareness and improve community participation.
- Improve development private actors' engagement of infrastructure maintaining investment on sewerage management.

The three primary ministries responsible for urban wastewater management and their roles, as outlined in the sub-decree, are as follows:

1. The Ministry of Public Works and Transport (MPWT):
    - Prepare policies, strategies and master plans for sewerage and WWTP development.
    - Prepare technical aspects on construction management and maintenance.
    - Coordinate with relevant ministries, development actors, and private sector organizations on sewerage and treatment plant investment.
    - Coordinate financial and material contribution to sub-national government on wastewater management.
    - Collaborate with other ministries and sub-national government to raise public awareness on wastewater management.
    - Collaborate with Ministry of Environment and stakeholders to provide capacity building and knowledge sharing on wastewater management to sub-national governments.
    - Enforce local government to manage and maintain sewage and wastewater treatment plants.
    - Conduct monitoring and evaluation of sewage and WWTPs.

2. The Ministry of the Environment (MoE):
    - Prepare policies and strategic plans for the protection of public water bodies from wastewater pollution.
    - Set standards, monitor and regulate for effluents discharging into water bodies from wastewater management systems.
    - Provide technical assistance on wastewater treatment proposals.
    - Monitor and evaluate the pollution control performance of equipment and materials within WWTPs.
    - Coordinate with relevant stakeholder, development partners, and private sector actors on sewerage and wastewater treatment investment.
    - Support and coordinate with relevant partners and sub-national government to raise awareness on the management of sewerage and wastewater treatment systems with the aim of protecting the environment.

[3] Unofficial translation.

3. Ministry of Interior (MoI):
    - Support and collaborate with relevant ministries to increase capacity and knowledges sharing on sewage and WWTPs.
    - Coordinate and mobilize sub-national government agencies to improve the quality of sewage and wastewater treatment management.
    - Intervene and support the monitoring and evaluation of systems and standards.
    - Reinforce and advise sub-national agencies on sewage and wastewater treatment management.

Other central agencies with lesser roles in the sector include the following:

- The Ministry of Industry and Handicrafts (MIH) for urban water supply; it is also responsible for delivering on the urban component of the Nation Water Supply and Sanitation Policy adopted by CoM in 2004 which has a specific section on urban water and sanitation provisions, approaches and guiding principles.

- The Ministry of Health (MoH) is responsible for adequate water, sanitation and hand washing facilities in health centres, in coordination with MRD. The Department of Preventive Health also has a role in hygiene promotion and has issued an Environmental Health Action Plan, although its implementation on the ground is limited.

- The Ministry of Land Management, Urban Planning and Construction (MLMUPC) is responsible for:

    - Providing building permits to properties larger than 500 square metres and with more than 2 floors. This is also relevant for small businesses. Smaller residential properties (<500 square metres) fall under the responsibility of the City Hall.
    - Checking on and approving all urban construction including the requirement for the adequacy and quality of water supplies 'septic tanks' for all urban construction, as required by the Construction Sub-Decree 1997. However, technical onsite inspection of onsite sanitation facilities is not carried out by DLMUP. This is the responsibility of DoE and DPWT. Final inspections of buildings can only be carried out if the owner has officially notified the authorities. This often does not happen as the owner is expected to pay the second tranche of the licensing fee (IRC/WaterAid. 2016. p.21).

In addition to MoI's role in the sector presented above, the Secretariat of the National Committee for Democratic Development (SNCDD), plays a role in supporting the implementation of the national decentralization and deconcentration (D&D) reforms in close coordination with line ministries. While the Organic Law of 2008 formalized the start of decentralization and deconcentrating, current control of financing as well as most technical capacity, remains at central government level. Local authorities, as part of their general mandate for poverty reduction, could - and are already playing to a limited extent –a role in water supply and sanitation (and are increasingly will be held responsible for health and

hygiene issues) with support from provincial departments, but the capacity for planning implementation and monitoring is weak at sub-national level. (WaterAid. 2015a)

3.1.3 Service provision

Offsite Sanitation Services

All O&M needs for the combined sewerage system and WWTP are managed by the DPWT. The building owners for any new houses or small business located along the existing sewerage pipe can connect by applying directly to the DPWT and paying an application fee of US$ 50. If approved, DPWT staff will come to the location to inspect the connection is done properly, but it is up to the building owner, or their contractor, to make the connection. In addition to the application fee, any labour or hardware needed to connect the building to the sewer line must also be paid for by the building owner.

Onsite Sanitation Services

As mentioned earlier in Section 2.1, for the most part the design, installation, maintenance and associated costs of any onsite facility is the responsibility of the building owner. In cases of buildings greater than 500 square meters and with more than two floors, a building permit must be obtained from the DLMUP, which requires submitting blueprints of the building layout and septic system. For most small buildings and houses, there are no sanitation system design requirements. There are, however, unofficial standards based on what local building contractors and local masons are accustomed to.

When wastewater removal services are needed, Battambang building owners have many options, including but not limited to, doing it themselves or hiring a service. Based on what is known from formative research of rural Cambodian building owners (see Figure 10), it is likely that most Battambang building owners prefer to hire a pump truck to come and remove the waste. It is estimated that there are over seven pump truck companies operating in Battambang including the DPWT which owns one pump truck that is mostly used for cleaning the sewer system. With the exception of DPWT, most of the pump truck companies are family owned and have only one or two trucks at their disposal, each with a capacity of 4 m^3. These companies post their contact information on electricity poles and notice boards throughout the city. Building owners can hire a pump truck by contacting them directly. The cost for the wastewater removal is negotiated typically between 20-50 US$ per truck load.

Future Development Plans

Plans are underway to decommission the existing WWTP and construct a new facility with support from ADB. The forthcoming project includes a rehabilitation and extension of the sewerage network intended to accommodate projected sewerage loadings from the densely populated areas of the town centre to the west of the Sangker River, and most of the intermediately populated areas just outside the centre. The project is expected to directly benefit some 8,500 households, connecting 46,750 inhabitants to the sewer (ADB, 2017).

3.1.4 Service standards

Offsite Sanitation Service Standards
Cambodia does not have its own standard designs for WWTPs. The Battambang WWTP was originally designed and build with support from the Dutch government in 1993-1994.

Environmental standards for rivers, lakes and so on are set in the Sub-Decree on Water Pollution Control (April 1999) by the MoE, which is responsible for the conservation of water resources and environmental issues. However, when Battambang's WWTP lost its financial support and fell into disrepair, effluent monitoring was also halted.

Onsite Sanitation Service Standards
There is a lack of standard designs for onsite wastewater facilities. Building drawings are expected to include technical details of the onsite facilities, however there is a general lack of expertise to check the designs within DLMUP and Municipality. The DPWT and the DoE are expected to provide this expertise and advise the DLMUP on the proposed designs. However, such guidance has yet to be officially disseminated.

For emptying services, there are currently no systems in place that requires pit emptying service providers to register or obtain a license to run this specific business. Emptying charges range from 20-50 $US per trip. Furthermore, there are currently no safety standards in place or practiced by pump truck operators, and there are no faecal sludge disposal or reuse standards in place (IRC/WaterAid, 2016).

3.2 Outputs

3.2.1 Monitoring and reporting access to services

Due to significant interest and potential investment in Cambodia's urban sanitation – particularly for centralized wastewater treatment – there have been several assessments conducted recently which outline the relevant institutions, policies and regulations at the national and sub-national levels. Furthermore, scoping and impact studies conducted in preparations for upgrades to Battambang's wastewater systems, supported by ADB, have produced a significant amount of reliable documentation regarding the existing system. Most of the reports were developed recently within the last five years, and by reputable sources including, but not limited to, JICA, IRC, and WaterAid. These secondary sources are considered to be reliable and were used significantly to prepare this Initial SFD report.

Significantly less data is available regarding Battambang's current onsite sanitation situation. Only one report prepared in 2017 for the MPWT provided information on the types of onsite sanitation containment technologies and estimates of the proportion of population using the identified technologies. However, the data in the MPWT report is not considered to be very reliable as it is based on a very small sample. The SFD researchers attempted to verify the data with key informants from the DPWT, however their data was also limited. To the best of their knowledge, the MPWT report seems correct. Despite some uncertainty, the MPWT report is currently the best available information and therefore used to estimate the onsite values presented in this Initial SFD report.

4 Stakeholder Engagement

This Initial SFD report was prepared with a light level of stakeholder engagement, primarily with staff from the MPWT's Sewerage Management and Construction Department, and their affiliated provincial departments. Engagement with MPWT staff included an introduction and consultation meeting held on July 24th, 2018. Furthermore, one MPWT staff member accompanied the team to Battambang to assist the team set up meetings with sub-national stakeholders and to take part in the process of developing an SFD.

On August 23rd the following meetings were held in Battambang city with the three of the most sanitation and wastewater relevant departments to verify the information collected during the desk review:

- Battambang Municipality
- Battambang DoE
- Battambang PDWT

In addition to the meetings above, observations were made of Battambang's WWTP, connecting canals and outflows as well as the sanitation technologies used by households and businesses not connected to the sewerage system. Due to the limited time, engagement with private sector pump truck owners or operators could not be arranged.

5 Acknowledgements

The SFD preparation team would like to thank the many MPWT and DPWT staff for their generous time and support, specifically: Director Chao, Deputy Director Lim, Department Deputy Director Sopary, and Mr. Sem.

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