

Department of Public Works and Transport,
Phnom Penh Capital City (DPWT/PPCC)

Summary Report

CAMBODIA

Verification Survey with the Private Sector
for
Disseminating Japanese Technologies
for
Improvement of Sanitation and Living
Condition Using Amphibious Excavator

FEBRUARY 2018

Japan International Cooperation Agency

Taiho Shoji Co., Ltd.

1. BACKGROUND

The inundation condition in Phnom Penh Capital City (hereinafter referred to as “PPCC”), has steadily been improving, and technologies as well as equipment for drainage pipe cleaning works have been transferred from XX to XX through the implementation of Japan’s Grant Aid Project: “The Project for Flood Protection and Drainage Improvement in Phnom Penh Capital City” (Phase 1 to 3). However, methodologies of cleaning works are not yet established in open drainage channels that are not approachable to ordinary excavators and dump trucks, and as a result, garbage and sludge have heavily accumulated in the open drainage channels, imposing negative impact to sanitary and living conditions in and around the open channels.

In order to improve the condition of open drainage channels in PPCC, Taiho Shoji Co., Ltd., proposed the use of the Amphibious Excavator. This proposal was discussed in a survey adopted by JICA, namely, the “Verification Survey with the Private Sector for Disseminating Japanese Technologies for Improvement of Sanitation and Living Condition using Amphibious Excavator”. The survey report indicates that Taiho Shoji Co., Ltd. verifies and transfers technologies and methodologies in cleaning drainage open channels through on-the-job training to the counterparts of Department of Public Works and Transport (DPWT)/PPCC, and establishment of operating manuals and phased drainage channel cleaning plan, and thus contributes to recover drainage function and improve deterioration of sanitary and living conditions in PPCC.

2. OUTLINE OF THE PILOT SURVEY FOR DISSEMINATING SME’S TECHNOLOGIES

(1) Purpose

The purpose of the survey is (i) to transfer technologies and methodologies for cleaning open drainage channels by utilizing Amphibious Excavator, (ii) to formulate operating manuals and phased cleaning plan for open channels, (iii) to assist activities for the sustainable implementation of the cleaning works by utilizing Amphibious Excavator and (iv) to establish a business promotion plan for disseminating Amphibious Excavator in Cambodia.

(2) Activities

Outputs of the Survey are enumerated below.

Output 1: Advantages and effectiveness of Amphibious Excavator is verified in cleaning garbage and accumulated sludge in open channels in PPCC.

Output 2: DPWT/PPCC's capacity for operating the Amphibious Excavator is developed through on-the-job training, and operating manuals for the Amphibious Excavator and phased drainage channel cleaning plan utilizing Amphibious Excavator are established.

Output 3: Framework for sustainable open channel cleaning work is established.

Output 4: A Business Plan is established to disseminate the Amphibious Excavator to the governmental agencies concerned, construction companies, and construction equipment retailers in Cambodia.

Activities to achieve the Outputs are itemized as follows:

Activities for Output 1

- 1-1: Preliminary survey on describing specifications of the Amphibious Excavator in accordance with the specific condition in Cambodia.
- 1-2: Fabrication of the Amphibious Excavator in Japan.
- 1-3: Transportation and assembling of the Amphibious Excavator.
- 1-4: Test drive and actual operation of the Amphibious Excavator in the drainage channels.

Activities for Output 2

- 2-1: Technologies transfer for operating the Amphibious Excavator through on-the-job training to counterparts of DPWT/PPCC.
- 2-2: Establishment of an operating manual for Amphibious Excavator.
- 2-3: Establishment of phased cleaning plan for drainage open channel that involves the utilization of the Amphibious Excavator.

Activities for Output 3

- 3-1: Assistance for establishing activity reports to assure sustainability of the cleaning works utilizing the Amphibious Excavator.
- 3-2: Assistance for establishing budget application for drainage channel cleaning works.
- 3-3: Reuse and recycle of accumulated sludge as a banking material in the drainage open channels.

Activities for Output 4

- 4-1: Market research on the Amphibious Excavator and other construction equipment
- 4-2: Establishment of a business plan for disseminating the Amphibious Excavator

in Cambodia

4-3: Holding seminar on “Amphibious Excavator, as an appropriate technology for cleaning drainage open channel” in collaboration with DPWT/PPCC

(3) Information of Product/ Technology to be Provided

Technology to be provided is “Amphibious Excavator” and its accessories to clean drainage open channels in Phnom Penh of which ordinary excavators and dump trucks cannot approach.

The following table shows the overview of Amphibious Excavator

Table 1 Overview of Amphibious Excavator

	
Name	Amphibious Excavator
Specification	<p>Weight : 10,300kg</p> <p>Bucket capacity : 0.25m³</p> <p>Size : Length 6.83m, Width 3.34m, Height 3.28m</p> <p>Gradeability : 20 grade</p>
Feature	<p>"Amphibious Excavator" is a special excavator designed to work in places where ordinary excavators cannot work, such as drainage channels, rivers, lakes, weak grounds and wetlands. The feature is that the traveling equipment is designed to be floatable on the water because it has a large hull shape and a closed type hollow structure. In addition, the shape of this traveling equipment keeps the contact pressure as low as possible, enabling it to freely travel without sinking even in soft ground.</p>
Competitive advantage compared to other products	<p>Operationality;</p> <ul style="list-style-type: none"> ➤ Since the proposed product has two motors on one side, powerful traveling can be realized, and even if problems occur in one motor, it can be operated with another one. ➤ The proposed product is easy to use even in narrow channel width since it can extend and retract the caterpillar right and left. <p>Safety;</p> <ul style="list-style-type: none"> ➤ By installing a sub float next to the main float and ensuring adequate buoyancy, it is possible to ensure the stability of the work even on the water. <p>Economic efficiency;</p> <ul style="list-style-type: none"> ➤ The range of the use of this product is broad and it is a highly effective product since it can be operated not only on water but also on land,

	<p>Maintenance;</p> <ul style="list-style-type: none"> ➤ Since the consumables and spare parts are stocked at all times, requests from customers can be addressed quickly.
Sales performance	<ul style="list-style-type: none"> • Japan : East Japan great earthquake disaster reconstruction project and sales performance in Okinawa prefecture • Overseas : None yet

(4) Counterpart Organization

Department of Public Works and Transport, Phnom Penh Capital City (DPWT/PPCC)

(5) Target Area and Beneficiaries

Target Area: Phnom Penh Capital City

Beneficiaries: Residents in Phnom Penh Capital City

(6) Duration

From March 2017 to April 2018

(7) Progress Schedule

		2016			2017												
		2	3	4	5	6	7	8	9	10	11	12	1	2	3		
Activity	Activity for Output1																
	【1-1】 Preliminary survey on describing specifications of Amphibious Excavator in accordance with the specific condition in Cambodia	(1)Investigation of specification of amphibious exporter			■	■											
		(2)Sampling and component analysis of sedimented sludge			■	■											
		(3)Selection of a drainage cleaning site				■	■										
	【1-2】 Fabrication of the Amphibious Excavator in Japan	(1)Manufacturing management of Amphibious Excavator	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		(2)Manufacturing management of incidental equipment	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	【1-3】 Transportation and assembling of the Amphibious Excavator	(1)Marine transport of amphibious excavator and incidental equipment				■	■										
		(2)Carried to DPWT / PPCC by local carrier					■	■									
		(3)Assembling and installing equipment						■	■								
	【1-4】 Test drive and actual operation of the Amphibious Excavator in the drainage channels	(1)Conduct trial operation							■	■							
		(2)Verification for full-scale introduction								■	■						
	Activity for Output2																
	【2-1】 Technologies transfer for operating the Amphibious Excavator through on-the-job training to counterparts of DPWT/PPCC	(1)Review of OJT proposal for operator training				■	■										
		(2)Policy explanation and consultation to DPWT / PPCC						■	■								
		(3)Implementation of OJT to DPWT / PPCC staff							■	■	■	■					
	【2-2】 Establishment of Amphibious Excavator operating manual	(1)Review of operation and maintenance management manual				■	■										
(2) Explain and discuss policy with DPWT / PPCC, submit manual plan						■	■										
(3) Presentation and consultation of manual revision proposal, confirmation of agreement								■	■	■	■		■	■			
【2-3】 Establishment of phased drainage open channel cleaning plan utilizing the Amphibious Excavator	(1) Examination of the draft drainage open channel cleaning plan				■	■											
	(2) Policy explanation and consultation to DPWT / PPCC, submission of plan draft					■	■										
	(3) Presentation and consultation on revision plan for drainage cleaning plan, confirmation of agreement							■	■	■	■						
Activity for Output3																	
【3-1】 Assistance for establishing activity report to assure sustainability of the cleaning works utilizing the Amphibious Excavator	(1) support for DPWT / PPCC activity based on drainage channel cleaning plan							■	■		■	■					
	(2) Support for creating drainage channel cleaning plan activity report								■	■	■	■		■	■		
【3-2】 Assistance for establishing budget application for drainage channel cleaning works	(1) Calculation of annual maintenance and maintenance work cost by DPWT / PPCC								■	■							
	(2) Support for creating budget application documents related to maintenance work costs									■	■		■	■			
【3-3】 Reuse and recycle of accumulated sludge as a banking material in the drainage open channels	(1) Demonstration experiment of sludge stabilization using soft sludge improver							■	■		■	■					
	(2) Examination of cleaning effect and environmental improvement effect by soft sludge improver								■	■		■	■				
	(3) Imprementation of promotion activities for awareness												■	■			
Activity for Output4																	
【4-1】 Market research on the Amphibious Excavator and other construction equipment	(1) Information gathering, planning of investigation plan				■	■											
	(2) Implementation and summary of market research						■	■	■	■							
【4-2】 Establishment of business plan for disseminating Amphibious Excavator in Cambodia	(1) Preparation of a dissemination plan based on market survey results						■	■	■	■			■	■			
【4-3】 Holding seminar on "Amphibious Excavator, as an appropriate technology for cleaning drainage open channel" in collaboration with DPWT/PPCC	(1) Holding of seminars aimed at promoting the dissemination of the equipment and the activity report of this project								■	■			■	■			

■ Plan
■ Actua

(8) Manning Schedule

In charge	Name	Affiliation	Plan/ Actual	FY2016			FY2017												Total			
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	Plan/ Actual	Cambodia	Japan	
Project manager	Yoshifumi Asanishi	Taiho Shoji Co., Ltd.	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	80	35
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	80	35
Comprehensive equipment instruction	Iseei Iwatate	Individual	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	63	25
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	63	25
Equipment operation, Management instruction 1	Tatsuo Hagi	Individual	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	70	25
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	70	25
Equipment operation, Management instruction 2	Masahiro Murayoshi	Taiho Shoji Co., Ltd.	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	80	35
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	85	35
Chief advisor	Hitoshi Shimodochi	CTI Engineering International Co., Ltd.	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	21	20
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	0	30
Drainage cleaning plan	Tuyoshi Kawamoto	CTI Engineering International Co., Ltd.	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	55	25
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	58	17
Environmental and social considerations	Zenjiro Egawa	CTI Engineering International Co., Ltd.	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	57	25
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	60	25
Business development	Katsuyuki Nobusawa	GeoBrain Co., Ltd.	Plan			1	2	3	4	5	6	7	8	9	10	11	12			Plan	51	26
			Actual			1	2	3	4	5	6	7	8	9	10	11	12			Actual	51	26

(9) Implementation System

Japan side: Taiho Shoji Co., Ltd.

Cambodia side: Department of Public Works and Transport, Phnom Penh Capital City (DPWT/PPCC)

Taiho Shoji Co., Ltd., which is the proposing company, is responsible mainly for the work related to the execution and management of the entire operation, and the other surveys and adjustments are made by outside personnel, namely, individuals (2 persons), CTI Engineering International Co., Ltd (hereinafter referred to as CTII), and Geo Brain Co., Ltd. In addition, since CTII has a liaison office in Cambodia and is involved in a JICA project titled “The Project for Flood Protection and Drainage Improvement in Phnom Penh Capital City”, this project could collaborate with it for more efficient operation.

Table 2 shows the project implementation structure and Table 3 shows the local liaison office of CTII.

Table 2 project implementation structure

Section	Member	Responsible
Proposing company	Taiho Shoji Co., Ltd.	Provide technical guidance on the overall management of work, introduction of technology and general guidance on management of the equipment and its operation.

Section	Member	Responsible
Outside personnel	Individuals (2 persons)	While assisting the proposing company, implement OJT training on comprehensive guidance and operation and maintenance of the proposed equipment.
	CTI Engineering International Co., Ltd	Support planning the drainage channel cleaning plan and construction of the structure considering the surrounding environment. In addition, coordination related to local affiliated organizations and various surveys, compiling reports and offering support through the local office.
	Geo Brain Co., Ltd.	Hold seminars for dissemination of proposed equipment, research and plan for business development, promotion of diffusion.

3. ACHIEVEMENT OF THE SURVEY

(1) Outputs and Outcomes of the Survey

(a) Verification Survey

Output 1

- Sludge sampling in Trabek and Tumpun drainage channel and water sludge quality analysis were implemented to select the working site for utilizing the amphibious excavator. As the result of analysis, significant contamination was not identified so that dredging was carried out at both Trabek and Tumpun drainage channels.
- Amphibious excavator and ancillary facility such as cart and pontoon were fabricated in Japan based on the preliminary survey (Photo 1).
- Required working hour for one cleaning cycle from dredging sludge to transporting to landfill was 2.0 to 2.5 hours (Table 3).
- Sedimentation status of sludge before and after dredging was investigated in order to show the effect of sludge dredging work (Table 4).

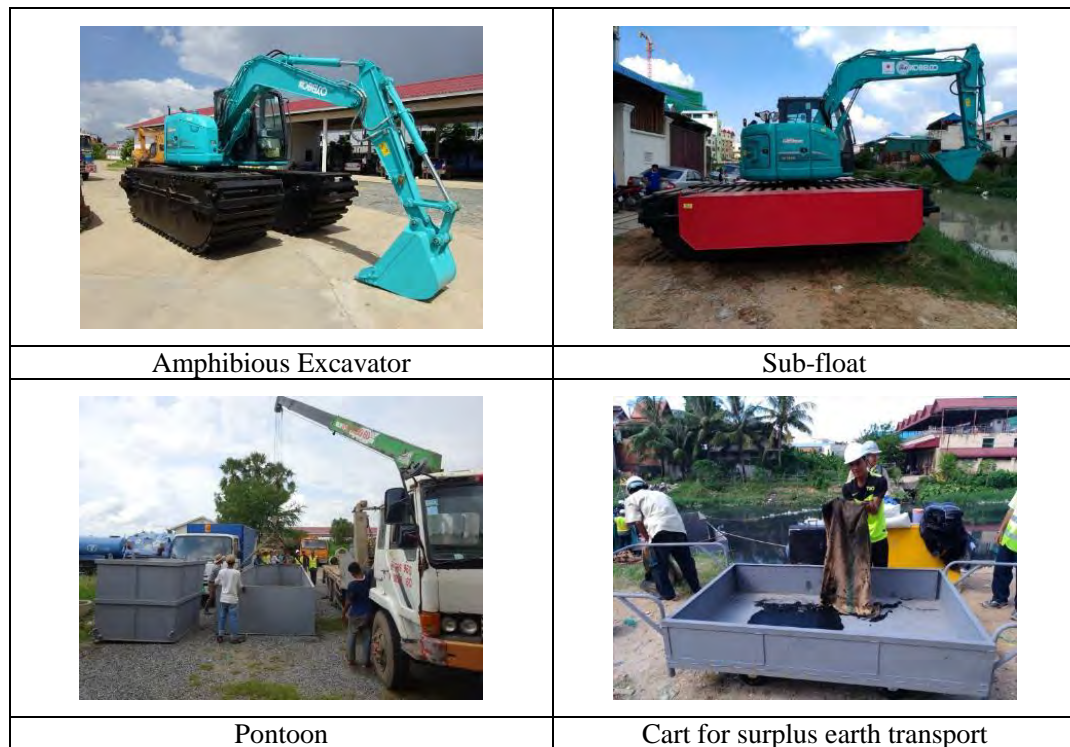


Photo 1 Amphibious Excavator and ancillary facility

Table 3 Required working hour each cycle

Item	Content	During investigation
Dredging work hour	Working hour for dredging 3m ³ of sludge	About 15-20 min
Sludge carrying hour	Working hour for carrying the sludge on land	About 20-30 min
Sludge transport	Working hour for transporting the sludge from the project site to disposal site.	1.5 hours
Working hour	Total working hour from dredging the sludge to transportation	2.0-2.5 hours

Table 4 Comparison of discharge capacity of before and after dredging at the 2.65 in Tumpun open drainage channel

Item	Unit	Plan (2001)	Before dredging		After dredging	
			Capacity	Degree of decreasing from 2001	Capacity	Degree of decreasing from 2001
Section area	m ²	48.00 (100%)	40.30 (84%)	16%	44.00 (92%)	8%
Velocity	m/s	0.94 (100%)	0.84 (89%)	11%	0.89 (95%)	5%
Discharge volume	m ³ /s	45.09 (100%)	33.77 (75%)	25%	39.09 (87%)	13%

Output 2

- Two supervisors and two machine operators were selected from DSD(Drainage

and Sewerage Division) and transferred the drainage cleaning technique through OJT (Table 5).

- Operation and maintenance manual and drainage cleaning plan were developed in cooperation with DSD and JICA survey team.

Table 5 Purpose and contents of On-the-Job training

Item	Purpose	Contents
Preliminary	Understand the concept of safety measures, transport route, and preliminary survey method.	<ul style="list-style-type: none"> • Securing work zones • Prohibited matter, emergency response • Confirmation of water level and sediment sludge thickness in the drainage system
Machine Operation	Understand the name of the equipment and how to operate it through lectures and OJT	<ul style="list-style-type: none"> • Name and performance of each device • How to enter and landing to/from drainage channel • Dredging method • Installation and operation method of incidental facilities
Sludge treatment and disposal	Understand treatment and dispose method of dredged sludge	<ul style="list-style-type: none"> • Sludge carrying method by manual • Sludge carrying method by sludge sucker • Reformulation and reuse of sludge
Maintenance	Understand maintenance inspection method of machine	<ul style="list-style-type: none"> • Preliminary inspection • Regular inspection and reporting

Output 3

- DSD staff acquired how to use drainage cleaning record, which was prepared in this project for assisting periodical activity report to put up sustainable drainage cleaning work as collateral.
- Annual cost for drainage cleaning work were estimated as a basis of budget request based on the drainage cleaning plan developed in Output 2 (Table 6).

Table 6 Annual Plan and Cost for Drainage Cleaning work

Drainage	Item	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	TOTAL
Tumpun (4,700 m)	Working days	200	200	200	200	200	175			1,175
	Length (m)	800	800	800	800	800	700			4,700
	Cost (1000 USD)	22.	22.	22.	22	22	19.3			129.3
	Cost (Million Riel)	88	88.0	88	88	88	77			517.0
Trabek (1,100 m)	Working days							200	75	275
	Length (m)							800	300	1,100
	Cost (1000 USD)							22	8.3	30.3
	Cost (Million Riel)							88	33	121

Drainage	Item	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	TOTAL
Total (5,800m)	Working days	200	200	200	200	200	175	200	75	1,450
	Length (m)	800	800	800	800	800	700	800	300	5,800
	Cost (1,000 USD)	22.	22.	22.	22	22	19.3	22	8.3	160
	Cost (Million Riel)	88	88.0	88	88	88	77	88	33	638.0

Output 4

- Interviews to understand and determine the need for the product was implemented upon government organizations (MPWT, DPWT, MOE etc.), construction companies and an education agency (Institute of Technology of Cambodia).
- Survey was implemented in areas where it was assumed that sludge cleaning in drainage channel and water bodies are required in Phnom Penh and Siem Reap. As a result, about 4.7 km of Tumpun drainage channel, about 1.1 km of Trabek drainage channel in Phnom Penh, and about 9 km of drainage channel in Siem Reap has a possibility to clean utilizing Amphibious Excavator.

(b) Business Development Plan

- Business development plan which includes not only providing the product but also technical guidance, providing spare parts and dispatching engineers was established.
- The following business development is assumed
 - Sales and rental of the product and technology in Phnom Penh and other areas in Cambodia.
 - Maintenance of products and provision of spare parts.
 - Technical guidance of products and construction method.
 - Dispatching advanced engineers and operators.
 - Training of operators for special constructing machines.

(c) Environmental and Social Considerations

As Amphibious Excavator was operated for the dredging work of the existing drainage channel, we thus considered the influence during operation of dredging work. The items of environmental and social considerations were selected through the screening/scoping based on the result of existing research output and field survey. Items on table 7 are the screening/ scoping result and they are assumed that negative

impact happen due to dredging work.

Table 7 Monitoring and Existing result of the item

Item	Survey Results							
Air Quality	➤ The environmental standard of Cambodia is shown below.							
	N	Parameter	1 Hour Average mg/m ³	8 Hour Average mg/m ³	24 Hour Average mg/m ³	1 Year Average mg/m ³		
	1	Carbon monoxide (CO)	40	20	-	-		
	2	Nitrogen dioxide (NO ₂)	0.3	-	0.1	-		
	3	Sulfur dioxide (SO ₂)	0.5	-	0.3	0.1		
	4	O zone (O ₃)	0.2	-	-	-		
	5	Lead (Pb)	-	-	0.005	-		
	6	Total Suspended Particulate (TSP)	-	-	0.33	0.1		
	Reference : Sub-decree No27 ANK/BK, Sub-decree on air and noise pollution -Annex 1 ambient air quality standard							
	➤ The existing result is shown below.							
Parameters	2000		2001		2002		2014	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
CO (mg/m ³)	3.06	7.12	1.98	2.42	3.50	5.71	3.02	3.87
NO ₂ (µg/m ³)	32.08	47.17	2.45	3.77	30.19	56.60	24	71
SO ₂ (µg/m ³)	-	-	2.60	7.80	7.80	13.00	10	27
TSP (mg/m ³)	-	-	0.63	0.84	0.41	1.00	0.128	0.169
<ul style="list-style-type: none"> Reference: MOE (2014), ADB 2006 Country Synthesis Report on Urban Air Quality Management, "Research collaboration with Yokohama University from 2000-2002. Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014 Quoted in MOE and Ministry of Health (2006). Country Report: Cambodia, Hang Dara, Chin Chamroeun, Sourn Pun Lork, and Chim Sophan, Paper presented at the Clean Air for Asia Training Course for Developing Countries, Thailand, 24 May-02. " from ADB 								
➤ According to the existing measurement results in Phnom Penh, Nitrogen Dioxide (NO ₂) and Sulfur Dioxide (SO ₂) greatly exceeded the environmental standard before 2014. The amount of day traffic in Phnom Penh is reported to be about 40,000 for route 1, about 26,000 for route 2 and over 10,000 for other major national highways. The number of vehicles in Phnom Penh is more than other provinces and it is assumed that the exhaust gas of the automobile is a major factor of deterioration of the atmospheric environment in Phnom Penh.								
➤ The daily operation time of this equipment is about 30 minutes to 40 minutes even when dredging work of 2 cycles is operated. It is about 1 hour of operation including moving time and it is unlikely that it will be an emission source affecting the surrounding environment.								
➤ The displacement of amphibious excavator is 2,179cc, the excavator possessed by DPWT is around 8,270 and ordinary vehicles about 1,000 to 1,500 cc. As appropriate maintenance of this equipment and prevention of unnecessary idling are properly implemented, it is assumed that the influence on the air environment accompanying the operation of this equipment is slight compared to vehicles and other heavy machinery.								

Item	Survey Results									
Water Quality	➤ The environmental standard of Cambodia and existing result are shown below.									
	Location		pH (-)	TSS (mg/l)	BOD (mg/l)	COD _{Mn} (mg/l)	COD _{Cr} (mg/l)	T-N (mg/l)	T-P (mg/l)	Cr ⁶⁺ (mg/l)
	A. Mekong River (Chroy Changvar)	Min	6.35	16.0	0.1	1.6	-	0.01	0.01	ND
		Max	8.50	592.0	4.9	7.8	-	1.15	0.50	0.090
		Average	7.41	108.5	2.0	4.0	-	0.26	0.08	0.023
	B. Sap River (Phnom Penh Port)	Min	6.49	22.0	0.2	1.4	-	0.08	0.02	ND
		Max	8.24	474.0	6.5	9.3	-	8.11	0.50	0.320
		Average	7.32	106.5	2.3	4.5	-	1.23	0.11	0.027
	C. Prek Thnot River (Thakhmao Bridge)	Min	6.09	5.8	0.2	1.3	-	0.13	0.03	ND
		Max	8.21	520.0	57.9	145.0	-	3.97	4.08	0.220
		Average	7.30	157.3	13.8	23.8	-	1.33	0.98	0.038
	D. Bassac River (Thakhmao)	Min	4.85	26.0	0.1	0.8	-	0.07	0.01	ND
		Max	8.50	526.0	5.8	9.4	-	0.74	0.34	0.110
		Average	7.31	108.3	2.0	4.2	-	0.31	0.12	0.023
	E. Mekong River (Kien Svay)	Min	5.52	29.0	0.0	0.6	-	0.04	0.00	ND
		Max	8.47	526.0	6.5	9.7	-	1.73	0.32	0.120
		Average	7.33	114.7	1.9	3.6	-	0.31	0.08	0.019
	Cambodian Standard for A. to E.			6.5-8.5	<100	<10	-	-	-	<0.005
	F. Kop Slov	Min	6.24	40.0	0.7	-	2.6	0.26	0.01	ND
		Max	8.59	300.0	54.8	-	126.4	8.56	1.88	0.010
		Average	7.49	129.1	16.4	-	35.4	2.08	0.56	0.007
	G. Prek Pnov	Min	6.41	42.0	1.0	-	3.4	0.09	0.03	ND
		Max	8.18	442.0	58.4	-	126.7	11.93	1.74	0.010
		Average	7.36	119.5	17.4	-	31.8	4.91	0.53	0.006
	H. Trabek	Min	6.35	46.0	70.9	-	47.9	1.48	0.81	ND
		Max	8.35	378.0	258.1	-	215.0	18.40	6.73	0.200
		Average	7.39	153.1	152.1	-	117.7	7.39	3.03	0.021
	I. Tumpun	Min	6.78	70.0	68.9	-	63.5	0.32	0.23	ND
		Max	8.02	402.0	261.3	-	226.2	18.55	6.60	0.020
		Average	7.39	155.2	161.9	-	111.6	6.05	2.93	0.009
	Cambodia Standard for F to I.			5.0-9.0	<120	<80	-	<100	-	<0.05
	Reference : MOE (2010.January- 2013 December), Sub-decree No.42 ANK/BK The Control of Air Pollution and Noise Disturbance									
	ND: Not Detected. CODMn: <8 mg/L based on ANNEX 4									
➤ The average values of TSS, BOD and COD in Trabek and Tumpun drainage channel of the target area in this project exceeds the environmental standard. It is assumed that the water quality in these drainage channels is bad on a daily basis so that domestic waste water and garbage from the residence are flowing in to the both drainage channel.										
➤ The daily operation time of this equipment is about 30 minutes to 40 minutes even when dredging work of 2 cycles is operated. It might cause the increasing of the turbidity due to hoisting of sediment accompanying the operation of this equipment but it is unlikely that the water quality is extremely deteriorated and the influence on the downstream is considered to be very minor.										

Item	Survey Results										
Waste	➤ The environmental standard of Cambodia and existing results are shown below.										
	No	Parameter	unit	No1	No2	No3	No4	No5	No6	No7	基準値
	1	Total Nitrogen (N)	g/100g	0.28	0.20	0.17	0.23	0.12	0.24	0.39	-
	2	Total Phosphorus (P)	g/100g	0.06	0.06	0.03	0.03	0.01	0.06	0.24	-
	3	Total Potassium (K)	g/100g	0.41	0.27	0.36	0.31	0.26	0.31	0.45	-
	4	Total Organic Carbon (TOC)	g/100g	7.78	8.12	8.80	6.31	2.87	8.41	10.70	-
	5	Iron (Fe)	g/100g	0.36	0.32	0.12	0.14	0.06	0.14	0.53	-
	6	Total Calcium (Ca)	g/100g	0.90	1.10	0.80	0.67	0.34	0.63	1.52	-
	7	Zinc (Zn)	mg / Kg	0.02	0.02	0.01	0.05	0.01	0.02	0.04	< 500
	8	Arsenic (As)	mg / Kg	-	-	-	-	-	-	0.05	< 40
	9	Mercury (Hg)	mg / Kg	-	-	-	-	-	-	0.01	< 10
	10	Lead (Pb)	mg / Kg	-	-	-	-	-	-	0.05	< 420
	11	Cadmium (Cd)	mg / Kg	-	-	-	-	-	-	0.02	< 5.0
	12	Chromium (Cr)	mg / Kg	0.03	0.02	0.02	0.03	0.01	0.05	0.12	< 380
	13	Nickel (Ni)	mg / Kg	-	-	-	-	-	-	3.20	< 75
14	Water content	g/100g	79.40	85.40	90.20	91.10	96.70	87.50	64.40	-	
The environmental standard are selected and described in the corresponding section out of the 74 items set in "Prakas No. 387 on Standard of Pollution or Hazardous Wastes in Cambodia".											
Soil Contamination	➤ As described in the item on waste, the components of sludge are less than the environmental standards and soil contamination has not been confirmed.										
	➤ The dredging work was carried out under appropriate management and it is assumed that the possibility of soil contamination by this work is low.										

Item	Survey Results				
Noise and Vibration	➤ The environmental standard of noise is shown below. There is no standard related to vibration.				
	No	Area	Period of time (dB)		
			From 6h AM to 18h	From 18h to 22h	From 22h to 6h AM
	1	Quiet areas - Hospitals - Libraries - School - Kindergarten	45	40	35
	2	Residential area: - Hotels - Administration offices - House	60	50	45
	3	Commercial and service areas and mix	70	65	50
	4	Small industrial factories intermingling in residential areas	75	70	50
	Reference : ANNEX 6, Sub-decree No.42 ANK/BK The Control of Air Pollution and Noise Disturbance,				
	➤ The existing result of noise is shown below.				
	Time		Cambodian Standard (*), dB(A)	Result, dB(A)	
Station 1: at Kunthak Bopha, Wat Phnom Northern, date July 20-21, 2016					
Day	(6:00 - 19:00)	70	63-66		
Evening	(19:00 - 23:00)	65	58-65		
Night	(23:00 - 6:00)	50	55-64		
Station 2: at Tela Station, Toul Kork date July 21-22, 2016					
Day	(6:00 - 19:00)	70	68-75		
Evening	(19:00 - 23:00)	65	59-67		
Night	(23:00 - 6:00)	50	53-68		
(*) Sub-Decree on Air Pollution Control and Noise Disturbance, Annex 6: Maximum permitted noise in public and residential area, point 3 Commercial and service areas and mix.					
Reference: JICA Survey Team, MOE's laboratory, the IEIA report on Phase IV, 2016.,					
➤ Based on the above measurement results in the Phnom Penh, the noise of daytime and night time is almost lower than the environmental standard but noise from the midnight to early morning tends to be somewhat higher.					
➤ The daily operation time of this equipment is about 30 minutes to 40 minutes even when dredging work of 2 cycles is operated and it is not assumed that it causes the impact on the surrounding residents. In addition, as maintenance of equipment and prevention of unnecessary idling are properly implemented, it is assumed that the influence of noise and vibration on the environmental and social aspect accompanying this project is minimized.					
Odor	➤ There is no standard related to odor.				
	➤ The dredging work was carried out under appropriate management and it is assumed that the influence of odor on the environmental and social aspect accompanying this project is minimized.				
Existing infrastructure and social services	➤ Transportation of heavy machinery is basically avoided during the time when traffic jams are expected. Thus, it is considered that existing social infrastructure and social services, especially the influence on transportation, are minimized.				
Working conditions	➤ The dredging work is carried out within fixed time (8:00 to 17:00) and no overtime has occurred.				
	➤ As a resting place is installed and labourers take a break regularly as measures against heat stroke, it is considered that appropriate measures to improve the working environment are taken.				

Item	Survey Results
Accident	➤ The meeting to alert attention is conducted before working every time. Traffic control personnel guide vehicles and people as traffic safety measures when transporting and installing heavy machinery. Thus, it is considered that appropriate measures to mitigate accidents were carried out.

(2) Self-reliant and Continual Activities to be Conducted by Counterpart Organization

Amphibious excavator for cleaning drainage channel was provided to DSD which is responsible for the maintenance of sewer and drainage in Phnom Penh, and technical transfer of sludge cleaning technique was implemented. DSD is used to operate and maintain a machine so they could smoothly acquire the operation technique.

It is expected that budget ensure and drainage cleaning work are conducted in the future, utilizing the periodical report and budget request form prepared in this project.

4. FUTURE PROSPECTS

(1) Impact and Effect on the Concerned Development Issues through Business Development of the Product/ Technology in the Surveyed Country

The following development effects are obtainable through business development:

- Improving living and sanitation conditions and mitigating inundation through dredging the sludge accumulating in drainage channels, rivers, and lakes in Cambodia.
- Acquiring and upgrading the operation and cleaning technique.
- Creating employment opportunities and increase income.
- Promoting environmental business by the private sector.
- Creating opportunities to raise public awareness.
- Disseminating the same technology and products into neighboring countries.

(2) Lessons Learned and Recommendation through the Survey:

- To conduct preliminary survey in the drainage channel and lake etc. before cleaning.
- To establish a work plan based on the survey result.
- To clean the drainage channel and lake etc. properly utilizing operation and maintenance manual prepared in this project

- To record and store the cleaning performance and to request a budget based on actual performance
- To maintain the machine regularly in order to extend its lifespan.

CAMBODIA

Verification Survey with the Private Sector for Disseminating Japanese Technologies for Improvement of Sanitation and Living Condition Using Amphibious Excavator

TAIHO SHOJI CO., LTD., Japan

Concerned Development Issues in CAMBODIA

- Increase of pollution load of surrounding water area due to inflow of untreated wastewater
- Sedimentation of sludge due to insufficient maintenance in the drainage open channel
- Lack of cleaning knowledge and technique in zones without approaches to drain channel (zones without administrative roads)

Implemented Activities in the Survey

- Removal of sludge which accumulates in drainage open channels in Phnom Penh (Trabek and Tumpun drainage channel)
- Fostering of local staff operators by creating OJT plan and operation maintenance manual.
- Planning of a phased drainage channel cleaning plan for Phnom Penh
- Establishment of a sustainable structure which operates the proposed product and the drainage channel cleaning plan
- Formulation of business development plan to disseminate the proposed product to government agencies, construction companies in other cities of Cambodia

Proposed Products/Technologies



Product and Technical name
 "Amphibious Excavator" is designed to work in a place where the existing excavator can not invade. It has a traveling device having sealed hollow structure and it can be used such as drainage, river, lake and other water, soft ground and wetland.

Survey Overview

Name of counterpart: Department of Public Works and Transport, Phnom Penh Capital City (DPWT/PPCC)
 Survey duration: from February 2017 to April 2018 (Total 14 Months)
 Survey Area: drainage open channel in Phnom Penh (Trabek and Tumpun drainage channel)

Impact on the Concerned Development Issues in CAMBODIA

- Efficient cleaning work using the proposed equipment eliminates sludge accumulated in the drainage channels and improves the public health and natural environment of the surrounding area

Outputs and Outcomes of the Survey

- Output 1: Advantages and effectiveness of Amphibious Excavator is verified in cleaning garbage and accumulated sludge in the drainage open channels in PPCC.
- Output 2: DPWT/PPCC's capacity for operating the Amphibious Excavator is developed through on-the-job training, and operating manuals for the Amphibious Excavator and phased drainage channel cleaning plan utilizing Amphibious Excavator are established.
- Output 3: Framework for sustainable drainage open channel cleaning work is established.
- Output 4: Business Plan is established to disseminate the Amphibious Excavator to the governmental agencies concerned, construction companies and construction equipment retailers in the entire Cambodia.