MYANMA PORT AUTHORITY (MPA)
THE REPUBLIC OF THE UNION OF MYANMAR

DATA COLLECTION SURVEY REPORT FOR IMPROVEMENT OF NAVIGATION CHANNEL OF YANGON PORT IN THE REPUBLIC OF THE UNION OF MYANMAR

FINAL REPORT

VOLUME 1

MAIN REPORT

MARCH 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
ASIA AIR SURVEY CO., LTD.

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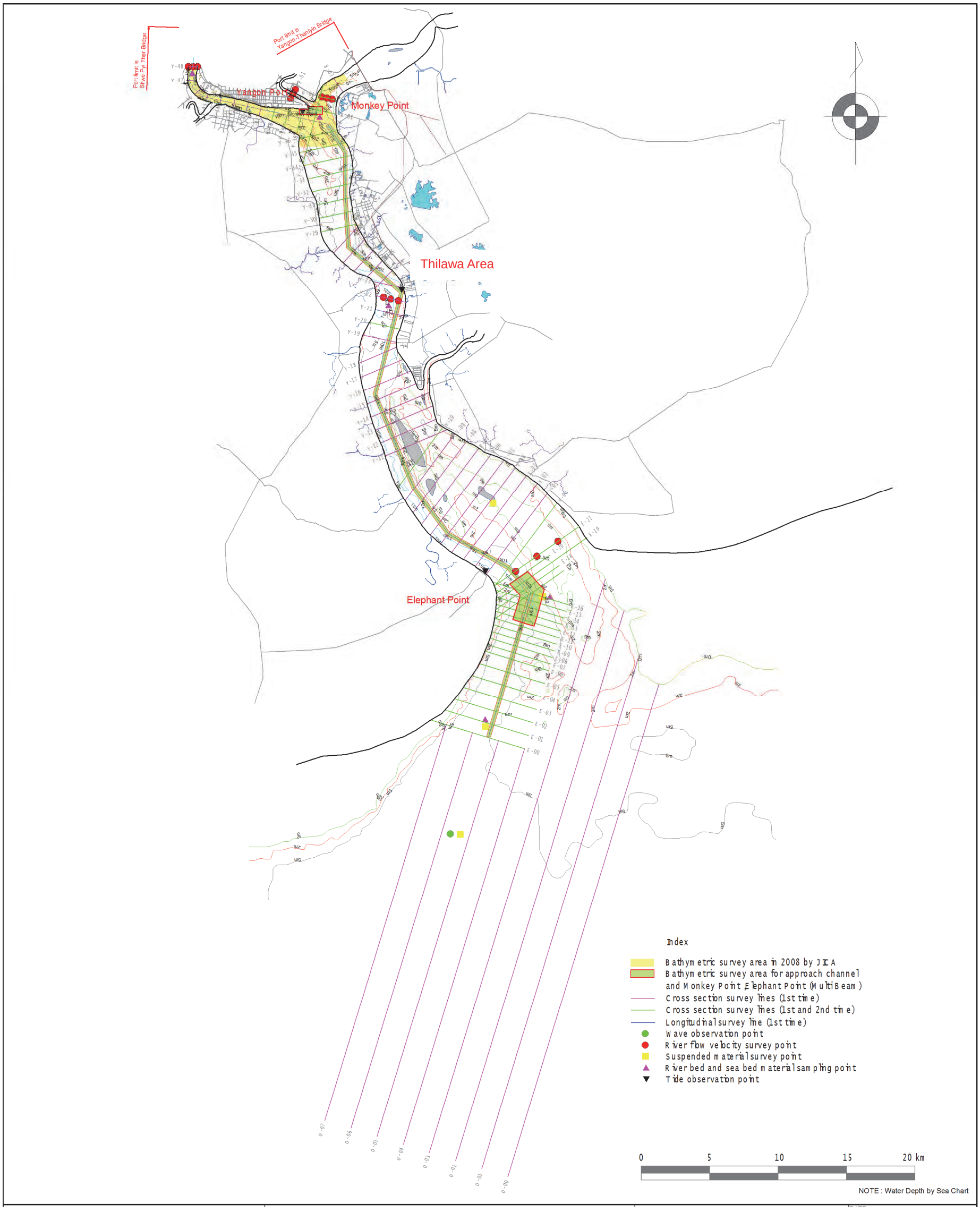
Yangon River


Port limit is Yangon-Thanlyin Bridge
Port limit is Shwe Pyi Thar Bridge
Yangon Port
Monkey Point
Thilawa Area
Elephant Point
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Bathymetric survey area in 2008 by JICA
Bathymetric survey area for approach channel and Monkey Point,Elephant Point (MultiBeam)
Cross section survey lines (1st time)
Cross section survey lines (1st and 2nd time)
Longitudinal survey line (1st time)
Wave observation point
River flow velocity survey point
Suspended material survey point
River bed and sea bed material sampling point
Tide observation point
0
5
10
15
20 km
NOTE : Water Depth by Sea Chart

Study Area

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Abbreviations

A	AWPT	Asia World Port Terminal (Yangon)
	AIPT1	Ahlone International Port Terminal (Yangon)
B	BSW	Bo Aung Gyaw Street Wharf (Yangon)
C	CAD	Computer Aided Design
	CDL	Chart Datum Level
D	dm	diameter
	D_{60R}	representative grain size
	Dwell time	The time cargo remains in a terminal's in-transit storage area
F	FY	Fiscal Year
G	GDP	Gross Domestic Product
	GPS	Global Positioning System
	GRT	Gross Register Tonnage
H	HOB	Hteedan Oil Terminal (Yangon)
	HPT	Hteedan Port Terminal (Yangon)
I	ICD	Inland Container Depot
	IMF	International Monetary Fund
K	knot	1knot = 0.514 444 m/s
L	LOA	Length overall (of the ship)
M	MIP	Myanmar International Port (Yangon)
	MIPL	Myanmar Integrated Port Limited (Thilawa)
	MITT	Myanmar International Terminal Thilawa (Thilawa)
	MSL	Mean Sea Level
N	NLD	National League for Democracy
S	SPW	Sule Pagoda Wharf (Yangon)
T	TEU	Twenty-foot Equivalent Unit
	TSHD	Trailing Suction Hopper Dredger
U	UN	United Nations Development Programme
	UTM	Universal Transverse Mercator
	USDP	Union Solidarity and Development Party
V	VTS	Vessel Traffic Service
W	WGS-84	World Geodetic System 1984

EXECUTIVE SUMMARY

S1. Objectives and Contents of Survey

S1.1. Recently, the cargo demand of Yangon Port is rapidly increasing, for which large-scale development plans are being implemented in the Thilawa area. The objective of this survey is the preparation of data that could be utilized to analyze how much ship traffic can be accommodated by the Yangon River channel, and to examine what kind of channel improvement facilities will be effective to increase the channel capacity, under the circumstances of the river that has two bottlenecks for navigation, namely Monkey Point and Elephant Point.

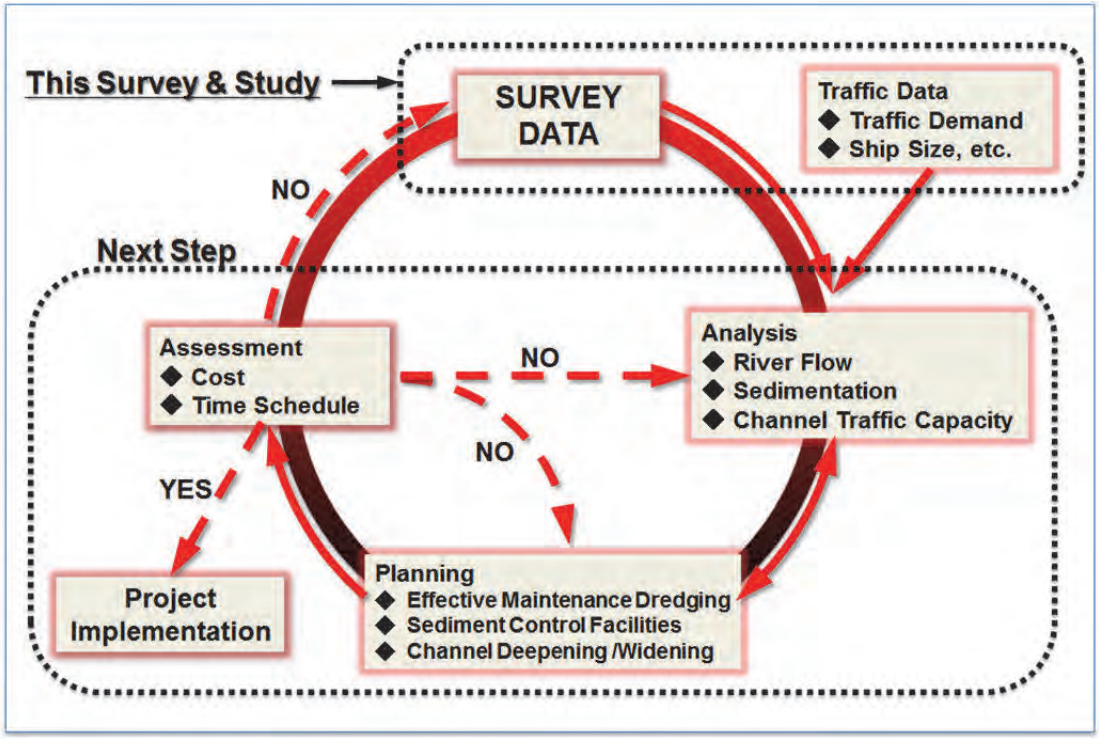


Figure S 1.1. Purpose of This Data Collection Survey

S1.2. For such purpose, the natural condition survey works covered not only a bathymetric survey but also other surveys such as flow speed, waves, suspended solids, and material sampling and testing, etc., which could be utilized for future numerical analyses for riverbed/coastal configuration deformations. In addition, information regarding cargo statistics and the practical method of navigation in the channel was collected. The way to use the collected data is summarized in the following table.

Table S1.1. Relationships Between Analyses and Collected Data

		Analyses in The Next Step		
		Coastal Sedimentation	River Bed Movement	Ships Traffic
Survey Data of This Study	Bathymetric Survey	○	○	○
	Flow Speed	○	○	○
	Soil Sampling	○	○	
	Suspended Solid	○	○	
	Wave Record	○		○
	Tidal Level	○	○	○
	Cargo Statistics			○
	Ship Size and Navigation Method			○

S2. Collected Information and Comments

S2.1. Natural Conditions Survey Data

S2.1.1. The following figure shows the results of the multi-beam survey at Elephant Point and Monkey Point before and after the rainy season. The survey data shows that there is little change in the channel depth at Monkey Point as MPA is executing continuous dredging works. However, the data made the fact to be known that there is considerable change in the channel floor, approximately ±5.0 m at Elephant Point during the rainy season. MPA is conducting a bathymetric survey to monitor the change of water depth at Elephant Point every month, and is changing the channel route whenever it is necessary to achieve safe navigation of the ships.

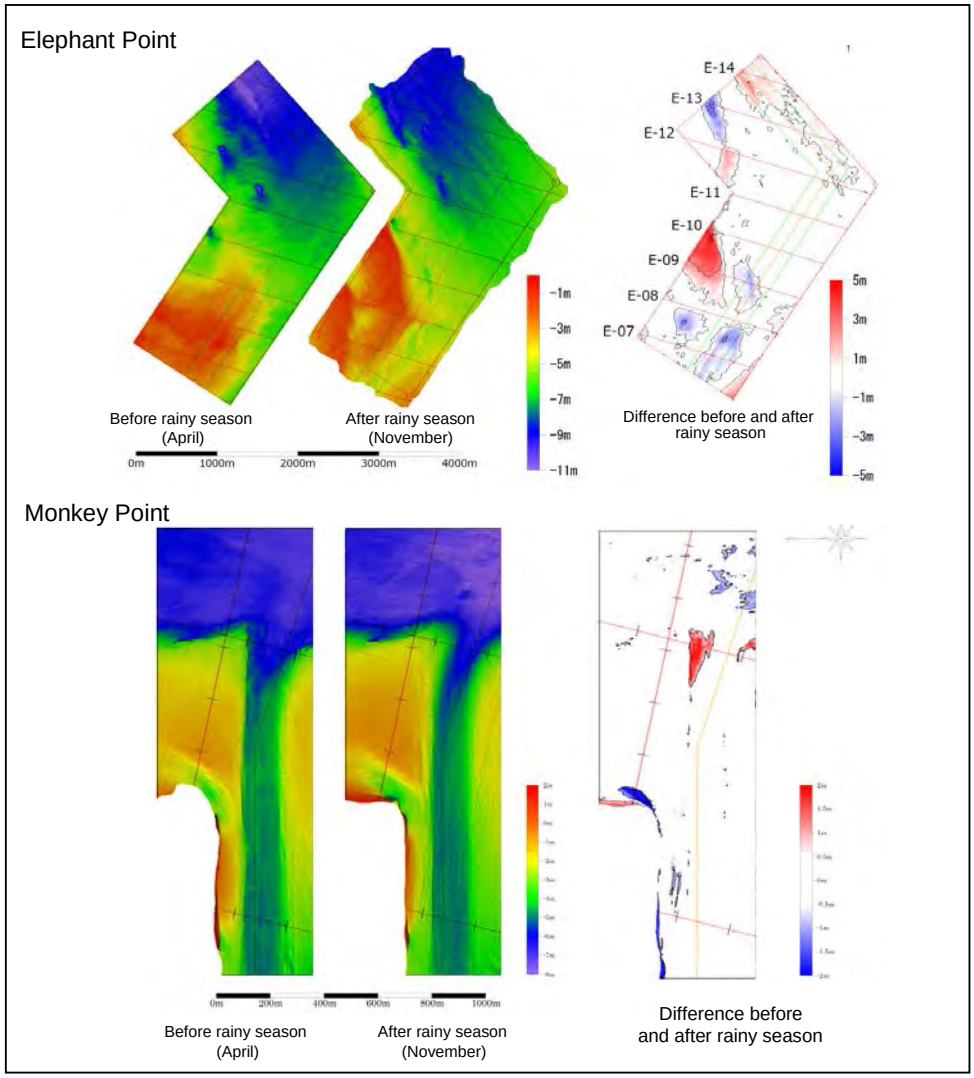


Figure S2.1. Change of Water Depth Before and After Rainy Season Elephant Point and Monkey Point

S2.1.2. The following factors are pointed out as causes of the change in water depth.

(1) According to the survey data of flow speed and bed material sampling, the condition of the river floor is such that it is easily moved, and the riverbed soil seems to be always moving upstream and downstream in accordance with the change in flow directions due to tidal movement.

(2) In the Yangon River, a large volume of sand material is continuously dredged by private parties and is used as fine aggregate in concrete material. This seems to be one of the factors of the change in the water depth of the channel. The estimate made by the JICA Study Team shows that the annual dredging volume for this purpose is approximately 1.3 million m^3.

(3) According to comparisons of the old nautical charts made by the UK in the years 1904 and 1930, and the recent satellite image of 2015, the river mouth has had a tendency to grow wider and shallower during the past 100 years. The analyses made by the JICA Study Team using the satellite images show that the river bank's erosion moves a volume of approximately 1.8 million m^3 from the right bank and 0.6 million m^3 from the left bank of the river, whose volume is assumed to be discharged to the river mouth every year.

(4) According to the study report made by the United Nations in 1976, the annual river discharge volume of bed material from the Yangon River is estimated at 100 million m^3. With the current decrease of forest in the river basin, river discharge volume might increase every year. Such increase of river water would cause an increase of discharge soil material by the river.

(5) The sea floor at the Yangon River mouth has a quite gentle slope toward the ocean. According to the wave monitoring data, it was found that the wave heights were generally low during the monitoring period, however their periods were constantly longer than common cases. In general, long period waves hold a certain energy to move the sea floor, which might influence the frequent change in the seabed configuration at the river mouth.

S2.1.3. It is recommended in the analyses as the next step to this survey that the "riverbed change analysis" should be applied to the upstream from Elephant Point, to calculate the state of riverbed materials moved by river/tidal flow, and the "siltation analysis" should be applied to the downstream from Elephant Point to calculate the state of sedimentation moved by waves/currents of the sea.

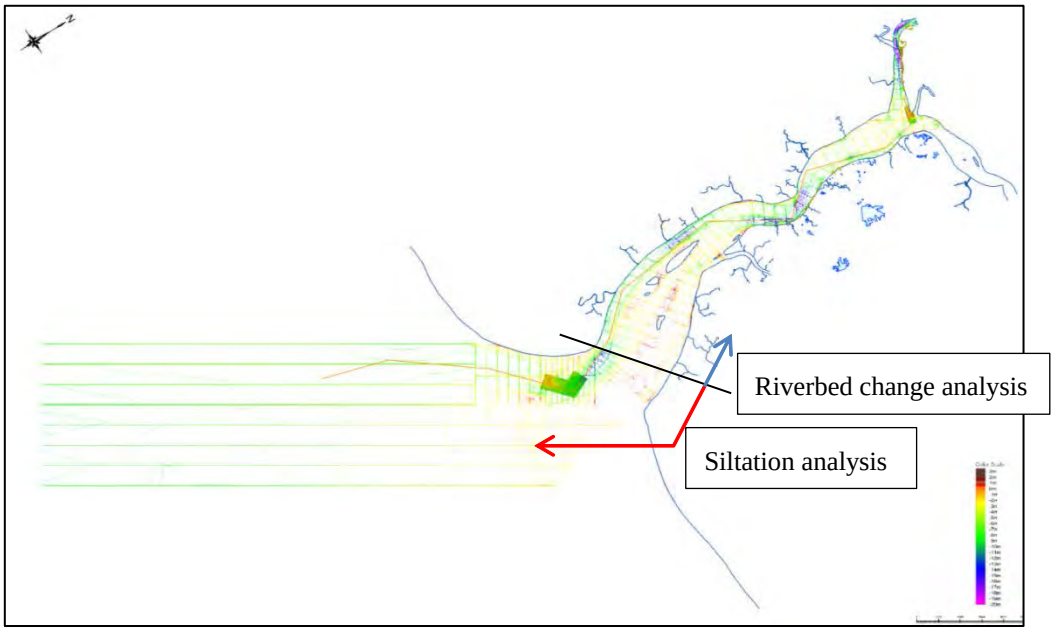


Figure S2.2. The Method of Analyses for River and Coast

S2.2. Channel Traffic Data

S2.2.1. According to the statistics of Yangon Port recorded by MPA, container throughput in 2014 was 0.72 million TEU, the cargo volume other than containers was 21.7 million tons, and the total of containers and other cargo was 30.6 million tons. The data shows that the volume of general/bulk cargo has increased a little during recent years since 2011, whilst container cargo is rapidly increasing with a growth rate over 20%. The JICA report issued in 2011 estimated the demand forecast of container cargo to increase at an average 16% growth rate. The actual current increase in container cargo appears greater than the forecast.

S2.2.2. It is recommended for the purpose of increasing traffic capacity of the existing channel that ship navigation during night time should be introduced, which would make it possible to utilize all high tide hours twice in a day. For this purpose, it should be set to work on projects such as improvement of navigation aids, installation of VTS systems for safe navigation, and to take measures to increase the number of pilots and establishments for their education and training.

Chapter 1. General

1.1. Background of the Study

On the further development of the Republic of the Union of Myanmar (hereafter: “Myanmar”), the most important thing is to develop the Yangon City Ports. The Yangon City Ports are comprised of Yangon Port, located in the city area, and Thilawa Port, regarded as a new development. Both ports are river ports located along the Yangon River.

The Yangon River is one of the big rivers in Myanmar. Although the height difference of water level between the rainy and dry seasons is approximately 1 m only, daily tidal change is over 6 m and the maximum river flow speed in ebb tide is very fast, reaching about 6 knots. Besides, it flows backwards upstream with almost the same speed in ebb tide as when it is in rising tide. That would be the main reasons to bring a big change of the riverbed shape and it can be seen especially at Monkey Point (known as Inner Bar), located at the junction point of two rivers, the Bago River and Pazundaung Creek, and Elephant Point (known as Outer Bar) near the west side of the river mouth of the Yangon River. These two points are regarded as constraints on the vessel traffic in the Yangon River Channel.

Amid the rapid economic growth of Myanmar, the urgent development of the Yangon City Ports is highly expected. Therefore, it is very important to grasp the current condition of the Yangon River, although the river has complicated natural conditions. From this viewpoint, The Data Collection Survey for Improvement of the Navigation Channel of Yangon Port is conducted as the initial stage for the future examinations and analyses.

1.2. Items of the Study

The survey / monitoring items to be conducted in this Study are shown in the following.

Table 1.2.1. The Survey and Monitoring items

Items	Period	Q'ty	Remarks
(1) Bathymetric Survey (River & Seabed Surveys)	Pre-rainy season(May~Jun.) Post-rainy season (Nov.~Dec.)	6.9 km^2 X 2 times	Multi-beam survey at the Monkey & the Elephant Points
	Post-rainy season (Nov.~Dec.)	16.2 km^2	Multi-beam survey at the navigation channel
(2) Bathymetric Survey (River Sectional Survey)	Pre-rainy season(May~Jun.) Post-rainy season (Nov.~Dec.)	River: 364 km Sea: 361 km River: 177 km	Single-beam survey *1
(3) Wave Monitoring	Continuous from Jun.	For 5 months	Interruption from Jun. to Sep.
(4) River Flow Observation	Jun. and Oct. in low tide	Total 4 times	Observation in low tide and, consecutive 12 hours observation
(5) SS Survey	Jun. and Oct.	4 sections	2 times
(6) River / Seabed Sampling	Aug. in low tide	5 points	1 time
(7) Tide Observation	During bathymetric surveys	3 points	Monkey Point, Thilawa Area, and Elephant Point

Note: Actually multi-beam equipment is used for (2) as well.

Source: The JICA Study Team

At first, the commencement of the surveys / monitoring were scheduled from April 2015, however, it was delayed one month due to the delay of approval procedures in MPA. Fortunately, the start of the rainy season in this year was late and other favorable conditions aligned so all surveys / monitoring were completed on time.

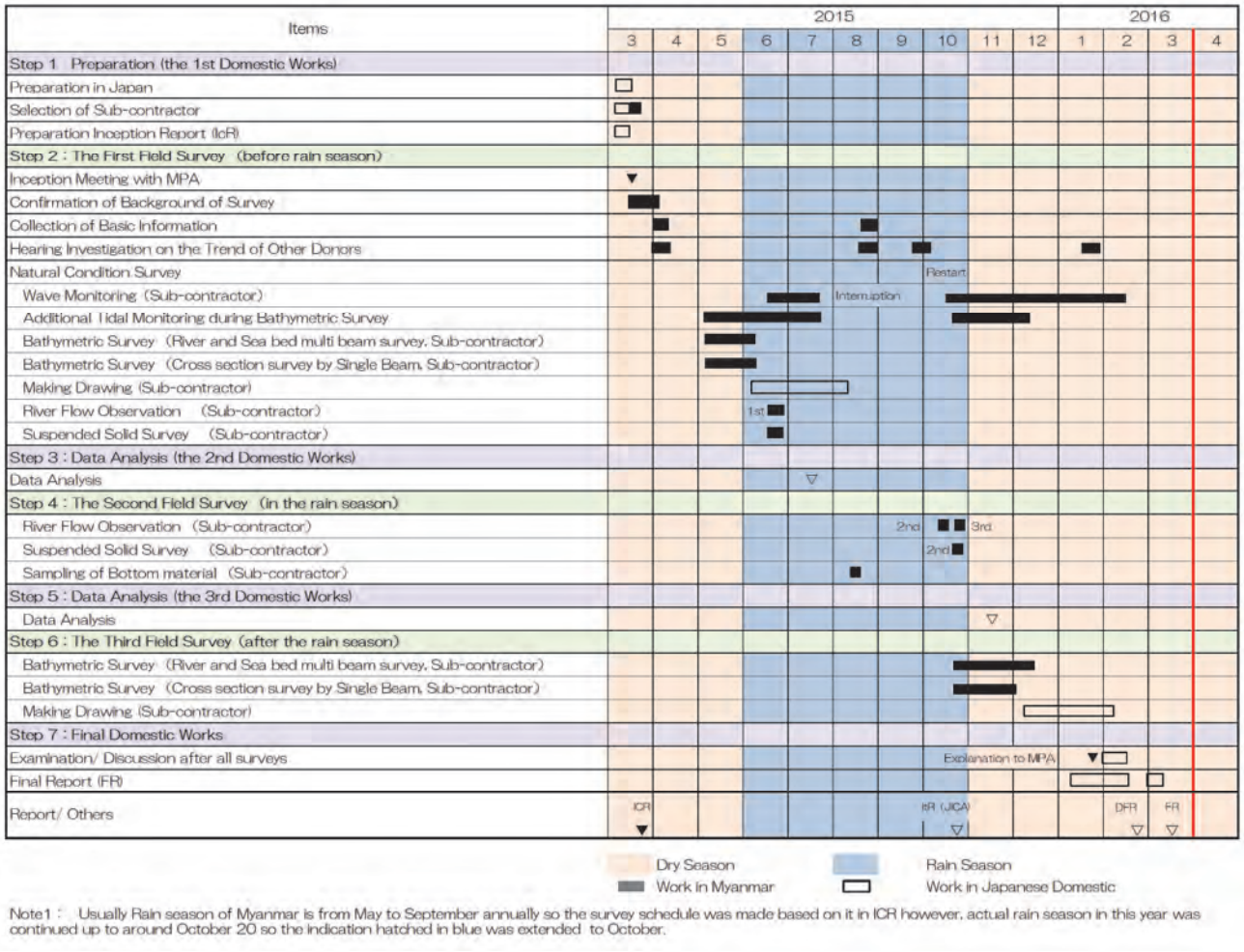
As for the wave monitoring, its commencement was also delayed for the same reason, and the monitoring was finally started from June 2015. After the installation of the equipment at the offshore point, the equipment was destroyed and the monitoring was interrupted but new equipment was procured and the monitoring was re-started from October 2015. The monitoring continued to the middle of February 2016 to get data as long as possible within the limited Study period.

All survey / monitoring data collected in this Study were redacted for further examinations and analysis. At the same time, the existing basic information related to the Yangon River like cargo-handling volume in the Yangon City Ports was collected. Based on the survey results and the collected information, discussions with some trial calculations were done in this Study.

1.3. The Schedule of the Study

The schedule of the Study is shown in the following.

Table 1.3.1. The Schedule of the Study



Note1 : Usually Rain season of Myanmar is from May to September annually so the survey schedule was made based on it in ICR however, actual rain season in this year was continued up to around October 20 so the indication hatched in blue was extended to October.

Source: The JICA Study Team

Chapter 2. Overview of Yangon Area and Port

2.1. Overview of the Politics and Economy of Myanmar

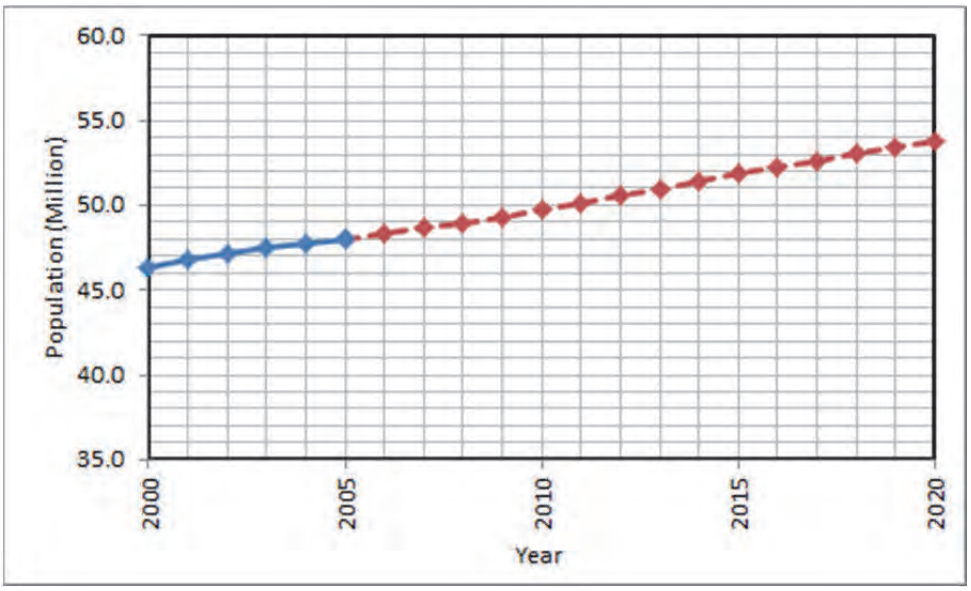
2.1.1. Politics

As the result of the general election in October 2011, the Union Solidarity and Development Party (USDP) obtained approximately 80% of the seats in the House. In the following year, the office of President Thein Sein started in March 2011. The government of Myanmar under the power of Thein Sein strongly forwarded the democratization of the nation. Western countries admired the Myanmar government's effort for the democratization and development of the economy; the USA eased economic sanctions on the export of Myanmar's products in November 2012 and the EU also eased sanctions on its import/export trades in April 2013. Similarly, Japan also admired the government's efforts, and it changed its policy for economic assistance to Myanmar, restarting financial support to Myanmar by means of financial schemes including ODA Loans.

2.1.2. Economy

(1) Population

The population of Myanmar is 51.41 million, according to statistics that were updated and announced by the government in September 2014. Figure 2.1.1. shows a graphic chart of Myanmar's population taking the data estimated by the IMF (World Economic Outlook Database, April 2015, IMF). The IMF estimates the future growth of the population of Myanmar at 0.7 ~ 0.8% annually.



(Note: IMF Staff's Estimate)

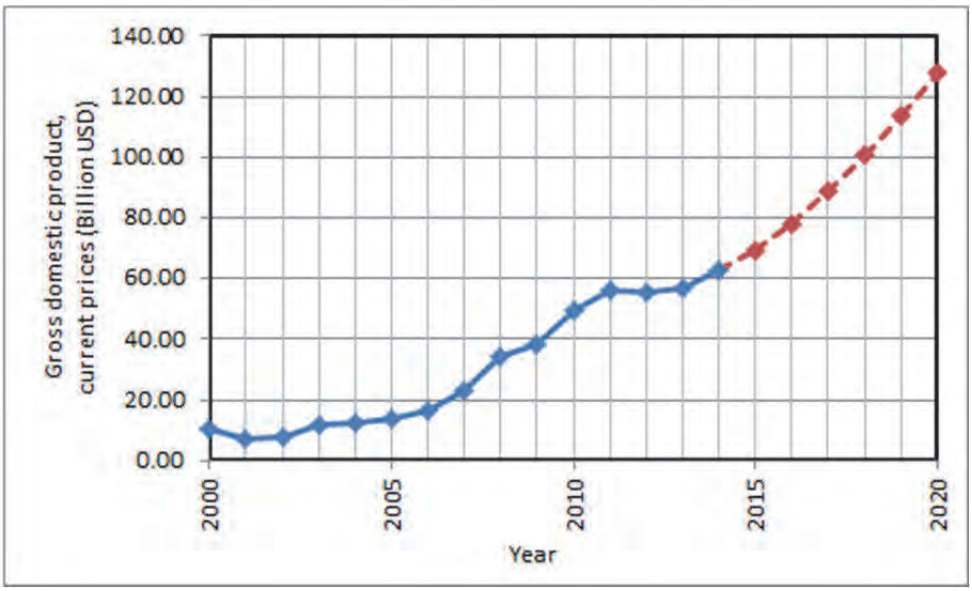
Source: World Economic Outlook Database, April 2015, IMF

Figure 2.1.1. Population of Myanmar

(2) GDP

For the present Myanmar, not only Japan but also China and Western countries are presenting their strong business intentions for economic investment. For instance, a number of Japanese firms that opened regional offices increased to 280, which is about six times the numbers of 5 years ago.

According to the estimate by the IMF, the nominal GDP of Myanmar in FY 2012/13 was US$55.3 billion. Figure 2.1.2. shows the graphic chart for Myanmar's GDP growth, taking the data estimated by the IMF (World Economic Outlook Database, April 2015, IMF). The IMF estimates the future growth of the GDP of Myanmar at 12 ~ 14% annually. The official estimate of economic growth rate of FY 2012/13 was 6.3%.



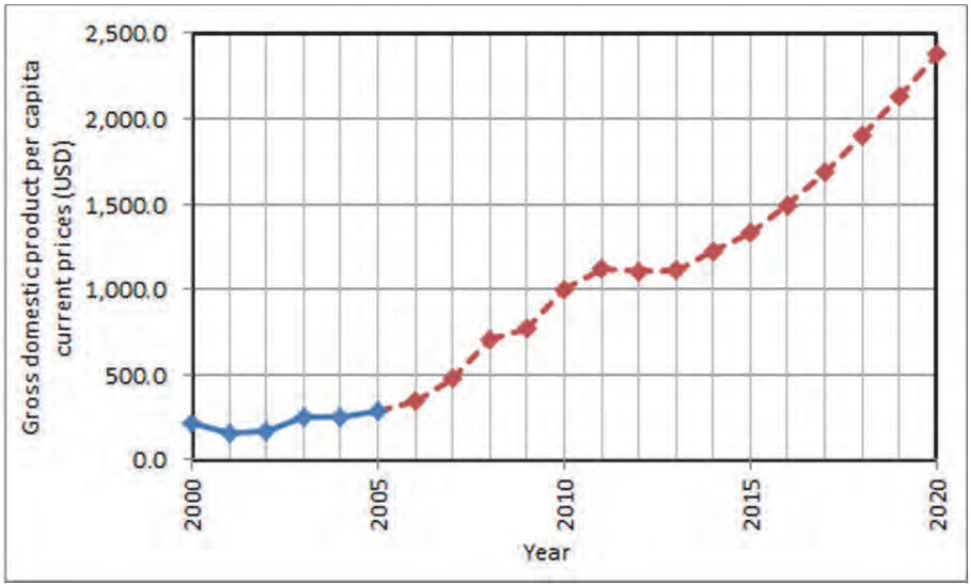
(Note: ▬ IMF Staff's Estimate)

Source: World Economic Outlook Database, April 2015, IMF

Figure 2.1.2. GDP of Myanmar

(3) GDP per Capita

According to the estimate by the IMF, the nominal GDP per capita of Myanmar in FY 2012/13 was US$868. Figure 2.1.3. shows the graphic chart for Myanmar's GDP per capita, taking the data estimated by the IMF (World Economic Outlook Database, April 2015, IMF). The IMF estimates the future growth of the GDP per capita of Myanmar at 10 ~ 14% annually.



(Note: ▬ IMF Staff's Estimate)

Source: World Economic Outlook Database, April 2015, IMF

Figure 2.1.3. GDP of Myanmar

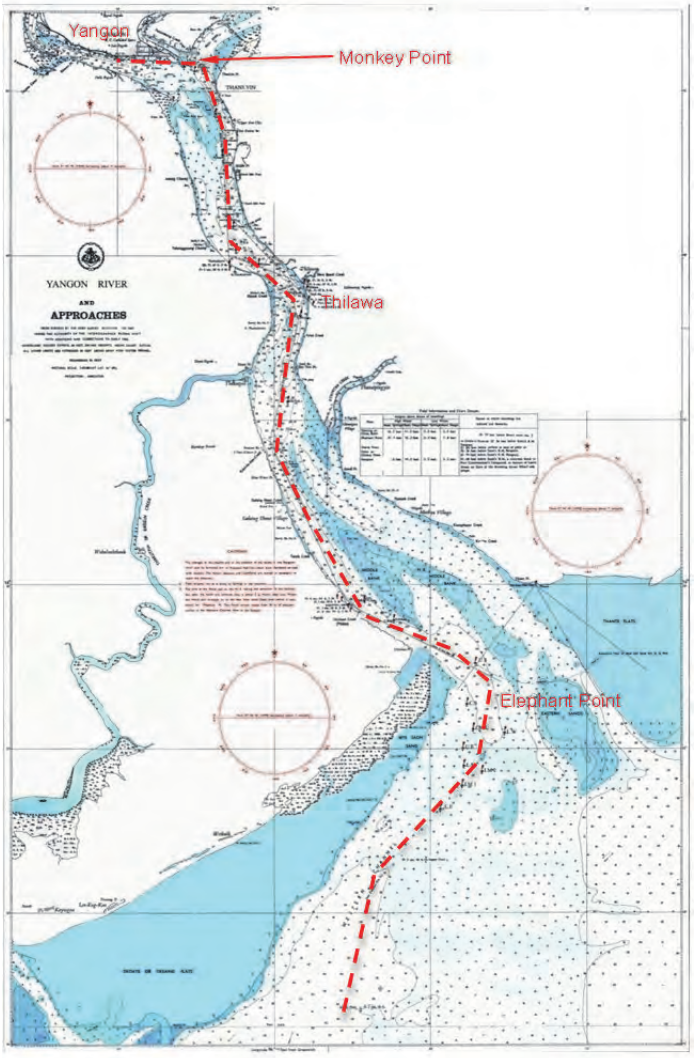
(4) Foreign Trade

Foreign trade of Myanmar in FY 2012/13 was US$8.97 billion for export and US$9.07 billion for import. (Source: Central Statistics Bureau of Myanmar) The major trading items are as follows. Export: natural gas, beans, precious stones (jade), and teakwood/wood. Import: crude oil, mechanical parts, palm oil, textiles, and metal/industrial goods. The major trading partner countries are as follows. Export: Thailand, China, India, Japan, Singapore, and Korea. Import: China, Singapore, Japan, Thailand, Malaysia, and Korea. (Source: Central Statistics Bureau of Myanmar)

2.2. The State of the Port

2.2.1. Locations of the Port Facilities

The Yangon Port is a river port located at the north latitude 16°47' and the east longitude 96°15', which is 48 km upstream from the mouth of the Yangon River. Port facilities are distributed in two locations, one of which is the area adjoining the Yangon City area and the other is the Thilawa area approximately 16 km downstream from Yangon City. The "Yangon Port" has the genetic name covering the two locations' port facilities, and both facilities are governed by Myanma Port Authority (MPA).



Source: The JICA Study Team

Figure 2.2.1. Location of the Yangon Port and River Channel

Along the port channel, there are two shallow spots that are called "Elephant Point" (depth -6m) at the river mouth and "Monkey Point" (depth -4m) at the immediate downstream of Yangon City area. The ships entering and sailing from the Yangon Port have to pass these shallow spots during high tide. The

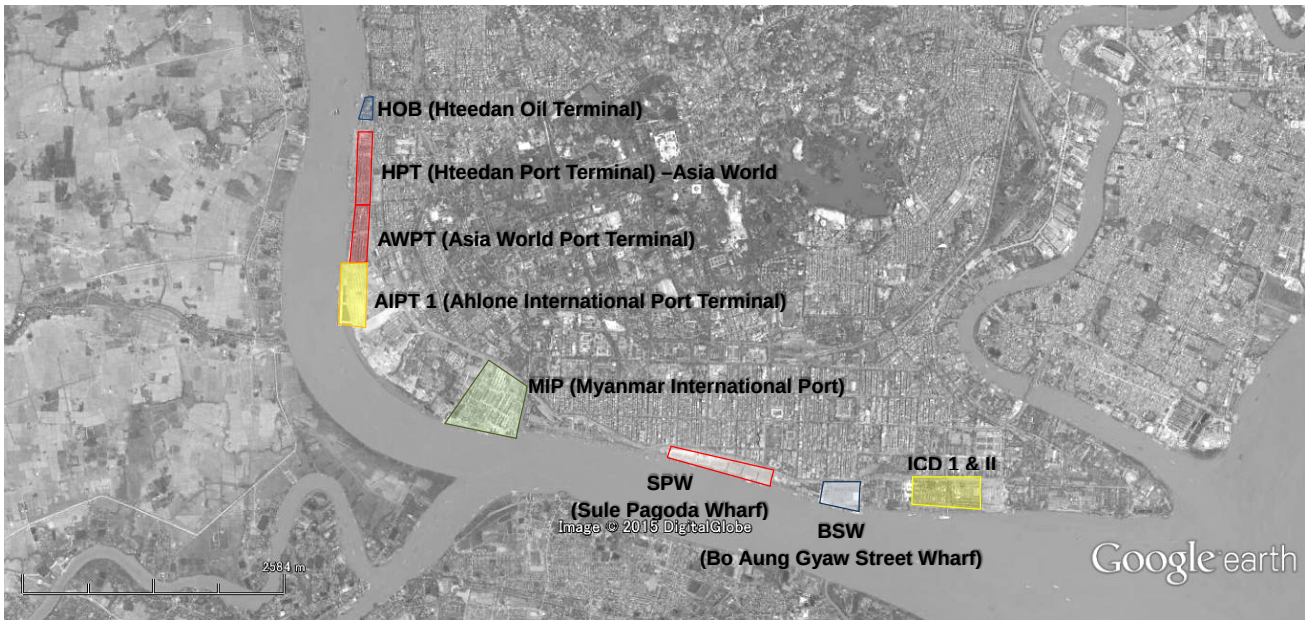
port regulation orders that ships over 200 GRT shall enter/sail with a port pilot on board. The distance between the Yangon area and the Thilawa area is approximately 16 km, the distance between Thilawa and Elephant Point is approximately 32 km, the distance between Elephant Point and the pilot station is approximately 32 km. The high water level (HWL) of the port is +5.85 m. During flood tide, the river flows backward, reaching over Yangon City port area. The flow speed of the river during both flood/ebb tides becomes approximately 4 ~ 6 knots. The wave conditions in the river mouth water are generally calm with wave heights less than 2.0 m.

2.2.2. Overview of Port Facilities of Each Terminal

Figure 2.2.2. and Figure 2.2.3. show the locations of the port terminals. In the Yangon City area, there are 7 port terminals with quays and ICDs without quays. The terminal of HOB is for liquid cargo, and SPW is for general cargo, which has warehouses in front of the quays. Container terminals are HPT, AWPT, AIPT1, MIP, and BSWICD I&II. HPT and AWPT are operated by Asia World Port Terminal Co., which has the largest container cargo throughput among the terminals in Yangon Port. The total container throughput of HPT and AWPT in 2014 was 440 thousand TEU, which is approximately 60% of the throughput of Yangon Port, whose total throughput was 720 thousand TEU. AIPT1 and MIP are the terminals that started their operation, which shows the recent trend of active private investors taking business opportunities based on the sharp increase of container cargos in Yangon.

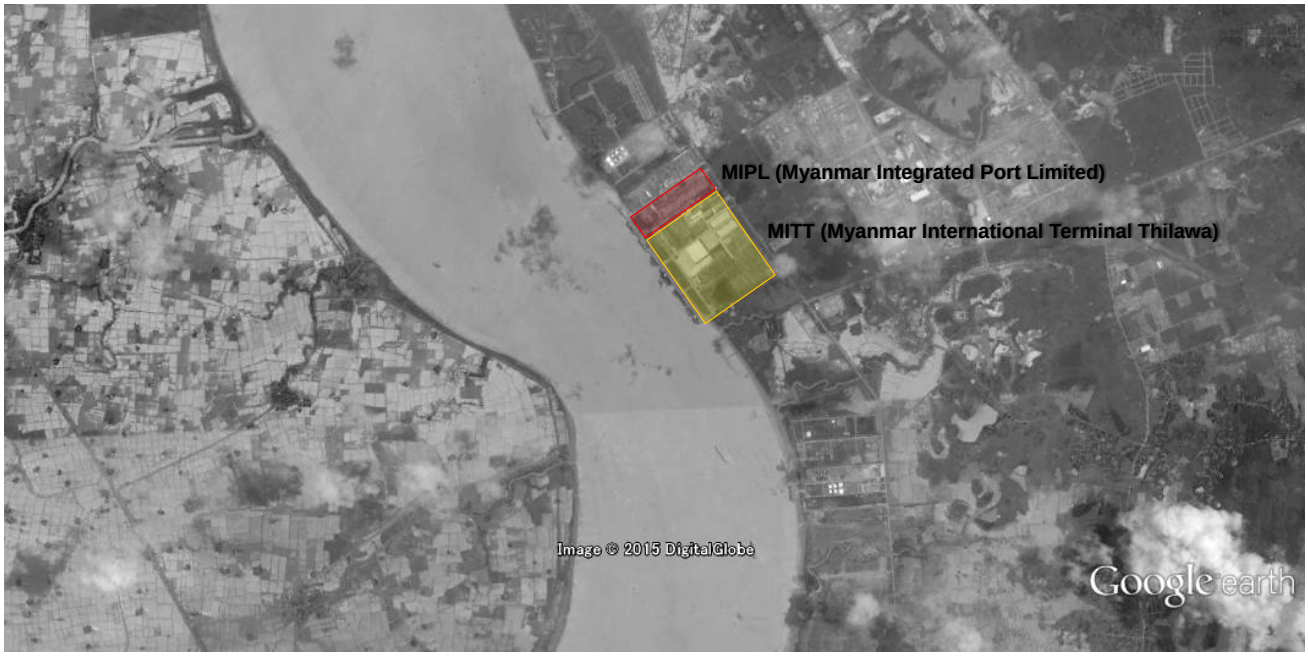
In the Thilawa area, MIPL and MITT are in operation. MIPL is the terminal for general cargo and handles no containers, while MITT was developed as a container terminal. Although the increase of container cargo in Yangon City area is very rapid, the container volume of MITT in 2014 was only 14 thousand TEU, which is a 2% share of the total cargo volume of Yangon Port. However, MITT announced the redevelopment plan of its container terminal, which will achieve a 1-million-TEU capacity, observing the current strong increase of cargo demand of Yangon. The area downstream near MITT is currently commencing port terminal development financed by Japan’s ODA, in which the planned container-handling capacity of the first phase of development is 200 thousand TEU.

The list of facilities/equipment of each terminal, taken from the terminals’ brochures, is shown in Table 2.2.1.



Source: The JICA Study Team

Figure 2.2.2. Locations of Port Terminals in Yangon City Area



Source: The JICA Study Team

Figure 2.2.3. Locations of Port Terminal in Thilawa Area

Table 2.2.1. List of Facilities/Equipment of Each Terminal

Location	Yangon									Thilawa	
Terminal Name	HOB	HPT	AWPT	AIPT	MIP	BSW	SPW	ICD (1)	ICD (2)	MIPL	MITT
Number of Berth	1	2	3	1		3	7	-	-	1	5
Cargo Equipment											
QGC (no.)		2	2 for Future	3	5	2	-	-	-	-	2
HMC (no.)		-	3	2	Gottwold 7		-	-	-	-	-
RTG (no.)		4	5 for Future	4	12	3	2	-	-	-	3
Reach Stacker (no.)		3	13	5	20	5	1	41 ton 5 high : 1 8 tons 7 high: 2	-	-	2 (40 tons)
Mobile Crane (no.)		-	-	1	8	-	3	-	-	-	-
Forklift (36t) (no.)		-		-	-	8	-	-	-	-	-
Forklift (15t) (no.)		-	-	1	1	-	1	-	-	1	-
Forklift (10ton) (no.)		-	-	1	15	-	1	-	-	1	-
Forklift (8ton) (no.)		-	-	-	-	-	1	-	8 tons (2 high: 2, 3 high: 2)	-	-
Forklift (7 ton) (no.)	Oil Terminal	-	-	-	1	-	-	2	-	-	-
Forklift (6ton) (no.)		3	4	-	1	2	-	-	-	1	2
Forklift (4ton) (no.)		4	-	-	-	-	23	-	-	-	-
Forklift (5ton) (no.)		-	-	-	5	-	4	-	-	-	-
Forklift (3.5ton) (no.)		-	-	-	1	-	-	-	-	-	-
Forklift (3ton) (no.)		4	1	-	2	2	7	1	-	-	5
2.5 tons battery forklift (no.)		-	-	-	-	5	4	-	-	-	-
Empty Container Lifter (no.)		-	3	3	31	2	3	-	-	-	-
Yard Tractor (no.)		15	30	8	40	24	8	6	-	-	15
Yard Chassis 20'/40' (no.)		15	30	8	40	9		3	-	-	5
Yard Chassis 20' (no.)		-	30	-	-	20		3	-	-	3
Tugboat		-	-	1 (1,100x2 Hp)	2	-	-	-	-	-	-
Terminal Capacity											
Container Yard (sq.m)		Phase I 56,620 sq.m Phase II 37,563 sq.m	-	-	208,382 sq.m	21,165.06 sq.m	-	-		-	
Container Storage Capacity (TEU)		5,222 TEU	7,045 TEU	13,210 TEU	20,265 TEU	2,046 TEU	-	5,000 TEU	1,800 TEU	-	2,500 TEU (present) Phase-I (350,000 TEU/Y) Phase-II (1 Mmillion TEU/Y)
Reefer Container Storage Capacity (TEU)		120 TEU	288 TEU	-	(4,000 TEU)	54 TEU	-	-		-	108 plugs
Empty Container Storage Capacity (TEU)		-	300 TEU	-	(12,000 TEU)	760 TEU	-	-		-	-
Container Stacking Haight - Laddern (layers)		-	4 high	-	5 high	6 high	-	-		-	4 high
Container Stacking Haight - Reefer (layers)		-	3 high	-	3 high	4 high	-	-		-	4 high
Container Stacking Haight - Empty (layers)		-	6 high	-	7 high	6 high	-	-		-	4 high
General Cargo Yard (sq.m)		-	-	2,400 sq.m	-	2,400 sq.m	-	-		1,500 sq.m	
General Cargo Storage Capacity (M. Tons)	Oil Terminal	-	-	8,500 M.T.	-	-	-	-		-	
Total Terminal Operation Area (sq.m)		94,183 sq.m	123,170 sq.m	190,000 sq.m	263905	-	-	-		110,000 sq.m	750,000 sq.m
CFS (sq.m)		372 sq.m	-	-	old: 2,722 sq.m new: 11,852 sq.m	840 sq.m	36,808 sq.m	-		3,000 sq.m	20,000 sq.m
Wharf Length (m)		Phase I 274 m Phase II 366 m	No.1 198 m No.2 156 m No.3 260 m No.4 238 m (Future)	600 m	750 m	No.1 137 m No.2 137 m No.3 183 m	No.1,2,3,4:137m No.5: 168 m No.6:162 m No.7:168 m	-		200 m	
Wharf Depth (m)		9.0 m	9.5 m	-	-	9.0 m	9.0 m	-		10.0 m	10.0 m
Max. Vessel Size (DWT)		-	-	20,000 DWT	15,000 DWT	-	18,000 DWT	-		20,000 DWT	35,000 DWT
Dwell time (days)		-	13 days	2 days	30days - limit 7 days	-	18 days	-		-	14 days (Avg)

Source: The JICA Study Team

2.2.3. Container-Handling Capacity of Port Terminal

The following table shows the calculation of existing terminal capacity for container cargo. In the calculation, the container storage capacity (TEU) of each terminal read from brochures was used. Also, an average dwell time of a container of 13 days and a peak factor of 1.3 were applied.

Table 2.2.2. Container-Handling Capacity in Each Terminal

ITEM	Yangon									Thilawa	
	HOB	HPT	AWPT	AIPT	MIP	BSW	SPW	ICD (1)	ICD (2)	MIPL	MITT
Container Storage Capacity (TEU)	-	10,288	14,952	13,210	20,265	2,046	-	5,000	1,800	-	2,500
Reefer Container Storage Capacity (TEU)	-	120	288	-	-	54	-	-	-	-	-
Empty Container Storage Capacity (TEU)	-	-	300	-	-	760	-	-	-	-	-
Total (TEU)	0	10,408	15,540	13,210	20,265	2,860	0	5,000	1,800	0	2,500
Yearly Container Handling Capacity (TEU)	0	224,788	335,627	285,305	437,676	61,769	0	107,988	38,876	0	53,994
Total Yangon/Thilawa (TEU)	1,492,029									53,994	

Source: The JICA Study Team

From this calculation, the container-handling capacity of the Yangon City area is estimated at 1.5 million TEU/year and that of the Thilawa area is estimated at 50 thousand TEU/year. In this table, the figures on the capacity of Asia World's terminals were adjusted by taking into account the actual throughput record in 2014 and their ground slot numbers. Besides, the capacity of the Thilawa area should be reconsidered taking into account the upcoming development plan of MITT (1 Million TEU/year) and the new terminal of Japan's ODA under development (200 thousand TEU/year), which was estimated at 1.2 million TEU/year in total. The estimated current container handling capacity of Yangon Port is summarized as follows.

Container-Handling Capacity of Yangon City Area:	Approximately 1.5 million TEU/year
Container-Handling Capacity of Thilawa Area:	Approximately 1.2 million TEU/year
Total	Approximately 2.7 million TEU/year

2.3. Cargo Throughput

2.3.1. Statistics of Cargo Throughput

The following table shows the summary of statistics obtained by the MPA during the period from 2000 to 2014. According to the statistics, the container throughput in 2014 was .72 million TEU, the cargo throughput other than containers and the total of containers and others were 2,170 tons and 3,060 tons respectively. The statistics show that the increase of container cargo since 2011 was remarkable, with more than 20% growth per year, while other cargo also increased but its rate of growth was small.

Table 2.3.1. Statistics of Cargo Throughput of Yangon Port

Containerized Cargo

Year	Total Ship Calls	Import		Export		Total	
		TEU	M'Ton	TEU	M'Ton	TEU	M'Ton
2000	270	78,508	1,039,406	77,840	1,178,946	156,348	2,218,352
2001	305	89,760	1,112,175	85,640	1,271,510	175,400	2,383,685
2002	315	93,645	1,178,927	97,586	1,473,047	191,231	2,651,974
2003	283	88,753	1,193,122	91,813	1,477,457	180,566	2,670,579
2004	248	80,394	1,087,986	77,553	1,247,984	157,947	2,335,970
2005	273	83,030	1,151,965	79,330	1,334,620	162,360	2,486,585
2006	313	93,962	1,246,601	95,782	1,726,990	189,744	2,973,591
2007	450	113059	1,541,239	109,953	1,916,073	223012	3,457,312
2008	442	125364	1,554,282	121,348	2,063,443	246712	3,617,725
2009	456	149,472	2,089,863	148,482	2,330,219	297,954	4,420,082
2010	456	168,335	2,496,199	167,011	1,939,262	335,346	4,435,461
2011	604	192,102	2,830,313	188,573	2,498,119	380,675	5,328,432
2012	530	239,397	3,335,885	234,903	2,733,733	474,300	6,069,618
2013	519	284,686	4,229,061	282,470	2,761,790	567,156	6,990,851
2014	640	361,605	5,657,318	355,321	3,246,806	716,926	8,904,124

Non Containerized Cargo

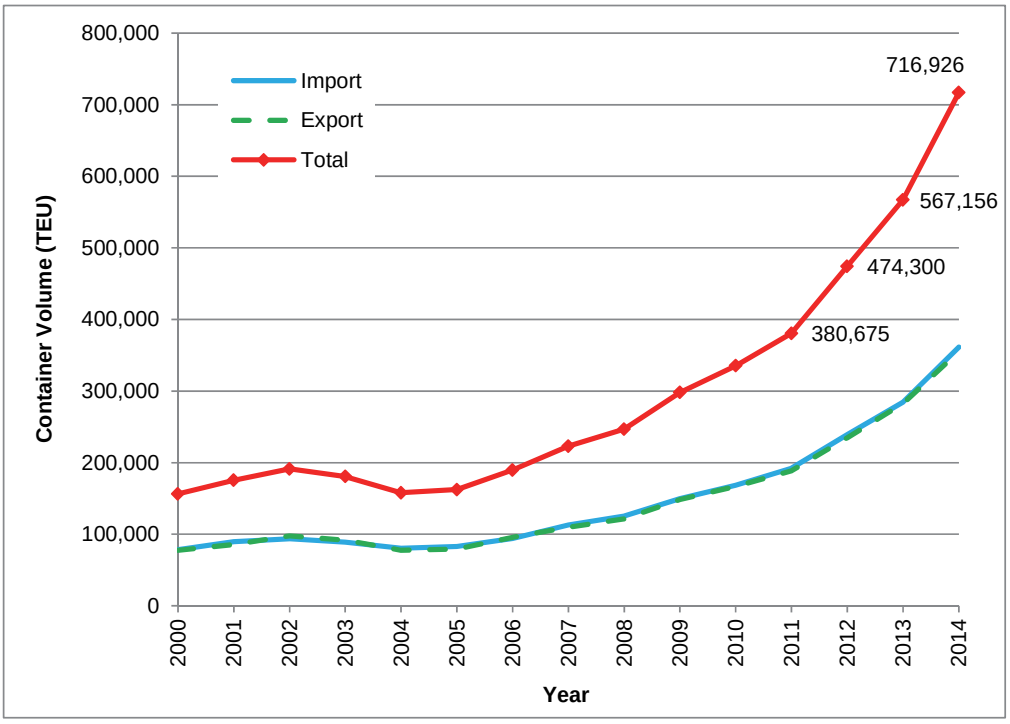
Year	Total Ship Calls	Import	Export	Total
		M'Ton	M'Ton	M'Ton
2000	687	5,065,966	3,252,643	8,318,609
2001	767	5,287,722	4,162,533	9,450,255
2002	712	4,752,909	3,810,398	8,563,307
2003	762	5,067,236	4,193,805	9,261,041
2004	843	4,747,120	4,289,757	9,036,877
2005	955	4,688,522	4,482,334	9,170,856
2006	997	4,649,853	4,379,659	9,029,512
2007	886	5,280,418	4,370,388	9,650,806
2008	1017	4,866,727	5,901,887	10,768,614
2009	1100	6,712,949	9,839,595	16,552,544
2010	1443	9,852,703	8,029,174	17,881,877
2011	1342	11,300,880	7,332,893	18,633,773
2012	1571	14,846,128	6,369,248	21,215,736
2013	1784	14,277,638	7,373,152	21,650,790
2014	1750	13,659,984	8,054,062	21,714,046

Grand Total

Year	Total Ship Calls	Import	Export	Total
		M'Ton	M'Ton	M'Ton
2000	957	6,105,372	4,431,589	10,536,961
2001	1072	6,399,897	5,434,043	11,833,940
2002	1027	5,931,836	5,283,445	11,215,281
2003	1045	6,260,358	5,671,262	11,931,620
2004	1091	5,835,106	5,537,741	11,372,847
2005	1228	5,840,487	5,816,954	11,657,441
2006	1310	5,896,454	6,106,649	12,003,103
2007	1336	6,821,657	6,286,461	13,108,118
2008	1459	6,421,009	7,965,330	14,386,339
2009	1556	8,802,812	12,169,814	20,972,626
2010	1899	12,348,902	9,968,436	22,317,338
2011	1946	14,131,193	9,831,012	23,962,205
2012	2101	18,182,013	9,102,981	27,284,994
2013	2303	18,506,699	10,134,942	28,641,641
2014	2390	19,317,302	11,300,868	30,618,170

Source: MPA

The following figure is a graphic plot of container cargo growth. It is viewed that the 380 thousand TEU of containers in 2011 was rapidly increased to 720 thousand TEU, with an apparent growth rate of 20 ~ 27% during the current three years.



Source: MPA

Figure 2.3.1. Statistics of Container Throughput in Yangon Port

2.3.2. Cargo Demand Forecast

The following table shows the demand forecast of cargo volume until the target year 2025 for Yangon Port, which was reported by the JICA Study in 2011. From the table, the forecast of container cargo in 2025 is 41 million tons. Assuming the average weight of 1 TEU is 13 tons, the forecast of container cargo in 2015 is calculated at 3.16 million TEU. The forecast implies that the average annual growth rate for container cargo is assumed to be 16%.

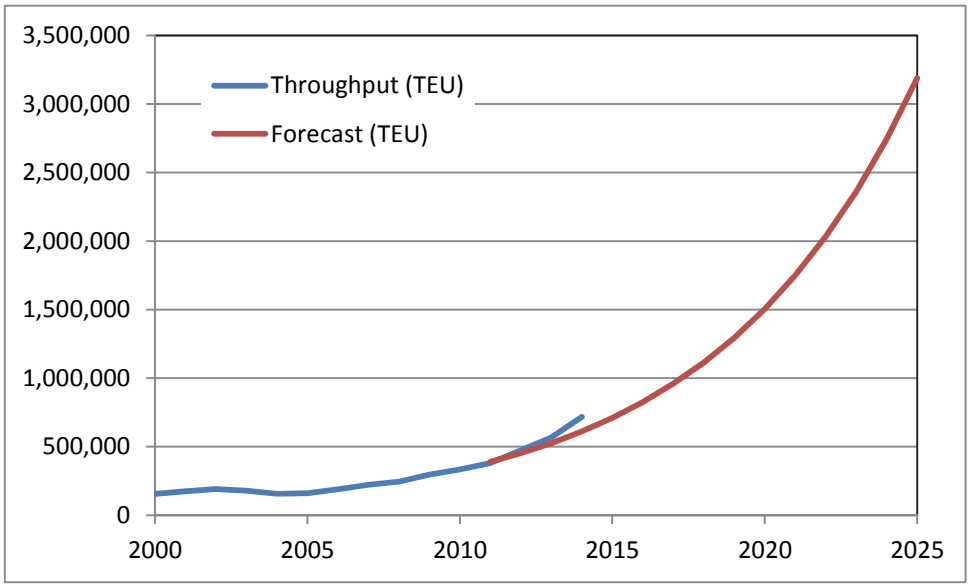
Table 2.3.2. Cargo Demand Forecast for Yangon Port

(Unit: 1,000 Mton)

Port	Category	Commodity	Y2010	Y2025
Yangon	Foreign	General Cargo	17,372	5,441
		Vehicle		396
		Grain		1,000
		Petroleum		7,285
		Container		41,063
		Total		55,185
	Coastal		1,067	2,000
	Sub-Total		18,439	57,185
Others			1,718	5,036
Total			20,157	62,221

Source: The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar (JICA)

The following figure shows the plots of both the demand forecast and statistics from 2000 to 2014. It is read that the current actual increase of container cargo is rapid and the growth rate exceeds the forecast.



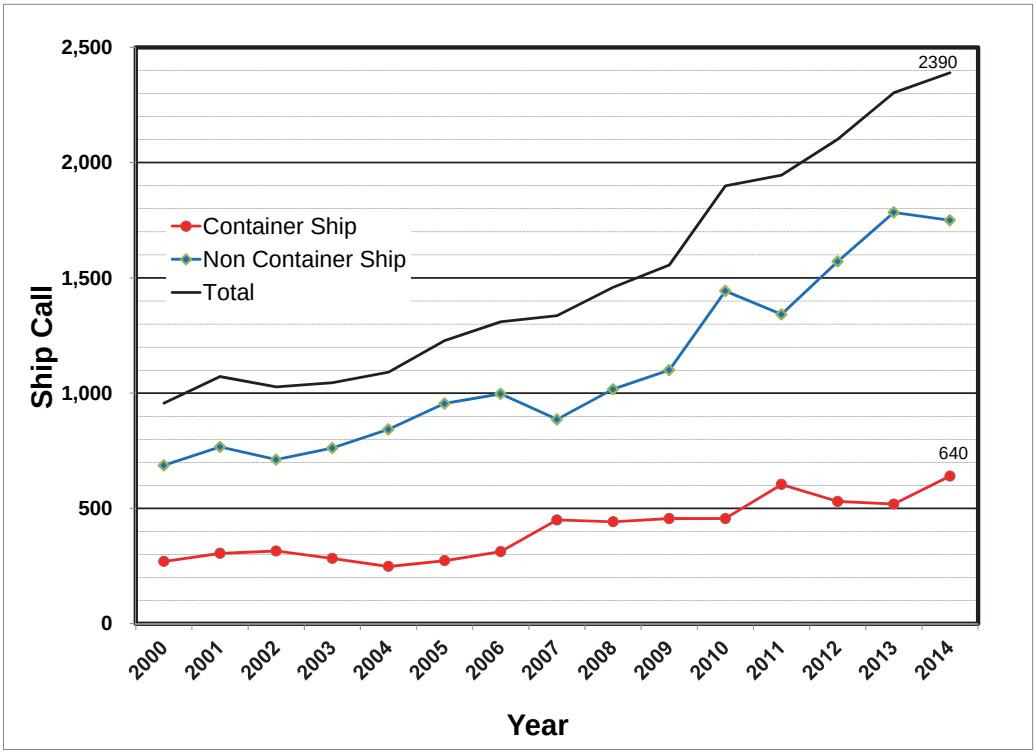
Source: The JICA Study Team

Figure 2.3.2. Comparison between Demand Forecast and Statistics for Container Cargo

2.4. Ship-Call

2.4.1. Number of Ship-Calls at Yangon Port

The following figure was made extracting the number of ship-calls from Table 2.3.1, the port statistics. This data is the figures announced annually on the website of MPA. The number of ship-calls in 2014 was 2,390, of which 640 ship-calls were for container ships. Container ships comprised a 27% share of the total numbers.



Source: Account Section, MPA

Figure 2.4.1. Number of Ship-Calls at Yangon Port

The following table shows the statistics for the number of pilot services at Yangon Port. In accordance with port regulations, all ships more than 200 GRT have to have a pilot onboard, thus the figures of the pilot services and the ship-call statistics are nearly the same. The statistics for pilot service shows that the frequency of shifting service is remarkably high, with 40% of the total service numbers.

Table 2.4.1. Numbers of Pilot Service in Yangon Port

	INWARD	OUTWARD	SHIFTING	Total
FY 2011-2012	1,866	1,864	2,687	6,417
FY 2012-2013	2,157	2,160	2,942	7,259
FY 2013-2014	2,216	2,204	3,169	7,589
FY 2014-2015	2,235	2,237	3,296	7,768

Source: Harbor Department, MPA

In order to obtain more detailed information on ships arriving at Yangon Port, the data was read and tabulated from the "Berthing Information 2014" which was recorded and provided by the Traffic Department of MPA. From this data, the length of arriving ships (LOA), the scheduled draft of the arriving ships, and the type of ships, etc., were obtained. For example, the following table shows the type of ships and the number of arrivals to each terminal in Yangon Port. The table below shows that container ships accounted for 41.9% of the total number of ship-calls in 2014.

Table 2.4.2. Numbers of Ship-Calls of Each Terminal (2014)

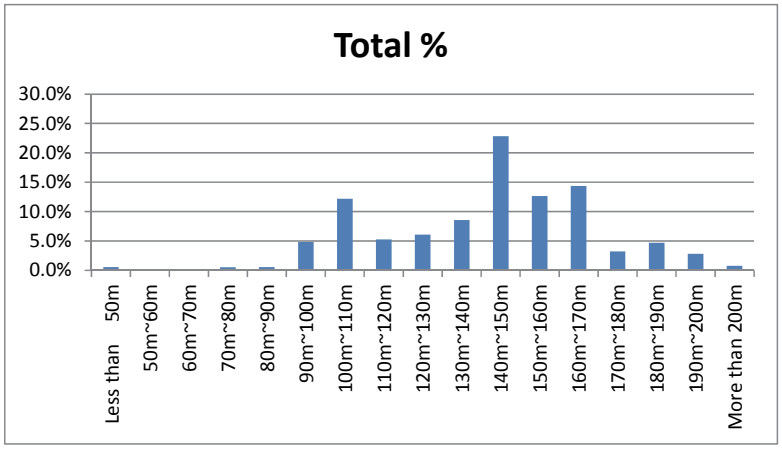
Terminal		Number of Berth	Container	Tanker	Cruise	Vehicles	Other GC	Total
Yangon	HOB	1	1	86	0	0	0	87
	HPT	2	175	0	0	0	25	200
	AWPT	3	161	0	0	0	62	223
	AIPT	1	2	0	0	0	10	12
	MIP	4	215	0	0	0	8	223
	BSW	3	48	0	4	1	87	140
	SPW	7	1	0	0	10	232	243
Thilawa	MIPL	1	1	9	0	27	34	71
	MITT	5	14	0	16	79	167	276
Yangon Port			603	86	4	11	424	1,128
Thilawa Port			15	9	16	106	201	347
Total			618	95	20	117	625	1,475

Source: Berthing Information, Traffic Department MPA

- Note the difference in data between the Account Section and the Berthing Information

  For the purposes of further study, the characteristics of the data figures are made clear below.
  From the Berthing Information, the ship-call data from 2014 shows 1,475 ships, while the same data from Port Statistics provided by the Account Section of MPA shows 2,390 ships, between which there is a difference of 915 ship-calls. On the other hand, the data for Pilot Service provided by the Harbour Department of MPA, 2,235 ship-calls in 2014, shows a similar figure to the data of the Account Section. Accordingly, ship-calls for container ships in the Berthing Information show 618 ships, which is consistent with the figure of the Account Section's 640 ships.

The frequency distribution on the LOA of the ships in the Berthing Information is shown in Figure 2.4.2. It is noticed from this figure that the data for Berthing Information seems to lack information for any LOA less than 90 m, notwithstanding that pilot service shall be applied to all ships over 200 GRT, i.e. the ships that have approximately LOA 60 m or more. The same assumption is able to prove from that the data of container ship-calls are nearly same between the data of Account Section and the data of the Berthing Information.

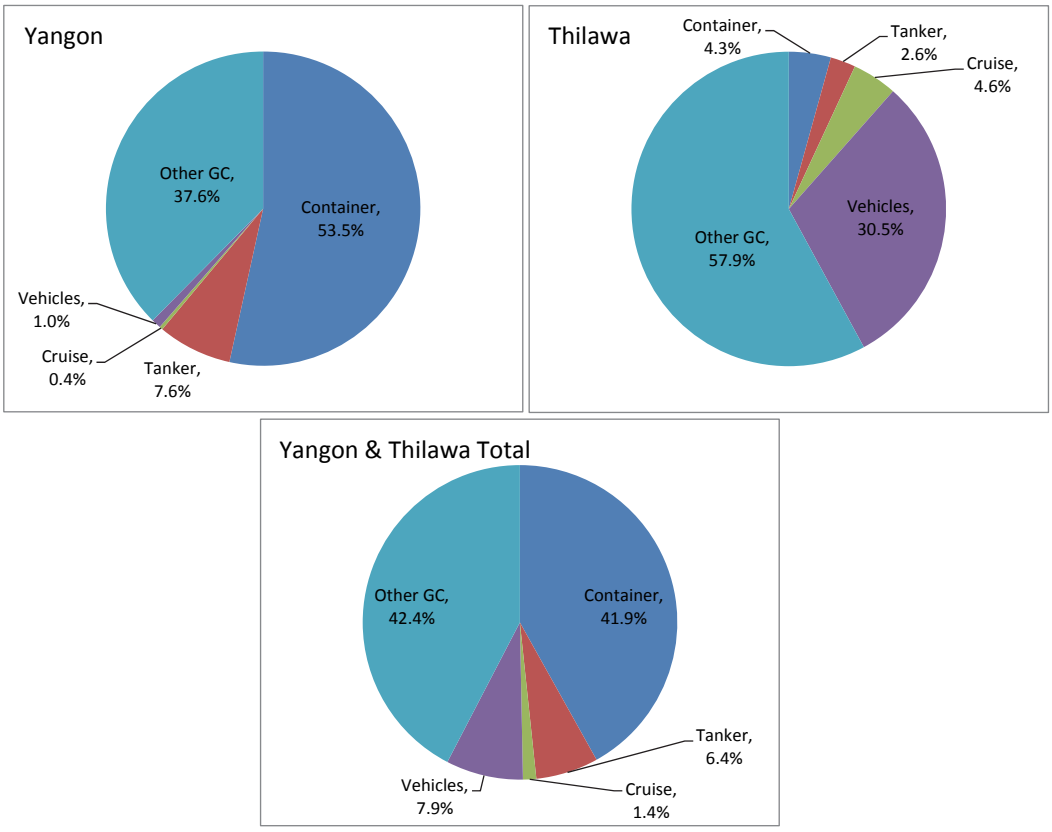


Source: Berthing Information, MPA

Figure 2.4.2. Frequency Distribution of LOA for the Ships in Yangon Port (2014)

2.4.2. Types of Arriving Ships

The following figure shows the percentage share of ship types arriving at Yangon Port, which is derived from the data of the Berthing Information. As mentioned in the above note, these data should be interpreted as each rate of ship type being consistent with the data for larger ships whose LOA is more than 90 m.



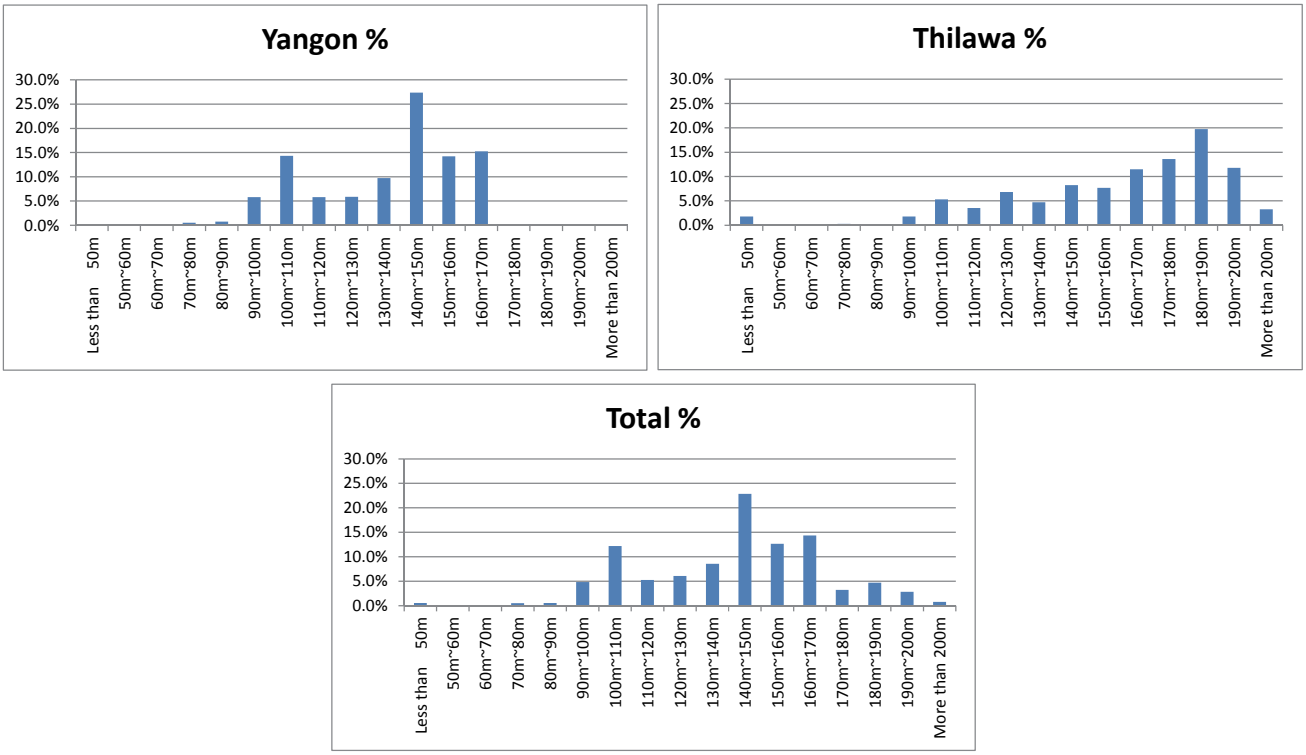
Source: Berthing Information, MPA

Figure 2.4.3. Percentage Share of Ship Types for Yangon Port (2014)

The data shows that the rate of container ships in Yangon City area is high, 53.5%, but the same of Thilawa shows only 4.3%. The total rate of container ships in Yangon & Thilawa is 41.9%.

2.4.3. Size of Arriving Ships

The frequency distribution of ship sizes in terms of their LOA, based on the Berthing Information, is shown in the following figure. The following table shows the maximum LOA and average LOA calculated with the same data.



Source: Berthing Information, MPA

Figure 2.4.4. Frequency Distribution of LOA for the Ships in Yangon Port (2014)

Table 2.4.3. Maximum and Average LOA of Ships in Yangon Port (2014)

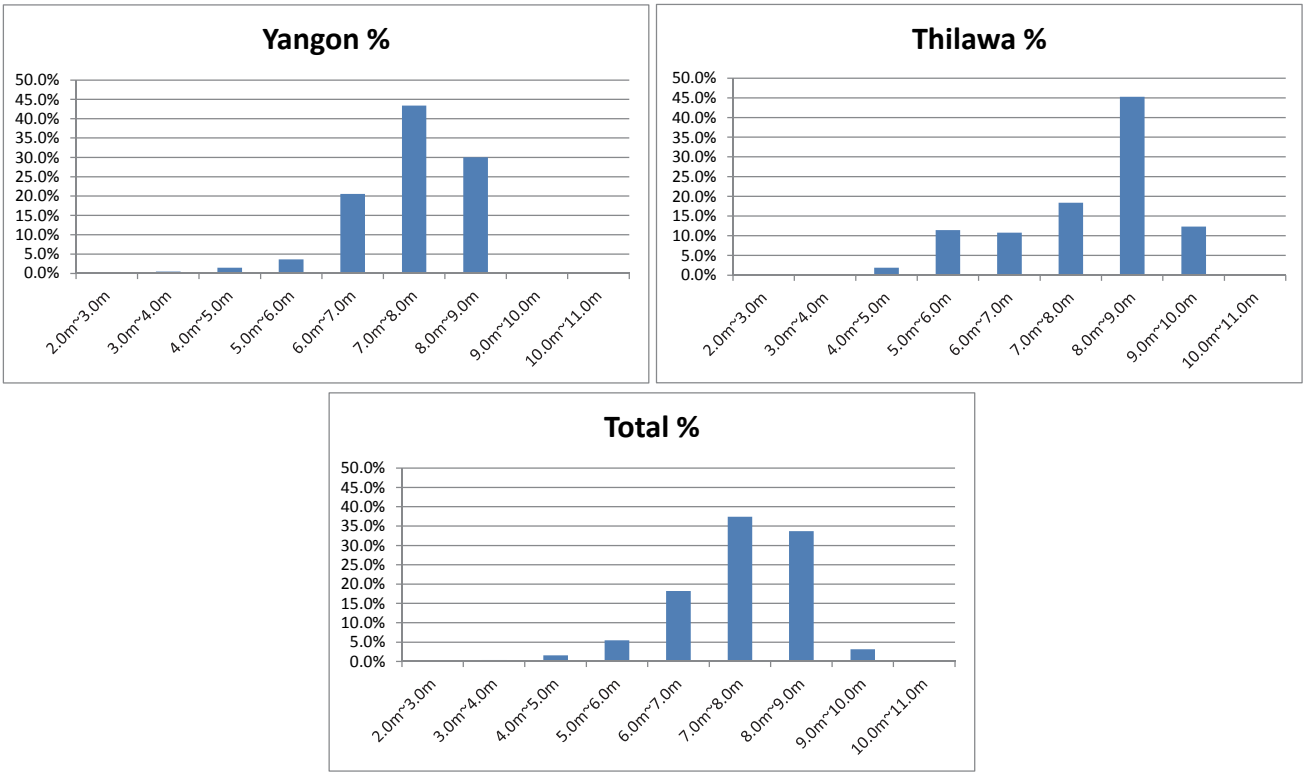
	Max (m)	Average (m)
Yangon	167.0	135.8
Thilawa	241.0	159.7
All	241.0	141.5

Source: Berthing Information, MPA

The average LOA of the ships in the Yangon City Area in 2014 was 135.8 m, while their maximum LOA was 167 m. In the Thilawa area, the average LOA was 259.7 m and the maximum LOA was 241 m. Yangon did not receive any ships with an LOA of more than 170 m, but Thilawa received ships with an LOA of more than 200 m. According to the information provided by MITT, the largest ships to enter Thilawa were cruise ships and usually they were docked at MITT berths.

2.4.4. Draft of Arriving Ships

The following Figure shows the frequency distribution on the draft of arriving ships based on the data of the Berthing Information. The following Table shows the maximum draft and average draft calculated with the same data.



Source: Berthing Information, MPA

Figure 2.4.5. Frequency Distribution on Draft of Ships in Yangon Port (2014)

Table 2.4.4. Maximum and Average Draft of Ships in Yangon Port (2014)

	Max (m)	Average (m)
Yangon	9.0	7.4
Thilawa	9.0	7.7
All	9.0	7.5

Source: Berthing Information, MPA

The average draft of the ships in Yangon City Area in 2014 was 7.4m, while its maximum draft was 9.0m. In Thilawa area, the average draft was 7.7m and the maximum draft was 7.7m.

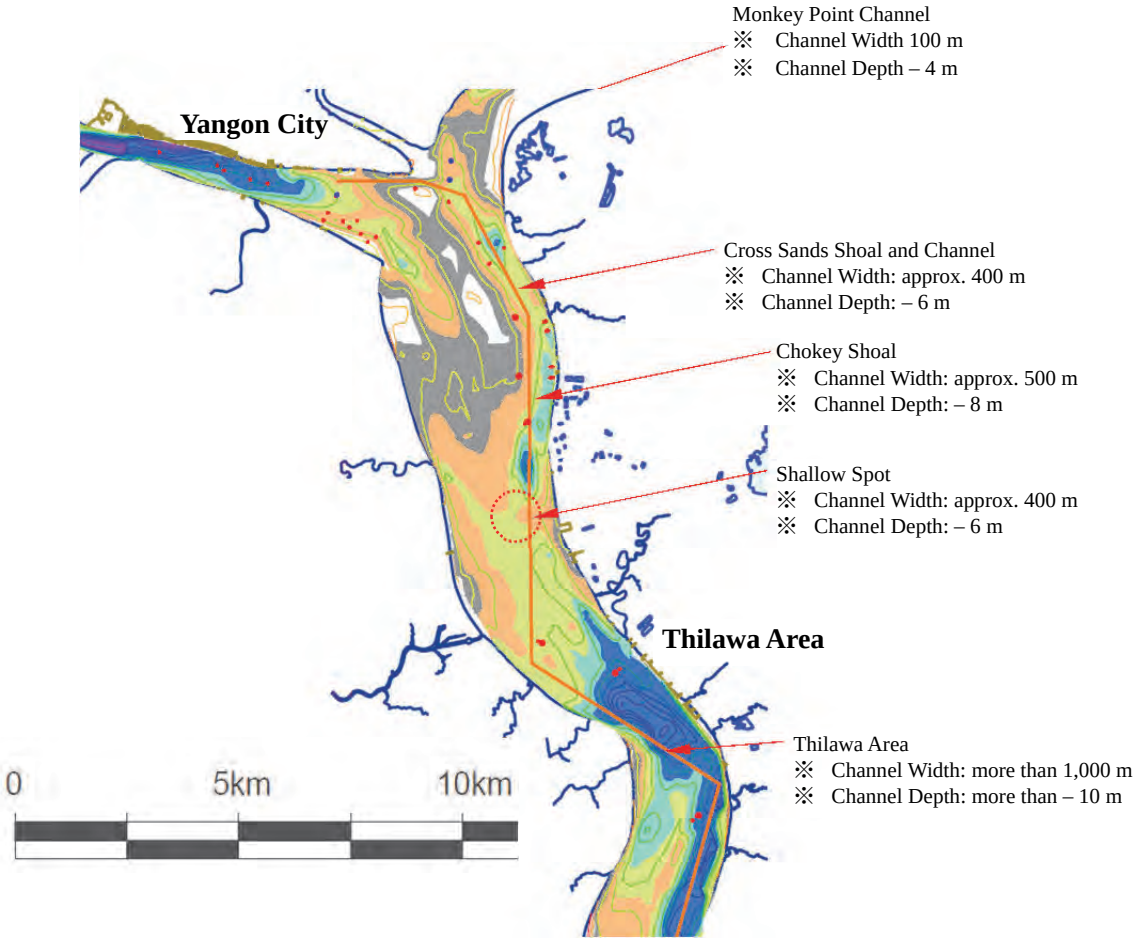
2.5. Overview of Yangon Channel

2.5.1. Depth and Width of Channel

The following figures show the water depth and width of Yangon Channel from the Yangon City area to Elephant Point and offshore.

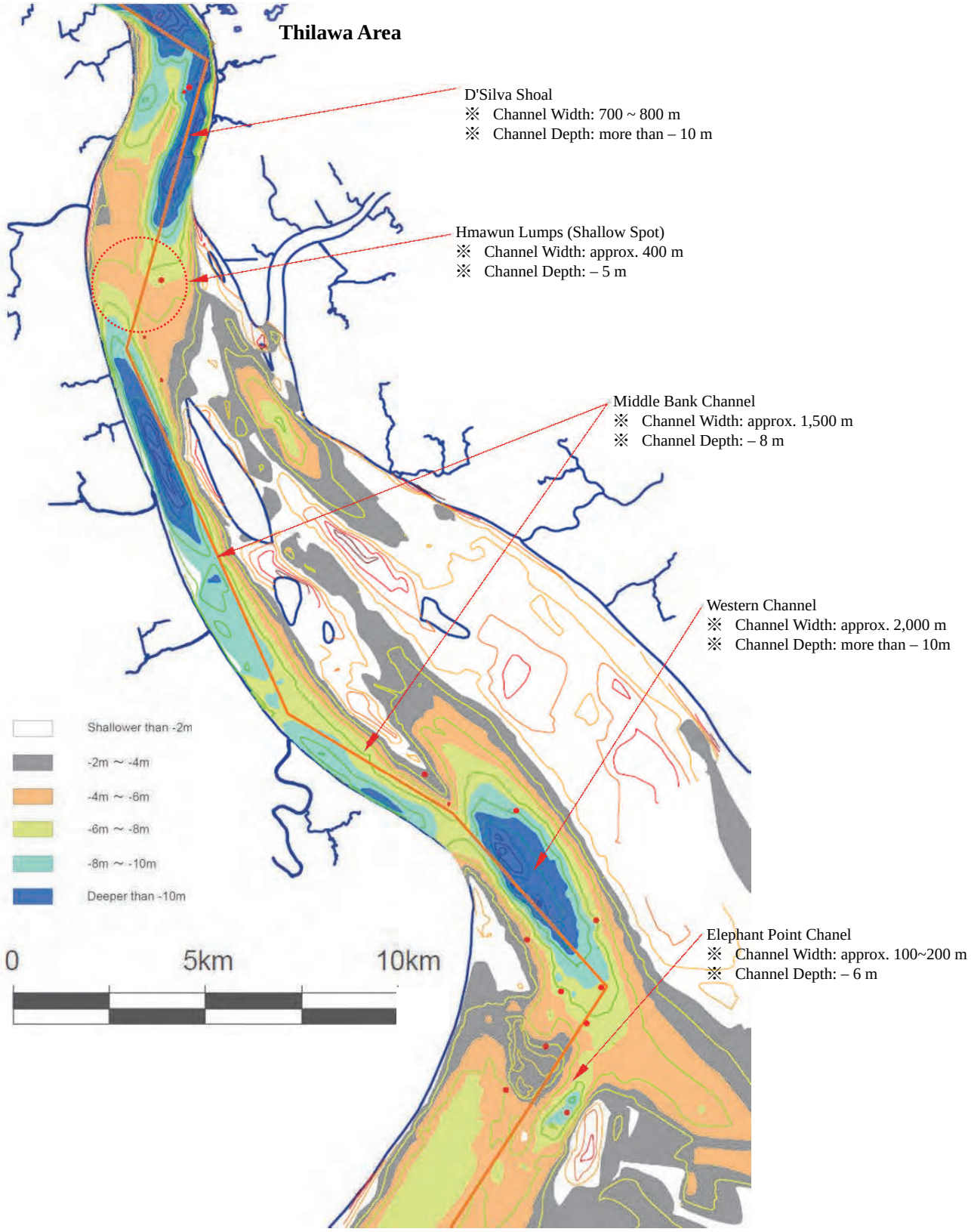
The channel width of Monkey Point is approximately 100 m, and the water depth is –4 m. The waterway from Monkey Point to the Thilawa area generally has a depth of approximately –6 m, where some areas are partially deeper water. The width of this waterway is more than 400 m. There is a shallow spot about 5 km upstream from the Thilawa area, where the width of the –6 m waterway becomes narrow.

The depth of the Thilawa area is generally deep, where the deepest spot has a –15 m water depth. The width of waterways with depths more than –10 m are wide, approximatly 1,000 m wide at the Thilawa area.



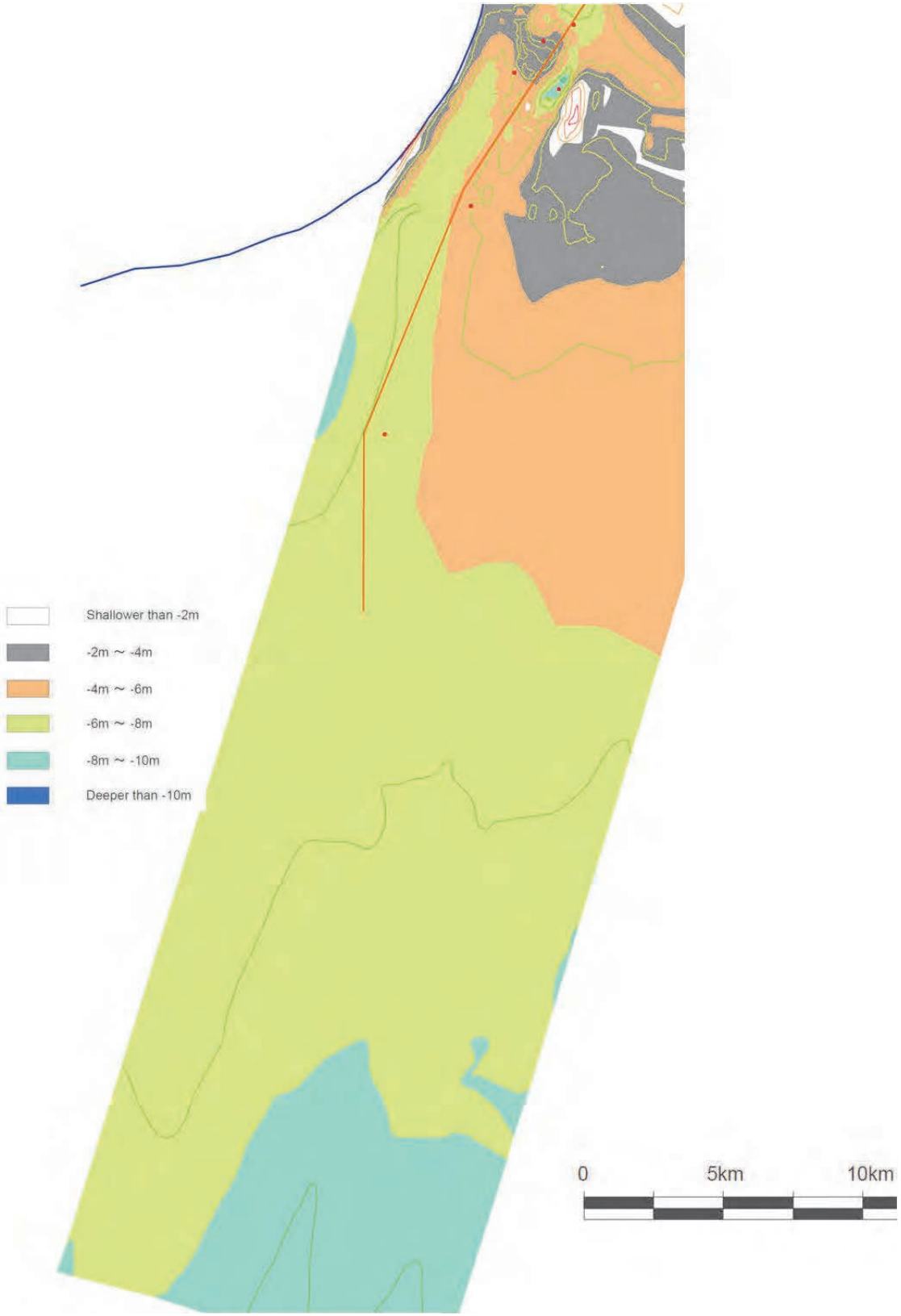
Source: The JICA Study Team

Figure 2.5.1. Depth and Width of Channel (Yangon ~ Thilawa)



Source: The JICA Study Team

Figure 2.5.2. Depth and Width of Channel (Thilawa ~ Elephant Point)



Source: The JICA Study Team

Figure 2.5.3. Depth and Width of Channel (Offshore of Elephant Point)

The waterway from Thilawa to Elephant Point has generally –6 m ~ –8 m depth and their width is more than 1,000 m. There is a shallow spot of –5 m deep about 10 km downstream from the Thilawa area. There is another shallow spot of –5 m deep at the south of Elephant Point.

The south area from Elephant Point has a gentle seabed slope, in which the distance from Elephant Point to the deep water with –10 m depth is approximately 50 km.

Port regulations for ships entering Yangon Port are shown below.

Table 2.5.1. Port Regulations for Ships Entering Yangon Port

Item		Yangon Monkey Point	Thilawa Elephant Point
Maximum Size of Vessel (DWT)		15,000	20,000
Length of Vessel (LOA; m)		167m or less	200m or less
Maximum Draft (m)	Rainy Season	9.0	9.0
	Dry Season	8.5	9.0
Pilotage		Daylight Flood Tide	Day & Night Flood Tide

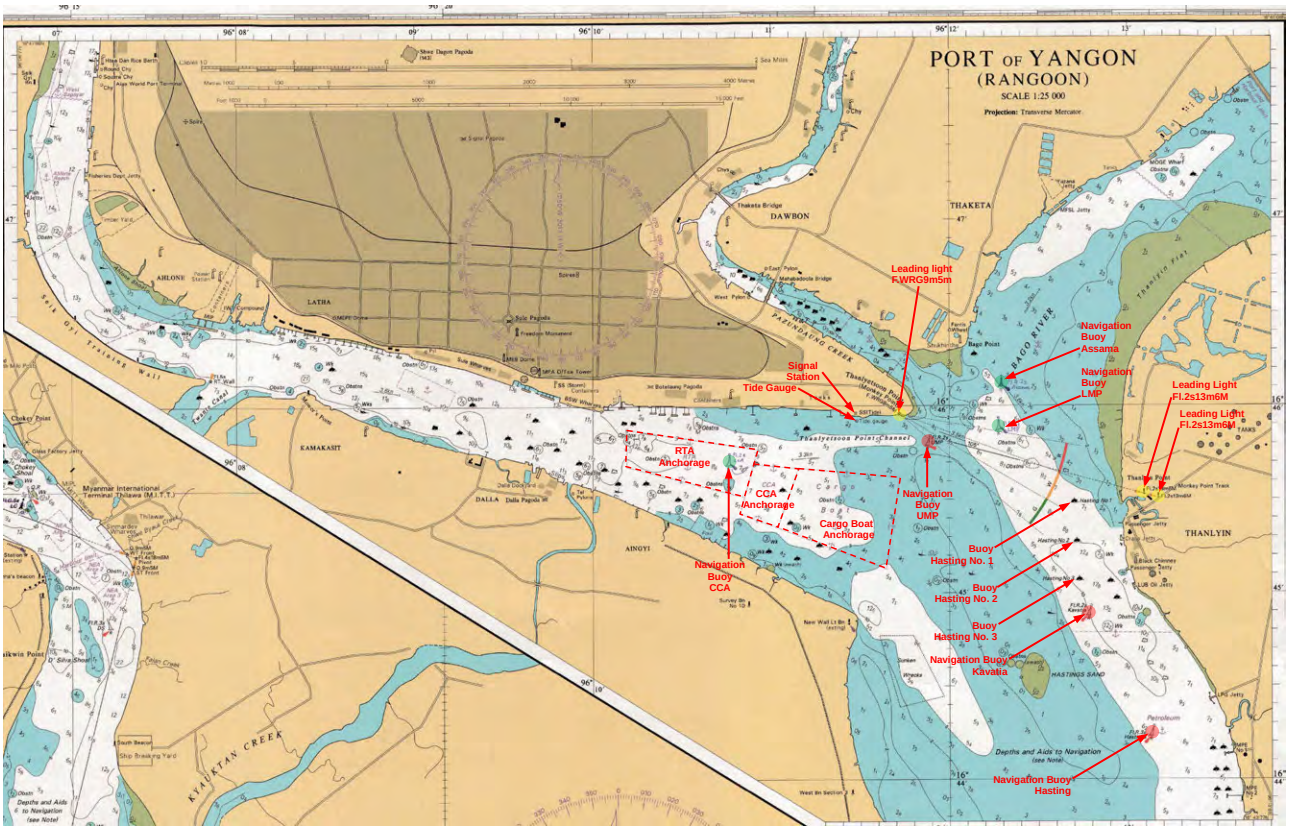
Source: MPA

2.5.2. Overview of Navigation Aids

The locations of navigation facilities are shown in the following figures. Table 2.5.2. shows the descriptions reported by the JICA Study "The preparatory survey for the project for expansion of Yangon port in Thilawa area : final report**"** and it was evaluated in 2009, and the results of this survey work. The JICA Study Team executed a site exploration, sailing from Yangon City to Elephant Point and back. The table shows the navigation facilities that the Study Team could confirm from the site visiting.

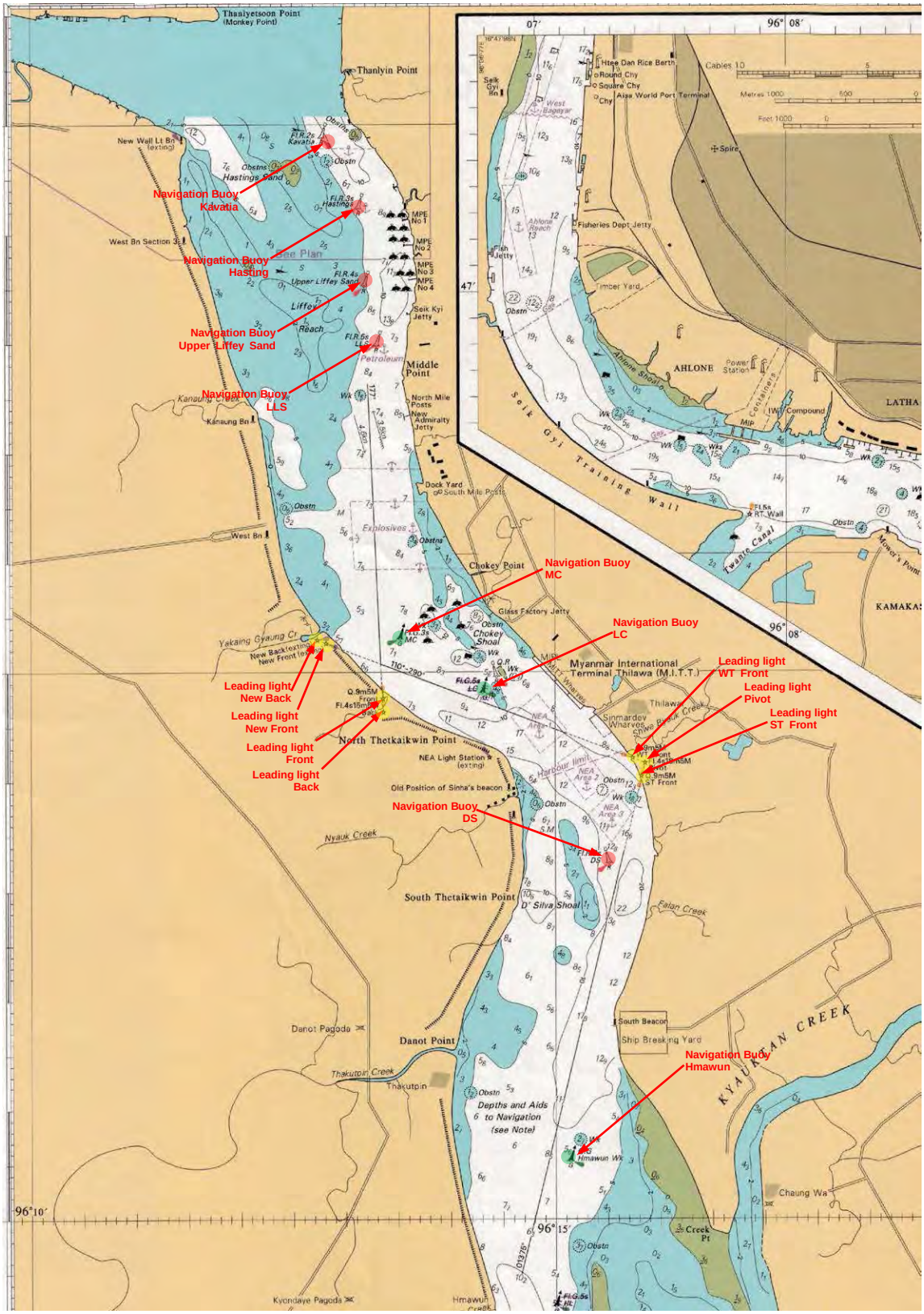
The Site Exploration Record

- In the water area upstream of Monkey Point, some navigation buoys were not found at the locations indicated on the nautical chart. For instance, a buoy was found near the location of CCA on the nautical chart, but the color of the buoy was red, while the nautical chart shows CCA to be a green color. There was a navigation buoy near the mouth of Twante Canal, but the nautical chart does not indicate such a buoy.
- No navigation buoy was visible in the vicinity of Monkey Point, the reason for which might be that the survey boat passed the south water of Monkey Point and the distance between the boat and the navigation buoys was too far.
- The leading light tower near Monkey Point was not visible. It was at dusk during the return sailing, but no light from the leading light tower was found.
- It was difficult to find all the light towers that were indicated on the nautical chart. Some of those might be lost or demolished.
- The buoys located upstream from DS were made of plastic and looked new. The buoys located downstream were made of steel frame.
- The buoy LC near the Thilawa area was damaged.
- The posts along the right riverbank of the Middle Bank Channel were not found except only Survey Beacon No. 8. They might have been lost due to erosions of riverbank.



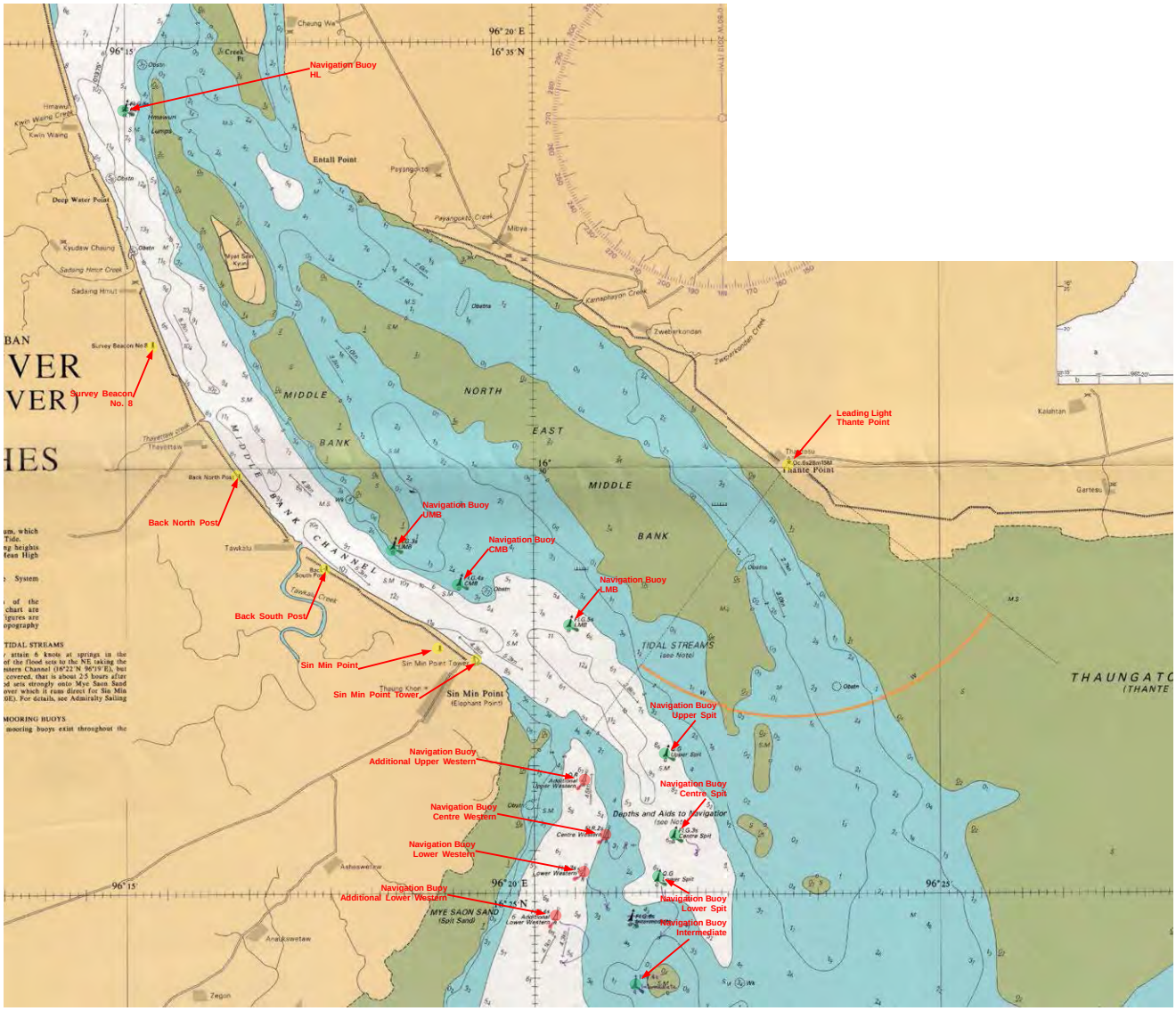
Source: The JICA Study Team

Figure 2.5.4. Locations of Navigation Aids (1)



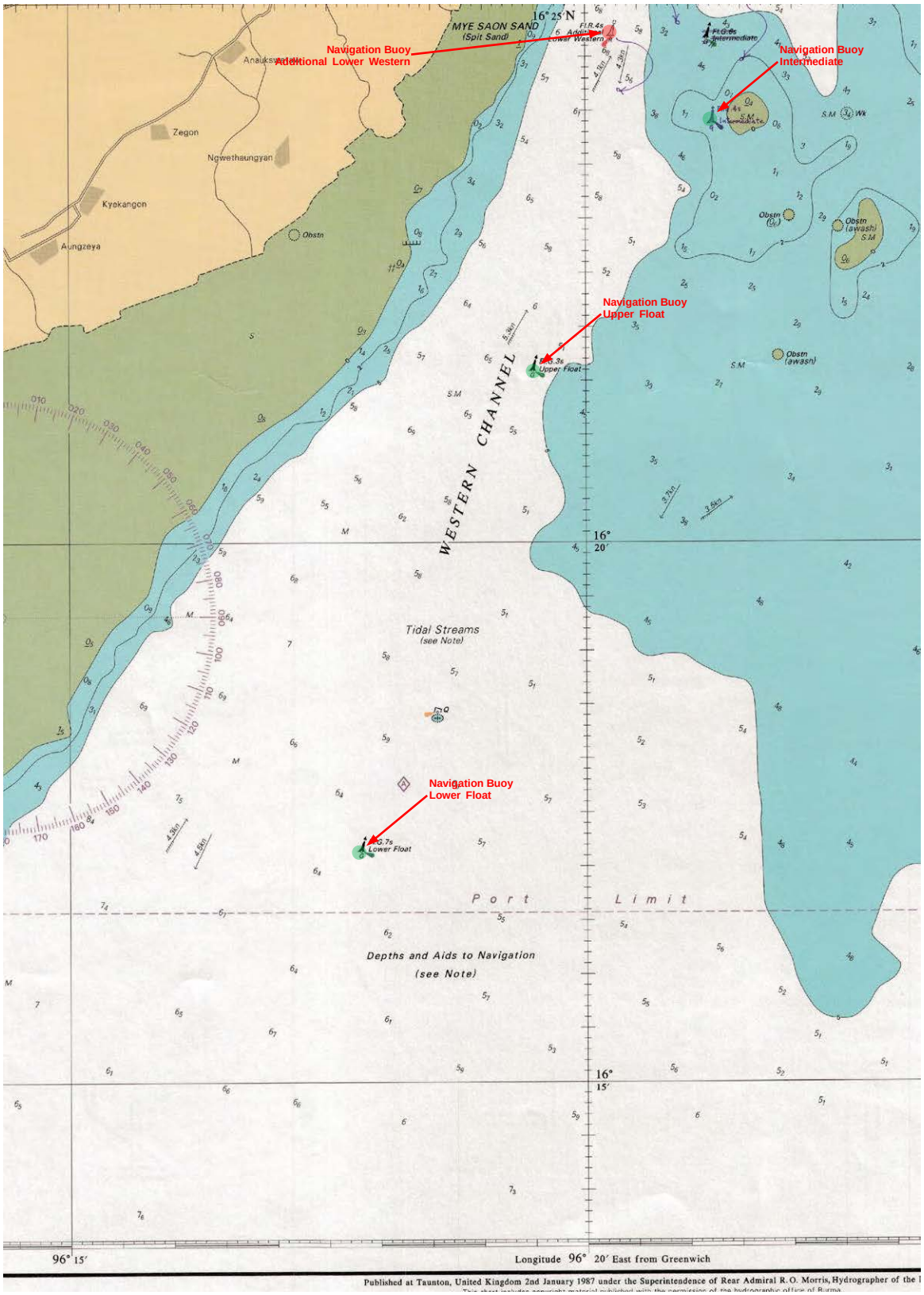
Source: The JICA Study Team

Figure 2.5.5. Locations of Navigation Aids (2)



Source: The JICA Study Team

Figure 2.5.6. Locations of Navigation Aids (3)



Source: The JICA Study Team

Figure 2.5.7. Locations of Navigation Aids (4)

Table 2.5.2. List of Navigation Aids

Location	Navigation Facilities/Aids/Software	2009 JICA Report			2015 JICA Update	
		Nos./ name/ Data	Rating	Remark	Visual exploration	Remark
Monkey Point Channel	Signal Station	1	3		-	
	Tide Gauge	1	-		-	
	Leading Light (Monkey Point)	4	1	damaged	-	
	Leading Light (Thalyin Point Front/Back)	2	-		-	
	Navigation Buoy CCA	1	-		not found	
	Navigation Buoy Assama	1	-		-	
	Navigation Buoy LMP	1	2		-	
Cross Sands Shoal and Channel	Navigation Buoy Cavatia	1	2		-	
	Navigation Buoy Hasting	1	2		-	
	Navigation Buoy Upper Liffey Sand	1	2		○	
	Navigation Buoy Lower Liffey Sand b (LLS)	1	2		○	
Chokey Shoal	Leading Light New Front/New Back	2	-		-	
	Leading Light Front/Back	2	-		-	
	Leading Light WT Front/Pivot/ST Front	3	-		-	
	Navigation Buoy MC	1	1	damaged	not found	
	Navigation Buoy LC	1	1		○	see picture
D'Silva Shoal	Navigation Buoy DS	1	2		○	see picture
Hmawun Lumps	Navigation Buoy Hmawun	1	2		○	see picture
	Navigation Buoy HL	1	2		not found	
Middle Bank Channel	Leading Light Survey Beacon No.8	1	-		○	see picture
	Leading Light Back North Post	1	-		not found	
	Leading Light Back South Post	1	-		not found	
	Leading Light Sin Min Point	1	-		-	
	Navigation Buoy UMB	1	2		○	see picture
	Navigation Buoy CMB	1	2		○	see picture
	Navigation Buoy LMB	1	2		○	
Western Channel	Elephant Point Tower (Sin Min Point Tower)	1	1	damaged	not found	
	Leading Light Thante Point	1	-		-	
	Navigation Buoy Upper Spit	1	2		○	
	Navigation Buoy Center Spit	1	2		○	
	Navigation Buoy Lower Spit	1	2		-	
	Navigation Buoy Intermediate	1	2		-	
	Navigation Buoy Additional Upper Western	1	2		○	see picture
	Navigation Buoy Center Western	1	2		○	see picture
	Navigation Buoy Lower Western	1	2		○	
	Navigation Buoy Additional Lower Western	1	2		-	
Elephant Point Chanel Outer Bar	Navigation Buoy Upper Float	1	2		-	
	Navigation Buoy Lower Flaot	1	2		-	
	Pilot Vessel	1	2		-	
	Dagon Light Ship	1	1	damaged	-	

Rating level - 1 : Very bad condition (not working by damage or lost)
Rating level - 2 : Bad condition (working, but need to be repaired or replaced)
Rating level - 3 : Normal condition (working and no need for immediate repairing)
Rating level - 4 : Good condition (working, repaired or replaced within 10 years)
Rating level - 5 : Excelent condition (working, newly installed within 5 years)
○ : Visual Inspection 2015

Source: The JICA Study Team

 Navigation Buoy DS D'Silva Shoal (Thilawa Area) 2015/09/05	 Navigation Buoy LC Chokey Shoal (Thilawa Area) 2015/09/05	 Navigation Buoy Hmawun Hmawun Lumps 2015/09/05
 Navigation Buoy UMB Middle Bank Channel 2015/09/05	 Navigation Buoy CMB Middle Bank Channel 2015/09/05	 Navigation Buoy Additional Upper Western Western Channel, 2015/09/05
 Navigation Buoy Center Western Western Channel 2015/09/05	 Survey Beacon No. 8 Middle Bank Channel 2015/09/05	

Source: The JICA Study Team

Figure 2.5.8. Photographs of Navigation Aids

2.6. Navigation Method

2.6.1. Overview of Pilotage

As of August 2015, the MPA holds 44 licensed pilots, of which 34 pilots are working for the Yangon Port channel. In general, the job cycle of the pilots is that a pilot boards the sailing ship from Yangon Port and goes to the Pilot Station located offshore of Elephant Point, then stays overnight waiting for the next flood tide, and again boards on the entering ship and returns to Yangon.

For the case of entering ships, the ship usually arrives at Elephant Point during flood tide, then sails with approximately 10-knot sailing speed and reaches Monkey Point. During the next flood tide, the ship passes Monkey Point and enters Yangon Port. The port regulation orders entering ships to pass Monkey Point only during daylight and on one-way passage. Because of this condition, the ships' navigation schedules are usually made based on the time of passage at Monkey Point. The passage of Elephant Point is also one-way passage by internal rule of the Harbour Department, but ships are passing Elephant Point even at night, adjusting their sailing schedules to the time of Monkey Point passage. The waterway other than Monkey/Elephant Point is a two-way channel where ships pass each other.

In the area of Elephant Point, maneuvering of ships shall be carefully done because the direction of current changes immediately. The initial current direction for an entering ship at Elephant Point is generally from the south to the north, however the current direction changes to east to west after passing Elephant Point where the ship should turn its bow westward.

The following table shows the frequency of pilotage services during the period from 2011 to 2014. The figures show that many ships uses pilotage service for not only entering/ departing but also for shifting from one quay to the other very frequently.

Table 2.6.1. Frequency of Pilotage Service

	INWARD	OUTWARD	SHIFTING	Total
FY 2011-2012	1,866	1,864	2,687	6,417
FY 2012-2013	2,157	2,160	2,942	7,259
FY 2013-2014	2,216	2,204	3,169	7,589
FY 2014-2015	2,235	2,237	3,296	7,768

Source: MPA

2.6.2. Sailing Truck Records of Actual Ships

For the purpose of knowing the actual way of entering port, i.e. sailing route, the ship's speed and keel clearance, etc., the Study Team conducted interviews with the ship's crew and captain.

(1) The Case of M.V. Fortune Tiger

M.V. Fortune Tiger is a general cargo carrier that arrived at the wharf of MITT in the Thilawa area passing by Elephant Point on 30th August 2015. The ship's particulars are shown below.

Name:	M. V. Fortune Tiger
LOA:	189.99 m
Breadth:	32.26 m
Depth:	18.00 m
Design Load Draft:	11.300 m
Fully Load Draft:	12.826 m
Gross Tonnage:	32,309 t
DWT:	58,159 t

The ship's draft was 9 m. The ship had sailed to the point approximately 10 nm distant from the Pilot Station, dropped anchor, and had been waiting for the next flood tide for entering.

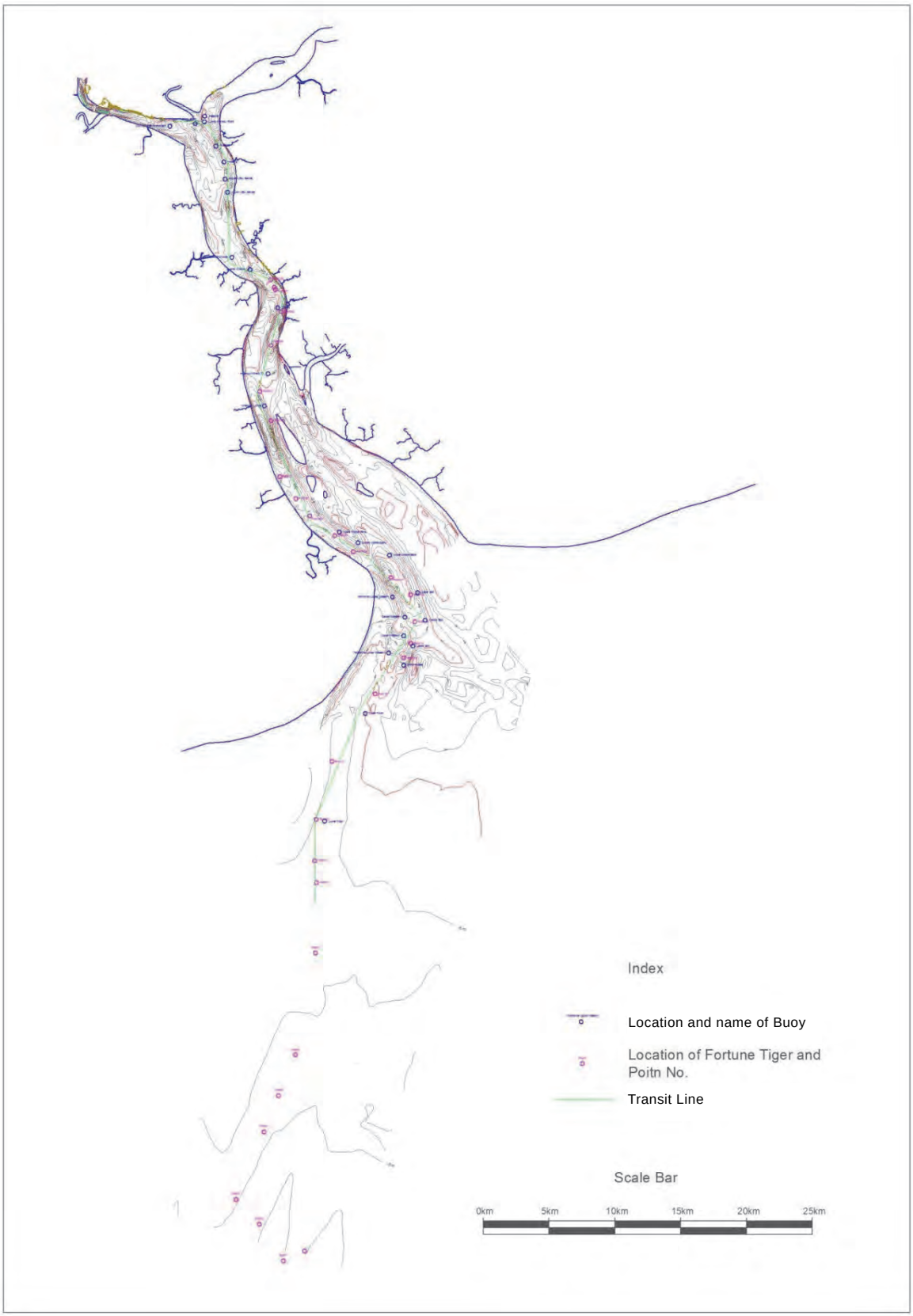
The time of highest tide on 30th August was 17:00, therefore the ship lifted its anchor and started to sail toward the Pilot Station at noon. The initial ship speed was about 8 ~ 10 knots. The water depth around the approach to the Pilot Station was approximately –8 m, while the tide level at this sailing time was still not high, +1.5 m ~ +2.5 m. The keel clearance was not enough, the ship was sailing with approximately 50 cm or 1.0 m of keel clearance.

The pilot boarded the ship at 13:50, the ship moved toward Elephant Point following the guidance of the pilot. The ship's speed at this time was 10 ~ 11 knots. The tide level moved up to +3.5 m ~ +5.5 m, and the keel clearance was enlarged to 1 m ~ 2 m.

The ship entered Elephant Point at 14:50, and completed passing the shallow point at 15:06. The time for passing Elephant Point was 16 minutes and the average ship speed was 11.5 knots. From the ship's truck record, the ship moved on the deepest route, from which it is evident that the ship was properly guided by the pilot. At the time of passing the shallow point, the tide level reached more than + 5.5 m, thus the keel clearance was about 4 m.

After this, the ship sailed to the front of the MITT wharf with a speed of 10 knots and dropped anchor near the MITT at 17:00.

The following figures and table show the truck record of the ship and the calculation of the ship's speed and keel clearance.



Source: The JICA Study Team

Figure 2.6.1. Truck Record of M.V. Fortune Tiger

Source: The JICA Study Team

Figure 2.6.2. Truck Record of M.V. Fortune Tiger (At Elephant Point)

Table 2.6.2. Truck Record of M.V. Fortune Tiger

Location	Event	Point	Time		N		E		From - To	Time		Distance	Velocity	Remarks	Depth (ACD)	Tide (ACD)	Ships Draft	Water Depth	Keel Clearance
		No.	hr	min	deg	min	deg	min		min	hr	n.mile	Knot		m	m	m	m	m
Anchorage - WP 32	Anchor Awaigh	-	12	00	15	59.42	96	17.02	-	-	-	-	-	12:00	-8.9	-	-		-
		1	12	00	15	59.00	96	16.30	-	-	-	-	-	Sea: Dir. SW, State 3	-9.0	-	-		-
		2	12	20	16	00.50	96	15.25	1 - 2	20	0.33	1.831	5.5	Visibility: 7	-8.8	1.51	9.0	10.3	1.31
		3	12	30	16	01.50	96	14.25	2 - 3	10	0.17	1.414	8.5	Weather: C	-7.9	1.61	9.0	9.5	0.51
		4	12	54	16	04.30	96	15.40	3 - 4	24	0.40	3.027	7.6	Temp: 30	-7.7	2.00	9.0	9.7	0.70
		5	13	06	16	05.80	96	16.00	4 - 5	12	0.20	1.616	8.1	Wet: 28	-7.5	2.27	9.0	9.8	0.77
		6	13	18	16	07.50	96	16.70	5 - 6	12	0.20	1.838	9.2		-7.3	2.59	9.0	9.9	0.89
	Pilot On Board (POB)	-	13	50	-	-	-	-	-	-	-	-	-		-	-	-	-	-
		7	13	40	16	11.70	96	17.50	6 - 7	22	0.37	4.276	11.7		-6.7	3.25	9.0	10.0	0.95
WP 32 - 33 Western Channel		8	13	55	16	14.60	96	17.50	7 - 8	15	0.25	2.900	11.6		-6.5	3.74	9.0	10.2	1.24
		9	14	00	16	15.50	96	17.40	8 - 9	05	0.08	0.906	10.9		-6.7	3.91	9.0	10.6	1.61
		10	14	10	16	17.20	96	17.45	9 - 10	10	0.17	1.701	10.2		-6.9	4.25	9.0	11.2	2.15
	Passing Lower Float Buoy	-	14	10	-	-	-	-	-	-	-	-	-		-	-	-	-	-
		11	14	25	16	19.60	96	18.10	10 - 11	15	0.25	2.486	9.9		-6.8	4.77	9.0	11.6	2.57
	Passing Upper Float Buoy	-	14	36	-	-	-	-	-	-	-	-	-		-	-	-	-	-
		12	14	42	16	22.40	96	19.90	11 - 12	17	0.28	3.329	11.7		-4.9	5.33	9.0	10.2	1.23
Elephant Point		13	14	50	16	23.90	96	21.10	12 - 13	08	0.13	1.921	14.4		-8.0	5.57	9.0	13.6	4.57
	Passing Intermediate Buoy	-	14	50	-	-	-	-	-	-	-	-	-		-	-	-	-	-
		14	14	55	16	24.50	96	21.40	13 - 14	05	0.08	0.671	8.0		-5.7	5.72	9.0	11.4	2.42
		15	15	00	16	25.40	96	21.55	14 - 15	05	0.08	0.912	10.9		-7.4	5.87	9.0	13.3	4.27
	Passing CMB Buoy (Lower Spit ?)	-	15	00	-	-	-	-	-	-	-	-	-		-	-	-	-	-
		16	15	06	16	26.50	96	21.35	15 - 16	06	0.10	1.118	11.2		-9.8	6.03	9.0	15.8	6.83
WP34 -35 Middle Bank Channel		17	15	12	16	27.20	96	20.50	16 - 17	06	0.10	1.101	11.0		-12.4	6.19	9.0	18.6	9.59
		18	15	20	16	28.25	96	18.88	17 - 18	08	0.13	1.935	14.5		-7.6	6.38	9.0	14.0	4.98
		19	15	28	16	28.90	96	18.08	18 - 19	08	0.13	1.031	7.7		-7.3	6.56	9.0	13.9	4.86
		20	15	34	16	29.70	96	17.00	19 - 20	06	0.10	1.340	13.4		-7.8	6.67	9.0	14.5	5.47
WP35 -36		21	15	43	16	30.40	96	16.40	20 - 21	09	0.15	0.922	6.1		-8.5	6.82	9.0	15.3	6.32
		22	15	48	16	31.30	96	15.70	21 - 22	05	0.08	1.140	13.7		-7.1	6.89	9.0	14.0	4.99
		23	16	00	16	33.60	96	15.03	22 - 23	12	0.20	2.397	12.0	16:00	-5.0	7.02	9.0	12.0	3.02
WP36 -37		24	16	12	16	34.80	96	14.80	23 - 24	12	0.20	1.221	6.1	Sea: Dir. SW, State 3	-5.8	7.09	9.0	12.9	3.89
		25	16	29	16	36.70	96	15.25	24 - 25	17	0.28	1.953	6.9	Visibility: 7	-12.5	7.09	9.0	19.6	10.59
		26	16	43	16	38.10	96	15.65	25 - 26	14	0.23	1.456	6.2	Weather: O	-13.0	7.07	9.0	20.1	11.07
Thilawa Water		27	16	54	16	39.00	96	15.40	26 - 27	11	0.18	0.934	5.1	Temp: 30	-12.1	7.03	9.0	19.1	10.13
	Drop Anchor	-	17	00	16	39.01	96	15.36	-	-	-	-	-	Wet: 28	-12.3	-	-	-	-
	Anchor Awaigh	-	17	56	-	-	-	-	-	-	-	-	-		-	-	-	-	-
		28	18	18	16	39.40	96	15.20	27 - 28	84	1.40	0.447	0.3		-13.5	6.24	9.0	19.7	10.74
	Departure Of Port (DOP)	-	19	10	-	-	-	-	-	-	-	-	-		-	-	-		-

Source: The JICA Study Team

(2) The Case of M.V. Maersk Aberdeen

M.V. Maersk Aberdeen is a container carrier, which passed through Elephant Point and arrived at Yangon Port on 6th January 2016. The ship's particulars and truck record to Elephant Point are as below.

Name:	M.V.Maersk Aberdeen
LOA	155 m
Breadth:	25 m
Depth:	13.5 m
Design Load Draft:	9.713 m
Fully Load Draft:	9.713 m
DWT:	18367

The ship had contacted the Pilot Station on 5th January at 23:30. After the pilot boarded the ship at 11:36 on 6th January, the ship moved toward Elephant Point following the guidance of the pilot. The ship reached the Upper Float Buoy at 12:36 (See Figure 2.6.3). From this point the ship was sailing at the speed of 12.25 knots and reached the Intermediate Buoy at 12:50. Then the ship was sailing at the speed of 2.57 knots and reached the Lower Spit Buoy at 13:16. That means the ship needed 50 minutes to sail from Point 1 to Point 4. According to the truck record, the ship moved on the deepest route, i.e. same as the Fortune Tiger (See Figure 2.6.4). The highest tide of 6th January was 4.58 m and occurred at 13:17. During sailing time from the Upper Float Buoy to the Lower Spit Buoy, the tide level was about 4.5 m. Hence the keel clearance was not enough and the ship was sailing with approximately 30 cm ~ 70 cm of keel clearance. The ship had passed the Lower Spit Buoy at highest tide level at 13:17 and sailed to Elephant Point with keel clearance about 2 m.

The following figures and table shows the truck record of the ship and the calculation of ship's speed and keel clearance.

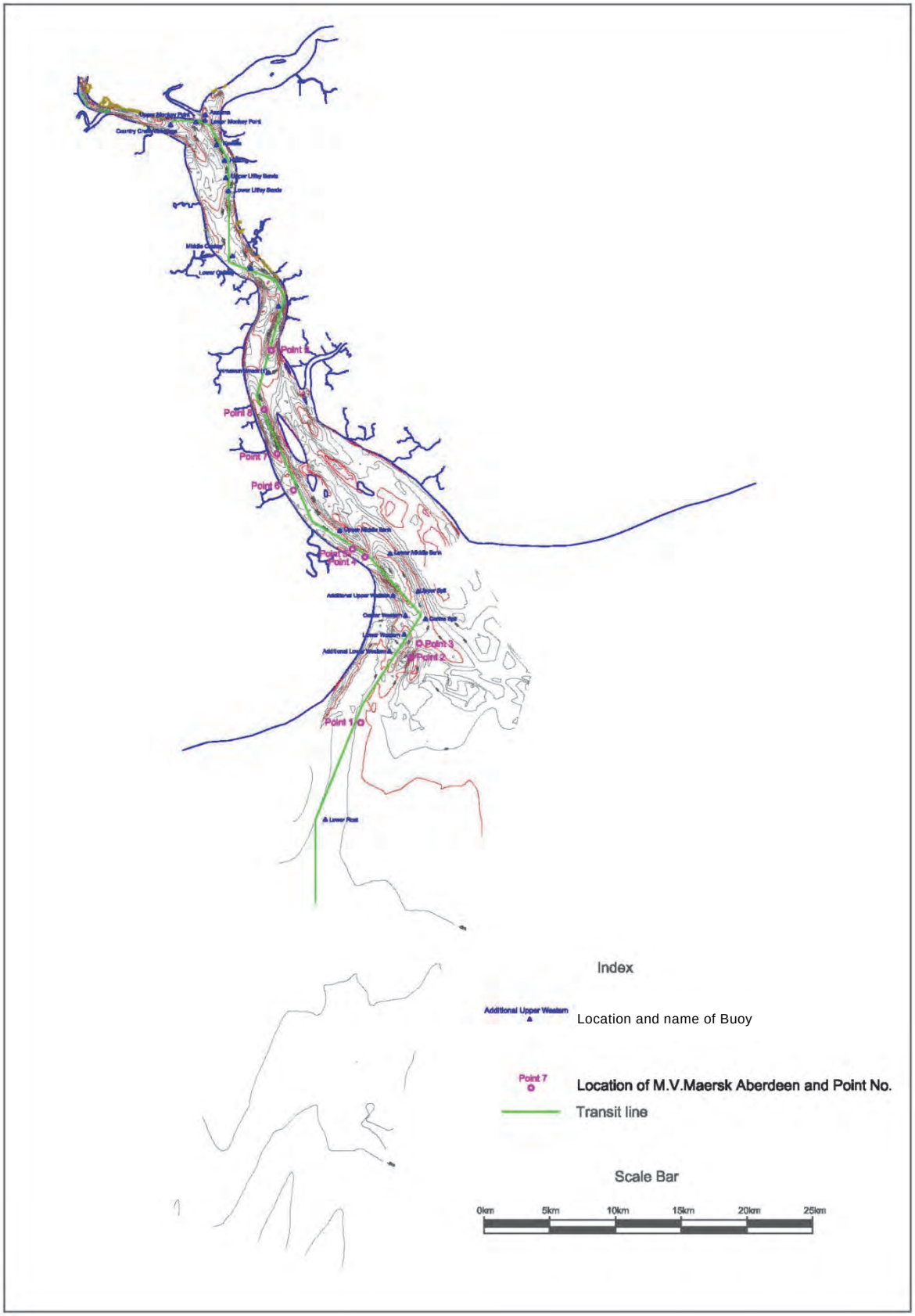


Figure 2.6.3. Truck Record of M.V. Maersk Aberdeen

Source: The JICA Study Team

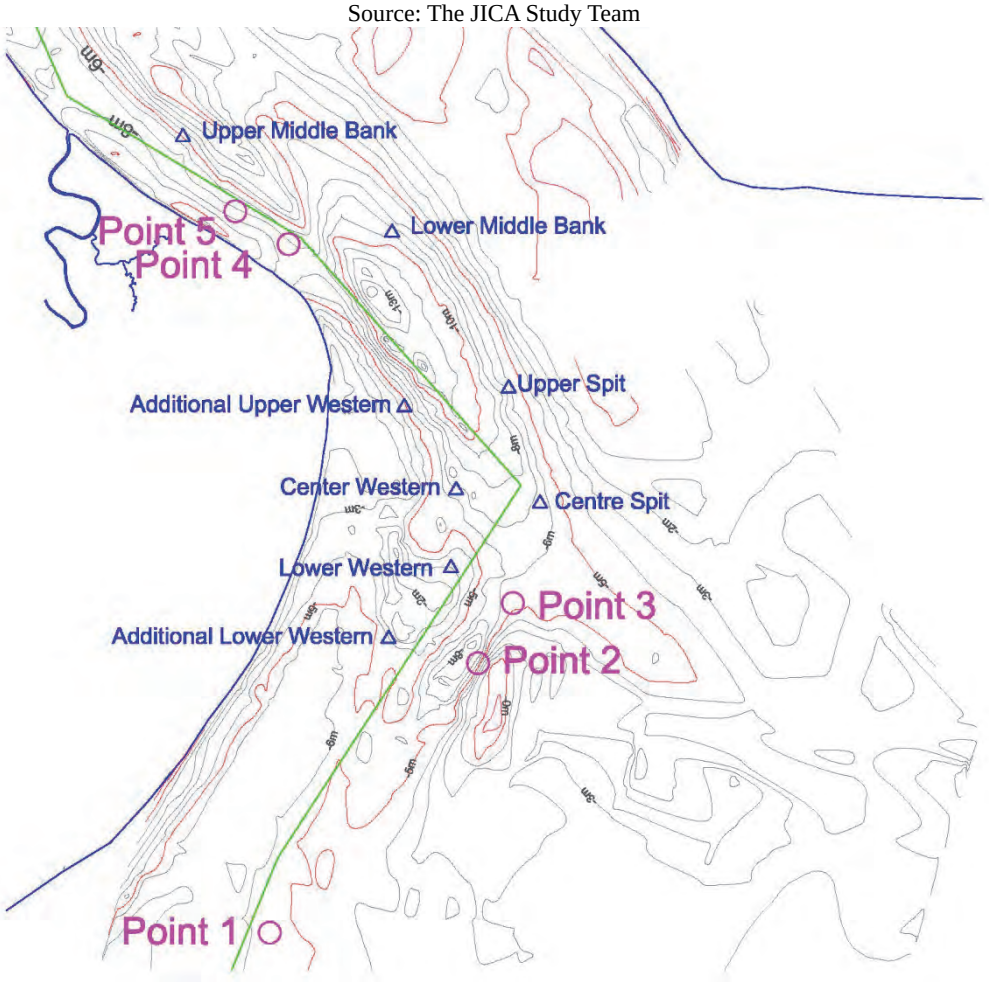


Figure 2.6.4. Truck Record of M.V. Maersk Aberdeen (At Elephant Point)

Source: The JICA Study Team

Table 2.6.3. Truck Record of M.V. Maersk Aberdeen

Point No.	Point name	Time		N		E		From - To	Time		Distance (km)	Velocity (knot)	Depth (m)	Tide (m)	Ship Draft (m)	Water depth (m)	Keel clearance (m)
		hr	min	deg	min	deg	min		min	hr							
1	Upper float bouy	12	36	16	21.71	96	19.27	-	-	-	-	-	-5.7	4.5	9.713	10.2	0.487
2	Intermediate bouy	12	50	16	23.87	96	21.37	1-2	14	0.23	5.47	12.65	-5.9	4.52	9.713	10.42	0.707
3	Lower spit bouy	13	6	16	24.47	96	21.72	2-3	16	0.27	1.27	2.57	-5.5	4.59	9.713	10.09	0.377
4	Elephant point	13	26	16	28.00	96	19.37	3-4	20	0.33	7.74	12.54	-7.2	4.58	9.713	11.78	2.067
5	CMB bouy	13	36	16	28.32	96	18.82	4-5	10	0.17	1.14	3.71	-7.3	4.55	9.713	11.85	2.137
6	Thayettan creek	13	50	16	30.71	96	16.27	5-6	14	0.23	6.33	14.65	-8.6	4.51	9.713	13.11	3.397
7	Sading HMWT creek	14	0	16	32.19	96	15.55	6-7	10	0.17	3.02	9.78	-11	4.49	9.713	15.49	5.777
8	Kwin waing	14	6	16	34.01	96	14.96	7-8	6	0.10	3.52	18.99	-8.9	4.45	9.713	13.35	3.637
9	Ship breaking yard	14	23	16	36.465	96	15.24	8-9	17	0.28	4.56	8.69	-10.1	4.35	9.713	14.45	4.737

Source: The JICA Study Team

2.7. Sunken Ships and Obstacles along the Navigation Channel

2.7.1. Sunken Ships and Obstacles along the Navigation Channel from the Viewpoints of Bathymetric Survey Results

The locations of the sunken ships and obstacles around the Yangon Port caused by the Cyclone Nargis in May 2008 were already identified by the results of the "Bathymetric Survey at the Yangon Port" by JICA in 2008.

The Government of Myanmar and also the MPA know which sunken ships or barges have been already salvaged or not.

The results of the 2nd bathymetric survey along the Transit Line, which were executed during October and November 2015 after the rainy season, show that no distinct sunken ships or obstacles exist within the bathymetric survey area along the Transit Line (150 m on both sides of the Transit Line and approx. 72.0 km length).

However, the results of the bathymetric survey at Elephant Point (color map of Elephant Point before rainy seasons) show three (3) elliptical depression points on the western side of the Transit Line. These elliptical depression points are approx. 50 m wide and 200 m long. Figure 2.7.1 shows area of the color map (which is the area of multi beam survey) and Figure 2.7.2 shows the locations of these elliptical depression points at Elephant Point.

The direction of the long axis of these three (3) elliptical depression points are almost the same (north by north west～south by south east direction). The river flow direction around Elephant Point of the Yangon River, which was observed in Package 2, is approx. 150 degrees.

Therefore, the direction of the long axis of these elliptical depression points coincides with the river flow direction at Elephant Point. The upstream of the elliptical depression points are deep and the downstream of the elliptical depression points become shallower than the upstream side.

The symbol of the sunken ship is shown at the western side of the Transit Line on the 1:35,000 scale bathymetric map of Elephant Point, prepared by the MPA in January 2015.

The values of longitude and latitude of this sunken ship were measured on the 1:35,000-scale bathymetric map at Elephant Point prepared by the MPA in January 2015. The values of longitude and latitude of the sunken ship were converted into UTM coordinates to be able to show the location of sunken ships on the color map of Elephant Point.

Table 2.7.1. shows the longitude and latitude values and the UTM coordinates of the sunken ship at Elephant Point, which is shown on the bathymetric map prepared by the MPA in January 2015.

Table 2.7.1. Longitude and Latitude, and UTM Coordinates of the Sunken Ship Shown on the 1:35,000-Scale Bathymetric Map Prepared by MPA in January 2015

Item	Location		Note
Location of sunken ship indicated on bathymetric map of MPA in January 2015	Longitude/Latitude		Ellipsoid: WGS-84
	16°25′18″N	96°20′57″E	
	Horizontal Coordinates		
	E (m)	N (m)	Ellipsoid: WGS-84 Projection: UTM Zone, No. 47 N
	216,900	1,817,431	

Source: JICA survey team

The location of the sunken ship was overlapped on the color map before the rainy season, based on the horizontal coordinates of Table 2.7.1. The red circle mark (○) on Figure 2.7.2. is the location of the sunken ship which is shown on the 1:35,000-scale bathymetric map of Elephant Point prepared by the MPA in January 2015.

The orange line is the Transit Line based on the horizontal coordinates provided by the MPA.

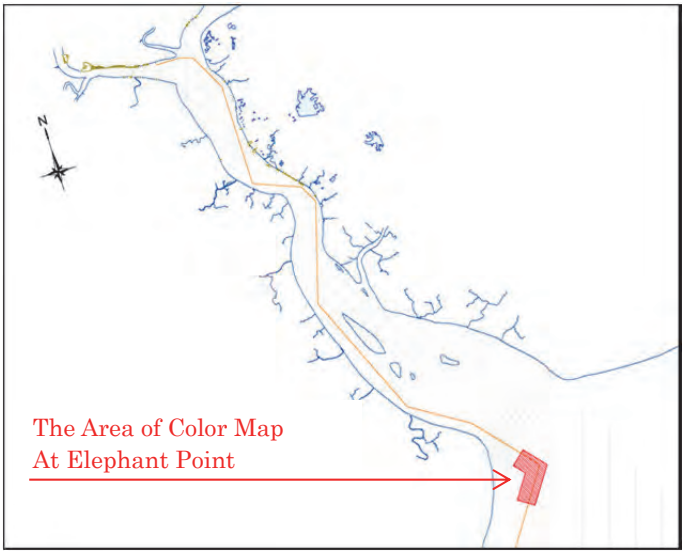
The location of the sunken ship shown on the 1:35,000-scale bathymetric map prepared by the MPA in January 2015 coincides with one of the elliptical depression points on the color map before the rainy season.

Considering the above-mentioned matters, it is believed that obstacles exist upstream of the elliptical depression points. The shape of the elliptical depression was formed by the river flow of the Yangon River.

Furthermore, one of the elliptical depression points is considered as a sunken ship according to the information of the bathymetric map at Elephant Point prepared by the MPA in January 2015.

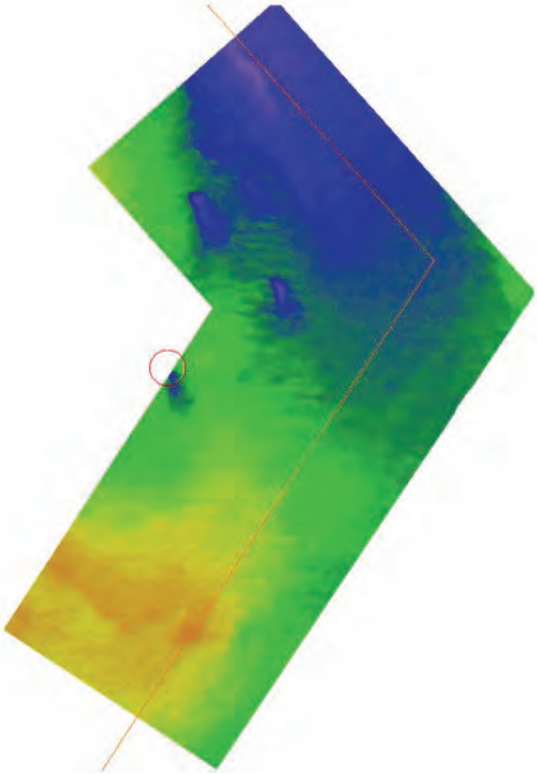
Figure 2.7.3 shows the image of the sunken ship at the Elephant Point prepared by the visualization of the river bed surface of the Yangon River based on the data of Multi-beam sounding system on 22nd November 2015. This image clearly shows that the object is a sunken ship. The size of sunken ship and the water depth at the location of sunken ship are estimated as follows:

1) Estimated width of sunken ship Approx. 5 m
2) Estimated length of sunken ship Approx. 25 m
3) Water depth at the location of sunken ship Approx. -9 m
4) Water depth at the top of sunken ship Approx. -4 m



Source: JICA survey team

Figure 2.7.1. The Area of Color Map at Elephant Point

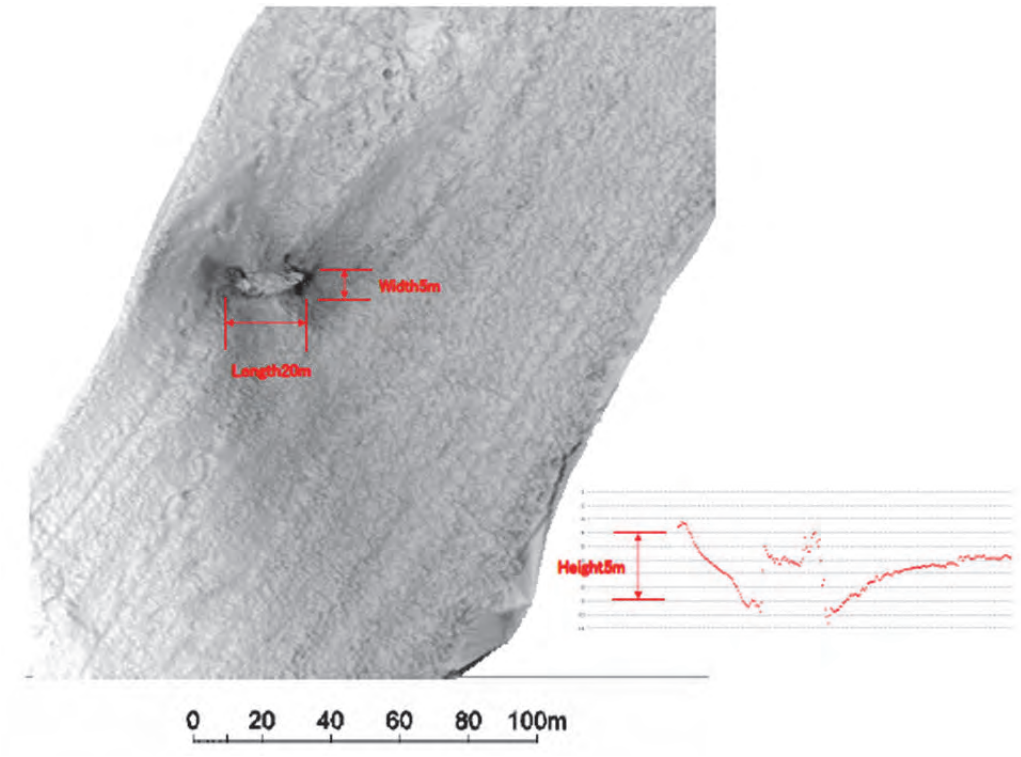


○ Location of the sunken ship shown on MPA bathymetric map (January 2015)

——— Transit Line provided by MPA

Note: Color map before rainy season

Figure 2.7.2. Location of Sunken Ship and Color Map Before Rainy Season



Source: JICA survey team

Figure 2.7.3. The Sunken Ship at Elephant Point (Observation on 22 October 2015)

The distance between these elliptical depression points and the Transit Line is approximately more than 500 m west from the Transit Line. Therefore, these obstacles may not affect the navigation of ships at Elephant Point.

However, the remaining two elliptical depression points are not shown on the 1:35,000-scale bathymetric map prepared by the MPA in January 2015 and other bathymetric maps of the MPA. Therefore, further investigation of these elliptical depression points will be necessary to define what the obstacles are.

2.7.2. Sunken Ships Shown on the Existing Chart

According to the existing chart (International chart series 833 Yangon River (Rangoon River and Approaches), Edition Number 3, Edition Date 1st August 2013), seven (7) sunken ships are shown between Monkey Point and the river mouth of the Yangon River. These sunken ships are shown as a red-colored circle mark (○) in Figure 2.7.4.

The location of the sunken ship shown on the 1:35,000-scale bathymetric map prepared by the MPA in January 2015 is shown as a blue-colored circle mark (○) on Figure 2.7.4. However, there is no sunken ship symbol at the location of the blue circle mark (○) on the existing chart.

The green line is the Transit Line based on the horizontal coordinates provided by the MPA. The locations of the sunken ships shown on the existing chart and also on the 1:35,000-scale bathymetric maps at Elephant Point prepared by the MPA in January 2015 are not located near the Transit Line.

Therefore, it is considered that these sunken ships do not interfere with the navigation of ships along the Yangon River and the river mouth area of the Yangon River under present circumstances.

Source: International Chart Series, Yangon River and Approaches 833
Edition Number: 3 Edition Date: 1st August 2013

Figure 2.7.4. Location of Sunken Ships Shown on the Existing Chart