Study of Transmission Pipeline Laying Position from WTP up to Hlaing River along Route No. 5

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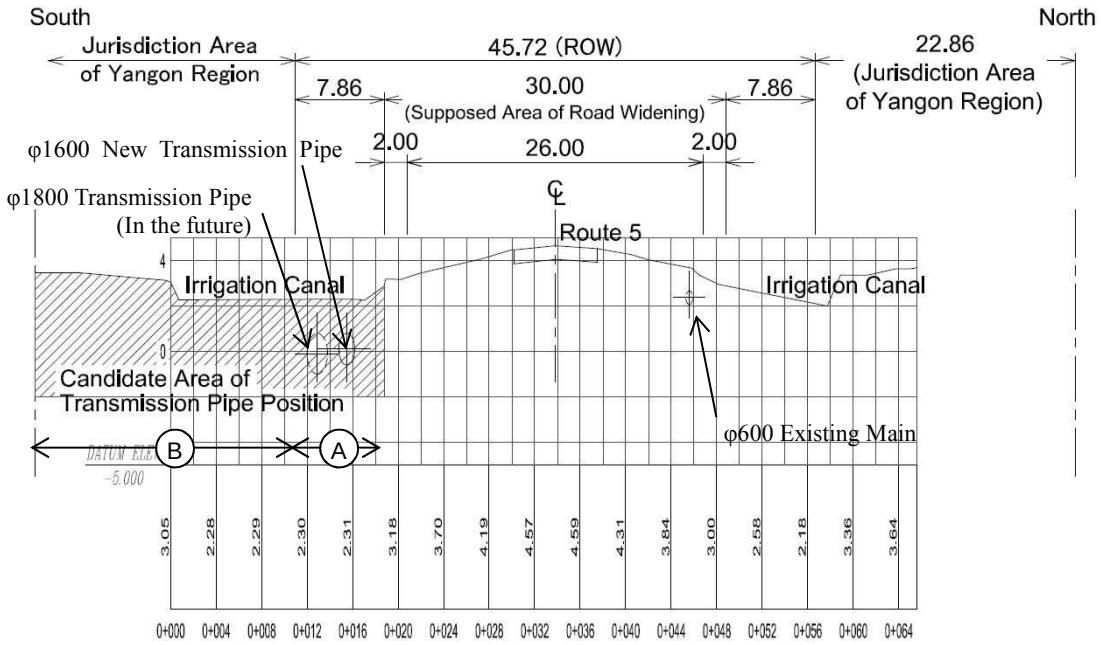
The current road situation is shown in the following Figure. The actual Route No. 5 is a 2-lane opposing road, but it is planned to be expanded to a 4-lane opposing road (lane width 3.25 m) with a sidewalk/ditch, and the expansion area width is estimated to be 30 m. The below two plans are proposed for the transmission pipe laying position for the construction of the loan project.

- Plan A: Inside the road land (outside of the future expansion site)
- Plan B: Inside the Yangon Government jurisdiction area adjacent to the road land



Source: JICA Study Team

Figure.1 Road Situation (Htantabin TS)

Following discussions with YCDC and MoAI, the general pipe laying position has been decided to adopt Plan A (within the road land) at a location 18.3 m (60 ft) away from the road center for the φ1600 mm transmission pipes of the loan project, since the area proposed in Plan B is used for irrigation canals. At several points in the area of Plan A the irrigation canals appear, since the sidewalls of canals are not formed by concrete, but the area of Plan A is road land.

As per the instructions of MoAI, the earth covering shall be over 1.5 m considering the heavy vehicles which shall be used for pipeline maintenance works.

During the construction, sandbags shall be used to divide the irrigation canal and the construction site, and to maintain the irrigation canal area and flow during excavation.

Discussions between YCDC and MoAI have not yet been hold for the φ1800 mm transmission pipeline of the future plans, hence said pipes are currently planned to be laid in the same Plan A position as the φ1600 mm transmission pipes. This is to be finalized when the actual development is being discussed, considering the road expansion plan and situation, and the usage of the land along the road at the time.

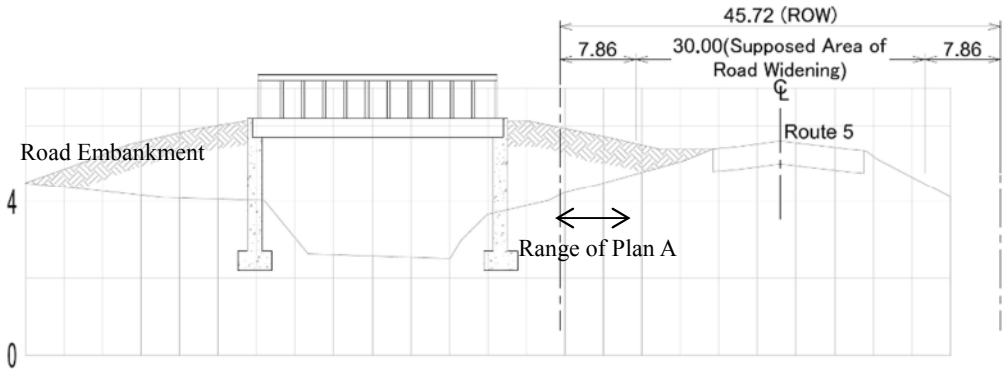
1.1.2 Obstacles

(a) Bridges Crossing Irrigation Canals

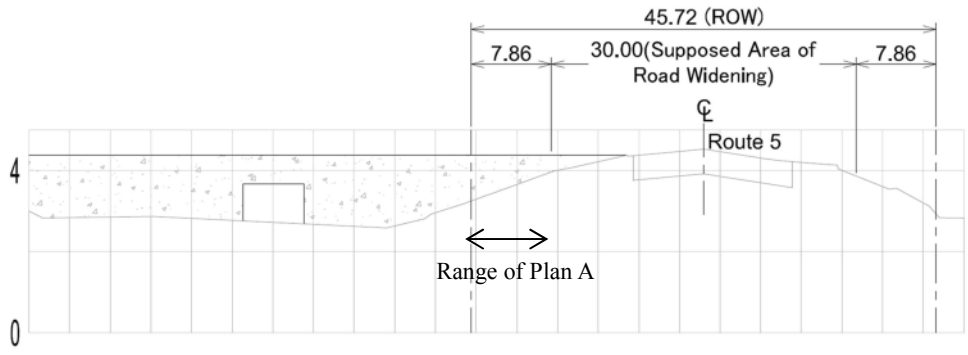
There are three (3) types of bridges crossing the irrigation canals which are located along the proposed route of the transmission pipelines.

- Pedestrian bridge
- Bridge through which vehicles can pass, and connect to public roads along Route No. 5
- Bridge through which vehicles can pass, and are used to enter private areas along Route No. 5

The bridges through which vehicles can pass are basically owned by MoC, including those which connect to private areas. Pedestrian bridges are simple and made up of wood, so they shall be removed and restored after the transmission pipeline construction. As shown in the following Figure, there are two (2) types of bridges through which vehicles can pass.



(a) Bridging Type



(b) Box-culvert Type

Source: JICA Study Team

Figure.2 Bridge Types Crossing Irrigation Canals (Htantabin TS)

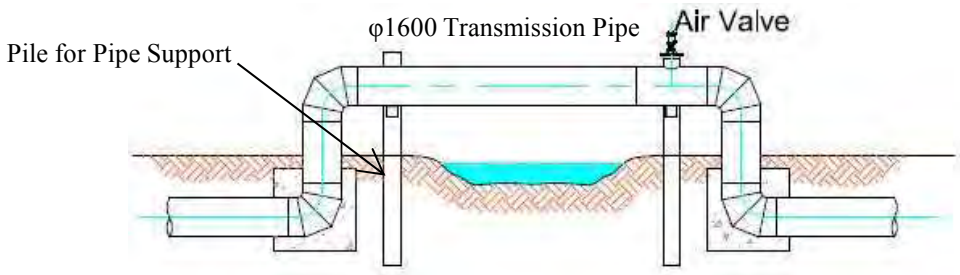
Bridging type is used for roads with narrow width, and box- culvert type is used for wide roads and bridges connecting to private areas. The retaining wall structure of the bridging type bridges within the

road land is embankment, and the box-culvert type is embankment and concrete or bricks, and there are no main structures for the upper construction. The transmission pipes are to be laid at locations which will not affect the upper construction. The retaining walls of the box-culvert types shall be partly removed and restored for the construction.

(b) Canals Crossing Route No. 5 to link Canals on Both Sides

There are six (6) locations in Htantabin TS where a canal crosses the road to link canals on both sides. As shown in Photo 1, these connecting parts are lower than its surroundings. It is required to dig deeper than normal to lay transmission pipes in order to cross under this structure, and the water suspension/draining works may be difficult since the water tends to concentrate in these locations. It is recommended to construct pipelines over the crossing canals at these locations, as shown in the following Figure.

Photo 1 Canal Crossing



Source: JICA Study Team

Figure 3 Cross-section of Connection Canal (Htantabin TS)

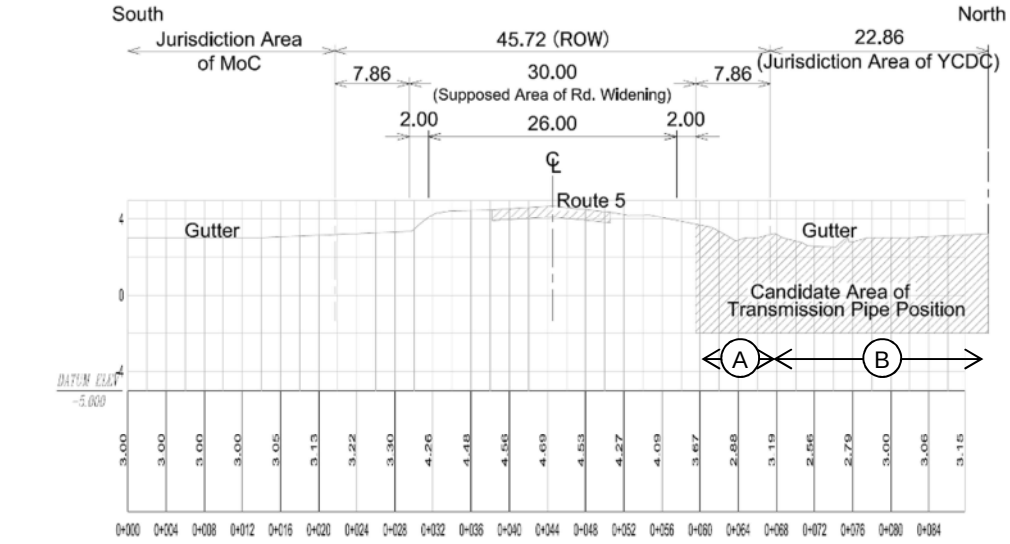
1.2 On the North Side of Route No. 5 (Hlaing Tharyar TS)

1.2.1 Transmission Pipe Laying Position

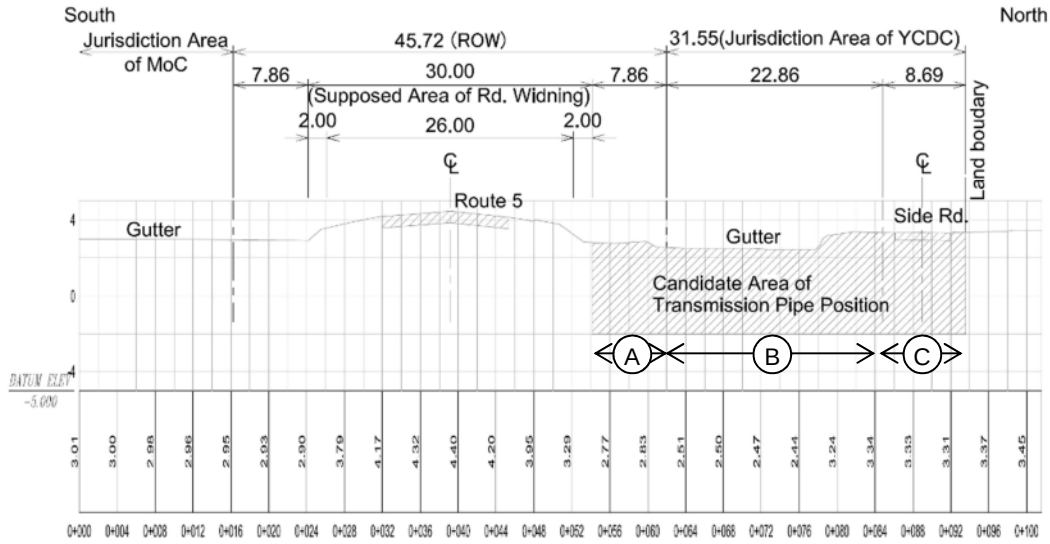
The current situation of road is shown in the following Figure. As shown in the Figure, there are two types of cross sectional drawings of the public land areas neighboring Route No. 5 land in Hlaing Tharyar TS: Lands which have public roads and others which do not. The actual Route No. 5 is a 4-lane road, but it is planned to be expanded to have 4-lanes on each side (lane width 3.25 m) with a sidewalk/ditch, and the expansion area width is estimated to be 30 m. The below three (3) plans are proposed as the transmission pipe laying position.

- Plan A: Inside the road land (outside of the future expansion site)
- Plan B: Inside the YCDC jurisdiction area adjacent to the road land

- Plan C: Inside the YCDC side roads neighboring YCDC jurisdiction area (only areas with side roads)



(1) No Side Road



(2) With Side Road

Source: JICA Study Team

Figure.4 Road Situation (Hlaing Tharyar TS)

The street status differs largely within Hlaing Tharyar TS. Therefore, the transmission pipe laying positions shall be considered divided into two (2) areas; the upper stream of Zone 9 SR/RPS, and the lower stream of SR/RPS.

1.2.2 Area 1: Upper Stream of Zone 9 SR

(a) Considered Area

This area is divided into 2 areas, based on whether it has a side road or not. The area is shown in the following Figure. The pipe laying position shall be decided by evaluating the status of water in the low grounds, obstacles such as steel towers and trees, illegal houses and construction workability.

- Area 1-1: No side roads. Laying plan A or B
- Area 1-2: With side roads. Laying plan A, B or C.

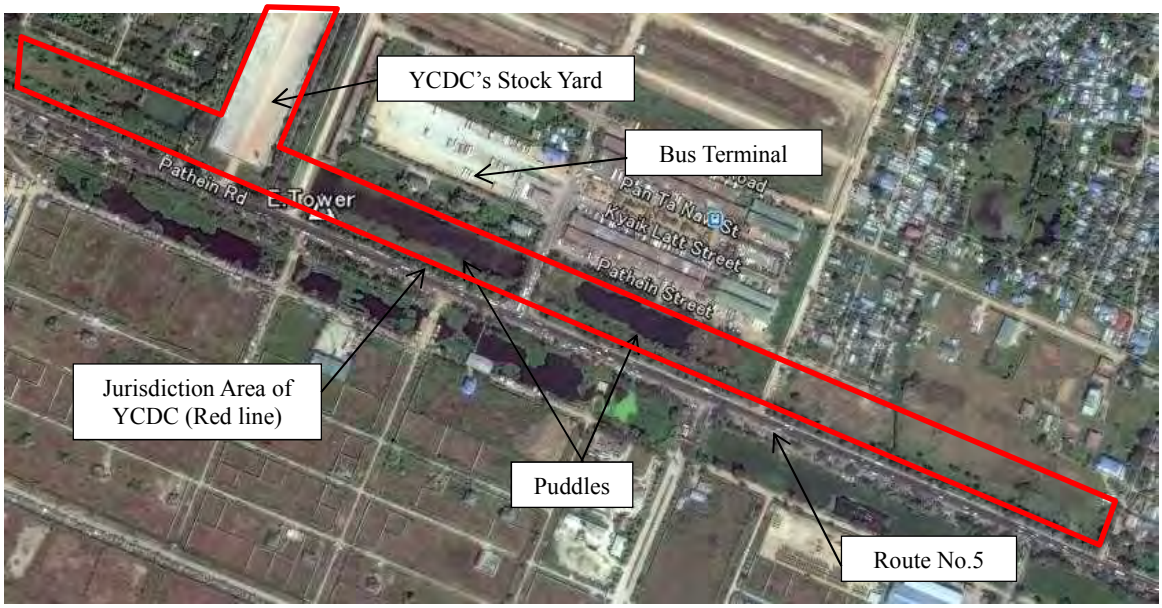
Source: JICA Study Team, Background Google Earth

Figure.5 Laying Plan Area (Hlaing Tharyar TS: Area 1)

(b) Area 1-1

Situation of Area 1-1

- No side roads.
- Transmission pipe of φ1600 mm (ODA loan project), and a distribution main of φ1000 mm (YCDC) are to be constructed by 2025. A transmission pipe of φ1800 mm (YCDC) is also to be added in the future.
- The width of YCDC jurisdiction area neighboring the road land is 60 m, and wider than the general design shown in the following Figure.
- There is a steel tower on the road side of the YCDC area (26 m from the road center). There are puddles in the 2 blocks located south of the bus terminal, but no other puddles have been found. Said puddles are not irrigation ponds.
- An YCDC stockyard is located next to the bus terminal.
- There are no illegal houses.



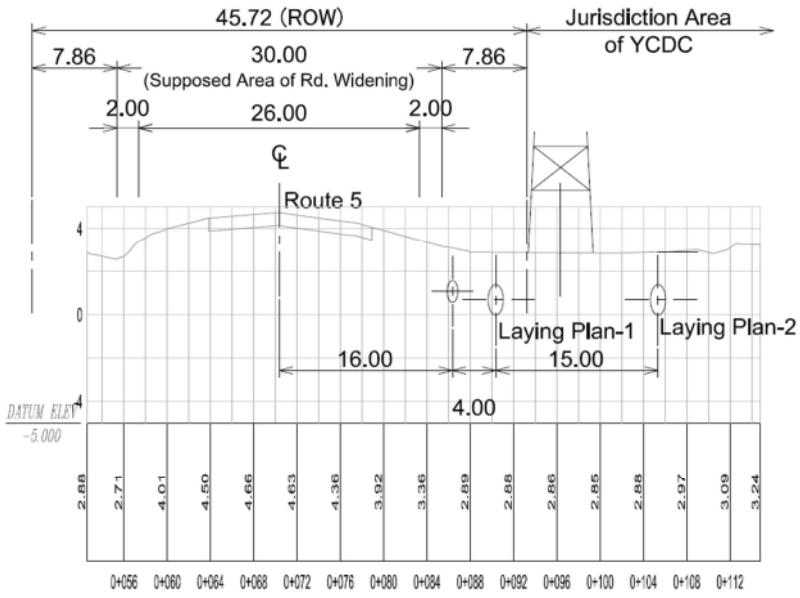
Source: JICA Study Team, Background Google Earth

Figure 6 Situation of Area 1-1

Considerations for Pipe Laying Position

2 plans are proposed for Area 1-1 to avoid the steel tower (refer to the following Figure). The considered methods are listed below.

- Laying plan 1: Area A, between the steel tower and Route No. 5
- Laying plan 2: Area B, avoiding the steel tower and located along the puddle at the south of the bus terminal



Source JICA Study Team

Figure 7 Laying Plan for Area 1-1

The comparisons of the 2 plans are shown in the following Table.
The construction workability is superior in Laying plan 2, the land condition, influence to traffic for maintenance works and social economic consideration points are equal in both plans.

From the study, **Laying plan 1** is recommended for the small diameter φ1000 mm distribution main (YCDC), and **Laying plan 2** is recommended for the φ1600 mm transmission pipe (JICA) and φ1800 mm transmission pipe (YCDC, future plan).

Table 1 Comparisons of Laying Plans for Area 1-1

Item	Laying Plan 1	Laying Plan 2
1. Technical Evaluation (Land Acquisition and Impact on Traffic)		
・Land Acquisition	No need	No need
・Land Owner	MoC	YCDC
・Impact on Traffic by Construction	No	No
・Impact on Traffic by Pipeline Maintenance	No	No
2. Technical Evaluation (Construction Workability and Maintenance)		
・Construction Workability	・Distance close to steel tower ・Many trees ・Measures necessary for water south of bus terminal	・Enough distance from steel tower ・Less trees than Plan 1 ・Measures necessary for water south of bus terminal
・Maintenance	OK	OK
・Evaluation	△	❍
3. Social Economic Evaluation		
・Illegal Households	0	0
・Illegal Squatters	0	0
・Evaluation	◎	◎
4. Overall Evaluation	△	○ (Recommended)

Source: JICA Study Team

(c) Area 1-2

Situation of Area 1-2

- There are side roads.
- Transmission pipe of φ1600 mm (loan project), and a distribution main (YCDC, φ1000 mm to the first roundabout and φ1600 mm from there to the SR) are to be constructed by 2025. A transmission pipe of φ1800 mm (YCDC) is also to be added in the future. There are 2 roundabouts in this area.
- There are steel towers in the area north of the road along the upper stream of YCDC jurisdiction area neighboring the road land (low land) to the first roundabout. There are no steel towers from this roundabout to Zone 9 SR, but there are public roads and pedestrian bridges. There are puddles, although the water amount declines in the dry season.
- There are many illegal households near the 2 roundabouts, mainly located along Route No. 5.

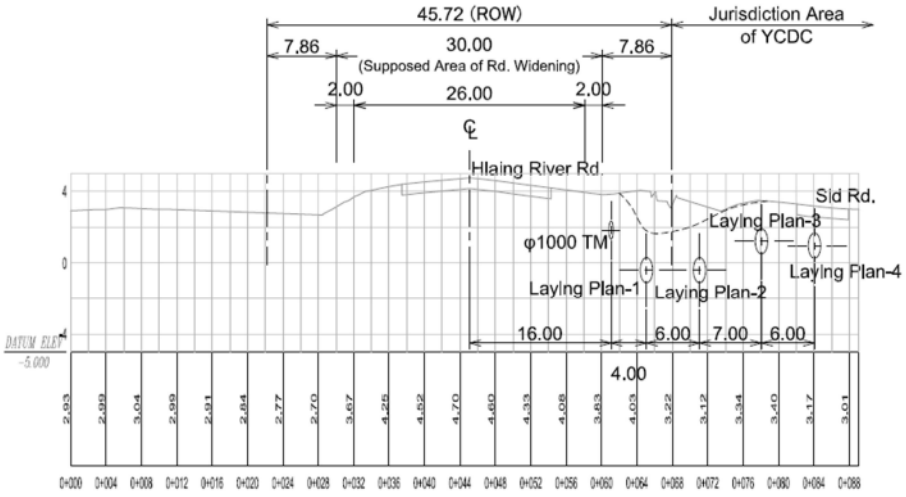
Source: JICA Study Team, Background Google Earth

Figure 8 Situation of Area 1-2

Considerations for Pipe Laying Position

4 pipe laying positions (following Figure) shall be compared for Area 1-2. The major points of each plan are as follows.

- Laying plan 1: Area A (Within road land)
- Laying plan 2: Area B, close to the road
- Laying plan 3: Area B, close to the side road
- Laying plan 4: Area C (Within side road land)



Source: JICA Study Team

Figure 9 Laying Plans for Area 1-2

The comparisons of the 4 plans are shown in the following Table.

Laying plan 1 has obstacles such as trees, pedestrian bridges and illegal households and the construction workability is poor, but it allows avoiding the removal of upper construction of the road bridges. The construction workability for laying plan 2 and 3 is also poor, due to steel towers, bridge crossings (pedestrian and road bridges) and illegal households. Laying plan 2 also requires measures for puddles. On the other hand, laying plan 4 is superior in terms of both construction workability and social economic consideration, since there are no obstacles and illegal housings in the area and it is also easy to avoid the two roundabouts.

For this reason, **laying plan 4** is proposed for the φ1600 mm construction of the loan project. Laying plan 1 is recommended for the φ1000 mm distribution main (from φ1600 mm to φ1000 mm) and future plan φ1800 mm transmission pipe construction by YCDC.

Table 2 Comparisons of Laying Plans for Area 1-2

Item	Laying Plan 1	Laying Plan 2	Laying Plan 3	Laying Plan 4
1. Technical Evaluation (Land Acquisition and Impact on Traffic)				
・Land Acquisition	No need			
・Land Owner	MoC	YCDC		
・Impact on Traffic by Construction	No			Small
・Impact on Traffic by Pipeline Maintenance	No			Small
2. Technical Evaluation (Construction Workability and Maintenance)				
・Construction Workability	・Obstacles (trees, bridges) throughout the area ・Measure for puddle is necessary ・Resettlement of illegal households is necessary	・Obstacles (steel towers, crossing bridges) throughout the area ・Measure for puddle is necessary ・Resettlement of illegal households is necessary	・Obstacles (crossing, bridges) throughout the area ・Resettlement of illegal households is necessary	・No obstacles ・Easy to avoid the round about
・Maintenance	OK	OK	OK	OK
・Evaluation	△	×	×	○
3. Social Economic Evaluation				
・Illegal Households	5	2	4	0
・Illegal Squatters	25	10	20	0
・Evaluation	○	○	○	◎
4. Overall Evaluation	△	×	×	○ (Recommended)

Notes: Interviews of illegal squatters were not permitted by YCDC due to safety reasons. The number of squatters was calculated as 5 persons per household (Reference: 2014 census 4.4person/household)
Source: JICA Study Team

1.2.3 Area 2: Lower Stream of Zone 9 SR (SR to Kyan Sittar Road)

(a) Considered Area

This area is divided into 2 areas, Area 2-1 and 2-2, depending on whether it has a side road or not. The area is shown in the following Figure. The pipe laying position shall be decided by evaluating the status of water in the low grounds, obstacles such as crossing bridges and trees, illegal houses and construction workability.

- Area 2-1 : No side road. Laying plan area A or B
- Area 2-2 : With side road. Laying plan area A., B or C

Source: JICA Study Team, Background Google Earth

Figure 10 Laying Plan Area (Hlaing Tharyar TS: Area 2)

(b) Area 2-1

Situation of Area 2-1

- No side roads.
- A transmission pipe of φ1600 mm (loan project) shall be constructed by 2025. A distribution main of φ1000 mm (YCDC) is also planned.
- There are 7 bridges crossing low grounds. 2 of the bridges connect to private areas.
- Illegal households are concentrated near the bridge at the center of the area, between the low-ground puddles and Route No. 5.

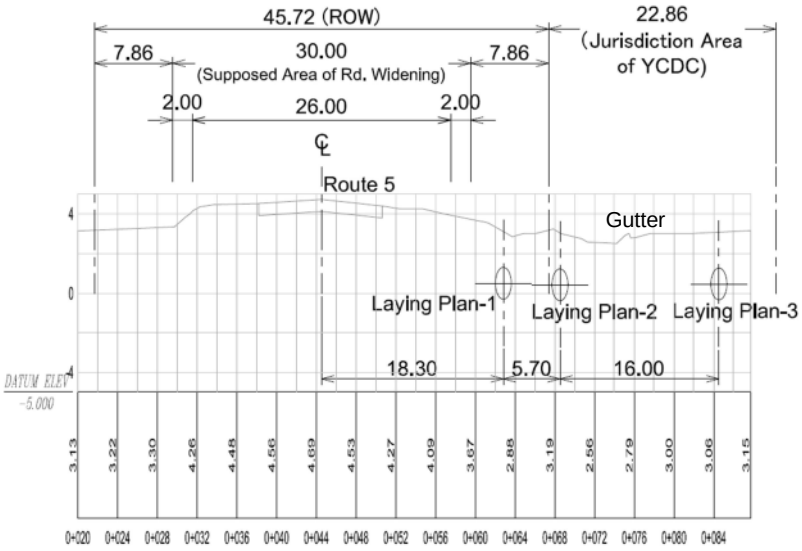
Source: JICA Study Team, Background Google Earth

Figure 11 Situation of Area 2-1

Considerations for Pipe Laying Position

3 pipe laying positions (following Figure) shall be compared for Area 2-1. The major points of each plan are as follows.

- Laying plan 1: Area A, outside the expected expansion area
- Laying plan 2: Area B, inside the puddle circle of the low grounds (road side)
- Laying plan 3: Area B, outside the puddle circle of the low grounds



Source: JICA Study Team

Figure 12 Laying Plans for Area 2-1

The comparison of the 3 plans is shown in the following Table.

There are 7 crossing bridges for the low grounds, but inside the road land of Route No. 5 there is only the approach parts to the bridges and not the bridging upper structures. Therefore, there is no need to remove the road bridges to lay the transmission pipes in laying plan 1, although resettlement of illegal households is necessary.

The approach parts of the bridges connecting to private areas are larger than other bridges. For laying plan 2, there is no need to interfere with the bridge upper structure of the bridges connecting to private areas, but the other bridges shall require removal and restore construction. And in addition, resettlement of illegal households is necessary. Laying plan 3 shall require the removal and restoration of the bridges connecting to private areas, but there are no other problems. There are no illegal households near the bridges connecting to private areas. By adopting laying plan 3 to lay pipes near this area, using plan 2 to cross the low grounds and pass the private area connecting bridges, and then returning to plan 3, it is possible to avoid both the removal of bridges and resettlement of illegal households.

Therefore **laying plan 2 is proposed for the areas near private area** connecting bridges, and **laying plan 3 for other areas**. For the distribution main construction by YCDC, laying plan 1 shall be proposed to avoid the removal and restoration of crossing bridges, instead of plan 2 which uses YCDC's land.

Table 3 Comparisons of Laying Plans for Area 2-1

Item	Laying Plan 1	Laying Plan 2	Laying Plan 3
1. Technical Evaluation (Land Acquisition and Impact on Traffic)			
・Land Acquisition	No need		
・Land Owner	MoC	YCDC	YCDC, Private land
・Impact on Traffic by Construction	No		Affect private land
・Impact on Traffic by Pipeline Maintenance	No		Affect private land
2. Technical Evaluation (Construction Workability and Maintenance)			
・Construction Workability	・No need to remove/ restore bridge ・Resettlement of illegal households is necessary	・No need to remove/ restore bridges connecting to private areas ・Remove/ restore is necessary for other bridges ・Resettlement of illegal households is necessary	・Partial private land. To avoid it, remove/restore of private area connecting bridges is necessary ・No obstacles, workability is high except the private land connecting bridge area
・Maintenance	OK	OK	OK
・Evaluation	△	△	△
3. Social Economic Evaluation			
・Illegal Households	7	1	0
・Illegal Squatters	35	5	0
・Evaluation	○	○	◎
4. Overall Evaluation			
・Area of private land connecting bridges	○	○	×
・Other areas	△	△	○

Notes: interview of illegal squatters were not permitted by YCDC due to safety reasons. The number of squatters was calculated as 5 persons per household (Reference: 2014 census 4.4person/household)
Source: JICA Study Team

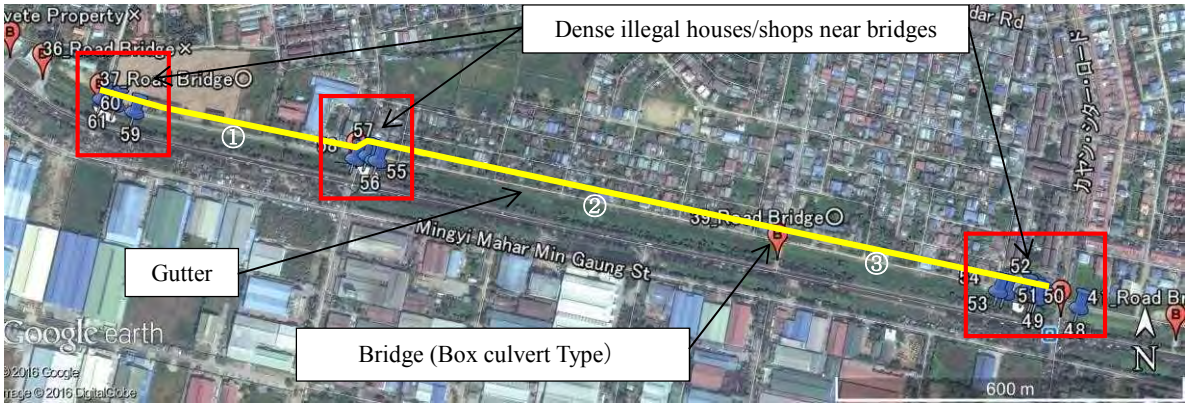
Source: JICA Study Team, Background Google Earth

Figure 13 Planned Laying Position for Area 2-1

(c) Area 2-2

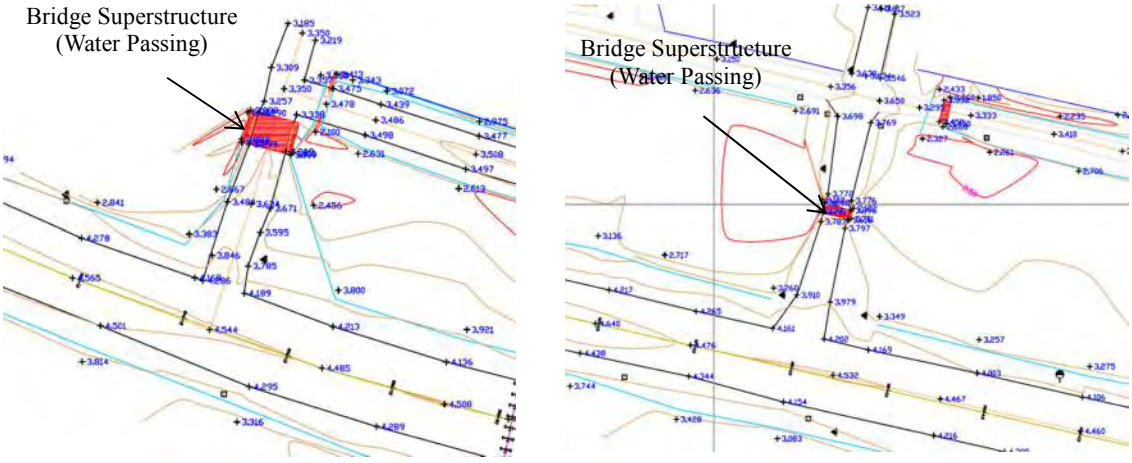
Situation of Area 2-2

- There are side roads.
- A transmission pipe of φ1600 mm (loan project) shall be constructed by 2025. A distribution pipe of φ800 mm (YCDC) is also planned.
- There are 4 bridges crossing the low grounds (including the area border), and the area is divided into 3 areas by these bridges. The crossing bridges are box-culvert type. As shown in Figure 15, water is running through the north of area 1, and the center of area 2 and 3.
- The width of the low grounds neighboring road land is narrow in the upper stream area.
- The amount of water in low grounds is small.
- Illegal households are concentrated near the bridges crossing the low grounds. There are more houses along the crossing bridges (inside the low grounds) than along Route No. 5.



Source: JICA Study Team, Background Google Earth

Figure 14 Situation of Area 2-2



Source: JICA Study Team

Bridge of No. 1 **Bridges of No. 2, 3 and Border**

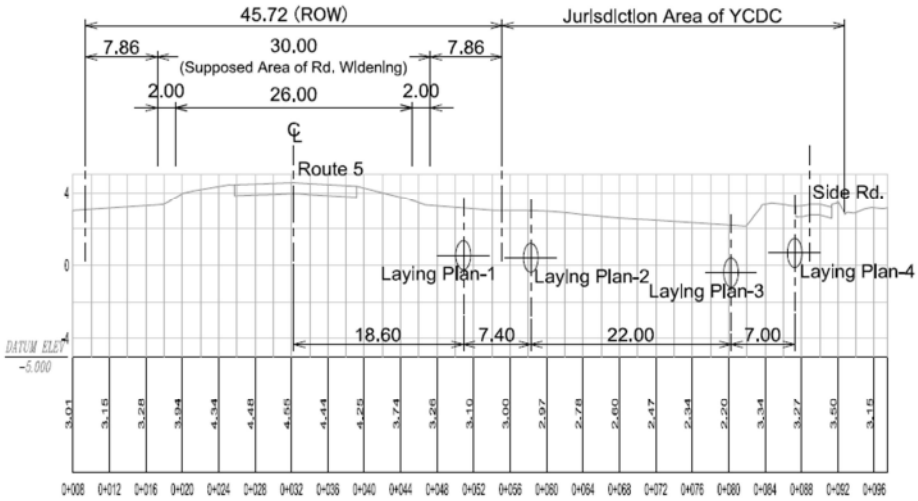
Figure 15 Bridge of Area 2-2

<u>Considerations for Pipe Laying Position</u>

4 pipe laying positions (following Figure) shall be compared for Area 2-2. The major points of each

plan are as follows.

- Laying plan 1: Area A, outside the expected expansion area.
- Laying plan 2: Area B, inside the puddle circle of the low grounds (road side)
- Laying plan 3: Area B, the side road side of the puddle circle of the low grounds.
- Laying plan 4: Area C, under the side road.



Source: JICA Study Team

Figure 16 Laying Plans for Area 2-2

The comparisons of the 4 plans are shown in the following Table.

For area 1, many trees and illegal households cause difficulties for laying plan 1 and 2. The area mentioned in laying plan 3 has a crossing bridge which water is running and hence water gathers at the point, in addition to that the pipes need to be laid at the water running point.

Laying plan 4 has no problems for the crossing bridge or illegal households.

For area 2, the construction workability has no problems for all laying plans, since there are no illegal households and the water of the crossing bridge is running through the center of the low grounds, although plan 1 and 2 areas have lower workability due to the many trees.

In area 3, many illegal households are concentrated along Kyan Sitter Road, and resident resettlement is necessary for all plans except laying plan 4. In addition, plan 1 and 2 areas have lower workability due to the many trees.

For the above reasons, the transmission pipe laying plans can be narrowed down to either laying plan 4 for all areas, or a combination of plan 4 for area 1 and 3 and plan 3 for area 2. **Laying plan 4** shall be proposed since it will enable to lay the transmission pipes straight through the area. For the distribution main which will be constructed by YCDC, laying plan 2 is proposed. The construction workability is low due to the trees, but the land is owned by YCDC.

Table 4 Comparisons of Laying Plans for Area 2-2

Item	Laying Plan 1	Laying Plan 2	Laying Plan 3	Laying Plan 4
1. Technical Evaluation (Land Acquisition and Impact on Traffic)				
・Land Acquisition	No need			
・Land Owner	MoC	YCDC		
・Impact on Traffic by Construction	No			Small
・Impact on Traffic by Pipeline Maintenance	No			Small
2. Technical Evaluation (Construction Workability and Maintenance)				
・Construction Workability	・Trees throughout the area ・Resettlement of illegal households is necessary	・Trees throughout the area ・Resettlement of illegal households is necessary	・Interfering with water point of crossing bridge at area 1 ・Resettlement of illegal households is necessary	・No obstacles
・Maintenance	OK	OK	OK	OK
・Evaluation	△	△	×	○
3. Social Economic Evaluation				
・Illegal Households	9	3	1	0
・Illegal Squatters	45	15	5	0
・Evaluation	○	○	○	◎
4. Overall Evaluation				
・Area 1	△	△	×	○
・Area 2	△	△	○	○
・Area 3	△	△	△	○

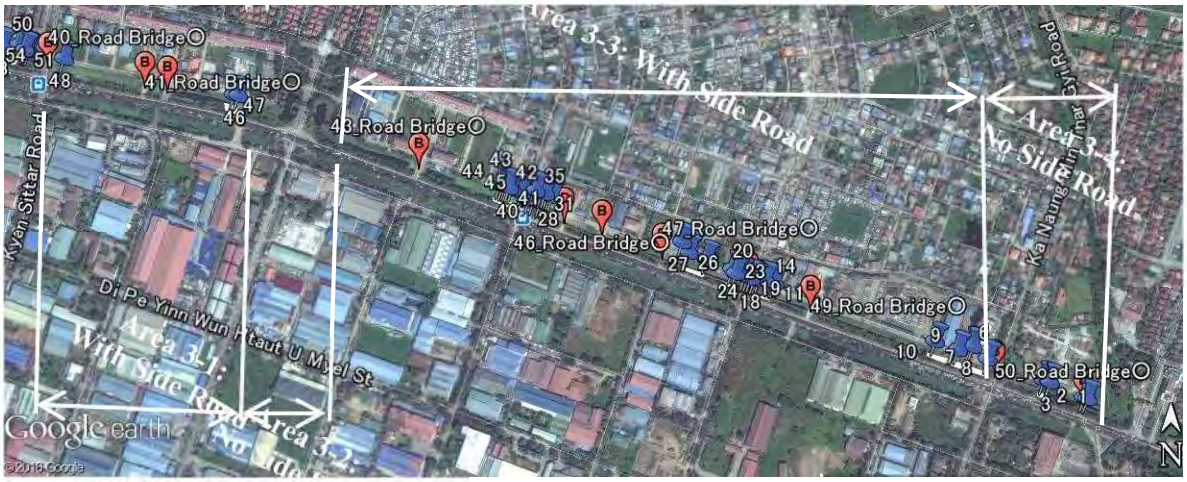
Notes: interview of illegal squatters were not permitted by YCDC due to safety reasons. The number of squatters was calculated as 5 persons per household (Reference: 2014 census 4.4person/household)
Source: JICA Study Team

1.2.4 Area 3: Lower Stream of Zone 9 (Kyan Shitter Road to North End Point of Route No. 5)

(a) Considered Area

This area is divided into 4 areas, Area 3-1 to 3-4, considering whether it has a side road or not. The area is shown in the following Figure. The pipe laying position shall be decided by evaluating the status of water in the low grounds, obstacles such as crossing bridges and trees, illegal houses and construction workability.

- Area 3-1: With side road. Laying plan area A, B or C
- Area 3-2: No side road. (Details mentioned below)
- Area 3-3: With side road. Laying plan area A, B or C
- Area 3-4: No side road. Laying plan area A or B



Source: JICA Study Team, Background Google Earth

Figure 17 Laying Plan Area (Hlaing Tharyar TS: Area 3)

(b) Area 3-1

Situation of Area 3-1

- There are side roads.
- A transmission pipe of φ1600 mm (loan project) shall be constructed by 2025. A distribution pipe of φ800 mm (YCDC) is also planned.
- There are 3 bridges crossing the low grounds (including the area border). The crossing bridges are box-culvert type shown in the following Figure.
- There are only 3 illegal households.
- The water amount of the low grounds throughout Area 3 is high.

Source: JICA Study Team, Background Google Earth

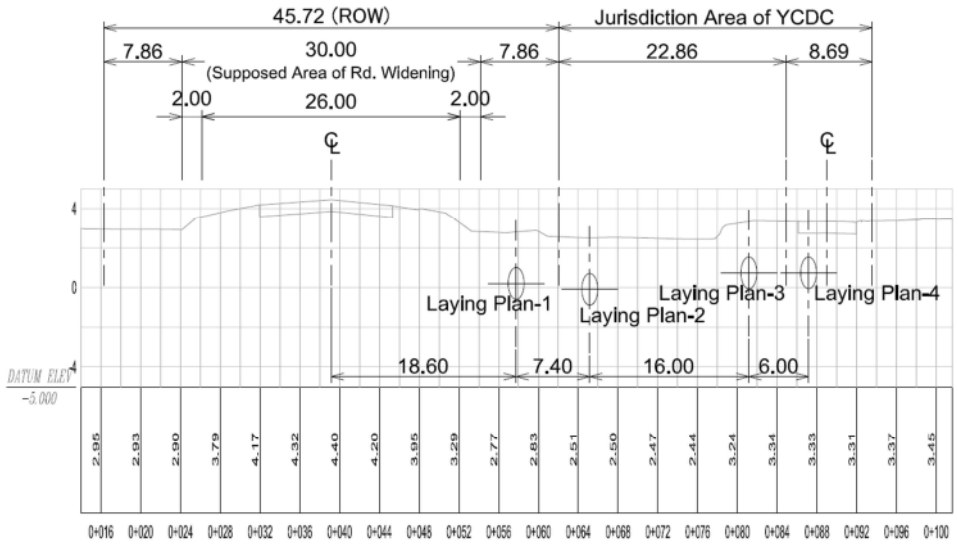
Figure 18 Situation of Area 3-1

Considerations for Pipe Laying Position

4 pipe laying positions (following Figure) shall be compared for Area 3-1. The major points of each plan are as follows.

- Laying plan 1: Area A, outside the expected expansion area

- Laying plan 2: Area B, inside the puddle circle of the low grounds (Route No. 5 side)
- Laying plan 3: Area B, the side road side of the puddle circle of the low grounds
- Laying plan 4: Area C, under the side road



Source: JICA Study Team

Figure 19 Laying Plans for Area 3-1

The comparisons of the 4 plans are shown in the following Table.

Laying plan 1 has poor workability due to the number of trees, and resettlement of illegal households is also necessary. Laying plan 2 and 3 have box-culvert type crossing bridges in the area. The bridge superstructure does not affect the construction works, but draining will be required since large amount of water accumulate, which is a cause of poor workability. Laying plan 4 does not have crossing bridges or illegal households, and the laying position is same as the neighboring Area 2-2.

For these reason, **laying plan 4** is proposed as the transmission pipe laying plan. For the distribution main which will be constructed by YCDC, laying plan 2 is proposed. The construction workability is low due to the trees, but the land is owned by YCDC.

Table 5 Comparison of Laying Plans for Area 3-1

Item	Laying Plan 1	Laying Plan 2	Laying Plan 3	Laying Plan 4
1. Technical Evaluation (Land Acquisition and Impact on Traffic)				
・Land Acquisition	No need			
・Land Owner	MoC	YCDC		
・Impact on Traffic by Construction	No			Small
・Impact on Traffic by Pipeline Maintenance	No			Small
2. Technical Evaluation (Construction Workability and Maintenance)				
・Construction Workability	・Trees throughout the area ・Resettlement of illegal households is	・Trees throughout the area ・Resettlement of illegal households is	・Trees throughout the area ・Measures for water collecting is necessary	・No obstacles

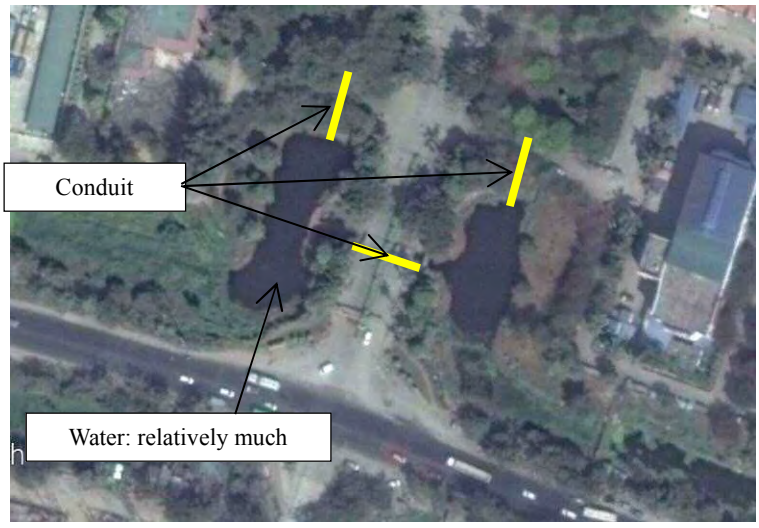
Item	Laying Plan 1	Laying Plan 2	Laying Plan 3	Laying Plan 4
	necessary	necessary		
・Maintenance	OK	OK	OK	OK
・Evaluation	△	△	△	○
3. Social Economic Evaluation				
・Illegal Households	2	1	0	0
・Illegal Squatters	10	5	0	0
・Evaluation	○	○	◎	◎
4. Overall Evaluation	△	△	△	○ (Recommended)

Notes: interview of illegal squatters were not permitted by YCDC due to safety reasons. The number of squatters was calculated as 5 persons per household (Reference: 2014 census 4.4person/household)
Source: JICA Study Team

(c) Area 3-2

Situation of Area 3-2

- There is a side road, but it runs around
- A transmission pipe of φ1600 mm is planned by 2025
- No crossing bridges or illegal households
- The water amount of the low grounds throughout Area 3 is high.



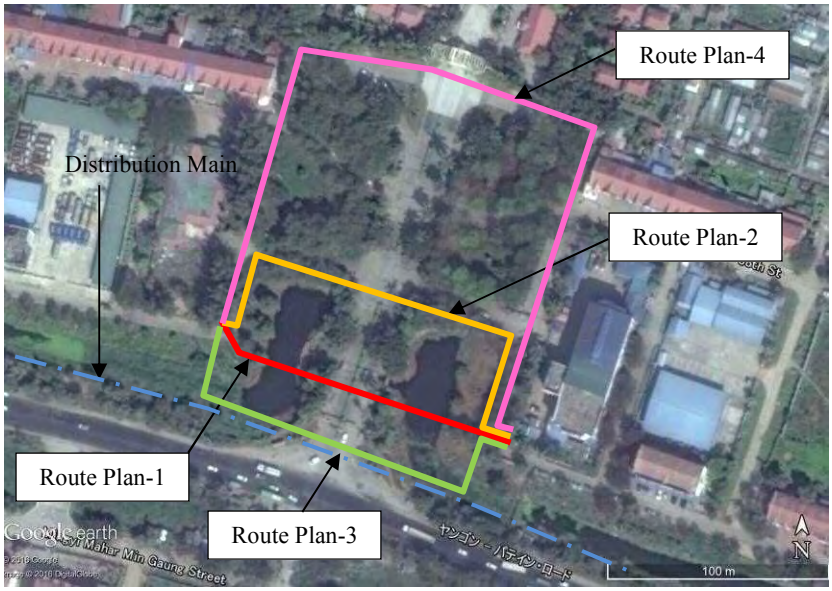
Source: JICA Study Team, Background Google Earth

Figure 20 Situation of Area 3-2

Considerations for Pipe Laying Position

4 pipe route plans (following Figure) shall be compared for Area 3-2. The major points of each plan are as follows.

- Route plan 1: Excavate low ground water puddle area to lay transmission pipes
- Route plan 2: Lay transmission pipes along the edge of side road (cross over the crossing canal)
- Route plan 3: Cross the canal to lay transmission pipes along Route No. 5
- Route plan 4: Lay transmission pipes along a further north side road



Source: JICA Study Team, Background Google Earth

Figure 21 Route plans for Area 3-2

Comparison of Route Plans is shown in the following Table. In Route Plan-1, length of pipe laying is short, but workability is poor because amount of standing water is relatively much. Route Plan-2 and Plan-4 were studied because it is able to avoid laying pipe crossing the standing water. However, alignment of pipeline of Route Plan-2 is sinuous and Route Plan-4 has a disadvantage because increased pipeline length is large. Pipeline alignment and workability of Route Plan-3 are relatively well, and this plan has a cost advantage because increased pipeline length is small.

Therefore, **Route Plan-3** is proposed for this area.

Table 6 Comparison of Laying Plans for Area 3-2

Item	Route Plan-1	Route Plan-2	Route Plan-3	Route Plan-4
Concept	Laying transmission pipeline in the shortest distance with crossing water puddle area and road	Laying transmission pipeline in the slope of the side road	Laying transmission pipeline along the Route No. 5 inside of YCDC's property	Laying transmission pipes along a further north side road
Pipeline Length	Shortest	Plan-1+75m	Plan-1+65m	Plan-1+260m
Water puddle area crossing	Workability is not preferable because water puddle area crossing is required.	Even though over crossing of conduit is required, workability is relatively well.	Workability is relatively well because water amount of pipe laying area is a little.	Workability is well because pipe is laid under the road.
Alignment of Pipeline	Up-down of pipeline is required in a short section because there is a road between water puddle areas. Therefore, pipeline alignment is not preferable.	Pipeline is laid over crossing at the conduit, and buried under the road in a short section. Therefore, pipeline alignment is not preferable.	Pipeline alignment is relatively well.	Pipeline alignment is relatively well.
Evaluation	Pipeline length is the shortest, but taking measure for standing water is necessary and	Workability is relatively well, but pipeline alignment is not preferable.	Workability and pipeline alignment is relatively well, and installation cost is	Workability and pipeline alignment is relatively well, but installation cost is

Item	Route Plan-1	Route Plan-2	Route Plan-3	Route Plan-4
	pipeline alignment is not preferable. ×	 △	cheap ○ (Proposed)	expensive because pipeline length is the longest. △

Source: JICA Study Team

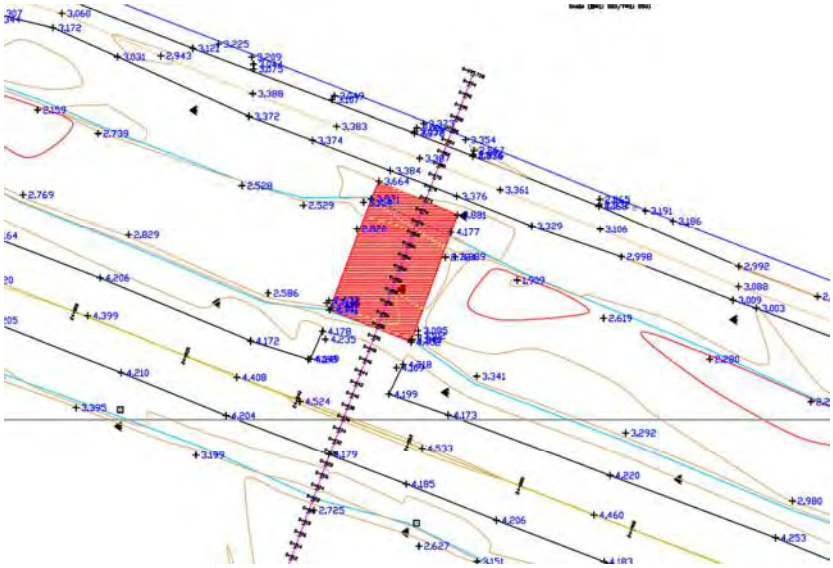
(d) Area 3-3

Situation of Area 3-3

- There are side roads.
- A transmission pipe of φ1600 mm (loan project) shall be constructed by 2025. A distribution pipe of φ800 mm (YCDC) is also planned.
- There are 8 bridges crossing the low grounds (including the area border). Several of the crossing bridges have bridge superstructure which has the same width of the low ground (following Figure).
- There are many illegal households, especially concentrated around the crossing bridge located at the point at which the road branches from Route No. 5. The houses can be found in the wide area from inside the low ground of Route No. 5 sides to the side roads.

Source: JICA Study Team, Background Google Earth

Figure 22 Situation of Area 3-3



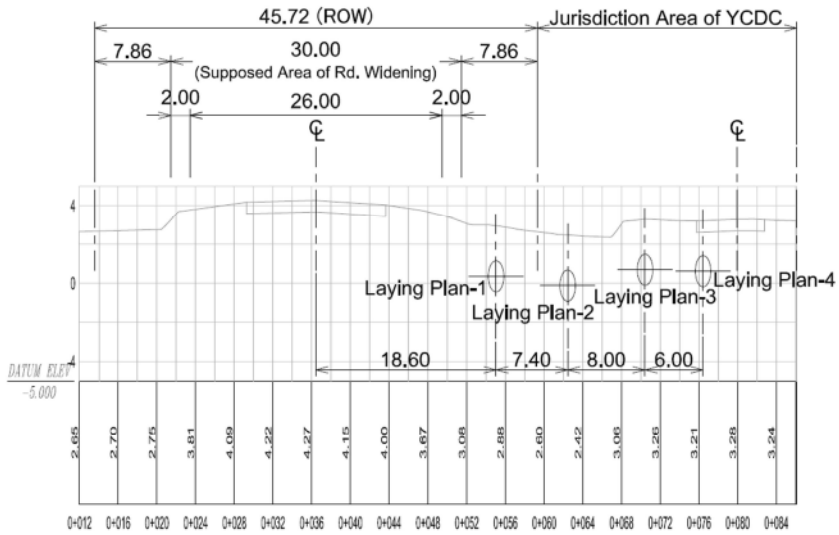
Source: JICA Study Team

Figure 23 Situation of Crossing Bridge of Area 3-3

<u>Considerations for Pipe Laying Position</u>

4 pipe laying positions (following Figure) shall be compared for Area 3-3. The major points of each plan are as follows.

- Laying plan 1: Area A, outside the expected expansion area
- Laying plan 2: Area B, inside the puddle circle of the low grounds (Route No. 5 side)
- Laying plan 3: Area B, on the side road side of the puddle circle of the low grounds
- Laying plan 4: Area C, under the side road



Source: JICA Study Team

Figure 24 Laying Plans for area 3-3

The comparisons of the 4 plans are shown in the following Table.

Laying plans 2 and 3 interfere with the bridge superstructure of the crossing bridge, and shall require large-scale construction for removal and restoration. The resettlement of illegal households will also be necessary. Laying plan 1 has many trees in the area. On the other hand, laying plan 4 has high workability, since it does not require removal/ restoration of crossing bridge structures and resettlement of illegal households.

For these reasons, laying plan 4 is proposed for this area. For the distribution main which will be constructed by YCDC, laying plan 2 is proposed. Resettlement of illegal households will be necessary, but the land is owned by YCDC. By shifting the laying position partly toward the road (laying plan 1) for the locations which interfere with the crossing bridge superstructure, the removal/restoration of the structure can be avoided.

Table 7 Comparisons of Laying Plans for Area 3-3

Item	Laying Plan 1	Laying Plan 2	Laying Plan 3	Laying Plan 4
1. Technical Evaluation (Land Acquisition and Impact on Traffic)				
・Land Acquisition	No need			
・Land Owner	MoC	YCDC		
・Impact on Traffic by Construction	No			Small
・Impact on Traffic by Pipeline Maintenance	No			Small
2. Technical Evaluation (Construction Workability and Maintenance)				
・Construction Workability	・Trees throughout the area ・Resettlement of illegal households is necessary	・Remove/ restore of crossing bridge is necessary ・Resettlement of illegal households is necessary	・Remove/ restore of crossing bridge is necessary ・Resettlement of illegal households is necessary ・Measures for water collecting is necessary	・No obstacles
・Maintenance	OK	OK	OK	OK
・Evaluation	△	×	×	○
3. Social Economic Evaluation				
・Illegal Households	8	20	11	0
・Illegal Squatters	40	100	55	0
・Evaluation	△	×	△	◎
4. Overall Evaluation	△	×	×	○(Recommended)

Notes: interview of illegal squatters were not permitted by YCDC due to safety reasons. The number of squatters was calculated as 5 persons per household (Reference: 2014 census 4.4person/household)
Source: JICA Study Team

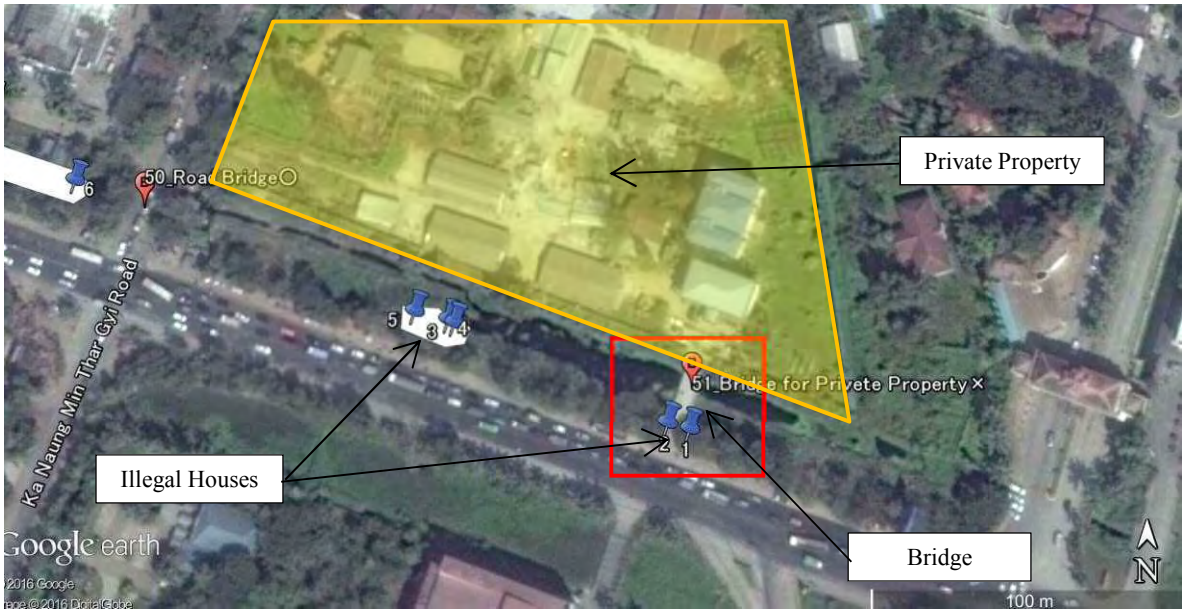
(e) Area 3-4

Situation of Area 3-4

- No side roads
- A transmission pipe of φ1600 mm (loan project) shall be constructed by 2025. A distribution pipe of φ800 mm (YCDC) is also planned.
- There are 2 bridges crossing the low grounds (including the area border). 1 bridge connects to private

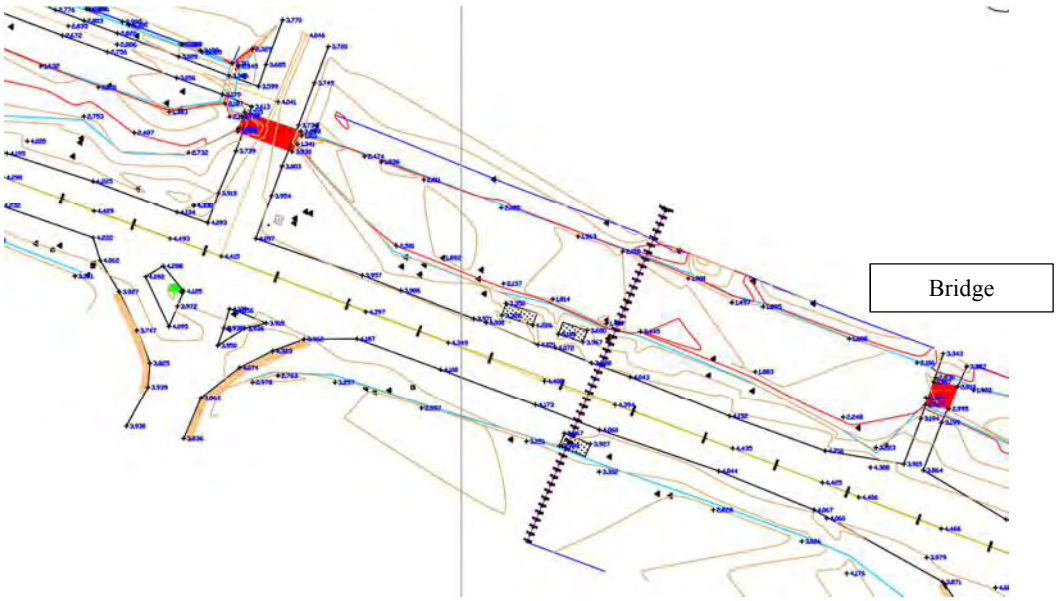
land. As shown in the following Figure, the bridge superstructure is located at a point away from Route No. 5, in the low grounds.

- 5 illegal households have been found in the low grounds along Route No. 5.



Source: JICA Study Team. Background Google Earth

Figure 25 Situation of Area 3-4



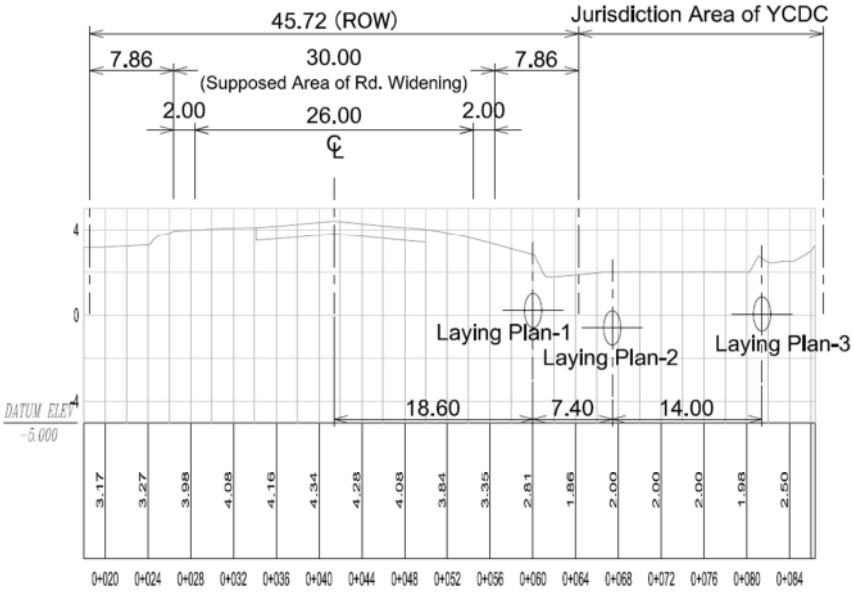
Source: JICA Study Team

Figure 26 Situations of Crossing Bridges of Area 3-4

<u>Considerations for Pipe Laying Position</u>

3 pipe laying positions (following Figure) shall be compared for Area 3-4. The major points of each plan are as follows.

- Laying plan 1: Area A, outside the expected expansion area
- Laying plan 2: Area B, inside the puddle circle of the low grounds (Route No. 5 side)
- Laying plan 3: Area B, inside the puddle circle of the low grounds (private land side)



Source: JICA Study Team

Figure 27 Laying Plans for Area 3-4

The comparisons of the 3 plans are shown in the following Table.
Laying plan 1 has many trees in the area, and also requires resettlement of illegal households. Laying plan 2 has fewer trees than plan 1, but also requires resettlement. Laying plan 3 consists of low grounds with a lot of water, and also interferes with the superstructure of crossing bridges and requires removal/restoration works. For these reasons, laying plan 2 is proposed for this area. Resettlement of illegal households will be required, but the scale of construction of bridge structure removal/restoration will be too large.

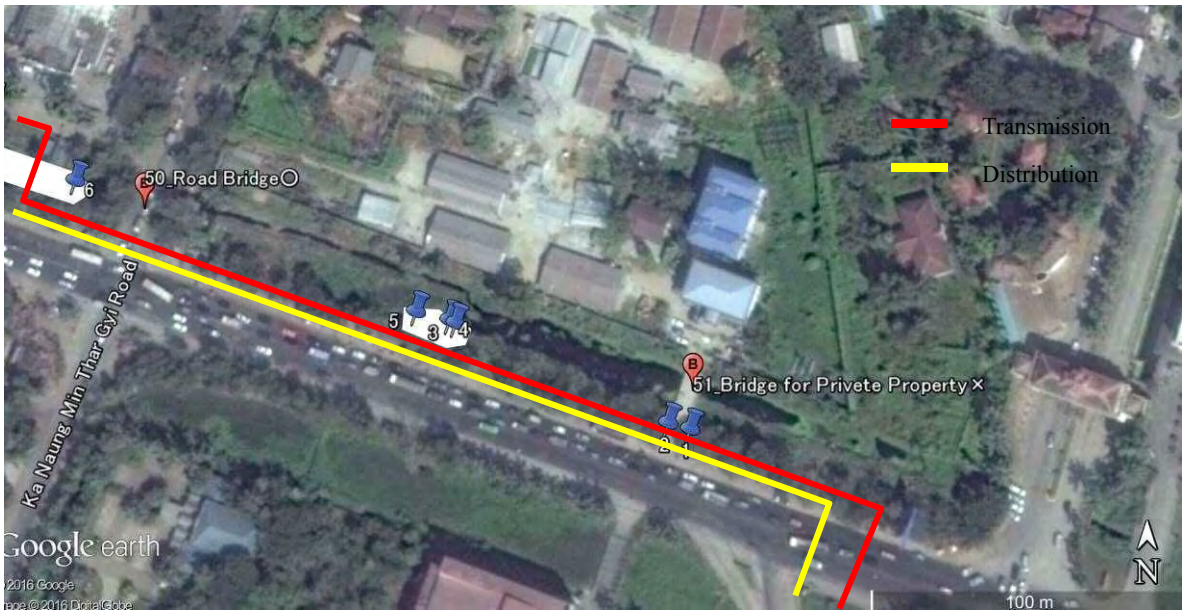
The laying plan is shown in the following Figure. The neighboring area plan is to use the side road; hence the transmission pipe is to be crossed at a location which will not be affected by illegal households to lay pipes according to the plan of this area. By this method, the removal/restoration of road bridges will not be necessary.

For the distribution main which will be constructed by YCDC, it is proposed to lay the pipes parallel to the transmission pipes at the location of laying plan 2.

Table 8 Comparison of Laying Plan for Area 3-4

Item	Laying Plan 1	Laying Plan 2	Laying Plan 3
1. Technical Evaluation (Land Acquisition and Impact on Traffic)			
・Land Acquisition	No need		
・Land Owner	MoC	YCDC	YCDC
・Impact on Traffic by Construction	No		To private land
・Impact on Traffic by Pipeline Maintenance	No		To private land
2. Technical Evaluation (Construction Workability and Maintenance)			
・Construction Workability	・Many trees ・Remove/restore of crossing bridges are not necessary ・Resettlement of illegal households is necessary	・Remove/ restore of crossing bridges are not necessary ・Resettlement of illegal households is necessary ・Measures for water collecting is necessary	・Measures for water collecting is necessary in several locations ・Remove/ restore of crossing bridges are necessary ・No obstacles, the workability is high except the bridges connecting to private land
・Maintenance	OK	OK	OK
・Evaluation	△	△	×
3. Social Economic Evaluation			
・Illegal Households	2	2	0
・Illegal Squatters	10	10	0
・Evaluation	△	△	◎
4. Overall Evaluation	△	△(Recommended)	×

Notes: interview of illegal squatters were not permitted by YCDC due to safety reasons. The number of squatters was calculated as 5 persons per household (Reference: 2014 census 4.4person/household)
Source: JICA Study Team



Source: JICA Study Team, Background Google Earth

Figure 28 Laying Plan Location of Area 3-4

1.2.5 Transmission Pipeline Laying Position from End-Point of Area 3 to Arrival Shaft

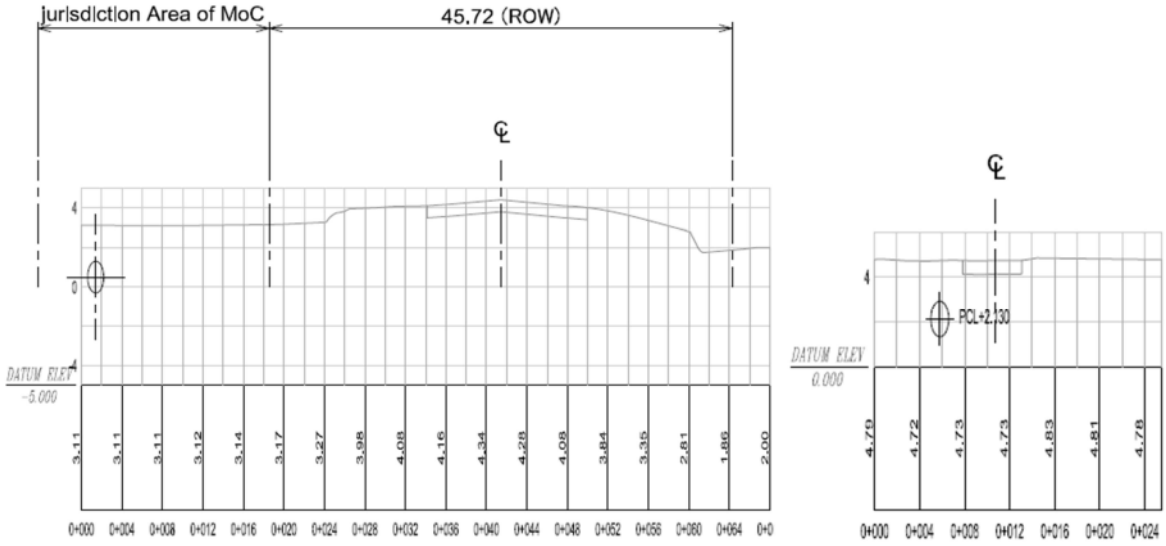
Overview of this Area is shown in Figure 29, and cross-section of each part is shown in Figure 30.

There is no obstruction along the south side of Route No. 5 from the start point of this area. Hlaing

River crossing is located on the south side from Route No. 5 from the point of view of securing site for arrival shaft, hence it was decided through the discussion that transmission pipeline is planned to be located along the south side of Route No. 5. And then, transmission pipeline is planned to be located west side of the road along Hlaing River within ROW.

Source: JICA Study Team, Back ground: Google Earth

Figure 29 Situation of the Area between End-Point of Area 3 and Arrival Shaft



(a) Area along Route No. 5 **(b) Area of the Road Along Hlaing River**

Source: JICA Study Team

Figure 30 Cross Section of Each Part between End-Point of Area 3 and Arrival Shaft

Distribution Option Plans Considering Water from Kokkowa and Reservoir System for Zone 1

Distribution of water in case of various option plans considering treated water from Kokkowa system and water from Reservoir system for Zone 1 is explained through Figures given below. The length of distribution pipes in corresponding plan is given in Tables below.

Table Facilities Considered for Cost Comparison of Various Distribution Plans

Item	Plan-0 (Original)	Plan-1 (JICA-YCDC discussion)	Plan-2	Plan-3	Plan-4
Considered facility in 2025 for cost comparison		**Pump Replacement in Yegu**			
	Repair of Kokine **	Repair of Kokine **	**Kokine SR Replacement (8.3 MGD)**	**Kokine SR Replacement (23.6 MGD)**	**Kokine SR Replacement (16.0 MGD)**
	Central SR **(8.3 MGD)**	Central SR **(8.3 MGD)**	Central SR **(15.3MGD)**	**0**	Central SR **(7.7 MGD)**
	Distribution Main (Low Zone)	Distribution Main (Low Zone)	Distribution Main (Low Zone)	Distribution Main (Low Zone)	Distribution Main (Low Zone)
	Distribution Main (High Zone)	Distribution Main (High Zone)	Distribution Main (High Zone)	Distribution Main (High Zone	Distribution Main (High Zone)
Construction Cost Mil. USD	51.016	52.932	59.001	56.528	51.693
	Pipe: 44.779 Cen SR: 3.737 Ko SR: **2.500***	Pipe: 44.779 Cen SR: 3.737 Ko SR: **2.500*** E&M: 1.916	Pipe: 48.374 Cen SR: 6.890 Ko SR: 3.737	Pipe: 45.900 Ko SR: 10.628	Pipe: 41.020 Cen SR: 3.468 Ko SR: 7.205

Note: **In Plan 1 and 0: Reconstruction of Kokine SR with capacity of 15.3 MGD if required: 6.89 million USD.

*Repair cost considering 25% of total construction cost: about 2.5 million USD

Source: JICA Study Team

【Plan-0 (Original Plan)】

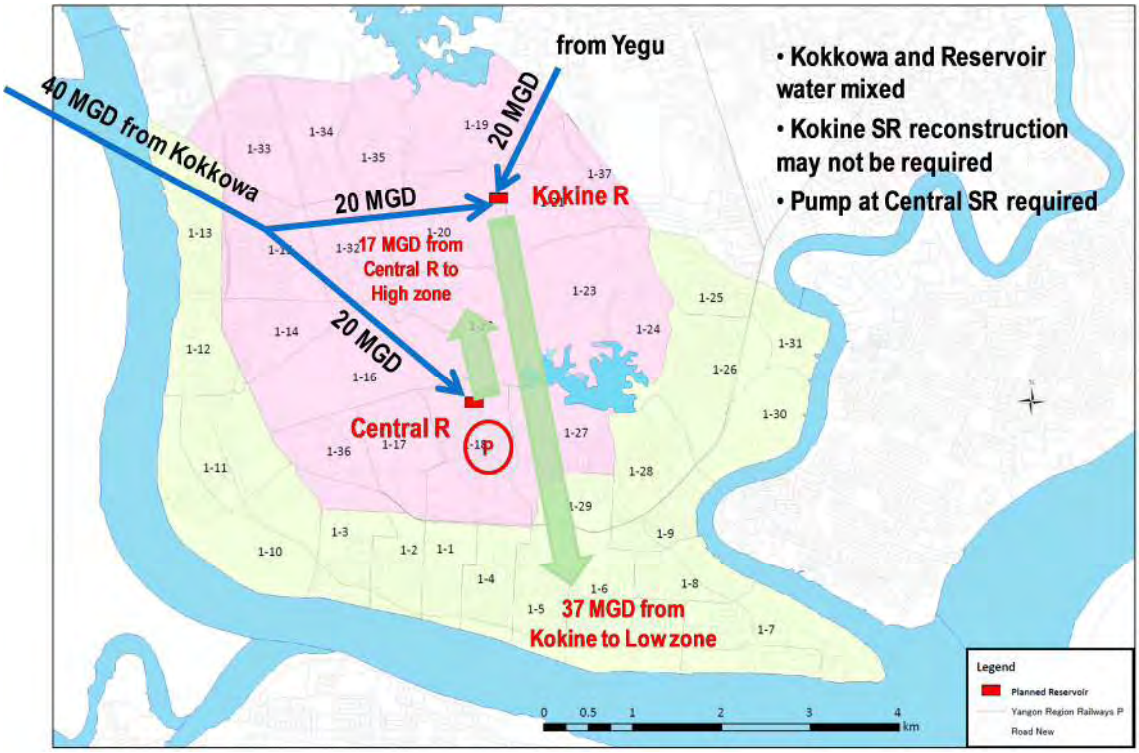


Figure 0 Schematic Diagram Showing Distribution Plan 0

Table 0 Length of Planned Distribution Main Pipe in Zone 1 in Case of Plan 0 (Kokine SR supplies to Low Subzone and Central SR Supplies to High Subzone)

Pipe Diameter (mm)	Length of Existing Pipe to be Used (m)	New Pipe Length Gravity (Low) Zone (m)	New Pipe Length Pump (High) Zone (m)	Total Length of Proposed Distribution Main (m)
	(2)	(3)	(4)	(2+3+4)
200			1,181	1,181
300		1,647	5,836	7,483
400	2,368 (823 Gravity + 1545 Pump)	7,663	4,446	14,477
450		252		252
500	893 (Pump)	7,126	4,588	12,607
600		3,863	1,603	5,466
800		4,938	2,252	7,190
900			1,369	1,369
1,000		1,862	826	2,687
1,200		10,738	377	11,115
1,400			455	455
1,800		156		156
2,000		223		223
Grand Total	3,261	38,468	22,932	64,661

Railway crossing: Dia. 600 and Dia.1200

Source: JICA Study Team

【Plan-1】

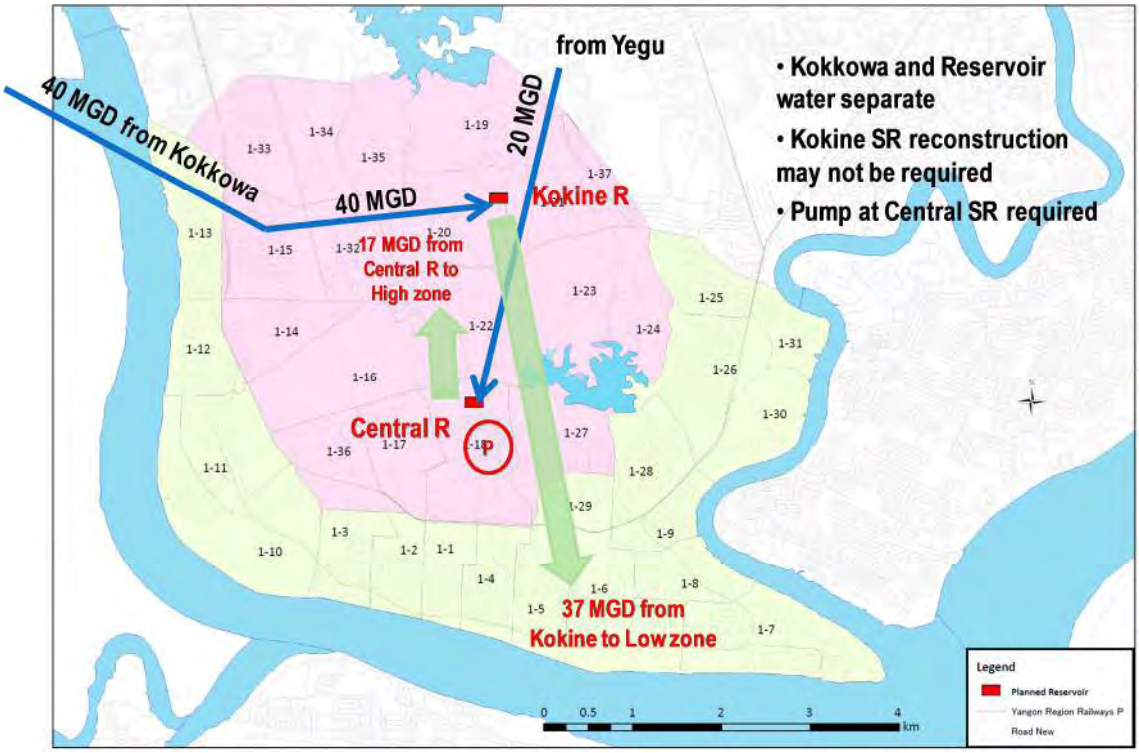


Figure 1 Schematic Diagram Showing Distribution Plan 1

Table 1 Length of Planned Distribution Main Pipe in Zone 1 in Case of Plan 1 (Kokine SR Supplies to Low Subzone and Central SR Supplies to High Subzone)

Pipe Diameter (mm)	Length of Existing Pipe to be Used (m)	New Pipe Length Gravity (Low) Zone (m)	New Pipe Length Pump (High) Zone (m)	Total Length of Proposed Distribution Main (m)
	(2)	(3)	(4)	(2+3+4)
200			1,181	1,181
300		1,647	5,836	7,483
400	2,368 (823 Gravity + 1545 Pump)	7,663	4,446	14,477
450		252		252
500	893 (Pump)	7,126	4,588	12,607
600		3,863	1,603	5,466
800		4,938	2,252	7,190
900			1,369	1,369
1,000		1,862	826	2,687
1,200		10,738	377	11,115
1,400			455	455
1,800		156		156
2,000		223		223
Grand Total	3,261	38,468	22,932	64,661

Railway crossing: Dia.600 and Dia.1200
Source: JICA Study Team

【Plan-2】

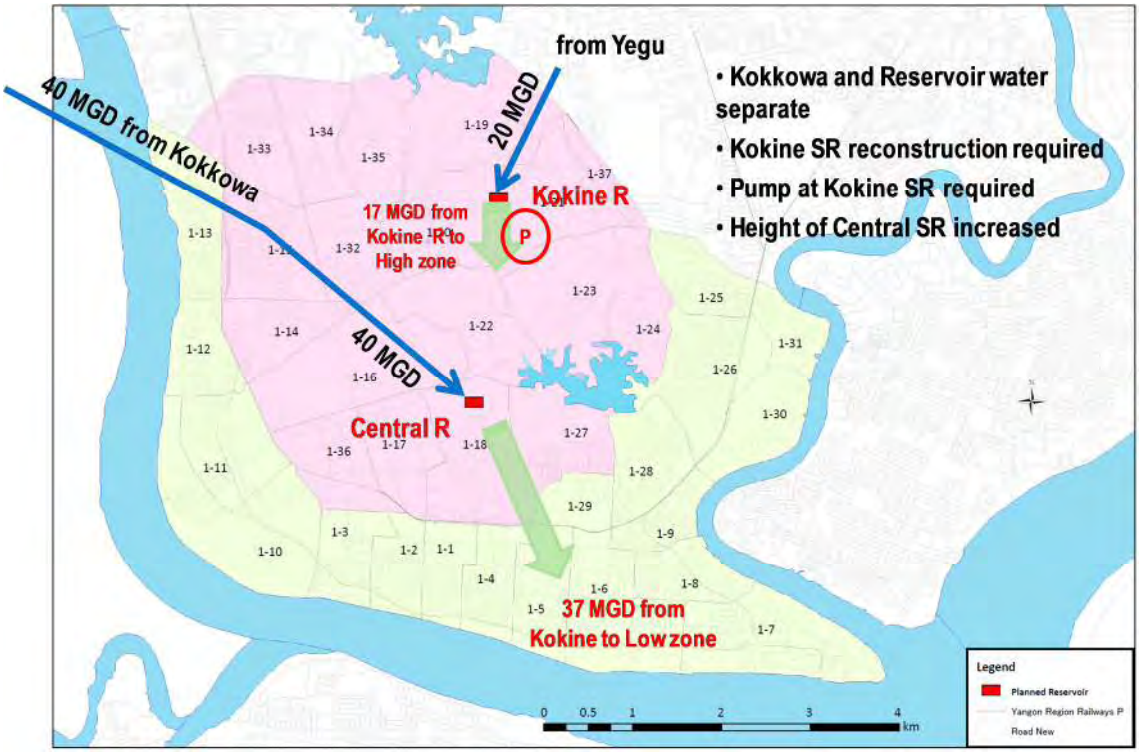


Figure 2 Schematic Diagram Showing Distribution Plan 2

Table 2 Length of Planned Distribution Main Pipe in Zone 1 in Case of Plan 2 (Kokine SR Supplies to High Subzone and Central SR Supplies to Low Subzone)

Pipe Diameter (mm)	Length of Existing Pipe to be Used (m)	New Pipe Length Gravity (Low) Zone (m)	New Pipe Length Pump (High) Zone (m)	Total Length of Proposed Distribution Main (m)
	(2)	(3)	(4)	(2+3+4)
300		3,336	6,586	9,922
400	283 (Gravity) 1545 (Pump)	4,447	4,309	10,584
500	893 (Pump)	3,132	5,126	9,151
600		2,885	2,000	4,885
800		4,211	2,700	6,911
900		871		871
1,000		3,662		3,662
1,200		2,494	1,007	3,501
1,300		1,182		1,182
1,400		593	1,087	1,680
1,500			102	102
1,800		2,455		2,455
2,000		2,340		2,340
Grand Total	2,721	31,608	22,917	57,246

Railway crossing: Dia.1200 and Dia.2000

Source: JICA Study Team

【Plan-3】

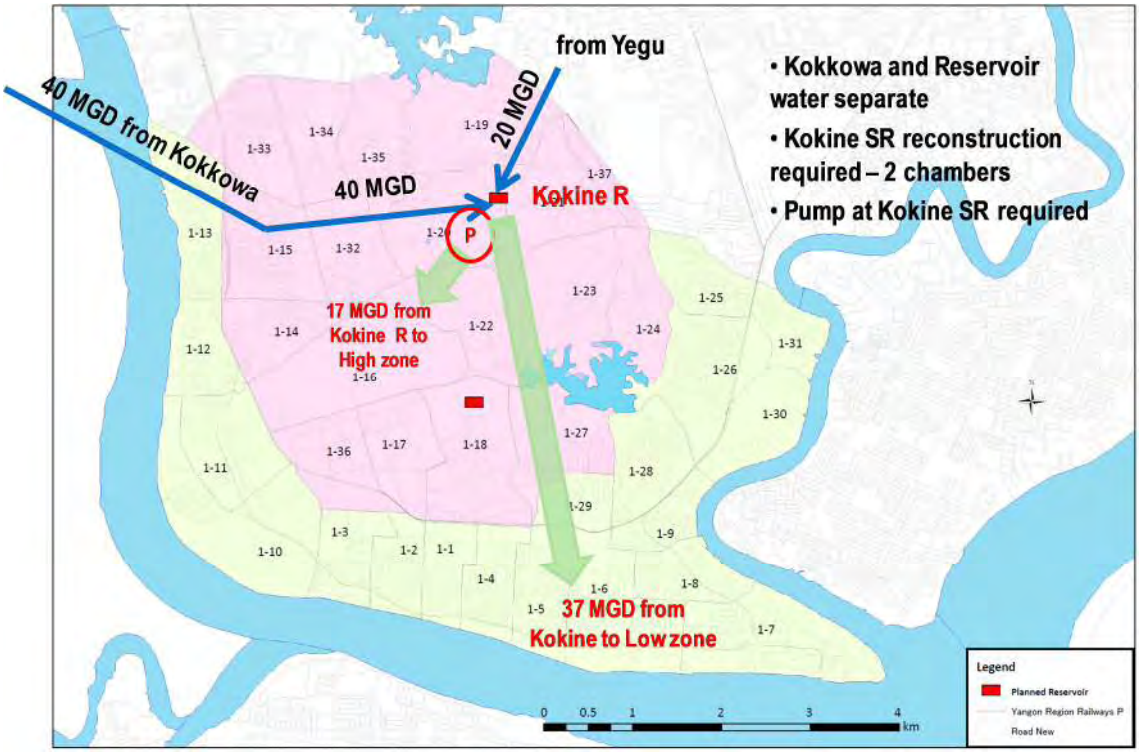


Figure 3 Schematic Diagram Showing Distribution Plan 3

Table 3 Length of Planned Distribution Main Pipe in Zone 1 in Case of Plan 3 (Kokine SR Supplies to both High Subzone and Low Subzone)

Pipe Diameter (mm)	Length of Existing Pipe to be Used (m)	New Pipe Length Gravity (Low) Zone (m)	New Pipe Length Pump (High) Zone (m)	Total Length of Proposed Distribution Main (m)
	(2)	(3)	(4)	(2+3+4)
300		1,647	6,586	8,233
400	823 (Gravity) 1545 (Pump)	7,663	4,309	14,340
450		252		252
500	893 (Pump)	7,126	5,126	13,145
600		3,863	2,000	5,863
800		4,938	2,700	7,638
900				
1,000		1,862		1,862
1,200		10,738	1,007	11,745
1,300				
1,400			1,087	1,087
1,500			102	102
1,800		156		156
2,000		223		223
Grand Total	3,261	38,468	22,917	64,646

Railway crossing: Dia.600 and Dia.1800
Source: JICA Study Team

【Plan-4】

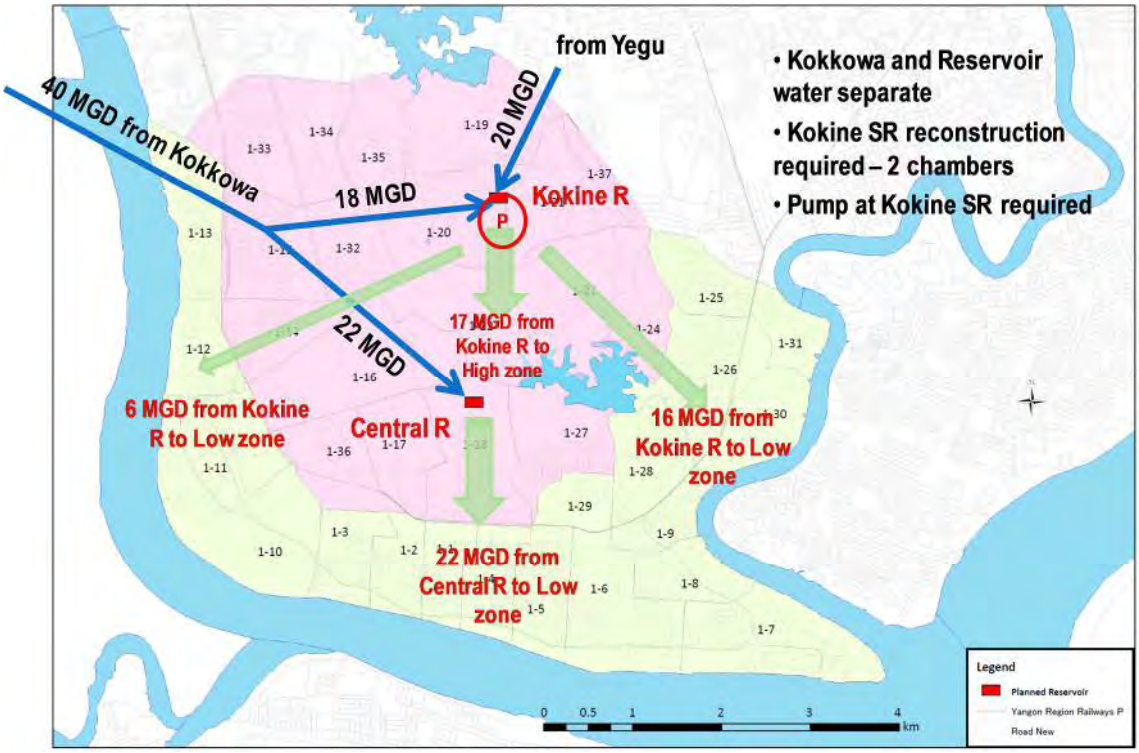


Figure 4 Schematic Diagram Showing Distribution Plan 4

Table 4 Length of Planned Distribution Main Pipe in Zone 1 in Case of Plan 4 (Kokine SR Supplies to High Subzone, and Eastern and Western Part of Low Subzone and Central SR Supplies to Southern Part of Low Subzone)

Pipe Diameter (mm)	Length of Existing Pipe to be Used (m)	New Pipe Length Gravity (Low) Zone from **Kokine** (m)	New Pipe Length Gravity (Low) Zone from **Central** (m)	New Pipe Length Pump (High) Zone (m)	Total Length of Proposed Distribution Main (m)
	(2)	(3)	(4)	(5)	(2+3+4+5)
300		1,959	1,248	6,586	9,793
400	823 (Gravity) 1545 (Pump)	1,712	5,681	4,309	14,070
500	893 (Pump)	4,668	330	5,126	11,017
600		2,045	1,255	2,000	5,300
700			1,412		1,412
800		2,314	2,655	2,700	7,669
1,000		932	958		1,890
1,100		5,818			5,818
1,200			798	1,007	1,805
1,400		225	1,544	1,087	2,856
1,500				102	102
Grand Total	3,261	19,673	15,881	22,917	61,732

Railway crossing: Dia.600 and Dia.1200
Source: JICA Study Team

Current Situation of Existing Facilities, Operation and Management System and Capacity

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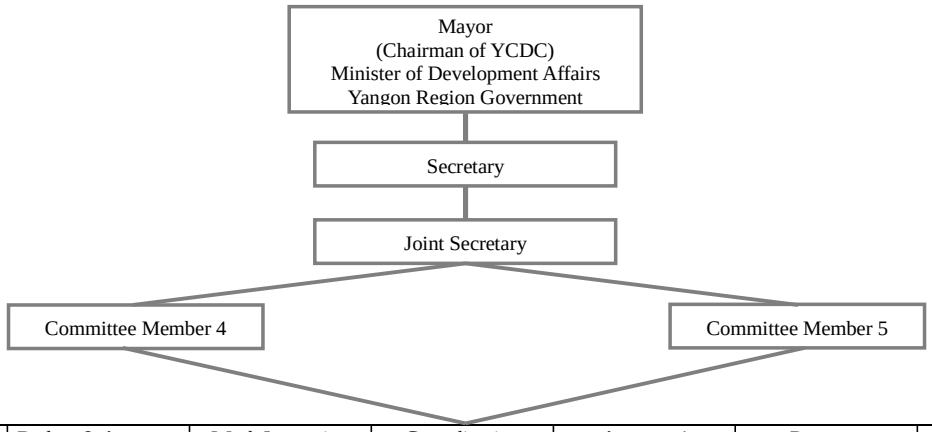
1.1 Organization, Duties and Responsibilities of EDWS

1.1.1 YCDC

YCDC was established based on the Yangon City Development Committee Law (revised from old version in 2013, amended in 2014) aiming to serve the Yangon city citizens for fulfilling the needs of the citizens under leadership of the mayor who is appointed by the regional government, and committee members.

The motto of YCDC is "Clean, green and fair Yangon City". The Council of YCDC consists of one mayor and eight committee members, which also includes the secretary and the joint secretary. In the existing situation, one committee member is responsible to manage three departments or districts concurrently. The departments and districts assigned to each committee member of YCDC are shown in YCDC organization chart below.



The Administration Department	Budget & Accounts Department	Work Inspection Department	Co-ordination Department	Assessors' Department	Revenue Department	Markets Department
Veterinary & Slaughter House Department	Pollution Control & Cleansing Department	Engineering Department (Roads & Bridges)	Engineering Department (Buildings)	Engineering Department (Water & Sanitation)	Motor Transport & Workshop Department	Central Stores Department
Playgrounds, Parks & Gardens Department	Security & Disciplinary Department	City Planning and Land Administration Department	Health Department	Public Relations and Information Department	Production Department	Committee Office

Source: YCDC

Figure 1 Organization Chart of YCDC

1.1.2 EDWS

Among the departments under YCDC, EDWS performs the function of supplying water to 33 T/Ss out of 45, and managing sewerage services within the downtown area .The 5 visions of the EDWS are as follows:

- To distribute adequate, safe and wholesome water to residents.
- To collect the water tariff from users.
- To prevent water leakage and manage the reduction of non-revenue water.
- To manage systematic sewage collection, treatment and disposal.
- To upgrade water supply and sewerage systems.

The department is administered by one Chief Engineer (head of department) and three Deputy Chief Engineers. In addition, in each of the seven divisions, there is one Assistant Chief Engineer who is responsible to perform their duties in order to provide water supply and sewerage services in the City and achieve abovementioned vision.

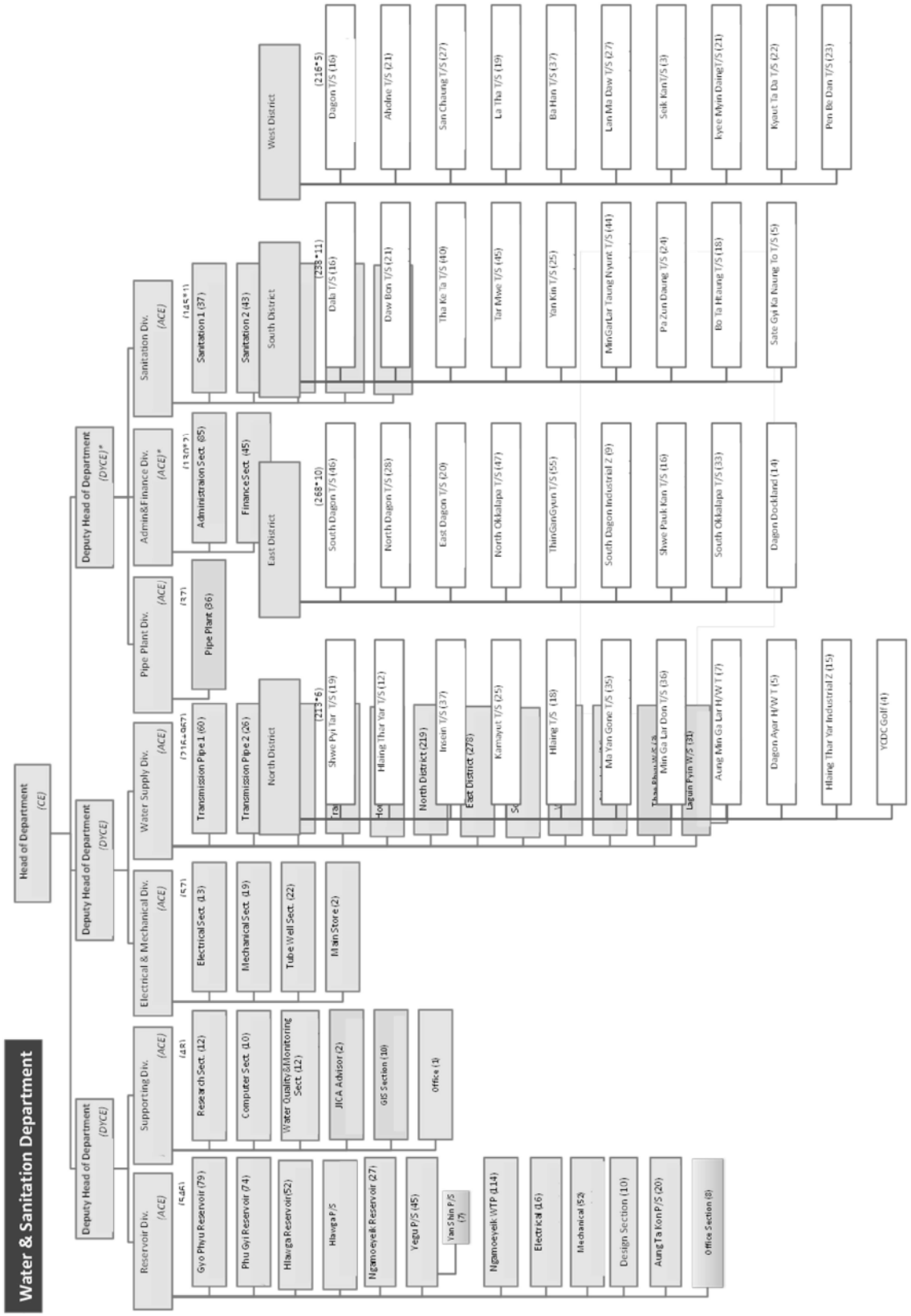


Figure 2 Organization Chart of EDWS as of 30 June 2016

EDWS is composed of 7 divisions. The responsibilities of each division are regulated by "Orders to be obeyed by YCDC staff" as given in Table below.

Table 1 Duties and Responsibilities of Each Division of EDWS

Division	Duties and Responsibilities
1. Reservoir Division	• Maintenance and preservation to be sustainable. • Protection of catchment area and forest cover. • Disinfection as chlorination, coagulation and chemical dosing for water purification. • Daily measurements of water levels and precipitations in or near reservoirs and the amount of delivered water • Operation of the main pumps in reservoirs and maintenance of main pumps, transformers and other electrical and mechanical equipment. • Cleaning and screening of rubbishes on the surface of reservoirs • Upgrading of roads, bridges and infrastructures for water supply in reservoirs.
2. Water Supply Division	• To maintain the main transmission pipes, additional pipe lines and the distribution ones and to install new pipe lines. • To operate the booster pumping stations in all T/Ss. • To distribute the water from tube wells to the T/Ss which have no direct distribution lines from the reservoirs. • To facilitate distribution of safe and clean water by dosing chlorine, alum and appropriate chemicals. • To prevent the non-revenue water caused by leakages. • To maintain and guard the communal tanks and fire hydrants. • To prevent illegal connections. • To manage the permission for construction of septic tank, connection of sewer lines and installation of service connection. • To arrange water supply to the new satellite towns and the T/Ss on the other sides of Yangon river.
3. Electrical and Mechanical Division	• To operate and maintain the booster pumping stations. • To implement the major repairs and maintenance of main pumps, transformers and electrical and mechanical equipment. • To maintain the old tube wells and to construct the new ones. • To maintain and install the mechanical and electrical equipment. • To maintain and assemble the submersible pumps for tube wells. • To maintain the vehicles and machines. • To upgrade the existing machines and equipment with the modernized ones and the auxiliary ones.
4. Supporting Branch	• Issuing, keeping the instrument necessary for the sites and the auxiliary ones. • To undertake collection of water sample, monitoring and analysis for water quality. • To estimate and workout for bill of quantity and preparation of engineering design for water supply facilities. • Documentation for designs, drawings, mapping and official assistance. • Planning of the projects and allocation of new water resources. • Sustainable development for the job training and preparation of the local and overseas training program.
5. Finance and Administration Division	• Documentation and collection of the water charges. • Receiving the incomes and managing the expenditures. • Preparation of short term and long term plans, and the estimation of current capital and expenditures. • To service for the liens. • To arrange the staffs to follow the disciplines. • To support the staffs for their good living.
6. Sanitation Division	• Maintenance for the sewer lines.

Division	Duties and Responsibilities
	• Operation and maintenance of the air compressor and ejector station. • Project planning for extension of sewerage system and desludging of septic tank system. • Implementation of the improvement of sewerage system. • Upgrading the existing facilities by replacing with the modernized machines and equipment
7. Pipe Production Factory	• Production of concrete pipes and special pipes for water supply purposes. • Production of other products for improvement of income. • Maintenance of electrical and mechanical equipment. • Supplying and purchasing the products used in manufacturing process, spare parts and modernized machineries.

The total number of existing staff as of 30 June 2016 in EDWS is 2,152 including 1,087 permanent and 1,065 temporary staff members. Staff are categorized by employment type into the following 5 types: (1) Officer, (2) Permanent, (3) Flat, (4) Work Authority, (5) Daily Wages.

(1) Current permanent staff- Officers	81
Other levels	1,006
Sub Total	1,087
(2) Numbers of temporary staff	
a. Flat	96
b. Daily Wage	85
c. WA (Work Authority)	884
Sub Total	1,065
Total (1) + (2)	2,152

The list of the assigned personnel and vacancies according to the positions is as follows.

Table 2 List of the Number of Permanent Staff by Position in EDWS

(As of 30 October, 2015)

	Position	Number of Permanent Staff-members
1	Head of Department (Chief Engineer: CE)	1
2	Deputy Chief Engineer (DYCE)	2
3	Assistant Chief Engineer (ACE)	5
4	Factory Manager	1
5	Executive Engineer (EE)	20
6	Deputy Factory manager	1
7	Assistant Engineer (AE)	39
8	Chief Officer	3
9	Chief Officer (Account)	3
10	Office Manager (Superintendent)	2
11	Accountant-1	7
12	Supervisor	36
13	Electronic Expert-1	-
14	Sub-Assistant Engineer-2 (SAE)	110
15	Computer Planner	2
16	Deputy Supervisor	61
17	Deputy Supervisor (Drawing)	-
18	Accountant 2	11
19	Branch Clerk	7

	Position	Number of Permanent Staff-members
20	Store Keeper 2	-
21	Junior Steno	-
22	Assistant Supervisor	189
23	Assistant Supervisor (Drawing)	-
24	Assistant Computer Planner	3
25	Senior Clerk	31
26	Accountant 3	2
27	Senior Typist	-
28	Skillful worker 4	324
29	Skillful worker 4 (measurement)	-
30	Deputy Assistant Computer Planner	-
31	Junior Clerk	54
32	Junior Typist	-
33	Filing & Copying	-
34	Accountant 4	1
35	Skillful worker	1
36	Labor	198
37	Security	-
38	Cleaner	-
	Total	1,114

1.2 Nyaunghnapin WTP (Phase 1 and 2)

1.2.1 Overview

Nyaunghnapin WTP is the first large scale WTP designed and constructed by YCDC. The specifications are given in Table below.

Table 3 Specifications of Nyaunghnapin WTP

WTP	Nyaunghnapin Phase 1	Nyaunghnapin Phase 2
Capacity	45 MGD (204,500 m^3/day)	45 MGD (204,500 m3/day)
Water source	Irrigation canal coming down from Ngamoeyeik reservoir	Irrigation canal coming down from Ngamoeyeik reservoir
Purification process	Coagulation sedimentation + Rapid sand filtration	Coagulation sedimentation + Rapid sand filtration
Coagulant	ACH (started from March 2015)	ACH (started from March 2015)
Chlorination	None	None
Completion year	2005	2013
Distribution area	Central and eastern area of Yangon City	Eastern area of Yangon City
Remarks	Water distribution pump station was replaced by Japanese Grant “The Project for Urgent Improvement of Water Supply System in Yangon City”	

1.2.2 Problems and Issues

Problems and issues related to this WTP based on the M/P and on this survey are as follows.

(1) Raw Water Conveyance

- **Raw water canal**

The canal under the jurisdiction of MoAI is used as a raw water transmission facility. According to MoAI, sand, mud, etc. accumulate in the canal, and flow capacity of canal is reduced. It is necessary to recover the flow capacity by dredging sand and mud. However during the dredging of canal, withdrawal of water for WTP will not be possible. Therefore, MoAI has recommended the construction of dedicated raw water transmission pipe to YCDC (Photo-1).

Photo-1 Raw water conveyance channel (Open channel)

- **Water quality**

Risk of contamination resulting from pesticides is a matter of concern due to higher turbidity in open channel than that of Ngamoeyeik reservoir.

When it rains heavily, turbidity of raw water becomes higher due to inflow of turbid water including plants and muddy water from open channel.

(2) Intake Facility

- **Intake amount**

Clogged plants and solid waste before the inlet screen gate between pre-sedimentation basin and intake pump well obstruct inflow of raw water, so the intake pumps are stopped due to the decrease of water level in the well. Therefore, it is difficult to intake sufficient amount of water (Photo-2).

The electric motor of one of the intake pumps in case of each of Phase 1 & 2 is out of order and are left without repair. If another pump gets out of order, it will be difficult to intake sufficient amount of water because of no reserve pump anymore (Photo-3 and 4).

Intake flow meters are not installed.

- **Maintenance**

Floor of intake pumping station is flooded due to the leakage from gland packing. (Photo-5)

Pressure gauge on outlet pipe of intake pump is out of order in case of Phase 1 facilities and there are no pressure gauges in Phase 2 facilities. Therefore, it is impossible to monitor water pressure which is necessary for taking decision on maintenance of pumps. (Photo-6)

Photo-2 Inlet gate of intake pump well, Front: Pump well Back: Pre-sedimentation basin,

Photo-3 Intake pump without electric motor

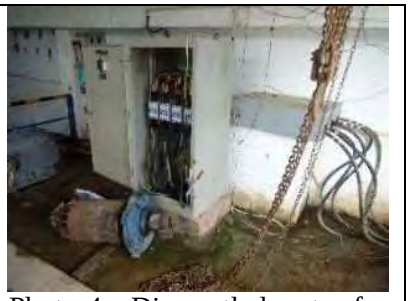


Photo-4 Dismantled parts of electric motor

Photo-5 Leakage through gland packing

Photo-6 Pressure gauge on outlet pipe

(3) Coagulant Injection Equipment

・ **Coagulant injection rate**

Coagulant dosing rate is an important factor for appropriate operation of coagulation sedimentation process but flow meter is not installed for this purpose (Photo-7).

Earlier coagulant from Malaysia was used along with coagulant injection equipment from Germany until March 2015. After that both coagulant and injection equipment from China are being used. Even though automatic coagulant injection system, which operates based on monitored turbidity level, is installed, coagulant dosage rate is set manually with frequency dial of injection pump because turbidity meter is already out of order and automatic injection is not working (Photo-8 and 9).

・ **Coagulant injection point**

Management of coagulant injection rate on each line is complicated because the injection point is located at two channels after outlet of receiving well. Therefore, the injection equipment should be reinstalled around outlet point of intake pipe in order to mix coagulant with raw water rapidly (Photo-10).

Photo-7 Cogulant injection facilities

Photo-8 Broken turbidity meter

Photo-9 Equipmtent for setting frequency

Photo-10 Coagulant injection point

(4) Coagulation Sedimentation Facilities

・ **Inflow rate to flocculation basin**

Inflow rate to each flocculation basin is not managed by adjusting opening of inlet gate valve, so floc size is different in each flocculation basin due to difference in detention time. Therefore, turbidity management in sedimentation basin is complicated (Photo-11 and 12).

Water flows over the wall of vertical baffled channel in some flocculation basins due to large inflow rate when three intake pumps in the Phase 2 are running at the same time. Consequently,

immature flocs flow out to sedimentation basin due to the shortage of floc formation time (Photo-13).

- **Structure**

Matured floc disintegrates by falling down along with water due to difference in level between flocculation and sedimentation basin (Photo-14).

Matured flocks are also broken by increase of flow velocity due to the small outlet; vertical 850mm x horizontal 1050mm, of flocculation basin (Photo-15).

It is difficult to drain sludge in the sedimentation basin due to the broken PVC pipe, so volume of sedimentation basin is reduced by accumulated sludge and detention time gets shorter.

Consequently, suspended particles that are not settled in sedimentation basin flows along with water to filtration basin and causes a load on the filtration basin.

- **Water quality**

Algae are observed on the walls of sedimentation basin, filtration basin and treated water reservoir, so chlorination should be considered at the points before flocculation basin and between sedimentation and filtration basins.

Photo-11 Small opening of inlet gate of flocculation basin

Photo-12 Large opening of inlet gate of flocculation basin

Photo-13 Over flow on the wall of vertical baffled channel

Photo-14 Outlet of flocculation basin in the Phase 1

Photo-15 Outlet of flocculation basin in the Phase 2

(5) Filtration Basin

- **Filter media**

Filter media in filtration basin consists of two layers; filter sand and anthracite. Some of filter media particles flow out of filter due to high-rate backwashing and as a result the filter layers get thin (Photo-16).

Some mud balls are found around insufficient backwashing portions in filtration basin, and suspected solids along with water flows out through the special route made by the mud ball (Photo-17).

Filter sand and anthracite are mixed in the upper layer of filter in the Phase 2, so the anthracite does not work effectively and cause increase of head loss and filter clogging (Photo-18 and 19).

Filtration basin is not managed and quality management of anthracite is not implemented. For example, big size anthracite; approximately 200mm x 100mm, was found around the place between filter sand and gravel layers in the Phase 2 (Photo-20).

Therefore, it is difficult to accomplish filtration effectively.

- **Washing filtration basin**

All filtration basins; 28 in the Phase 1 and 32 in the Phase 2, are supposed to be washed once a day but based on observation during survey period it seems these basins are not washed every day.

Workers only open and close manual valves for washing basins but washing process, flow rate and duration of washing is not managed appropriately (Photo-21).

Size of backwashing drainage pipe in the basin is too small; dia. 300 mm, so backwashing flow rate should be reduced by adjusting backwashing pump or by closing drainage valve a little.

A surface washing pipe and a backwashing pipe are installed in each basin. However, the basins have to be washed one by one due to capacity shortage of pumps, so one hour is spent in washing (Photo-22).

Some surface washing pipes are out of order.

Some holes are drilled at the bottom of surface washing pipes but injection nozzles are not attached to the pipes, so it is difficult to wash uniformly (Photo-23).

- **Quality control**

Filter media; filter sand and anthracite, are bought in huge quantity for refilling and stored on the ground, so contamination with foreign materials is a matter of concern (Photo-24 and 25).

Particle size of anthracite stored in Nyaunghnapin WTP is bigger than that in Japan. Filter sand and anthracite are mixed due to the large specific gravity, so effect of anthracite would be disappeared (Photo-26 and 27).

Photo-16 Discharged filter sand in the drainage

Photo-17 Mud ball

Photo-18 Mix of anthracite and filter sand

Photo-19 Divided two layers; anthracite and filter sand in Fukuoka

Photo-20 Big size anthracite

Photo-21 Operating valves for backwashing

Photo-22 Washing a filtration basin

Photo-23 Surface of filter layer

Photo-24 Filter sand stored on the ground

Photo-25 Anthracite stored on the ground

Photo-26 Anthracite in Japan with small particle size

Photo-27 Anthracite in Yangon with big particle size

- **Difference of coagulation sedimentation**

The performance of coagulation sedimentation process in not better than before because turbidity of outflow from sedimentation basin on 12 Oct. 2015 is clearly worse than that of outflow sample collected on 25 Feb. 2014 (Photo-28 and 29). Turbid water puts a load on the filtration basin and raises head loss, so it is required to increase washing frequency of filter.

Photo-28 Water collection device after sedimentation basin on 25 Feb. 2014

Photo- 29 Water collection device after sedimentation basin on 12 Oct. 2015

(6) Transmission Facilities

- **Water hammer**

Since power supply interruption occurs very frequently and surge tank capacity of transmission pumps is insufficient, there is concern about damages of pumps and valves due to occurrence of water hammer.

- **Operation**

New transmission pumping station installed in the Phase 1 started its operation in September 2015 (Photo-30).

Flow rate to distribution is not managed appropriately, as a result treated water sometimes overflow from the treated water reservoir (Photo-31).

- **Structure**

As an improvement, a cover has been constructed for treated water reservoir in the Phase 2 but there is risk of contamination due to foreign materials through an opening that still exists in the cover (Photo-32).

		
Photo-30 New transmission pumping station in Phase 1	Photo-31 Over flow from treated water reservoir in Phase 2	Photo-32 Opened portion of treated water reservoir in Phase 2

(7) Electrical Instrumentation

- **Electrical suspension**

Power supply failure occurs very frequently; more than 150 times a year, and total duration is about 128 hours a year (average about 20 min/day).

- **Maintenance**

Although transmission flow rate is measured by flow meters installed in Phase 2, it is difficult to confirm the existing condition of the equipment due to flooding in the chamber. Electrical equipment such as flow meters should not be flooded to prevent it from failure.

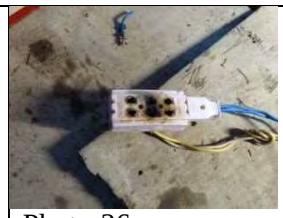
Equipment for water quality monitoring such as turbidity meters and pH meters installed at the transmission pumping station in Phase 2 are out of order (Photo-33).

Some parts are removed from the washing pump board of Phase 2, so it is impossible to operate the pump (Photo-34).

- **Safety management**

There are risks of electric leakage and shock on the electric board of the Phase 1 & 2 because their doors are opened and there are some foreign matters inside boards (Photo-35).

There is a high risk of electric leakage while using power supply socket with burnt mark (Photo-36).

			
Photo-33 Broken equipment for water quality monitoring	Photo-34 Empty electric board	Photo-35 Electric board with grass	Photo-36 Socket with burnt mark

(8) Others

- **Contamination**

  There is concern of contamination at following three places in the Phase 1 facilities; clear water channel without cover, clear water tank without cover, washed water drain without cover if water from this drain comes in contact with clear water (Photo-37).

- **Maintenance**

  It is difficult to procure spare parts after a warranty period because there are few maintenance services in Myanmar.

  Some valves and gates are out of order (Photo-38).

- **Leakage**

  Leakage occurs from some old concrete structure and from some valves and gates (Photo-39, 40 and 41).

- **Safety management**

  There is risk of accidents of workers during inspection and operation due to some broken floors at WTP (Photo-42).

- **Water quality**

  There is no disinfection equipment.

		
Photo-37 Treated water reservoir and drainage basin in the Phase 1	Photo-38 A broken gate valve	Photo-39 Leakage from concrete structure

Photo-40 Leakage from inlet gate of filtration basin

Photo-41 Leakage from drainage valve of filtration basin

Photo-42
Broken floor

The list of main equipment used in Nyaunghnapin WTP Phase 1 & 2 are as follows.

Table 4 Main Equipment List in The Phase 1

Name of equipment	Specification	Total Number (standby)	Remark
Coarse mesh screen	Width of mesh 100 mm	4	
Water intake pump	Horizontal shaft double - suction single - stage volute pump 2,841 m^3/hour x 10 m x 110 kW	4(1)	Made in China
Inlet gate of filtration basin	Manual gate, 450 mm square	28	Made in Myanmar Out of control and water leakage occurs often.
Valve of surface washing	Manual butterfly valve, Diameter 150 mm	56	Made in YCDC
Valve of back washing	Manual butterfly valve, Diameter 300mm	56	Made in YCDC
Outlet gate of filtration basin	Manual gate, 600 mm square	28	Made in Myanmar Out of control and water leakage occurs often.
Outlet gate of treated water tank	Manual gate, 1,050 mm square	4	Made in Myanmar
Suction valve	Manual shut valve, Diameter 600 mm	4	Morita Iron Works Co., Ltd.
Water distribution pump	Horizontal shaft double - suction single - stage volute pump 2,850 m^3/hour x 72 m x 800 kW	4	TORISHIMA Pump Manufacturing Co., Ltd.
Back flow prevention valve	Non water hammer back flow prevention valve, Diameter 600 mm	4	Yokota Manufacturing Co., Ltd.
Discharge valve	Motor-operated butterfly valve, Diameter 600 mm	4	Morita Iron Works Co., Ltd.
Air compressor	605 L/min x 0.93 MPa(Max) x 5.5 kW	1	SANWA Co., Ltd.
Surge tank	Steel plate 65m3	2	Lack of capacity
Backwashing pump	Horizontal shaft single - suction single - stage volute pump 792 m^3/hour x 25 m x 90 kW	2(1)	New construction for backwashing (2012), Made in Singapore
ACH storage tank	FRP tank, 14 m^3	4	2012
ACH transfer pump	23 m^3/hour x 16m x 0.75 kW	2(1)	Made in China
ACH Injection pump	120 L/hour x 70 m x 0.37 kW	2(1)	Made in China

Table 5 Main Equipment List in The Phase 2

Name of equipment	Specification	Total Number (standby)	Remark
Coarse mesh screen	Width of mesh 100 mm×40 mm	4	
Water intake pump	Horizontal shaft double‐suction single‐stage volute pump 2,841 m^3/hour x 10 m x 110 kW	4(1)	Made in China
Inlet gate of filtration basin	Manual gate, 450 mm square	32	Made in Myanmar Out of control and water leakage occurs often.
Valve of surface washing	Manual butterfly valve, Diameter 150 mm	64	Made in YCDC
Valve of backwashing	Manual butterfly valve, Diameter 300 mm	64	Made in YCDC
Outlet gate of filtration basin	Manual gate, 600 mm square	32	Made in Myanmar Out of control and water leakage occurs often.
Outlet gate of treated water tank	Manual gate, 1,050 mm square	6	Made in Myanmar
Suction valve	Manual butterfly valve, Diameter 500 mm	6	Made in China
Water distribution pump	Horizontal shaft double‐suction single‐stage volute pump 2,130 m^3/hour x 72 m x 560 kW	6(2)	Made in China
Back flow prevention valve	Rapid closing valve, Diameter 500 mm	6(2)	Made in China
Discharge valve	Motor-operated butterfly valve, Diameter 500 mm	6(2)	
Air compressor	300 m^3/min x 70 m x 15 kW	2	Made in China, No backup
Surge tank	Steel plate 65 m^3	2	Lack of capacity
Backwashing pump	Horizontal shaft double‐suction single‐stage volute pump 733 m^3/hour x 25 m x 90 kW	3(1)	New construction for backwashing(2012), Made in Singapore
ACH storage tank	FRP tank, 1 m3・14m3	4	
ACH transfer pump	23 m^3/hour x 16 m x 0.75 kW	2(1)	Made in China
ACH injection pump	120 L/hour x 40 m x 0.13 kW	2(1)	Made in China

1.2.3 Water Purification Process

The purification process of Nyaunghnapin WTP is illustrated in the following schematic diagram.

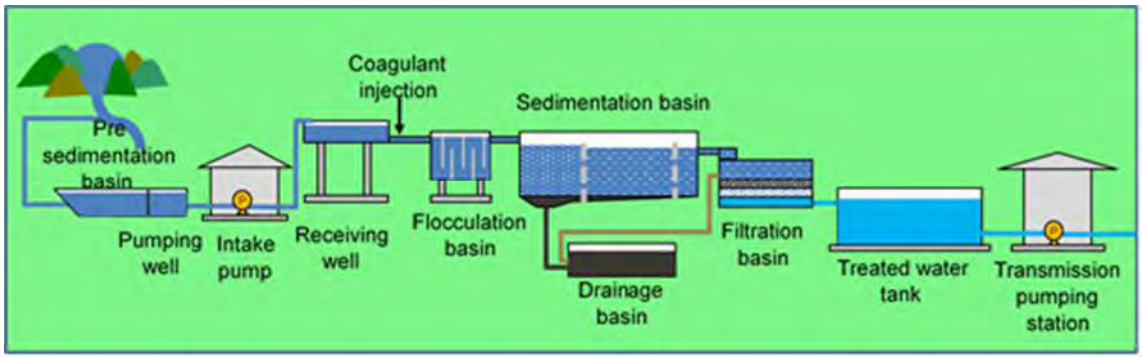


Figure 3 Water Purification Process of Nyaunghnapin WTP

1.2.4 Operation and Maintenance

(1) Organization

- There are 112 numbers of staffs including plant manager and deputy plant manager at Nyaunghnapin WTP.
- There are 2 Assistant Engineers (AE) as a plant manager and a deputy plant manager, 4 Sub-Assistant Engineers (SAE), 1 Junior Engineer 6 (JE6), 1 Junior Engineer 4 (JE4) and 104 Work Assistants (WA) who are hired at Nyaunghnapin WTP (organization chart of Nyaunghnapin WTP is shown in Figure 4).
- The working hours are divided into three shifts: 6:00 to 14:00, 14:00 to 22:00 and 22:00 to 6:00, but in actual practice there are only two shifts of working hours: 6:00 to 18:00 and 18:00 to 6:00.

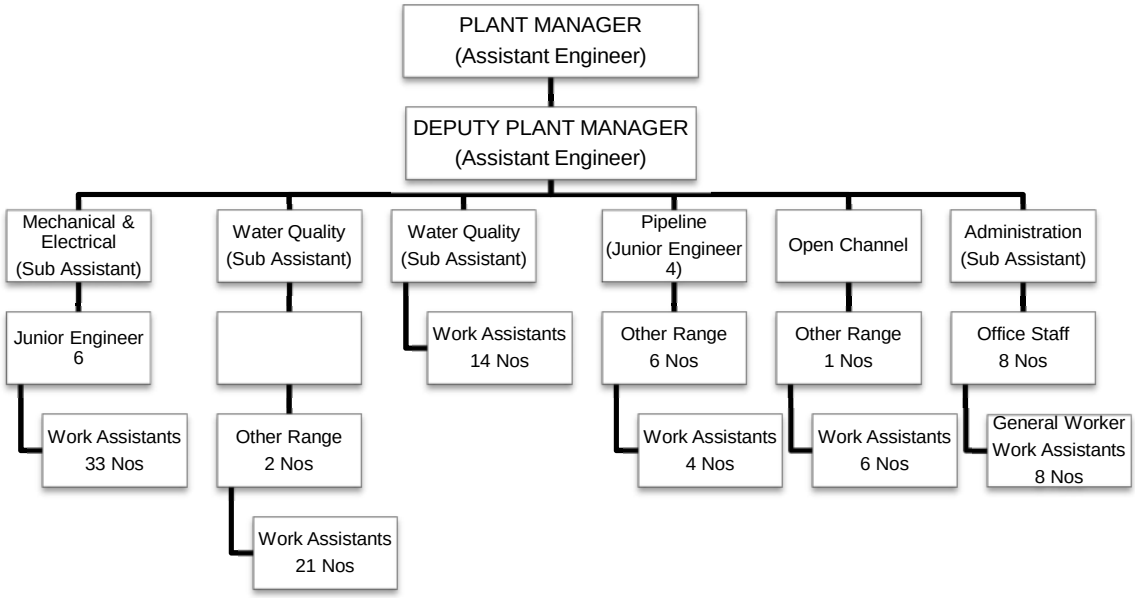


Figure 4 Organization Chart of Nyaunghnapin WTP

Table 6 Operation Staff of Nyaunghnapin WTP

Staff	Assistant Engineer	Sub Assistant Engineer	Junior Engineer 6	Junior Engineer 4	Work Assistants	Total
Plant manager	1					1
Deputy plant manager	1					1
Mechanical & Electrical		1	1		33	35
Water Quality		1			23	24
Water Quality		1			14	15
Pipeline				1	10	11
Open Channel					7	7
Administration		1			16	17
Total	2	4	1	1	103	111

(2) Capacity of staffs

Staff members who are managing each section have knowledge about purification process and some of them have experiences of participating in overseas trainings.

(3) Water quality management

- **Facility and equipment**

  Water quality laboratory is located on the second floor of the administration building at the WTP (Photo-43 and 44).

  Equipment for jar test will be installed in the laboratory.

  Turbidity and color should be measured correctly by measuring equipment instead of portable ones.

  Pumps and pipes for water sample collection are installed and the water sample reaches to the laboratory where it can be easily collected (Photo-45 and 46).

- **Water quality test**

  It is required to improve the reliability of tests by clarifying the calibration procedure and the frequency of water quality test measurements.

  It will be required to measure ammonia of raw water because YCDC will install hypochlorous acid injection equipment in the future.

Photo-43
Water quality test laboratory

Photo-44
Equipment for water quality test

Photo-45
Taps for collecting water sample

Photo-46
Pipes of water sample

(4) Operation record

- There are few operation records.

- It is possible to check operation status by monitoring displayed records and trend graph on monitor in the monitoring room of pumping station of Phase 1 and 2 (Photo-47 and 48).

Photo-47 Operation status

Photo-48 Trend graph

(5) Inspection record of facilities and equipment

- Operation records are sent to Yangon regional government every day.
- There are no records of inspection, repairs and consumption of chemicals and electricity.
- Records of washing filtration basin were recorded before.

(6) Others

- Consciousness related to maintenance has improved. The scum is removed, water quality laboratory has been constructed and sample water pipes are installed.

1.3 Transmission & Distribution Pipeline and Water Supply Facilities

1.3.1 Transmission Pipeline

There are 5 transmission pipelines; one from Gyobyu, two from Hlawga, one of which was laid when Phugyi reservoir was constructed, and two from Nyaunghnapin, to supply water to Yangon City. However, leakages and unregistered connections on transmission pipelines are not repaired and registered due to lack of maintenance activities such as patrol and inspection of pipelines and valves. Current situation of leakages and unregistered connections on Gyobyu pipeline; 68 km length, dia. 56 inches and mild steel, which were laid up to Kokine SR before 1940 above ground, are as follows (Photo-49~58).

・ 89 numbers of leakages

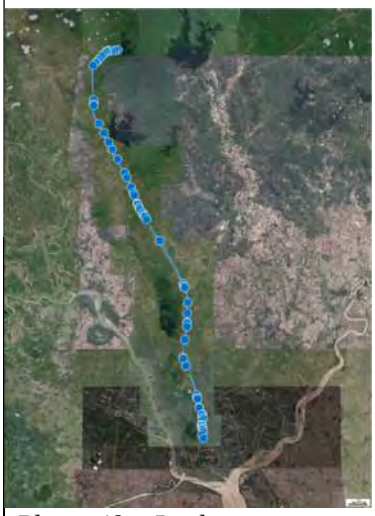


Photo-49 Leakage map

Photo-50
Leakage on main pipe

Photo-51
Leakage on drain

Photo-52
Leakage on joint portion

Photo-53
Leakage near air valve

・ 95 numbers of unregistered connections

Photo-54
Unregistered connection map

Photo-55
Connection on main pipe

Photo-56
Connection on a drain

Photo-57
Connection on joint portion

Photo-58
Connection on an air valve

As a result of the survey, it was estimated that only 51.5% of water from Gyobyu reservoir which is about 63,390 m^3/day out of 123,000 m^3/day, reaches Kokine SR. And it was also estimated that YCDC lost about 1.92 billion kyat of water charges yearly due to the leakage amount of about 610 m^3/day which can be supplied to about 6,100 persons, and water consumption by unregistered connections amounts to about 59,000 m^3/day.

1.3.2 Distribution Pipeline

(1) Distribution Network

Distribution pipes in downtown area were systematically laid in the first water served area in Yangon,

so it is understood that they are already old. On the other hand, some leakages are identified on water supply pipes where a lot of service pipes are laid parallel and distribution pipes are not laid systematically. Distribution pipe networks are designed using EPANET in 2014 for establishing DMAs (Photo-59~66).

Photo-59 Systematic distribution network in downtown area

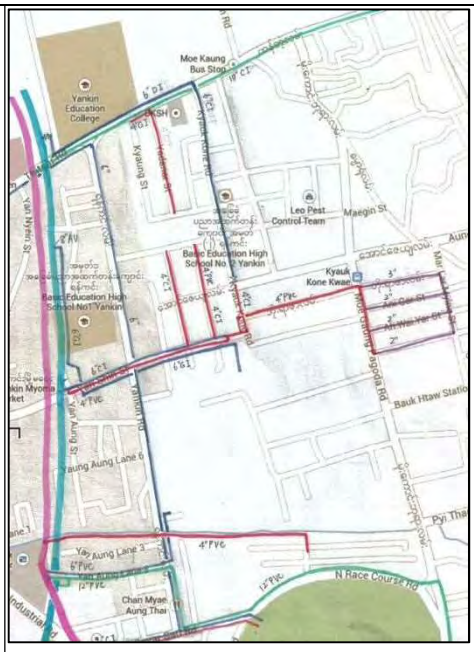


Photo-60
Unsystematic distribution network in other areas

Photo-61
Old distribution pipes

Photo-62
Service pipes above ground

Photo-63
Service pipes above ground

Photo-64
Leakage on service pipe

Photo-65
Leakage on service equipment

Photo-66
Leakage on service pipe

(2) Insufficient Water Amount and Low Water Pressure

Key issues in existing water supply services are insufficient amount of water and low water pressure at the tail end of service area. As a result, tube well pipes are connected with distribution pipes and distribution booster pumps are used in order to supply water to customers. Some of customers mix YCDC water with rain water (Photo-67~69).

Photo-67 Connection with tube well water

Photo-68
Distribution pump

Photo-69
Mixing with rain water

(3) Specifications and Regulations

Specifications of materials and constructions such as excavation width and earth covering are not standardized. Leaking from PVC and/or aged pipe is a matter of concern when water pressure is expected to be raised after restructuring of pipe network. Nowadays, HDPE pipes of PN (Nominal pressure) 6 is used as transmission and distribution pipes (Photo-70~73).

Photo-70
Laying distribution pipes

Photo-71
Laying distribution pipes

Photo-72
Laying distribution pipes

Photo-73 High Density Polyethylene Pipe (PN6)

(4) Distribution Pipeline Maps

Distribution pipeline maps were originally prepared by Auto-CAD. The existing maps were observed to have some issues; different scale in each township, only one information about pipe diameter, and pipe data were not updated frequently. To overcome these issues, these maps were prepared as A1 size paper maps with same scale. More data on pipes, such as pipe diameter, installation year and materials were added wherever available, and when new pipes are laid or old pipes are replaced updating is carried out in database also. Gradually, distribution pipe data is also being input and compiled in GIS system (Photo-74~76).

Photo-74
AUTOCAD version

Photo-75
A1 size paper version

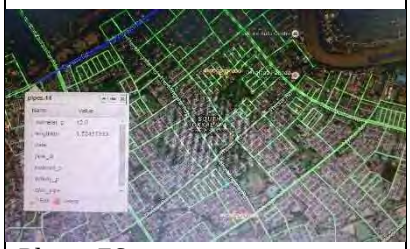


Photo-76
GIS version

(5) Records of Leakage

Leakage repair report is prepared and leakage point is recorded on maps in order to replace pipes and carry out leak detection effectively (Photo-77~79).

Photo-77
Leakage repair report

Photo-78
Leakage repair report

Photo-79
Leakage history maps

(6) Outlines of Donor of NRW Projects

In current situation, there is high level of non-revenue water in YCDC area. So, assistance is being provided by International Agencies to help reducing NRW. YCDC is cooperating with these organizations to improve water distribution for reduction of NRW.

Table 7 List of Activities of Donors

Item	Project for NRW Reduction in Mayangone T/S	FS on NRW Reduction by Denmark	FS on NRW Reduction by Manila Water	Rehabilitation Program of Yangon Water Supply System – Pilot Project
Source of fund	MOFA of Japan, Grassroots grant aid			
Implementation body (Consultant etc.)	Japan Construction	DWS (Danish Water Service + My Associate)	Mitsubishi –Manila Water	EGIS, France ; MWI
Implementation period	Oct 2014 – Oct 2015	Feb. 2013	1 year	May.2014 (Agreement)
Current status	Almost completed	Feb. 2014 (F/S)	Survey	May.2015 (Final Report)
Target areas	A pilot area in Mayangone	Yankin (ward No 13, 14, 15, 16)	Pilot Area (TO, JS)	Tarmwe, Thingangyun
Scale of pilot project (the number of households)	400 households	259 households	TO -372 connections, JS -311/321 connection	

1.3.3 House Connection

(1) Connections with Distribution Pipe

Apartments with an underground tank are connected to distribution pipe through one service pipe. However, customers who live in apartments without underground tanks have to connect to distribution pipe through separate service pipes at short intervals, so there is a high leakage risk. (Photo-80~82)

		
Photo-80 Aged connection	Photo-81 Connections by each customer	Photo-82 Service pipes to each customer

(2) Water Meters

Specifications of water meters are not defined, so there are various types of water meters in use (Photo-83).

It is impossible to read some meters because they are damaged, for example, in case of a site survey in Yankin township, out of 112 meters surveyed, approximately 90% were damaged (Photo-84).

Meters are owned by customers, so it would be difficult to ask them to replace damaged meters to new ones by their own cost.

Photo-83 Various water meters

Photo-84 Impossible to read meter data

1.4 Customer Management

(1) Customer Registration

Latest customer registration books are managed in each township office.

Application for new service connections is made by customers to the Head Office of YCDC. Upon confirmation with each township office whether it is possible to supply water or not in terms of amount and pressure around their houses, and after receiving application charges, approval is made by Head Office for new connection. New customers are registered on the book in each township. Flow chart of the process is shown in the following Figure.

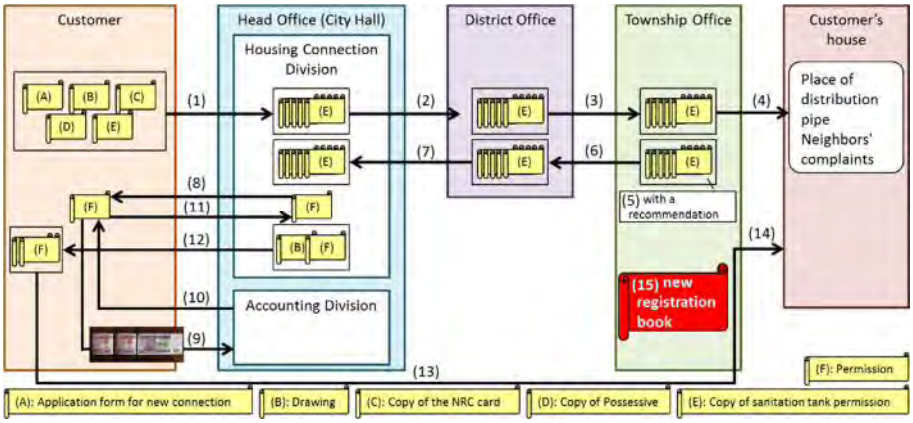


Figure 5 Flow Chart of New Service Connection

(2) Water Charge Collection

In old practice, there were a lot of formats in hand writing for water charge collection (Figure 6). However, in October 2014, use of e-governance system was started for collecting water charges from customers who have flat rate connections (Figure 7). Also, in December 2015 use of e-governance has started for meter connections. Consequently, it is expected that the number of formats in hand writing for these purposes will reduce and eventually disappear.

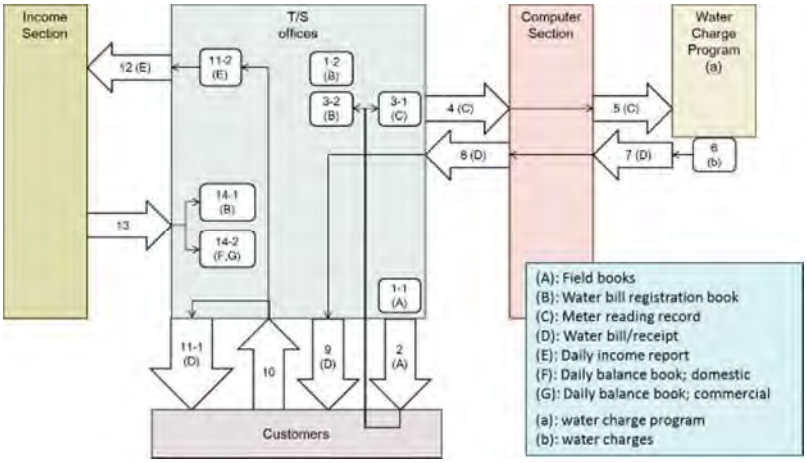


Figure 6 Flow Chart of Old System of Water Charge Collection (up to Sep. 2014)

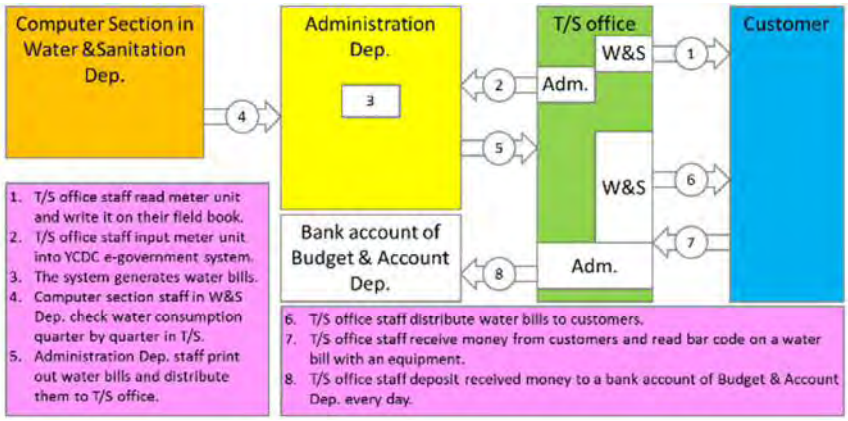


Figure 7 Flow Chart of New System of Water Charge Collection (Oct. 2014 onwards)

The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects

Chapter 1 General Rules

1.1 Purpose

The Guidance contain the basic policies for safety management, and technical guidance on specific methods for safe execution of works in order to prevent occupational accidents and public accidents on ODA construction projects for public and other facilities.

By fully understanding these Guidance and complying with the regulation therein, Project Stakeholders will be in a position **to respect the basic human rights** of all parties involved in ODA construction projects. **This will help prevent the occurrence of occupational and public accidents by creating a culture of safety, and help realize social development in the recipient country.** This is the purpose of these Guidance.

1.1.2 Composition of the Guidance

The Guidance are composed of the following six chapters:

Chapter 1 General Rules
Chapter 2 Basic Policies for Safety Management
Chapter 3 Contents of the “Safety Plan”
Chapter 4 Contents of the “Method Statements on Safety”
Chapter 5 Technical Guidance for Safe Execution (by the Type of Work)
Chapter 6 Technical Guidance for Safe Execution (by the Type of Accident)

Chapter 2 Basic Policies for Safety Management

2.1 Basic Principles of Safety Management

2.1.1 Basic principle 1: Safety is a top priority

All Project Stakeholders shall put top priority on safety and use their best endeavors to eliminate the occurrence of accidents.

2.1.2 Basic principle 2: Elimination of causes

The Contractor shall identify every possible danger in each process of construction work, and examine, analyze and eliminate the causes of such danger and take appropriate action to ensure the safe execution of the work.

2.1.3 Basic principle 3: Thorough precautions

The Contractor shall give consideration to in advance the inherent risk of accidents at each stage of construction work, review appropriate measures to cope with such risks, and commence work once these preventive measures have been implemented.

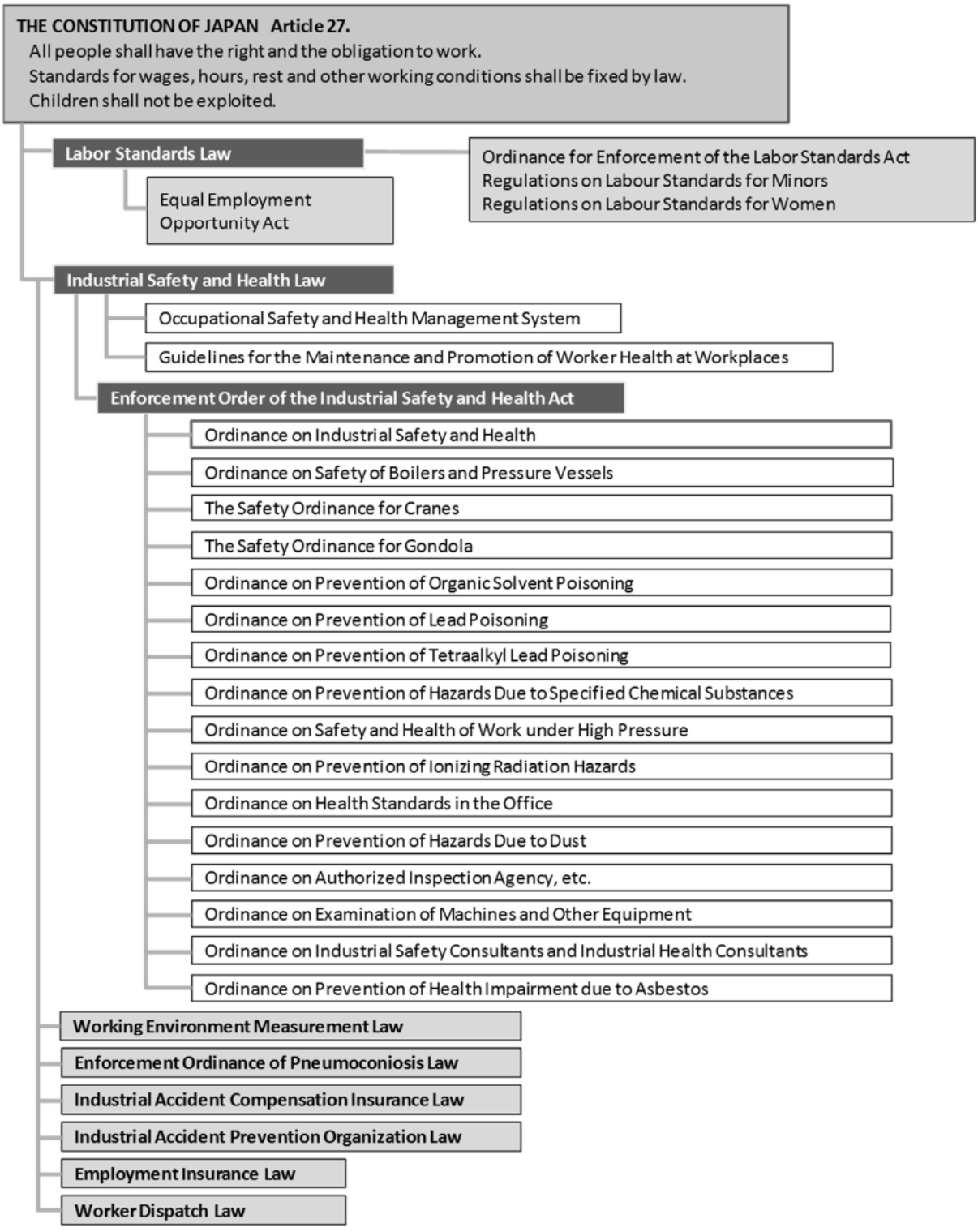
2.1.4 Basic principle 4: Thorough compliance with relevant laws and regulations

In addition to following the Guidance, the Contractors shall conduct ODA Projects in compliance with all related laws and regulations of the recipient country.

The Republic of the Union of Myanmar

The Labor Organization Law

Chart of Industrial Safety and Health Act and related government Ordinance -JAPAN-

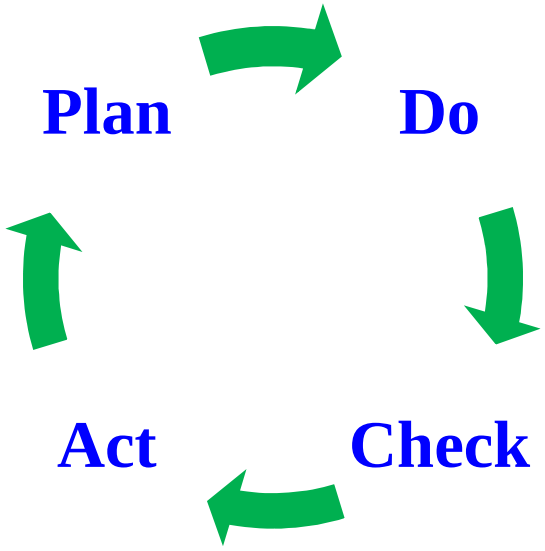


2.1.5 Basic principle 5: Thorough prevention of public accidents

All Project Stakeholders shall implement safety management measures taking the interests of third parties duly into consideration in order to prevent public accidents.

2.1.6 Basic principle 6: Thorough implementation of PDCA cycle for safety management

The basic principle of PDCA for safety management shall be the cycle of "Plan, Do, Check, Act" with "Plan" being the process of establishing the Safety Plan and its Method Statements on Safety, "Do" being the specific implementation of the plan thus established, "Check" being the observation and confirmation of the safety management process, and "Act" being the implementation of improvements to the implemented plans based on the past performance to ensure the continuous development of field site safety standards. The cycle of these processes shall be defined as PDCA for safety management. The Contractor shall have chief responsibility for the implementation of safety management.



2.1.7 Basic principle 7: Thorough sharing of information

All Project Stakeholders shall share all safety-related information they possess in a manner and at times as appropriate in the circumstances.

2.1.8 Basic principle 8: Thorough participation of all Project Stakeholders

All Project Stakeholders shall actively participate in activities related to safety management at construction sites.

Chapter 3 Contents of the “Safety Plan”

3.1 Composition of the Safety Plan

3.1.1 Items for inclusion in the Safety Plan

A typical Safety Plan shall comprise of the following:

(1) Basic Policies for Safety Management
(2) Internal Organizational Structure for Safety Management
(3) Promotion of the PDCA Cycle
(4) Monitoring
(5) Safety Education and Training
(6) Voluntary Safety Management Activities
(7) Sharing Information
(8) Response to Emergencies and Unforeseen Circumstances

Chapter 4 Contents of the “Method Statements on Safety”

4.1 Composition of the “Method Statements on Safety”

4.1.1 Items for inclusion in a “Method Statements on Safety”

The Contractor shall formulate a Method Statements on Safety for each type of work based on the design or documents implementing the design in order to accurately and efficiently undertake work, maintain a safe working environment and prevent any unsafe action by workers. The Contractor shall incorporate the following items in any Method Statements on Safety:

(1) Construction plant and machinery

The Contractor shall include the specifications and quantity of any construction plant and machinery to be used for the works.

(2) Equipment and tools

The Contractor shall include any equipment and tools to be used for the works.

(3) Materials

The Contractor shall include the specifications and quantities of any major materials to be used for the works.

(4) Necessary qualifications and licenses

The Contractor shall include the required qualifications and licenses required for each type of work.

(5) The order of command for the works

The Contractor shall include the order of command for the works specifying the relevant supervisors for each type of works. At times, the process for monitoring the implementation of works may be unclear, especially in cases involving subcontractors. As such, in order to avoid any confusion, the Method Statements on Safety should specify the relevant supervisors for each type of work (including subcontract works).

(6) Work items

The Contractor shall categorize each item of work and set them out according to the

works schedule.

(7) Procedure for the execution of the works

The Contractor shall specify the procedure for the execution of major work operations for each type of work.

(8) Foreseeable risks

The Contractor shall include all foreseeable risks for each work item.

(9) Precautionary measures

The Contractor shall review and include precautionary measures to prevent occurrence of foreseeable risks, including information on the type of protective gear required for the works.

4.1.2 Method Statements on Safety - Template

Method Statements on Safety [*Enter the type of work or Project name*]

(1) Construction plant and machinery	[*Enter the specifications and quantity of construction machines to be used in the work.*]
(2) Equipment and tools	[*Enter the equipment and tools to be used in the work.*]
(3) Construction materials	[*Enter the specifications and quantities of major materials to be used in the work.*]
(4) Necessary qualifications and licences	[*Enter the qualifications or licenses necessary for the work.*]
(5) Order of command (including names of supervisors)	[*Enter the name of supervisors for each section of work.*]

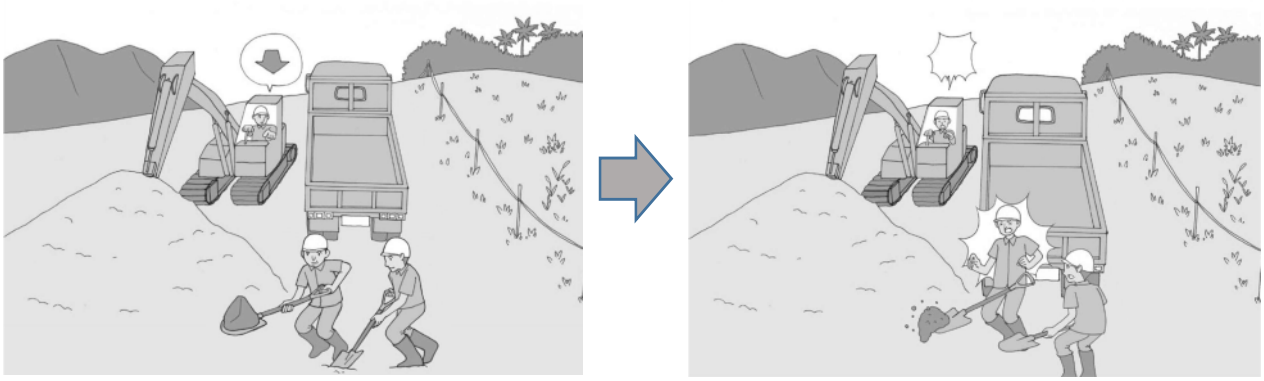
(6) Work items	(7) Procedure for the execution of the works	(8) Foreseeable risks	(9) Precautionary measures
[*Enter the work items classified into the unit work according to the order in the works schedule.*]	[*Enter the procedure for the execution of the major work operations for each type of work item.*]	[*Enter the foreseeable risks for each work item.*]	[*Enter the countermeasures to prevent the foreseeable risks and the necessary protective gear.*]

4.2 Applicable Standards for the "Technical Guidance for Safe Execution of Works"

4.2.3 Checklist for foreseeable risks

1) Does the work involve a risk that workers will fall from high places?
2) Does the work involve a risk that flying or falling objects will hit workers?
3) Does the work involve a risk that workers will be crushed by the collapse or fall of sediment or structures?
4) Does the work involve a risk that workers will be caught or entangled by machines or structures?
5) Does the work involve a risk of explosion?
6) Does the work involve a risk of fire?
7) Does the work involve a risk that the general public or any other third party will suffer adverse effects?
8) Does the work involve a risk that underground facilities, aerial lines, or surrounding facilities will be damaged?
9) Does the work involve the risk of traffic accidents?

Case	Dump truck is going back without checking back side...



5.1.2 Key points for excavation work

5.1.2.1 Prevention of ground collapse

(1) The Contractor shall have excavation work undertaken strictly in accordance with the instructions of the responsible supervisor and in accordance with the excavation procedure and methods.

(2) The Contractor shall not place or store excavated earth and sand near excavated slopes. In case the earth and sand has to be temporarily stored near an excavated slope, the Contractor shall take appropriate measures to prevent collapse of the excavated slope or falling of the earth and sand into the excavated area.

(3) When the surface of the ground falls as a result of rain, wind or water flowing from the ground surface to the excavation site, the Contractor shall implement protective measures such as covering the slope surface with protective sheets or nets.

(4) The responsible supervisor shall immediately evacuate workers to a safe place when there is a risk of ground collapse or landslide.

(5) The Contractor shall cancel excavation work when there is a risk that workers will be exposed to danger during those excavation works as a result of bad weather such as strong wind or rainstorms.

(6) When bad weather due to sudden change or a natural disaster occurs, the responsible supervisor shall immediately suspend the work and evacuate workers to a safe place.

5.1.2.5 Prevention of public accidents and traffic accidents

(1) When work is undertaken on a public road, the Contractor shall adopt appropriate measures to prevent the entry of unauthorized personnel including third parties into the work area, such as barricading the work site and stationing the watch-personnel and traffic-control personnel.

(2) When work is undertaken on a public road, workers shall wear reflector vests.

(3) Where buried utilities or facilities are located under the ground of a work site or where excavation is undertaken in the ground near a structure, then if damage to those utilities, facilities or structures by overturning or collapsing is likely, the Contractor shall take appropriate measures prior to the commencement of work, so as to prevent the risk, such as the relocation or reinforcement of the utilities, facilities or structures.

(4) When earth and sand is backfilled over buried utilities or facilities, the Contractor shall undertake backfilling undertake according to the predetermined specifications, without applying unsymmetrical pressure or damaging the buried utilities or facilities.

5.1.2.6 Working environment

(1) Where there is seepage water at or an inflow of surface water to a work site, the Contractor shall properly treat such water prior to the commencement of any work.

(2) The Contractor shall provide lighting strong enough to ensure safe excavation at the excavation site, taking into account the depth of excavation and the working environment.

(3) When powder dust is generated from work, workers shall wear protective gear such as respirators when undertaking the work.

(4) When loud noise is generated from the works, workers shall wear protective gear such as earplugs when undertaking the work. Since verbal communication is difficult in such circumstances, the Contractor shall determine an alternative means of communication in advance.

(5) The Contractor shall install ventilation equipment as required to properly maintain the air quality at an excavation site. Particularly when a mechanical apparatus that houses an internal combustion engine is installed at an excavation site, installation of ventilation equipment is necessary to prevent accidents by exhaust gas poisoning.

5.1.2.7 Inspection of excavation sites

(1) The Contractor shall inspect the ground and the area surrounding at an excavation site as follows:

1) Inspection timing

a) Before the start of work and at the beginning of each work shift

b) After the occurrence of heavy rain or an earthquake

2) Items to be checked

a) The ground to be excavated

b) The condition of seepage water at an excavation site

(2) In case the ground inspection indicates a risk of ground failure, the responsible supervisor shall immediately suspend excavation work and take appropriate anti-failure measures. The Contractor shall clarify the appropriate method of excavation or means to prevent ground failure taking into account the particular ground conditions, and resume the work only after confirming there is no likelihood of ground failure.

(3) The Contractor shall ensure that mechanical equipment such as excavation machines or rock drills undergo predetermined inspection before the commencement of work and at any predetermined time, so as to ensure that equipment is free of all defects. The Contractor shall immediately remove or repair any equipment that is found to be defective, prior to the start of work.

5.1.3 Key points for cofferdam and timbering

5.1.3.1 When installing cofferdam and timbering, the Contractor shall:

(1) Install cofferdam and timbering in accordance with the predetermined sequences.

(2) Commence excavation only after it is clear that the necessary structural of the cofferdam and timbering have been precisely safely installed in their correct positions.

(3) Firmly fix the cofferdam wall and timbering to prevent dislocation caused by vibrations and/or other external forces such as excavation works. In addition, the Contractor shall align the structural of all timbering in a linear fashion and normal to the cofferdam wall.

(4) Not place heavy materials on the structural of the timbering.

(5) Not use the timbering structural for suspension used in the protection of buried utilities or facilities unless otherwise specified. The Contractor shall install another structural columns suspended for purpose of protection separately from

the timbering.

(6) Regularly inspect the cofferdam walls and timbering for deformation of the structural, slackening of the fastening portions, or changes in groundwater or the surrounding ground level of the cofferdam wall and timbering during the construction. The Contractor shall undertake such inspections even during a period when no work is being undertaken.

(7) Ensure that when any anomaly is observed in the cofferdam wall and timbering, the responsible supervisor shall immediately evacuate workers to a safe place and take all necessary action to cope with the observed abnormal phenomenon. The responsible supervisor shall notify the appropriate manager in charge of the work suspension and also take appropriate action while the work is suspended.

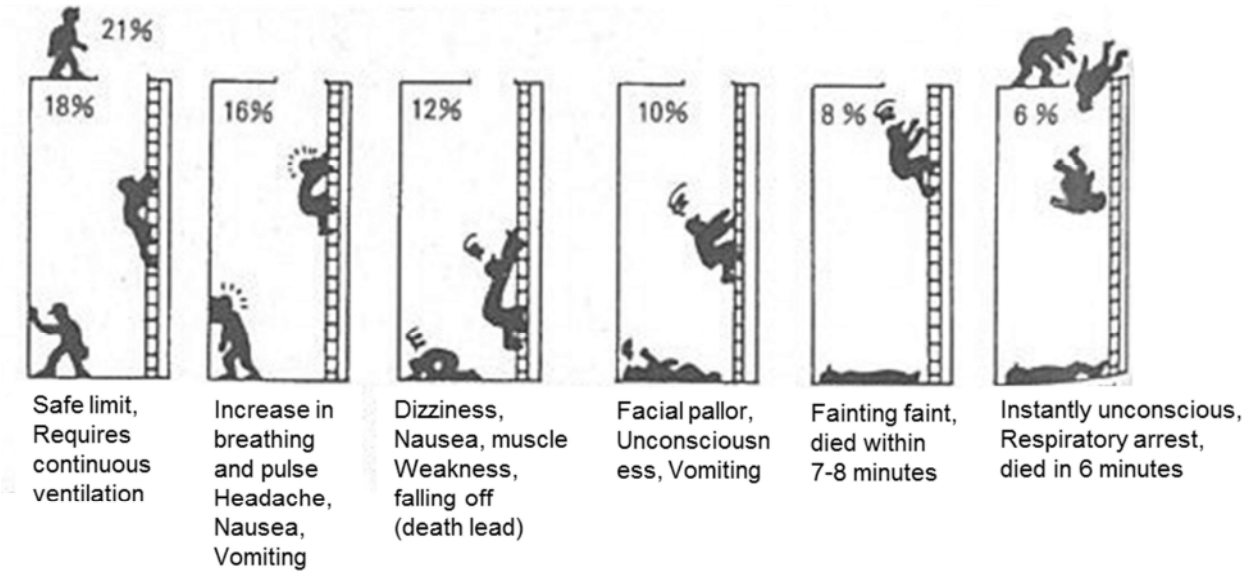
5.8 Work where there is danger of oxygen deficiency

5.8.1 Key points for the preparation stage

5.8.1.1 Understanding of the conditions for construction

The Contractor shall take appropriate measures that assume oxygen levels are deficient when undertaking works in the following circumstances:

1) Wells, open caissons, shafts, tunnels, pneumatic caissons and other similar places that have not been used for a long period of time
2) The insides of those places listed in 1) above, that are in contact with or either lead to the following layers:
   a) Sand gravel layers that have impermeable layers located right above, which have little or no water content or running water
   b) Strata containing ferrous salts or first manganese salts
   c) Strata containing methane, ethane or butane
   d) Strata gushing out or likely to gush out with carbonated water
   e) Sludge layers
3) Cisterns, conduits, manholes and pits
4) The insides of cisterns, conduits, manholes and pits where rainwater, river water, or seepage water stagnates or previously stagnated at some point in time.
5) The insides of tanks, holds, cisterns, pipes, conduits, manholes, ditches, pits in which human waste, sapropel, sludge, pulp liquid, or other corroded or easily decomposable substances are contained or were once contained.
6) An excavation work site, a pile foundation work site or surroundings, where construction by a pneumatic method is or once was carried out .
7) Places where work is undertaken with internal combustion engines of construction machines operated in a closed environment.



5.8.1.2 Procedure for execution of the works

The Contractor shall specify in advance the procedure for execution of the works and the supervisors responsible for work to be undertaken where there is a danger of oxygen deficiency, taking into account the relevant conditions for construction and other relevant factors.

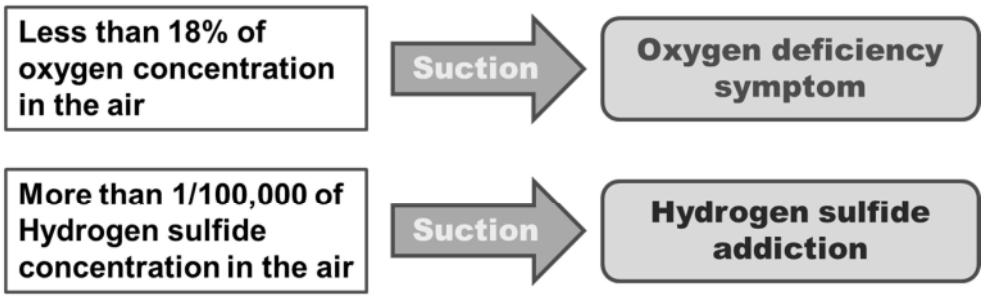
5.8.1.3 Measurement of the working environment

The Contractor shall specify in advance the timing and method for measuring oxygen concentration, and the procedure when the management concentrations in various working environments is to be applied.

5.8.1.4 Advance training to workers

The Contractor shall provide training to workers undertaking work in areas where there is a risk of oxygen deficiency on:

1) The influence of oxygen deficiency on the human body and the related symptoms
2) Usage of protective gear including a respirator
3) Evacuation in the event of accident and methods of emergency treatment



5.8.1.5 Protective gear

Workers shall wear safety helmets and protective gear to protect their feet when undertaking work. Where toxic gas exists, they shall wear gas masks or respirators. They shall use safety belts when working at places where they may fall.

5.8.2 Key points for working in places where there is a risk of oxygen deficiency

The Contractor shall:

(1) Install and maintain measurement equipment necessary to measure gas concentration in the working environment, when working in places where there is a risk of oxygen deficiency.

(2) Undertake measurements of the working environment when undertaking work in places where there is a risk of oxygen deficiency, prior to the start of each and every work shift. If the measurement result exceeds the management standard, the Contractor shall immediately take necessary measures and ensure that no work is undertaken until the measurement reading shows a value below the standard value.

(3) Comply with the following requirements when measuring the working environment:

1) When entering the measuring area, protective gear such as respirators shall be worn so as not to directly breathe in the air in the measuring area.
2) Measurements shall not be made by a single worker only; they shall be made always

with the appropriate watch-personnel stationed.

(4) Always maintain ventilation when work is undertaken at a place where there is a risk of oxygen deficiency.

(5) Provide protective gear including respirators, evacuation tools including ladders and ropes, and other appliances necessary for rescue, when work is undertaken at a place where there is a risk of oxygen deficiency.

(6) Take measures to prevent unauthorized access in areas where there is a risk of oxygen deficiency, and post relevant signs.

(7) Ensure that the supervisor responsible immediately suspends the work whenever there is the potential for oxygen deficiency and evacuates workers to a safe place.

(8) Ensure that rescue crew use protecting gear (such as respirators) when rescuing victims of oxygen deficiency and take measures to prevent secondary accidents.

(9) Ensure that work is always undertaken with constant ventilation, when working in a closed space where an internal combustion engine of a construction machine is being operated.

6.1 Measures for Prevention of Fall Accidents

6.1.1 General rules

When undertaking work at a place more than two meters above ground level, the Contractor shall construct scaffolding prior to the execution of the works and ensure that workers wear safety helmets when conducting the works.

Where it is impossible to construct scaffolding, workers shall use protective gear such as safety belts, fall arrestors and other anti-fall gear. The Contractor shall affix handrails, main ropes and other equipment as appropriate where the use of anti-fall protective gear is contemplated.

6.1.2 Scaffolding

6.1.2.1 Structure and materials of scaffolding

The Contractor shall:

(1) Analyze the structural strength required for scaffolding based on the loads to be applied in the working areas and the expected service loads, and determine the appropriate structure for scaffolding.

(2) Design the scaffolding structure to sustain expected loads for the relevant works after adequate review of the risk of any overturning or collapse of the structure.

(3) Use materials for scaffolding that can be reasonably procured within the country in which the project is located. More specifically, the Contractor shall select reliable, durable and appropriate materials that are free of defects in terms of strength, damage or corrosion.

(4) Construct scaffolding on a firm and flat foundation to prevent sliding or collapse and use additional supports as appropriate where any part(s) of the foundation is on soft ground.

(5) Provide supporting measures such as braces to prevent the collapse of the scaffolding structure.

6.2 Measures for Prevention of Accidents Involving Flying or Falling Objects

6.2.1 General rules

When undertaking work involving a risk of flying or falling objects, the Contractor
shall take the following measures into account for the particular work conditions.
The workers shall also wear safety helmets.

(1) Measures for the installation of safety nets
(2) Measures for work areas with height differences or openings
(3) Measures for work conducted at different heights
(4) Measures for work with rotating machines

6.4 Measures for Prevention of Accidents Involving Construction Machinery

6.4.1 General rules

The Contractor shall consider the following particulars when undertaking work using construction machinery.

1) The Operator
2) Inspection and maintenance of the machines
3) Safety devices on the machines
4) Stationing of flagmen
5) Measures to prevent unauthorized access
6) Measures for the suspension and completion of work
7) Provision of training on safety issues

6.4.1.1 Operator

(1) The Contractor shall appoint and permit only trained, qualified and certified operators of construction machinery to operate the machines. The names of the regular operators shall be inscribed on their respective machines and only those appointed operators shall operate the machines.
(2) The Contractor shall take steps to ensure the good physical and health condition of the operators. The operators shall be trained to have sufficient rest and shall not be subject to excessive work.
(3) The Contractor shall not permit any operator to operate construction machinery if he is seen to be under the influence of any of the following conditions:
   1) Intoxicated from consumption of alcohol

2) Suffering from the effects of excessive consumption of alcohol
3) Extremely exhausted
4) Suffering from any other condition that makes him unfit for any works for the operation of construction equipment or machinery.

6.4.1.2 Inspection and maintenance

The Contractor's personnel with requisite knowledge and skill shall undertake inspection and maintenance of construction machinery in accordance with the relevant laws and regulations of the recipient country, prior to the start of work and at the predetermined times.

The Contractor shall undertake such inspection and maintenance taking into account the following requirements.

The Contractor shall:

1) In principle, undertake inspection and maintenance only after ensuring the machine has ceased to operate and the power is turned off.
2) Take appropriate measures to prevent falling or overturning machines.
3) Take appropriate measures to prevent any unauthorized access to the work area where inspection or maintenance is undertaken.
4) Undertake inspection and maintenance on a flat and secure surface when the machine is not in operation. If for some unavoidable reason it has to be undertaken on a slope, stoppers shall be applied for the undercarriage of the machine to prevent slippage or movement.
5) Shut down the engine of the construction machinery, engage the brake and lock all rotating parts.
6) Lower all attachments onto the ground. If for some unavoidable reason inspection or maintenance has to be undertaken under a raised blade or bucket, the Contractor shall take appropriate measures to prevent the attachment from dropping, for example, by using supports such as struts or blocks.
7) Take appropriate measures when a machine is being repaired, including the complete shutdown of the machine's functions and preventing any operation or movement of the machine during repair.

6.4.1.3 Safety devices

(1) The Contractor shall check the safety devices fitted to construction machinery confirm the operation of the device, and shall not operate any construction machinery if the safety device has been removed or modified.
(2) For construction machines capable of moving backwards, the Contractor shall

use only such machines fitted with safety devices that give a warning when the machine moves backwards.

6.4.1.4 Stationing of flagmen

The Contractor shall:

(1) Station flagmen when work is undertaken at the road shoulder, on the edge of a slope, and at other locations where there is a risk of vehicles overturning.

(2) Station flagmen where workers and construction machinery are required, for unavoidable reasons, to work in the same vicinity.

(3) Establish standardized signs and controlling procedures where flagmen are stationed.

6.4.1.5 Prevention of unauthorized access

The Contractor shall declare danger zones to be off-limits to unauthorized personnel in order to prevent the occurrence of accidents, such as injury caused by collision with construction machinery. Where it is impossible to restrict access for unavoidable reasons, the Contractor shall station flagmen or other appropriate personnel.

6.4.1.6 Measures for suspension and completion of work

When suspending or completing work using construction machinery, the Contractor shall:

1) Station construction machinery on flat and secure ground and lower buckets onto ground level.
2) Apply stoppers around the undercarriage of construction machinery to immobilize them when they must be positioned on a slope.
3) Turn off the engine, engage the brakes and remove the key from the vehicle.

6.4.1.7 Provision of education on safety

(1) The Contractor shall provide operators and workers engaging in work using construction machines with necessary training, including training on the deployment of construction machines, the work area, the scope of work, the method of work, and the work procedures to be undertaken prior to the commencement of work.

(2) Whenever any major changes are made to the deployment of construction machinery, the work area, the scope of work, the method of work, and the work procedures, the Contractor shall provide further training to the relevant operators and workers.

6.4.2.1 Guiding and signaling for mobile cranes

(1) The Contractor shall appoint only one signalman, who shall use the predetermined signals and provide signals in a clear manner.

(2) The signalman shall give signals from a position outside the work range that holds a good view of the hoisted cargo and is reasonably visible by the crane operator.

(3) In case the signalman has no choice but to give signals at a position not visible to the operator, he shall use radio or other means to allow the operator to receive the signals.

6.4.2.2 Measures for the arrangement and installation of mobile cranes

The Contractor shall:

(1) Ensure that there are no obstacles in the work range of the mobile crane.

(2) Establish a procedure that considers any obstacles in the work area and alerts all relevant workers and operators as to their existence in advance.

(3) Check the ground conditions on which to position or transport the mobile crane.

(4) Apply steel plates or conduct ground improvement works when the load-bearing capacity of the ground is insufficient, so as to prevent the crane from overturning.

(5) Set the body of the mobile crane horizontally and extend the outriggers to their fullest depending on the load.

(6) Conduct pre-operation inspection of the mobile crane to check safety devices or warning equipment. Safety devices or warning equipment shall not be turned off during work.

(7) Check the condition of the outriggers or the condition of the ground on which the crane is positioned during operation. Any anomaly, if found, shall immediately be corrected or removed.

6.4.2.3 Measures for operation of mobile cranes

The Contractor shall:

(1) Immediately suspend work if anomaly is found during the work, investigate the causes, and take all necessary measures prior to resuming work.

(2) Confirm that the entire weight, including the cargo to hoist, hooks, slinging equipment and other hoisting attachments, is less than the rated hoisting load.

(3) Provide indications or other means that allow operators and slinging workers to always be aware of the rated load of the mobile crane.

(4) Use anti-release appliances when hoisting cargo, so as to prevent slinging equipment from releasing from the hooks.

(5) When slinging cargo, temporarily stop the cargo when it is afloat only slightly from ground level, and check the machine for stability, the center of gravity of the cargo and the condition of sling.

(6) When hoisting cargo, position the hook right above the cargo to hoist.

(7) When turning cargo, confirm that there are no workers or obstacles inside the turning range, and the operators shall slowly turn the cargo.
(8) Slowly and silently lower cargo.
(9) Not use mobile cranes to transport or hoist workers unless, because of the nature of the work or the need to complete the work, it is necessary to undertake such crane operation, in which case the Contractor shall take the following measures:
    1) Provide means to prevent overturning or falling off of the hoisting basket.
    2) Have workers use protective equipment such as safety belts.
    3) Use the power-driven lowering when the hoisting basket is lowered down.
(10) Ensure that no operators leave the operator's cabin with the cargo hoisted up.
(11) Ensure that no workers are present under the hoisted cargo.
(12) Take appropriate measures to restrict unauthorized access during the mobile crane work, so as to prevent workers from entering areas where cargo may fall.

6.7 Measures for Prevention of Public Accidents

6.7.1 General rules for prevention of third-party accidents

When undertaking work with a risk of third-party accidents, the Contractor shall review following measures taking into account the particular work conditions:

1) Installation of temporary enclosures and gates and related measures
2) Measures relating to the area around gates to construction sites
3) Installation of temporary pedestrian passages

4) Communication with local residents in the vicinity of the construction sites
5) Decluttering and cleanliness
6) Measures relating to work on public roads
7) Prevention of flying or falling object accidents to third parties
8) Prevention of dust generation
9) Provision of sufficient lighting
10) Prevention of noise and vibration
11) Site patrol

6.7.2 General rules on preventing accidents relating to underground utilities or facilities

(1) When the presence of underground utilities or facilities is foreseen at a construction site, the Contractor shall conduct a survey on such buried utilities or facilities based on the design documents and preliminary survey information, taking into account safe work methods and procedures for the protection of buried utilities or facilities.
(2) When the presence of underground materials or facilities is foreseen at a work site, the Contractor shall consult with the relevant organizations in charge of such buried utilities or facilities, and after obtaining all appropriate permissions, shall undertake the necessary work in accordance with the relevant laws and regulations of the recipient country.

(3) The Contractor shall check the kind and type, location (plan and depth), relevant standard, structure, and other details of the underground utilities or facilities in advance, so as to accurately understand the area of impact associated with excavation of those buried utilities or facilities.

(4) The Contractor shall notify and ensure the relevant workers understand the information on the underground utilities or facilities, the method and procedure of excavation, the method of protection, emergency response and other necessary data relating to those utilities or facilities.

6.8.2.2 Measures relating to work on public roads

The Contractor shall:

(1) Obtain the relevant permission when it is necessary to conduct work on public roads, through the relevant procedures in accordance with the provisions of the relevant laws and regulations of the recipient country prior to the commencement of work.

(2) Clearly indicate work areas on public roads and take measures to prevent unauthorized access by third parties to the area. Relevant watch-personnel shall be stationed as needed.

(3) Maintain the travelling areas for pedestrians and public vehicles so as to prevent road traffic issues, and station flagmen at appropriate spots to guide public vehicles.

(4) Maintain safe pedestrian passages for the smooth passage of children and the elderly.

(5) Take measures to allow drivers of public vehicles to be able to identify the work area from a distance and drive in a safe and secure manner by:

1) Installing road signs at work areas.
2) Installing notice boards to give advance notice of work on public roads.
3) Providing lighting that increases the visibility of road signs and notice boards, when working after nightfall.
4) Firmly affix road signs and notice boards, so as to ensure they do not overturn owing to strong wind or rainfalls.

(6) Provide appropriate lighting when undertaking work after nightfall, and take care to prevent the dazzling light of the installed lighting fixture from disturbing drivers of public vehicles.

(7) Install a detour information board to inform public vehicles and pedestrians of the need for diversions of public vehicles, and deploy flagmen as appropriate.

(8) Notify local residents of the plan to work on public roads, so as to obtain their understanding and cooperation.

6.9 Protective Gear

6.9.1 General rules

The Contractor shall:

(1) Ensure that workers use personal protective gear appropriately for the type of work and working environment where they may be exposed to danger during construction work.

(2) Use personal protective gear that is properly certified by the relevant laws and regulations of the recipient country.

(3) Provide workers with training on how to use and manage protective gear, and instruct them to use it appropriately.

(4) Ensure that workers use appropriate protective gear depending on the work, and undertake work in a safe and secure manner.

6.9.2 Safety helmet

(1) The Contractor shall ensure that safety helmets are used to reduce the impact to the head in the event of a fall, and protect the head from flying or falling objects.

(2) The Contractor shall inform workers of the type and location of work that requires safety helmets to be worn, and provide them with education on how to use the helmets. They shall also be instructed to use them whenever necessary.

(3) The safety helmet shall be designed or conditioned to fit the head of a wearer, and the chinstrap shall always be tightened when the wearer conducts work with a risk of falling.

(4) The Contractor shall ensure that damaged safety helmets are never used.

6.9.3 Safety belts

The Contractor shall ensure that:

(1) Safety belts are used to prevent falls when work is undertaken at a high level, on the edge of a working floor, and near an opening where workers may fall.

(2) Safety belts are used that are appropriate to the location or contents of work.

(3) Workers are notified of the type and location of work that requires use of safety belts, and trained to correctly use them. They shall also be instructed to use them whenever necessary.

(4) Damaged safety belts (even if damaged from a single event) are not used.

(5) Safety belt hooks that have a latch are used.

(6) Safety belt hooks are attached at a position higher than the waist.

(7) A safety belt attaching system is installed whenever using a safety belt. The attaching system is strong enough to support a fall, and shall be checked for any anomalies before use.

6.9.6 Protective gear for hands

(1) The Contractor shall ensure that protective gear is used to protect hands against substances that may damage the skin, and during welding or cutting work.

(2) When protective gear such as gloves is used, the right type of gear shall be used taking into account the type of work.

(3) Workers shall be notified of the type and location of work requiring hand protective gear, trained to correctly use them and given detailed instructions to use them whenever necessary.

6.9.7 Protective gear for feet

(1) The Contractor shall ensure that protective gear is used to protect feet against injuries from falling objects, being caught between objects, electric shocks and skin-damaging substances.

(2) When protective gears for feet such as safety boots or high boots are used, the right type of gear shall be used taking into account the type of work.

(3) Workers shall be notified of the type and location of work requiring feet protective gear, trained to correctly use them and given detailed instructions to use them whenever necessary.

PROCUREMENT OF SERVICES AND APPLICATION OF PUBLIC PRIVATE PARTNERSHIP

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1) Construction period

・ Construction period should be shorter to tackle chronical water shortage.

2) Project cost

・ Project cost should be reduced as low as possible.

3) Operation and maintenance skills

・ Life of facilities and equipment should be prolonged as much as possible by appropriate operation and maintenance.

・ Capacity development activities on operation and maintenance of new facilities and equipment should be implemented because this is the first experience for YCDC to purify river water.

4) Risk of Contractor

・ Low construction risks for a contractor are preferable.

1.1.2 Implementing Agency

(1) Implementing Agency

Standard Process of ODA loan, Design Build (DB), Life Cycle Cost (LCC) and Design Build Operation & Maintenance (DBO) are studied as measures against the issues. Implementing agencies for activities in case of each plan is given in the following table. In addition, PPP is considered as section 2.

Table.1 Implementing Agency of Activities under each Plan

Activity	CONTENTS	(A) Standard Process	(B) DB	(C) LCC	(D) DBO	(E) DBO
Finance	Japanese ODA loan	YCDC	YCDC	YCDC	YCDC	Contractor
(D) Design	Detail design of WTP	Contractor A	Contractor	Contractor	Contractor	
(B) Build	Construction of WTP	Contractor B				
(O) Operation	Operation of WTP	YCDC	YCDC			
(M) Maintenance	Routine inspection of WTP and Repair of equipment	YCDC	YCDC	YCDC		

Source: JICA Study Tem

(2) Study of Procurement of Services

1) Construction period until start of operation

Construction period until start of operation in case of DB, LCC and DBO is generally shorter than that of standard process because the contractor can design as well as construct the facilities.

2) Project Cost

a) Design and Build (DB)

The cost of design and construction in case of DB is generally smaller than in case of standard process because the contractor can design and procure the materials/equipment of specifications matching their requirement.

b) Life Cycle Cost (LCC)

LCC is formation in which a verification test with a period is added to DB. The outline of LCC is; A tender party calculates the construction cost (CAPEX: capital expenditure), and O&M cost during 15 years (OPEX: operating expenditure) with the unit price specified by an ordering party. The total amount of two types of cost is evaluated at the time of bidding. Contractor calculates actually required OPEX through verification operation during one to three years (generally) after trial operation. Then, the guaranteed OPEX during 15 years at the time of bidding is compared with actual OPEX during 15 years. The contractor has to pay a compensation payment, when the actual OPEX exceeds the guaranteed OPEX, Or has to improve the plant by its own expense, in order to satisfy the guaranteed OPEX. Therefore, candidate contractor with sufficient experience only participate in such bidding. However, the risk cost after verification test is included in bidding expenses, and the expense becomes large compared to the case of DB.

c) Design, Build, Operation and Maintenance (DBO)

The cost of design and construction is equivalent to DB. Operation and maintenance cost in case of DBO is generally higher than that of LCC because the contractor shall arrange experienced staff from Overseas for O&M of WTP. However, this method has an advantage in terms of maintenance of facilities and equipment properly. As a period of O&M, 15-20 years after M&E equipment replacement is advisable.

3) Operation and Maintenance Skills

a) In case of Standard Process and DB

The ordering party (owner of facilities) needs to operate and maintain the facilities by themselves, so O&M manuals should be provided to the owner of facilities and O&M activities be demonstrated by the contractor during warranty period based on the manual.

In this case, the contractor shall ask suppliers or maintenance companies to implement regular inspection and carry out simple repairing once a year and parts replacement after precise inspection during warranty period. In order to manage proper O&M of facilities and equipment, supply obligation of spare parts of 3 years or more is proposed.

b) In case of LCC and DBO

The contractor operates and maintains the facilities during term of the contract, so the ordering party does not need to do anything during the period. It is required to hand over the experiences of

the contractor to YCDC before end of the term of contract.

4) Risk of Contractor

Uncertain natural conditions are the large risks for Contractor. Particularly, deep pile foundation is planned in this project, and this issue contains upside risk of construction cost. It is difficult for Contractor to estimate these construction costs accurately before bidding. For that reason, DB, LCC and DBO have high-risk for Contractor. In general, public organizations should owe large risks.

(3) Evaluation

The summary of measures against issues is as follows. The standard process is proposed from the following table.

It is understood that in terms of implementation, DB method is better than standard process to achieve the objectives considering current situation and issues due to construction period and project cost. However, there exists concern about high contractor's risk. It is difficult to implement the project by DBO method because YCDC has a plan to continue operation and maintenance of facilities and equipment by itself. In case of LCC, under the current situation of non-existent operation record as reference, it is difficult to set up unit prices of OPEX for bidders.

Table.2 Comparison of Procurement of Services

	(A) Standard Process	(B) DB	(C) LCC	(D) DBO
Experience of YCDC	O	X	X	X
Construction period until starting operation	$D_{(A)} > D_{(B)} = D_{(C)} = D_{(D)}$			
Project Cost	$C_{(D)} > C_{(C)} > C_{(A)} > C_{(B)}$			
Operation & Maintenance	(Implementing Agency) Water utility immediately after completion of construction (Skills) Demonstration of operation and maintenance based on manuals is required		(Implementing Agency) The contractor during contract period (Skills) Handover of experiences from the contractor to YCDC before end of the contract.	
Contractor's Risk	Low	High	High	High

Source: JICA Study Tem

1.2 Public Private Partnership (PPP)

1.2.1 Background of PPP

The proposed Phase 2 project is planned to be implemented by YCDC with public funding mostly considered to be financed by Japanese ODA loan. None of the stakeholders on both Myanmar and Japanese sides have recently expressed their intention to implement the project as a Public-Private Partnership (PPP) except some past failed attempts by other proponent foreign investors to formulate the project through PPP. Given such understanding of existing situation, however, in accordance with the terms of reference of this survey, the present chapter covers a brief overview of PPP environment in Myanmar, the current status of infrastructure development through PPPs, and its possible application to the water supply sector in future.[1]

1.2.2 Legal and Institutional Framework

(1) Overview

There is no institutional or regulatory framework that governs PPP in general in Myanmar. A potential private investor interested in a PPP project often makes a proposal to a respective sector ministry, state, region or any other government department like YCDC, and negotiates with relevant authority. PPP projects are usually implemented based on an agreement in the form of MOU concluded between the investor and the respective government counterpart sometimes without any competitive procurement process. On the other hand, foreign investment and formation of business entities in general are governed by the Foreign Investment Law (2012) and Myanmar Companies Act (1913).

In short, foreign investors who intend to carry out PPP projects in Myanmar are required to follow the steps below to start their business:

- Concluding an agreement with a sector ministry or a state-owned entity based on proposal and negotiation about details of the project;
- Obtaining a permit from Myanmar Investment Commission (MIC Permit) as stipulated in Foreign Investment Law;
- Obtaining a Permit to Trade for which the particulars are determined by Myanmar Companies Act; and
- Incorporating and registering the company with the Company Registration Office.

(2) PPP regulations and institutional setup

There are no comprehensive laws or regulations in Myanmar so far, which determine the national

[1] Primary sources of the information for the present chapter are "Data Collection Survey on Investment Climate for Infrastructure Development" by JICA in June 2013; and presentation materials of "National Workshop on Public-Private Partnerships in Myanmar" in November 2014 by United Nations Economic and Social Commission for Asia and Pacific (ESCAP) retrieved from http://www.unescap.org/events/national-workshop-public-private-partnerships-myanmar, unless otherwise indicated.

policy on PPP, or standardized conditions and process applicable to all infrastructure development through PPP. There is no specific institutional setup or agency on national level that formulates policies and governs the process for PPP projects in general. Recent private participation has taken place in many public infrastructure projects in various sectors such as roads and power generation under management of respective sector ministries such as MOC and MOEE as well as respective states and regions. However, it is pointed out in the JICA survey (2013) that even ministerial-level regulations also lack rules or regulations specifically designed for PPP infrastructure projects, in addition to the lack of abovementioned general PPP regulations on national level.

Since there is no standardized process for PPP project preparation and implementation, sector ministries often respond proposals from potential private investors on a solicited basis, rather than formulating their own development priorities which effectively apply to both PPP and public investment projects towards integrated development goals. There are no procurement standards for PPP development either on a solicited or unsolicited basis; hence PPP project implementation is typically determined by individual agreements such as MOUs based on negotiations sometimes without any competitive bidding.

To cope with the said underdeveloped institutional and regulatory framework for PPP, Asian Development Bank (ADB) is currently providing technical assistance called "Support for Public-Private Partnership Framework Development" for Ministry of National Planning and Economic Development (MNPED) and MOEE to develop PPP framework in Myanmar including establishment of PPP Unit in MNPED.

As of March 2016, this technical assistance project has implemented two major components: (a) project assessment and prioritization for MNPED; and (b) overall enhanced public financial management/ oversight for MOEE. According to ADB's Project Data Sheet dated April 8, 2016, Component (a) has seen the consulting team evaluate 7 unsolicited proposals of MNRED's choosing, comparing those to the recently completed competitive bidding process for Myingyan Power Plant project, and all of those against international benchmarks, which has helped MNPED understand the value of competitive bidding. Currently work is underway on creating a policy-based transition structure from unsolicited reliance to government-run competitive bidding. This work is also feeding into the development of standardized bid specifications, contracts and terms and conditions of requests for quotation (RFQs) and requests for proposal (RFPs).

Component (b) is creating a standardized means for capturing and quantifying the direct and contingent liabilities coming out of PPP contracts, projecting prospective subsidies, and project foreign exchange requirements. This work is creating standardized reports and management criteria for the government to follow. The ADB assistance is expected to complete in December 2016 with

one-year extension from December 2015.

(3) Foreign Investment Law (2012)

The union government enacted the Foreign Investment Law (FIL) in 2012 which repealed the former law of the same title of 1988. FIL regulates all foreign private investment in the country and establishes a new legal base of Myanmar Investment Commission (MIC) as the regulatory body of foreign investment under MNPED. MIC is managed by Directorate of Investment and Companies Administration (DICA) of MNPED. Based on FIL (Article 56), two bylaws, namely MNPED Notification No. 11/2013 and MIC Notification No. 1/2013, are established as detailed rules and regulations. Following Table summarizes the salient features of FIL.

Table.3 Features of Foreign Investment Law (2012)

Item		Regulation on 2012 FIL
1.	Types of permitted foreign investment	Listing various principles for foreign investment allowed in Myanmar (Article 8). MNPED and MIC Notifications lists various business categories exclusively reserved for Myanmar citizens, prohibited, or only allowed in case of Joint Venture with Myanmar citizens.
2.	Applications for investment permit	Apply to MIC. MIC must accept/reject within 15 days and make final decision within 90 days (Article 20).
3.	Minimum capital investment threshold	MIC may prescribe thresholds (Article 10 (a) (iii)). In practice, the minimum thresholds determined in the 1998 FIL remain in place: - Heavy industry, hotels and manufacturing: USD 500,000 - Service industry: USD 300,000
4.	Permitted level of foreign ownership (FDI)	100 % (at discretion of MIC)
5.	Permitted level of foreign ownership (Joint Venture)	Concerned parties may decide. There is maximum limit of 80 % for foreign ownership for certain restricted businesses.
6.	Income tax exemption	5 years (investors in goods and services)
7.	Land	Leases permitted up to 50 years with up to two discretionary 10 year extensions.
8.	Labor	Myanmar citizens must make up at least 25 % of workforce for the first two years, 50 % in the second two years, and 75 % in the third two years. Investors must provide training.

Source: Project for the strategic urban development plan of the Greater Yangon

(4) Myanmar Companies Act (1913)

Myanmar retains the British common law system which was established before the country's independence. Laws enacted well over hundred years ago still continue to be applied unless expressly amended or repealed.

Myanmar Companies Act (MCA) originally enacted in 1913 with later amendments, is applied today to govern the formation, constitution and administration of companies. MCA is further supplemented by its sub-legislation, namely the Companies Rules and the Companies Regulations. Of importance to foreign investors in Myanmar will be the requirements stated in the MCA and the Companies

Regulations for the registration of companies since in fact FIL stipulates that a foreign investor must carry out its business by forming a company under Myanmar law.

There is distinction drawn by MCA between Myanmar companies and foreign companies. A Myanmar company, as defined by MCA, is a company whose share capital is entirely owned by citizens of Myanmar. Therefore, if a company has one or more foreign shareholders (even if that interest is a single share), or is incorporated outside of Myanmar, it will be considered a foreign company. Every foreign company is required to obtain from the DICA a "Permit to Trade" before registration of the relevant company. A foreign company is not entitled to carry out business unless it has obtained such a permit.

Other than MCA, Myanmar Partnership Act (1932) sets out the details of partnerships between a foreign company and local companies; whereas Special Company Act (1950) applies to joint ventures formed with state-owned economic enterprises.

(5) State-owned Economic Enterprises Law (1989)

State-owned Economic Enterprises Law (1989) determines a number of activities in which only state-owned enterprises (SOEs) are allowed to engage, such as mining, post and telecommunication, electricity generation, etc.; however, the law's Sections 4 and 5 also offer the government a legal basis to permit involvement by other entities (such as foreign investors) if it is in the interest of Myanmar to do so. Such involvement may be via a joint venture with a SOE or independently, under other conditions. Thus, foreign investors may legally engage in such sectors using this legislature but only with government support. Along with the respective sector laws and regulations, potential investors should follow this law and negotiate with respective government department to formulate the details of PPP projects.

(6) Other laws related to PPP

A number of other laws are related to the activities of foreign investors engaged in PPP projects, such as Myanmar Contract Act (1872), Land and Revenue Act (1879), etc. Amongst these, Myanmar land laws stipulate that all land in Myanmar is owned by the government with administration delegated to various government departments. Transfer of Immovable Property Restriction Act (1987) explicitly prohibits foreigners from owning land with few exceptions. Therefore, it is normally required for foreign companies to obtain an interest in land to implement PPP projects either (i) through land lease from government departments; or (ii) in the form of in-kind contribution from a state-owned entity which is a joint venture partner for the subject PPP project.

As for the international commercial arbitration, Myanmar formally became a signatory of the New York Convention in 2013. According to the JICA survey on Investment Climate (2013), however,

"Myanmar's outdated legislation on arbitration will require extensive overhaul in order for it to incorporate the provisions of the New York Convention in domestic law and provide an effective framework for international arbitration and the enforcement of recognition of foreign awards."

1.2.3 Process of PPP Infrastructure Projects

Based on the current FIL regulations and procedure established for foreign investment, PPP infrastructure projects shall follow the process below to obtain MIC Permit.

1) Project proposal from private company

A private company submits project proposal to a relevant line ministry (or government entity).

2) Discussion and consultation on the proposal

A private company and a line ministry have a discussion and consultation on the contents of the proposal to conclude an agreement between the parties.

3) Application to MIC

Line ministry completes the application form and submits the completed form to MIC.

4) Request for review from MIC to DICA

After receiving the report, MIC requests DICA of MNPED (secretariat of MIC) to review the project.

5) Request for assessment to PAPRD

DICA asks Project Appraisal and Progress Reporting Department (PAPRD) of MNPED for assessment of the proposal.

6) PAPRD's assessment report

PAPRD provides assessment on the project from various aspects (e.g. political, financial and environmental). Obtaining environmental clearance is responsibility of the line ministry. PAPRD report is submitted to MIC through DICA.

7) Approval of project by MIC

Based on the report submitted by DICA (based on the PAPRD assessment), MIC finally approves the investment to the project. MIC is not bound by the conclusion of the PAPRD assessment and can make its own decision regardless of the contents of the assessment.

1.2.4 Recent PPP Projects

According to the World Bank's Private Participation in Infrastructure Database, eight PPP projects have been implemented since 1995 for gas pipelines, hydropower and gas-fired power generation, seaport container terminal, and telecommunication, with investment amounting to USD 2,995 million in total. Besides these, a number of PPP projects have been executed or is in progress in other sectors such as roads and airport. Table below summarizes recent developments of PPP projects in selected sectors in Myanmar. It is noted that all the on-going PPP infrastructure development in Myanmar is initiated by respective line ministries under sector laws and other laws applicable such as FIL and State-owned

Economic Enterprises Law. Land required for the projects is either leased to private-sector participant or in-kind contribution under joint venture agreements.

Table.4 Recent PPP Projects in Selected Sectors

Sector	Recent Projects			Applied PPP Scheme Salient Features
	Year	Project	Investment (USD million)	
Electricity	2006	Shweli River Cascade 1 Hydropower	414	Joint venture or Build-Operate-Transfer (BOT) contracts are applied to power generation projects.
	2006	Nanli 1-2 Hydropower	142	
	2013	Ahlone Gas-fired Power Plant	170	
Seaports	1997	Myanmar International Terminal Thilawa	101	25 to 30-year BOT contracts are applied to seaport terminal operation. One internal container depot is operated under JV of Myanmar Port Authority and a private company from 1995.
	1998	Asia World Port Terminal (Ahlone No. 2)	5	
	1998	Myanmar Integrated Port (Thilawa)	18	
	2001	Asia World Port Terminal (Ahlone No. 1)	21	
	2003	Myanmar Industrial Port Terminal	(4,837 million kyat)	
	2005	Asia World Port Terminal (Ahlone No. 3)	18	
Telecommunication	2014	Telenor Myanmar	1,000	Two greenfield mobile telecommunication business licenses are awarded to foreign investors through competitive biddings.
	2014	Ooredoo Myanmar	500	
Roads	-	61 BOT projects have been implemented from 1996 until May 2012 by Myanmar private companies.	-	40-year BOT contracts are applied to brownfield toll road projects through competitive biddings. No greenfield projects are implemented so far.
Airport	2014	Hanthawaddy International Airport	1,500	Bidders were able to opt for PPP scheme from BOT and JV on their proposal
	2014	Mandalay International Airport	100	

Source: JICA Study Team based on JICA (2013) "Data Collection Survey on Investment Climate for Infrastructure Development" and World Bank (2014) "Private Participation in Infrastructure Database"

1.2.5 Environment for PPP Infrastructure Development

Along with the country's rapid economic growth and government's policy promoting foreign direct investment, there seems to be vast potential needs for infrastructure development with private sector participation. However, there has been relatively small number of PPP infrastructure projects in various sectors such as electricity, seaport, telecommunication, etc., as described in the previous section. Underdeveloped institutional and legal framework is one of the bottlenecks for PPPs among others. The JICA survey (2013) summarizes a number of challenges faced by PPP infrastructure development in Myanmar as given in Table below.

Table.5 Issues of PPP in Myanmar

Item	Issue
1. Legal and Regulatory Framework	
Public and procurement rules	- Public procurement law is not in place.
PPP law	- PPP is not defined under regulation/laws. - New foreign investment law/regulation (i.e. 2012 FIL) is currently used for PPP - Revision of sector law is underway.
2. Institutional Framework	
Institutions to promote/implement PPPs	- PPP promotion is not institutionalized.
Process for project preparation and approval	- Guidelines on the process for the project preparation and approval are not defined.
3. Finance	
Long-term financing	- Limited availability of long-term financing (limited recourse financing).

Item	Issue
	- Long-term loans denominated in local currency are not available.
Government financial support/guarantee	- No support mechanism is defined, although government has provided cash in kind for some past transactions with private sector participation.
4. Implementation Capacity	
Project development capacity	- Awarding agency (implementing government agencies) has limited capacity and funds for preparation are limited. Advisory services have been provided by international consultants on a project-by-project basis. - Knowledge sharing and capacity development of awarding agencies will be required.
Number of successful transactions and project in pipeline	- A limited number of transactions have been conducted.
5. Political Will	
Political will	- Government identifies the needs of private sector participation for public services.
Government payment risk	- Political stability has been a concern of the private sector.

Source: JICA (2013) "Data Collection Survey on Investment Climate for Infrastructure Development"

1.2.6 Application of PPP in Water Supply Projects

There are no on-going PPP projects in water supply sector in Myanmar so far. Before the present JICA preparatory survey, some foreign investors expressed interest in developing a water supply project through Build-Operate-Transfer (BOT). According to YCDC officials, the project development was not carried out due to absence of regulations for YCDC to develop and implement a PPP project.

However, to accelerate the investment in water supply infrastructure, YCDC might opt to implement PPP projects in future, to which Japanese ODA loan or Private Sector Investment Finance (PSIF) could be applicable for financing. Certain challenges and possibilities for implementation of PPPs for water supply facilities of YCDC are considered in following sections. It is considered that considerable institutional development of YCDC's water supply services is required before it implements PPP projects.

(1) Political will

While YCDC has not yet developed a comprehensive policy on the financing of facility development proposed in M/P, YCDC and the union government have not explicitly stated its political will to implement water supply projects in Yangon area with private sector participation.

According to YCDC officials, it is confirmed that PPP for water supply projects is still considered in premature stage because (i) water supply projects are still financially not viable due to the current low water tariff level, etc.; and (ii) the union government policy and legal framework on PPP for water supply projects is underdeveloped.

(2) Institutional and legal framework

The legal basis of YCDC's water supply service is The City of Yangon Development Law (No.11/90) which stipulates very general mandates for YCDC to implement relevant activities. Moreover on the

national level, there is no institutional and legal framework that governs the water supply utilities in general. Besides the absence of national PPP regulations as described in the previous sections, there is no clear legal basis for public sector water utility provider like YCDC to implement PPP projects for facility development; hence there is no standardized process established for PPP water supply projects in Myanmar so far. Such absence of institutional and legal framework is one of the bottlenecks to promote private sector participation in water supply projects.

(3) Water tariff and financial structure of water supply service

Current domestic water tariff is set as low as 88 kyat/m^3 which is far lower than the cost recovery level. In FY 2014, YCDC earned 9,288 million kyat from water supply services which accounts for only 15 % of total expenditure including its capital expenditure, or only 68 % of operational expenses excluding capital expenditure (See Chapter 10). Water tariff level is politically controlled to extremely low level which makes the water supply service financially unviable to potential private investors. Financial structure of the Engineering Department (Water and Sanitation) heavily relies on revenue of other departments of YCDC and is not given mandates to be self-sustainable. This indicates that availability payment contracts will be the only viable option for water supply development through PPP.

(4) Necessary capacity development for PPPs in water supply development

As described in sections above, PPP environment in Myanmar is still underdeveloped. It is considered that it is very difficult for YCDC to implement PPP projects for water supply facilities in near future. On the other hand, the union government is currently developing national policy framework to promote PPPs with donor assistance. Besides such efforts on national level, it is necessary to develop institutional capacity and policy framework for YCDC to implement PPP projects as summarized in Table below. If YCDC opts to implement PPP infrastructure development in future, it is required to continue and enhance the capacity development efforts to ensure appropriate environment for preparation of private sector participation.

Table.6 Institutional Development for PPP Water Supply Projects

Item	Current Status	Necessary Capacity Development
National Level		
1. Regulatory and institutional framework for PPP	There is no regulatory and institutional framework to implement PPPs.	[MNPED is developing PPP framework with technical assistance by ADB.] - Regulatory framework for PPP project development principles - Prioritization of PPP projects - PPP tendering and evaluation processes, etc. - Establishment of national level PPP unit
2. Regulatory and institutional framework for water supply service	There is no regulatory and institutional framework that governs water supply sector on national level.	Policy and legal framework for water supply development should be established on national level
Local Level (YCDC)		
1. Policies of financing for water supply projects	M/P does not contain financing policies for water	Capacity development of YCDC is necessary to be able to establish financing policies

Item	Current Status	Necessary Capacity Development
	supply projects	- Prioritizing water supply projects - Financing principles for water supply projects - Financing plan for each project
2. Financial management of water supply service	- Water supply service of YCDC is not financially self-sustainable. - Financial management of water supply service is not independently accounted or evaluated	[Capacity development is underway through JICA Technical Cooperation "Project for Improvement of Water Supply Management of YCDC"] - Staff training on financial management of water supply service - Financial planning for future projects - Staff training on PPPs, etc.

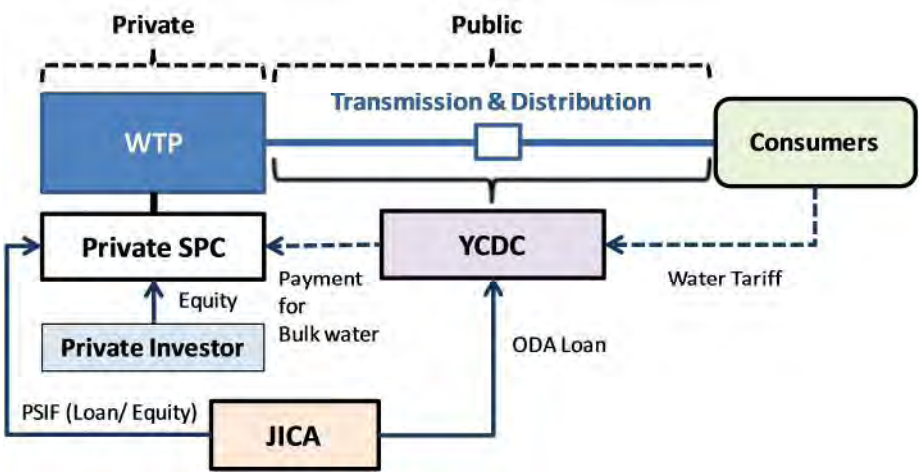
Source: JICA Study Team

(5) Potential PPP project types and JICA finance in future

As stated above, it is considered that capacity development and establishment of policy framework is firstly needed before YCDC implements PPP projects for its water supply facility development. Under such conditions, two potential PPP project types could be envisaged for future development utilizing Japanese ODA loan and PSIF.

1) Bulk water supply

- A private investor will be responsible for WTP construction and operation whereas YCDC will be responsible for transmission and distribution network development and operation (See following Figure).
- Bulk water supply from the private-owned WTP is sold to YCDC based on an availability payment contract at bulk water price to cover both capital and operational costs of the WTP. Consumer water charge is collected by YCDC which also covers the gap between the bulk water price and lower consumer tariff.
- The WTP component is implemented by Design-Build-Finance-Operate (DBFO) whereas the transmission and distribution network development is implemented through conventional public investment by YCDC.
- Potential involvement of Japanese ODA loan would be financing for the public component implemented by YCDC. Japanese PSIF may be used for private investment portion for WTP development.
- Similar project scheme would be applicable to the case where the private operator sells the bulk water directly to large-scale users such as industrial zones at a higher tariff that is able to fully cover both capital investment and operational cost.

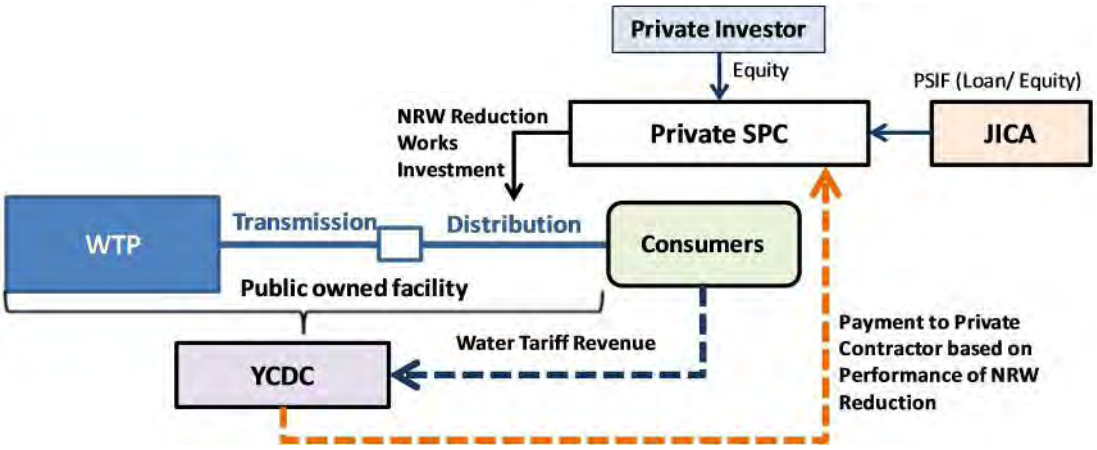


Source: JICA Study Team

Figure.1 PPP Project for Bulk Water Supply

2) Performance based contract for NRW reduction

- A private investor is responsible for investment and maintenance works in distribution facility to reduce NRW in certain designated area.
- Capital and maintenance cost borne by the private operator is covered by revenue sharing from YCDC in accordance with the performance of NRW reduction.
- Japanese PSIF would be applicable to financing the private sector investment for distribution facilities.



Source: JICA Study Team

Figure.2 Performance Based Contract for NRW Reduction

Financial Analysis of YCDC

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1.1 Fiscal Conditions of YCDC

According to YCDC officials, financial accounts of YCDC are independently managed from those of Yangon Region Government or Union Government. However, its budgeting decisions are subject to approval of the Yangon Region Government and Union Government. Normally YCDC does not receive any subsidy from Yangon Region Government or Union Government. As for the Water and Sanitation Department of YCDC, all the revenue derived from water supply services is directly received by YCDC and there is no fund transfer from Yangon Region Government.

Following Table shows recent fiscal status of YCDC. YCDC's total revenue and expenditure are managed to be balanced in each year, with exception that YCDC had a deficit budget in FY2015 due to the Union Government's decision on the salary hike for all government employees after the YCDC budget approval, for which YCDC is granted the special withdrawal right to compensate the planned deficit (5.6 billion Kyat) as an ex-post measures by the Union Government. Though the YCDC's overall fiscal status is managed to be balanced, as it is seen in the next section, revenue and expenditure are not necessarily balanced in individual department accounts.

It is noted that YCDC's fiscal scale has rapidly increased from FY2011 to FY2015 mainly due to the rapid growth in capital revenue that represents property development projects which YCDC operates in joint venture with private entities as well as recurrent revenue increase such as property tax and stamp duty because of the recent economic growth of the Yangon area. FY2016 budget, however, has decreased by 18% from FY2015 revenue. According to YCDC officials, this mainly reflects the current drop in property market prices.
From FY 2013, YCDC receives foreign grant and loans for water supply projects including ODA loan for the Phase 1 project.

Table 1 Revenue and Expenditure of YCDC

(million Kyat)

Fiscal Status of YCDC	Actual FY2011	Actual FY2012	Actual FY2013	Actual FY2014	Budget FY2015	Revised FY2015	Actual FY2015	Budget FY2016
I. Revenue	**58,152**	**103,167**	**145,768**	**252,179**	**339,719**	**340,203**	**279,359**	**228,721**
(Growth %)	-	*77%*	*41%*	*73%*	-	-	*11%*	*-18%*
1. Recurrent revenue	51,886	95,311	92,180	134,232	103,354	119,229	141,795	106,832
2. Capital revenue	6,266	7,856	52,953	115,562	216,593	200,745	122,210	76,542
3. Foreign Grant			634	2,385	14,468	14,926	12,539	1,811
4. Loan					5,303	5,303	2,815	43,536
II. Expenditure	**52,214**	**100,198**	**145,727**	**252,141**	**345,335**	**345,819**	**284,826**	**228,721**
1. Recurrent expenditure	36,008	48,273	50,410	67,693	87,937	87,964	79,779	99,803
2. Capital expenditure	16,206	51,926	94,682	182,062	237,626	237,626	189,693	83,570
3. Grant expenditure			634	2,385	14,468	14,926	12,539	1,811
4. Expenditure from Loan					5,303	5,303	2,815	43,536
III. Surplus (Deficit)	**5,938**	**2,969**	**41**	**38**	**-5,616**	**-5,616**	**-5,467**	**0**

Source: JICA Study Team

1.2 Financial Conditions of Water and Sanitation Department

Following Table shows revenue and expenditure of Water and Sanitation Department. It is noted that

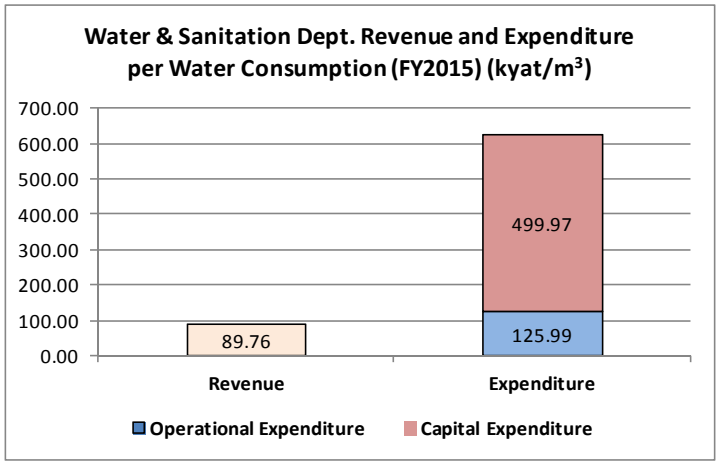
the water supply revenue is not able to cover operational cost. Also, the operational deficit has rapidly increased mainly due to the hike in electricity expense from FY 2013.

Table 2 Revenue and Expenditure of Water and Sanitation Department

Water & Sanitation Department Fiscal Status (Unit: million Kyat)	Actual FY2012	Actual FY2013	Actual FY2014	Budget FY2015 (Revised)	Actual FY2015	Budget FY2016
I. Revenue	**6,640**	**7,599**	**9,288**	**9,500**	**11,753**	**10,550**
1. Water Tariff Revenue	6,345	7,084	8,515	8,571	10,193	9,371
(1) Government	1,073	1,111	1,608	1,500	1,697	1,500
(2) Public	5,272	5,973	6,906	7,071	8,497	7,871
2. House Connection Fees	145	218	296	400	536	500
3. Water Meter Sales	54	130	280	68	732	550
4. Others	96	167	197	461	292	129
II. Operational Expenditure	**6,777**	**9,377**	**13,614**	**18,778**	**16,496**	**19,541**
1. Salary and allowance	1,252	1,512	1,719	2,308	2,233	2,326
2. Materials and service expenses	4,175	5,631	9,552	13,482	11,474	14,217
(1) Labor expenses	700	951	1,055	1,315	1,192	1,163
(2) Transportation	27	27	28	40	30	40
(3) Fuel and lubricant	115	121	72	125	45	125
(4) Electricity	2,528	2,865	6,374	9,716	8,964	10,700
(5) Equipment	747	1,603	1,943	2,200	1,192	2,098
(6) Others	58	63	80	86	50	92
3. Maintenance expenses	1,350	2,234	2,343	2,988	2,789	2,998
(1) Machinery and accessories	150	240	290	200	143	75
(2) Buildings	229	340	340	365	337	400
(3) Roads	16	59	60	100	95	150
(4) Vehicles	35	20	18	20	19	20
(5) Watercrafts	5	10	9	3	3	3
(6) Others	916	1,566	1,626	2,300	2,192	2,350
Operational Margin	**(137)**	**(1,779)**	**(4,326)**	**(9,278)**	**(4,743)**	**(8,991)**
(% to Revenue)	-2%	-23%	-47%	-98%	-40%	-85%
III. Capital Expenditure	**17,586**	**35,357**	**49,366**	**91,616**	**65,461**	**64,490**
1. Expansion of piping	98	190	2,243	4,872	5,146	1,310
2. Water supply projects	16,273	32,153	38,860	82,910	56,055	61,950
(1) Ngamoeyeik-Hlawga	14,724	13,299	11,571	30,887	31,766	3,601
Ngamoeyeik-Hlawga (YCDC)	14,724	12,665	9,185	16,419	19,227	1,790
Ngamoeyeik-Hlawga (ODA Grant)	0	634	2,385	14,468	12,539	1,811
(2) Lagunbyin	0	12,834	22,328	23,651	15,913	52,106
Lagunbyin (YCDC)	0	12,834	22,328	18,348	13,098	9,570
Lagunbyin (ODA Loan)	0	0	0	5,303	2,815	42,536
(3) Greater Yangon Water Supply	202	3,350	930	304	282	1,000
(4) Reservoirs and tube wells	1,097	2,556	3,527	5,257	5,231	243
(5) Hlawga-Yangon	250	115	5	183	80	0
(6) Kokkowa	0	0	498	14,328	2,783	5,000
(7) Phugyee-Yangon	0	0	0	8,300	0	0
3. Sanitation works	200	167	241	227	208	700
4. Water supply facility expansion	956	1,843	7,950	3,565	4,013	530
(1) Water supply facility expansion (Downtown)	637	732	4,922	2,995	2,990	530
(2) Myo Daw purified water production	19	784	3,028	570	1,024	0
(3) Pipe production factory	300	327	0	0	0	0
5. Sewerage treatment plant	58	49	69	40	39	0
6. Machinery	0	955	4	2	0	0
Total Revenue	**6,640**	**7,599**	**9,288**	**9,500**	**11,753**	**10,550**
Total Expenditure	**24,363**	**44,734**	**62,980**	**110,393**	**81,957**	**84,031**
IV. Surplus (Deficit)	**(17,723)**	**(37,136)**	**(53,692)**	**(100,893)**	**(70,205)**	**(73,481)**

Source: JICA Study Team

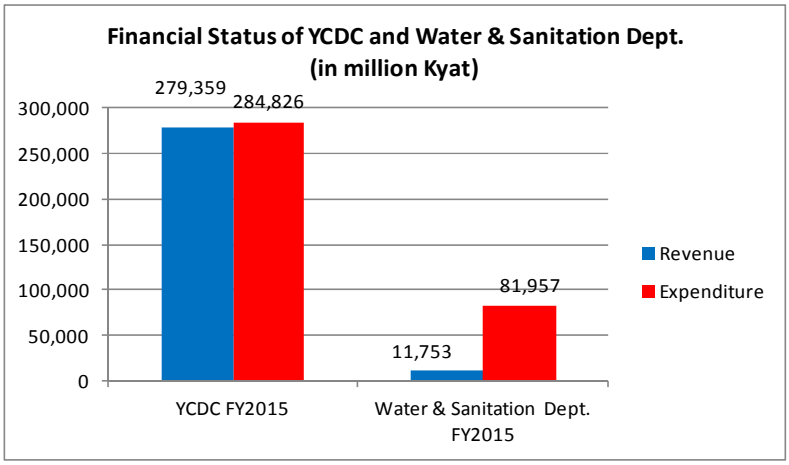
In terms of average revenue and expenditure per water consumption, the average expenditure of EDWS accounts for 626 kyat/m^3 i.e. 696 % of average revenue (90 kyat/m^3) due to extremely low level of water tariff (See following Figure). The revenue cannot even cover the operational cost (126 kyat/m^3).



Source: JICA Study Team

Figure 1 Revenue and Expenditure per Water Consumption

Huge deficit of Water and Sanitation Department (70.2 billion kyat in FY 2015) is financed by other departments' surplus within YCDC; therefore, the fiscal status of YCDC as a whole is balanced taking into account that in FY 2015 YCDC had to take special arrangement for additional salary expense to be funded by the union government as mentioned in Section 10.1 (See the following Figure). As seen in Table 2, it is anticipated that fiscal burden of YCDC due to the EDWS's deficit seems to continuously increase as the operation and investment of water supply service expands in future.



Source: JICA Study Team

Figure 2 Financial Status of YCDC and Water and Sanitation Department

1.3 Financial Projection of Phase 2 Project

(1) Introduction

As seen in Chapter 10, the project is not financially viable mainly due to the extremely low water tariff. The financial analysis results show that, in case the subject customer base is limited to that of the project (Zone 1 and 9), the current water tariff level must be increased by 9.1 times in real terms except inflation (See 10.1 (7) of Chapter 10), which is very unlikely.

In the present section, the financial projection will be carried out to estimate (i) the project's tariff increase effect for the whole YCDC customer base; and (ii) subsidy and subsidiary loan conditions in order to enhance financial viability of the project.

The projection will follow the same assumptions made for the financial analysis in Chapter 10 except for the prices expressed in current value including inflation in the present projection, applying 1.6 % inflation rate for FC and 5.8 % for LC in the base case scenario, which are the same as the price escalation precondition applied in the cost estimates presented in Chapter 9. The subsidiary loan conditions for the base case are (i) interest rate (0.01 % p.a.), loan amount and repayment period are the same as those of ODA loan; and (ii) exchange risk premium of 6.0 % is assumed.

(2) Case Scenarios

Following case scenarios are envisaged for the analysis.

- Base Case: No subsidy from Central Government is provided to YCDC.
- Case 1: No subsidy from Central Government is provided to YCDC. Two equal-percentage tariff increases for all YCDC customers in 2019 (Phase 1 commissioning) and in 2023 (Phase 2 commissioning) are estimated to achieve a zero cumulative cash position at the end of project life.
- Case 2: 25 % of ODA loan portion is given to YCDC as grant subsidy.
- Case 3: 50 % of ODA loan portion is given to YCDC as grant subsidy.

(3) Financial Projection and Necessary Water Tariff Increase

Financial projection of Base Case scenario is shown in Table 3 and Figure 3. Since YCDC bears all the financial burden of ODA loan and own-fund portion of initial investment, net cash flow of the case is negative during the entire project period. Cumulative cash position at the end of project period is ■■ kyat. The Base Case is deemed financially not viable.

Non-disclosure

Figure 3 Financial Projection (Base Case)

In Case 1 (See Table 4 and Figure 4), water tariff increase for all YCDC customers (equal percentage in 2019 and 2023 each) is estimated to achieve a zero cumulative cash position at the end of project period. Necessary tariff increase is calculated at +62.1% in nominal terms each in 2019 and 2023, or 2.6 times in total which is much lower than the case of projections in Chapter 10 in which necessary tariff increase (9.1 times in total) is applied only to Zone 1 and 9 customers. As shown in Figure 4, the tariff increase of entire YCDC customers significantly raises operational cash flow to surplus position in each year.

Non-disclosure

Figure 4 Financial Projection (Case 1)

In Case 2 and Case 3, grant subsidy from the central government is provided to YCDC to ease its financial burden that derives from subsidiary loan for initial investment. Grant subsidy accounts for 25 % of ODA loan portion in Case 2 and 50 % of ODA loan portion in Case 3 respectively. Results are shown in Table 5 and Figure 5 (Case 2) and Table 6 and Figure 6 (Case 3). Since YCDC's debt service payments are reduced by the grant subsidy, the water tariff increase requirements are lowered to 2.4 times (Case 2) and 2.3 times (Case 3) in total.

Non-disclosure

Figure 5 Financial Projection (Case 2)

Non-disclosure

Figure 6 Financial Projection (Case 3)

(4) Results of Financial Projection

Results of financial projection in respective case scenarios are summarized in the following Table and Figures. Cases with Central Government subsidy (Case 2 and Case 3) have lowered water tariff increase requirement. However, even with 50 % subsidy for ODA loan portion in Case 3 the required tariff increase in 2019 and 2023 accounts for over 50 % in nominal terms. As shown in the results, in order for the project to achieve financial viability, it is necessary to increase the current water tariff for all customers by 62.1 % (Case 1) to 50.1 % (Case 3) depending on the subsidy provided by Central Government.

On the assumption of 3 to 4 % of household income affordability criteria (See Section 2.3 of Chapter 2), the increased water tariff level in all the four cases are lower than 3 %, indicating the required tariff increase is considered affordable by the domestic customers.

Table 3 Results of Financial Projection

Non-disclosure

Non-disclosure

Figure 7 Required Tariff Increase in Four Cases

Results of sensitivity analysis in terms of tariff increase percentage in 2019 and 2023 and projected inflation rate in the 2026-2055 period are presented in the following Table. Even in Case 3 where the government grant for 50 % of ODA loan portion is provided, significant tariff increase around 40 % - 80 % of the current level will be required in 2019 and 2023.

Table 4 Sensitivity Analysis

Base Case

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-2,158	-2,410	-2,842	-3,499	-3,595	-4,915	-7,244
	25%	-945	-1,196	-1,629	-2,286	-2,381	-3,701	-6,030
	50%	532	280	-152	-809	-905	-2,225	-4,554
	75.0%	2,271	2,020	1,587	930	835	-485	-2,814
	100%	4,274	4,022	3,590	2,933	2,837	1,517	-812
	125%	6,539	6,288	5,855	5,198	5,103	3,783	1,454
	150%	9,068	8,816	8,384	7,727	7,631	6,311	3,983
	175%	11,859	11,608	11,175	10,518	10,423	9,103	6,774
	200%	14,914	14,662	14,230	13,573	13,477	12,157	9,829

Case 1

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-2,158	-2,410	-2,842	-3,499	-3,595	-4,915	-7,244
	25%	-945	-1,196	-1,629	-2,286	-2,381	-3,701	-6,030
	50%	532	280	-152	-809	-905	-2,225	-4,554
	62.1%	1,341	1,090	657	0	-96	-1,416	-3,744
	75%	2,271	2,020	1,587	930	835	-485	-2,814
	100%	4,274	4,022	3,590	2,933	2,837	1,517	-812
	125%	6,539	6,288	5,855	5,198	5,103	3,783	1,454
	150%	9,068	8,816	8,384	7,727	7,631	6,311	3,983
	175%	11,859	11,608	11,175	10,518	10,423	9,103	6,774
	200%	14,914	14,662	14,230	13,573	13,477	12,157	9,829

Case 2

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-1,757	-2,009	-2,441	-3,098	-3,194	-4,514	-6,842
	25%	-544	-795	-1,228	-1,885	-1,980	-3,300	-5,629
	50%	933	681	249	-408	-504	-1,824	-4,152
	56.2%	1,341	1,090	657	0	-96	-1,416	-3,744
	75%	2,672	2,421	1,988	1,331	1,236	-84	-2,413
	100%	4,675	4,423	3,991	3,334	3,238	1,918	-410
	125%	6,940	6,689	6,256	5,599	5,504	4,184	1,855
	150%	9,469	9,217	8,785	8,128	8,032	6,712	4,384
	175%	12,260	12,009	11,576	10,919	10,824	9,504	7,175
	200%	15,315	15,063	14,631	13,974	13,878	12,558	10,230

Case 3

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-1,356	-1,608	-2,040	-2,697	-2,793	-4,113	-6,441
	25%	-143	-394	-827	-1,484	-1,579	-2,899	-5,228
	50%	1,334	1,082	650	-7	-103	-1,423	-3,751
	50.1%	1,341	1,090	657	0	-96	-1,416	-3,744
	75%	3,073	2,822	2,389	1,732	1,637	317	-2,012
	100%	5,076	4,824	4,392	3,735	3,639	2,319	-9
	125%	7,341	7,090	6,657	6,000	5,905	4,585	2,256
	150%	9,870	9,618	9,186	8,529	8,433	7,113	4,785
	175%	12,661	12,410	11,977	11,320	11,225	9,905	7,576
	200%	15,716	15,465	15,032	14,375	14,279	12,959	10,631

Source: JICA Study Team

1.4 Combined Financial Projection of Phase 1 and Phase 2 Projects

The present section estimates the water tariff requirement taking into account the cash flow projection of the Phase 1 project in addition to Phase 2, following the same assumptions stated in the previous sections as well as the costs and assumptions used for Phase 1 project in Chapter 10. The applied assumptions in the projection are summarized in the following Table. The same case scenarios as in the previous section are applied in terms of degree of government subsidy for ODA loan portion of initial investment.

Table 5 Assumptions of Combined Cash Flow Projection

1 Exchange Rate	Kyat 1.00 = JPY 0.0923 USD 1.00 = JPY 109.2 = Kyat 1,183 except for Phase 1 costs conversion
2 Price Escalation	FC = 1.6% LC = 5.8%
3 Physical Contingency	Construction: 5% Consulting Services: 5%
4 Administration Cost	5%
5 Taxation	VAT: 5% Import Tax: 2%
6 JICA ODA Loan Conditions	Currency: JPY Interest Rate (% per anum): 0.01% Front end fee: None (0%) Repayment period: 40 years repayment period including 10 year grace period Interest During Construction: Phase 1: Loan-covered, Phase 2: Not covered by loan
7 Union Government Subsidiary Loan to YCDC	Same conditions as JICA ODA Loan Exchange risk premium applied to the financial projection: 6.0% p.a. (Cost of debt applied in the financial projection: 0.01% interest rate + 6.0% risk premium = 6.01%)
8 Project Lifetime	From 2014 to 2055 (42 years)
9 Prices	All prices are expressed in current (nominal) price including inflation 2016 - 2025 peiord: Same inflation rates as the price escalation is applied 2026 - 2055 period: 5.8% infalation rate for LC is applied as base assumption
10 Phase 1 Cost Data Conversion	Exchange rates applied for cost data conversion: Kyat 1.00 = JPY 0.102 USD 1.00 = 970.9

Source: JICA Study Team

Financial projection of Base Case scenario is shown in Table 10 and Figure 8. Since YCDC bears all the financial burden of the two ODA loans and own-fund portion of initial investment, cumulative cash position at the end of project period is ■■kyat showing that the Base Case is deemed financially not viable even combined with Phase 1 project.

Non-disclosure

Figure 8 Combined Financial Projection (Base Case)

In Case 1 (See Table 11 and Figure 9), water tariff increase for all YCDC customers (equal percentage in 2019 and 2023 each) is estimated to achieve a zero cumulative cash position at the end of project period. Necessary tariff increase is calculated at +93.6 % in nominal terms each in 2019 and 2023, or 3.7 times in total which is more than the estimation applying only Phase 2 cash flows (2.6 times).

Non-disclosure

Figure 9 Combined Financial Projection (Case 1)

Results of Case 2 and Case 3, where grant subsidy from the central government (25 % for Case 2 and 50 % of Case 3) is provided to YCDC for Phase 2 ODA loan, are shown in Table 12 and Figure 10 (Case 2) and Table 13 and Figure 11 (Case 3). With the grant subsidy, the water tariff increase requirements are lowered to 3.6 times (Case 2) and 3.4 times (Case 3) in total.

Non-disclosure

Figure 10 Combined Financial Projection (Case 2)

Non-disclosure

Figure 11 Combined Financial Projection (Case 3)

Results of the combined financial projection in the four case scenarios are summarized in the following Table and Figures. Cases with Central Government subsidy (25 % subsidy for Case 2 and 50 % subsidy for Case 3) have lowered water tariff increase requirement from that of Case 1 with no government subsidy. However, these three (3) cases require water tariff increase of over 3.4 times in total.

In terms of affordability among the residents, the increased water tariff levels in three (3) cases are within the range of 3.0-4.0 % of household income which is the generally considered affordability threshold.

Table 6 Results of Combined Financial Projection

Non-disclosure

Non-disclosure

Figure 12 Required Tariff Increase in Four Cases

Results of sensitivity analysis of combined cash flow projection, in terms of tariff increase percentage in 2019 and 2023 and projected inflation rate in the 2026-2055 period.

Table 7 Sensitivity Analysis

Base Case

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-2,766	-3,351	-4,358	-5,891	-6,114	-9,199	-14,648
	25%	-1,552	-2,137	-3,145	-4,678	-4,901	-7,986	-13,435
	50%	-76	-661	-1,668	-3,201	-3,424	-6,509	-11,958
	75%	1,664	1,079	71	-1,462	-1,685	-4,770	-10,219
	100%	3,666	3,081	2,074	541	318	-2,767	-8,216
	125%	5,932	5,347	4,339	2,806	2,583	-502	-5,951
	150%	8,460	7,875	6,868	5,335	5,112	2,027	-3,422
	175%	11,252	10,667	9,659	8,126	7,903	4,818	-631
	200%	14,306	13,721	12,714	11,181	10,958	7,873	2,424

Case 1

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-2,766	-3,351	-4,358	-5,891	-6,114	-9,199	-14,648
	25%	-1,552	-2,137	-3,145	-4,678	-4,901	-7,986	-13,435
	50%	-76	-661	-1,668	-3,201	-3,424	-6,509	-11,958
	75%	1,664	1,079	71	-1,462	-1,685	-4,770	-10,219
	93.6%	3,126	2,541	1,533	0	-223	-3,308	-8,757
	100%	3,666	3,081	2,074	541	318	-2,767	-8,216
	125%	5,932	5,347	4,339	2,806	2,583	-502	-5,951
	150%	8,460	7,875	6,868	5,335	5,112	2,027	-3,422
	175%	11,252	10,667	9,659	8,126	7,903	4,818	-631
	200%	14,306	13,721	12,714	11,181	10,958	7,873	2,424

Case 2

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-2,365	-2,949	-3,957	-5,490	-5,713	-8,798	-14,247
	25%	-1,151	-1,736	-2,744	-4,277	-4,500	-7,585	-13,034
	50%	325	-259	-1,267	-2,800	-3,023	-6,108	-11,557
	75%	2,065	1,480	472	-1,061	-1,284	-4,369	-9,818
	88.6%	3,126	2,541	1,533	0	-223	-3,308	-8,757
	100%	4,067	3,483	2,475	942	719	-2,366	-7,815
	125%	6,333	5,748	4,740	3,207	2,984	-101	-5,550
	150%	8,861	8,277	7,269	5,736	5,513	2,428	-3,021
	175%	11,653	11,068	10,060	8,527	8,304	5,219	-230
	200%	14,707	14,123	13,115	11,582	11,359	8,274	2,825

Case 3

Cumulative Cash Position (billion Kyat)		Inflation Rate Assumption (2026 - 2055)						
		0.0%	2.0%	4.0%	5.8%	6.0%	8.0%	10.0%
Tariff Increase in 2019 and 2023	0%	-1,964	-2,548	-3,556	-5,089	-5,312	-8,397	-13,846
	25%	-750	-1,335	-2,343	-3,876	-4,099	-7,184	-12,632
	50%	726	142	-866	-2,399	-2,622	-5,707	-11,156
	75%	2,466	1,881	873	-660	-883	-3,968	-9,416
	83.6%	3,126	2,541	1,533	0	-223	-3,308	-8,757
	100%	4,468	3,884	2,876	1,343	1,120	-1,965	-7,414
	125%	6,734	6,149	5,141	3,608	3,385	300	-5,148
	150%	9,262	8,678	7,670	6,137	5,914	2,829	-2,620
	175%	12,054	11,469	10,461	8,928	8,705	5,620	172
	200%	15,108	14,524	13,516	11,983	11,760	8,675	3,226

Source: JICA Study Team