Chapter 15 Preliminary Construction Planning and Project Cost Estimate

15.1 Preliminary Construction Planning

15.1.1 Summary

Contract packaging, procurement of materials and machinery, construction method, temporary facilities and construction schedule were studied in the preliminary construction planning taking into account the construction quantities, scale and characteristics of structures and site conditions to formulate a realizable and optimum preliminary construction plan. As for the erection method of the main bridge of 4th Panama Canal Bridge, two cases of using/without using the navigation channel in the erection works were studied. The preliminary construction plan of concept design section for Omar Torrijos Intersection and west additional ramps is not included (see Section 11.1.2).

15.1.2 Related Regulation and Standards

According to the survey results, there are no exact regulations and standards system for construction works in Panama. As for the regulation of construction safety, this is described in Section 15.1.8 of this Interim Report.

15.1.3 Contract Packaging

(1) Project Facilities and Approximate Construction Quantities

The main facilities of the Project are the 4th Panama Canal Bridge including the approach roads and access roads to the Bridge of the Americas. The main construction works are road and bridge construction including temporary facilities and the demolition of the existing flyover at the Omar Torrijos Intersection. The facilities and equipment related to the Metro Line-3 and Omar Torrijos Intersection were excluded from this preliminary construction planning. The main construction quantities of the Project are shown in Table 15.1.

Table 15.1 Main Construction Quantities

Section	Construction Work		Item	Unit	Quantities
East Approach Road	Bridge Works	Flyover No.1-1	PC-I Girder	m	270
		Flyover No.1-2	Steel Box Girder	m	250
		FlyoverNo.2-1	PC-I Girder	m	260
		FlyoverNo.2-2	Steel Box Girder	m	480
	Road Works	Earth Work	Embankment	m3	200,000
			Excavation	m3	50,000
		Pavement Work	Asphalt Pavement	m2	8,000
			Concrete Pavement	m2	36,000
		Road Structure Work	Retaining Wall	m2	14,000
			Removal Existing Flyover	unit	1
4th Panama Canal Bridge	Bridge Works	East Approach Bridge No.1	Metal Box Girder	m	533
		Main Bridge	Arch	m	840
		West Approach Bridge No.1	Steel Box Girder	m	470
		West Approach Bridge No.2	Steel Box Girder	m	340
		West Approach Bridge No.3	PC-I Girder	m	360
West Approach Road	Road Works	Earth Work	Embankment	m3	270,000
		Pavement Work	Asphalt Pavement	m2	4,000
			Concrete Pavement	m2	24,000
Access Road to the Bridge of the Americas	Bridge Works	Access Bridge No.1	PC-I Girder	m	360
		Access Bridge No.2	PC-I Girder	m	400
	Road Works	Earth Work	Embankment	m3	220,000
		Pavement Work	Asphalt Pavement	m2	5,000
			Concrete Pavement	m2	15,000

Source: JICA Study Team

(2) Construction Sections

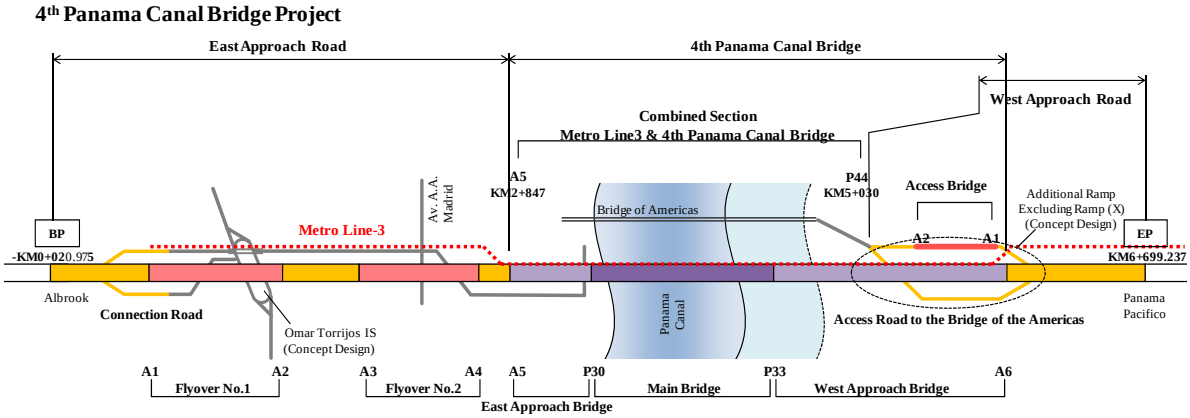
The geographical conditions are divided into east and west sides of the Panama Canal, and the eastern side is located in an urban area including intersections and existing roads. Since the only existing transportation network that connects the eastern and western sides in the vicinity of the Project is the Bridge of the Americas, a separate transportation route is needed for construction on the eastern and western sides.

Furthermore, the main construction works are road and bridge works, and various types of structures are included in the construction items and the construction of these structures needs to be implemented in parallel in a limited work space. Therefore, the construction yards and work schedule shall be adjusted each other to avoid the interference. By these reasons, one construction contract package was assumed for this Study, since this would allow a joint schedule management for the control and implementation of a unified project.

In addition, for the purpose of design and construction quantities, the Project was divided into 3 sections in consideration of the long construction section (6.7 km) as shown in Figure 15.1.

- East Approach Road
- 4th Panama Canal Bridge
- West Approach Road

Omar Torrijos Intersection was included to another construction section, and west additional ramps (excluding ramp X) were included in West Approach Road.



Source: JICA Study Team

Figure 15.1 Construction Sections

15.1.4 Procurement of Labor, Material and Equipment

(1) Labour

Based on the experience of the Metro Line-1 Construction Project, it was assumed that it will be possible to secure engineers, foremen, skilled and common labours. However, support of foreign engineers with technological skills and experience are necessary for assisting in the construction of a long-span arch bridge erected in water, steel pipe sheet pile foundation, high piers, and high-elevation girders, since these skilled labours are not in Panama.

(2) Construction Material and Equipment

Regarding the construction material and equipment to be used in the Project, embankment material, crushed stone, asphalt, cement, and aggregate will use domestic products, while the other materials will be imported products, based on the experience of Metro Line-1 Construction Project. Steel girders will be fabricated in a foreign country and the high yield point steel materials will also be supplied by a foreign country.

The procurement plan for the main materials used in the project is as shown in Table 15.2.

Table 15.2 Procurement Plan for the Main Materials in the Project

Materials	Procurement Plan		
	Panama	Imported Products	Notes
Embankment Material	✓		
Sub-grade Crushed Stone	✓		
Asphalt	✓		
Cement	✓		
Aggregate for Concrete	✓		
Reinforcing Bar		✓	
Steel for PC		✓	
Steel Girder		✓	
Steel Pipe Sheet Pile		✓	
Bearing		✓	
Expansion Joint		✓	
Road Facilities (Guard fence, Lighting, etc.)	✓		
Drain pipe	✓		

Source: JICA Study Team

(3) Construction Machinery

Excavators, truck cranes, concrete pumping trucks, etc. were used for the construction of the elevated sections in the Metro Line-1 Construction Project. In the 4th Panama Canal Bridge Construction Project, since special construction machinery such as heavy cranes, gantry, and equipment for erecting on the Canal cannot be supplied domestically, special machinery will be obtained from foreign countries. The main bridge arch rib is assembled on a barge; a large barge with temporary support beams should be also procured from a foreign country. Supplying the machinery for the approach road section will be comparatively easy. However, it is assumed that provision from foreign countries will also be necessary because parallel works need to be carried out in a short period.

15.1.5 Construction Method

(1) 4th Panama Canal Bridge (Main Bridge)

1) Superstructure

The method for the erecting the superstructure of the main bridge of 4th Panama Canal Bridge was studied for the following two conditions:

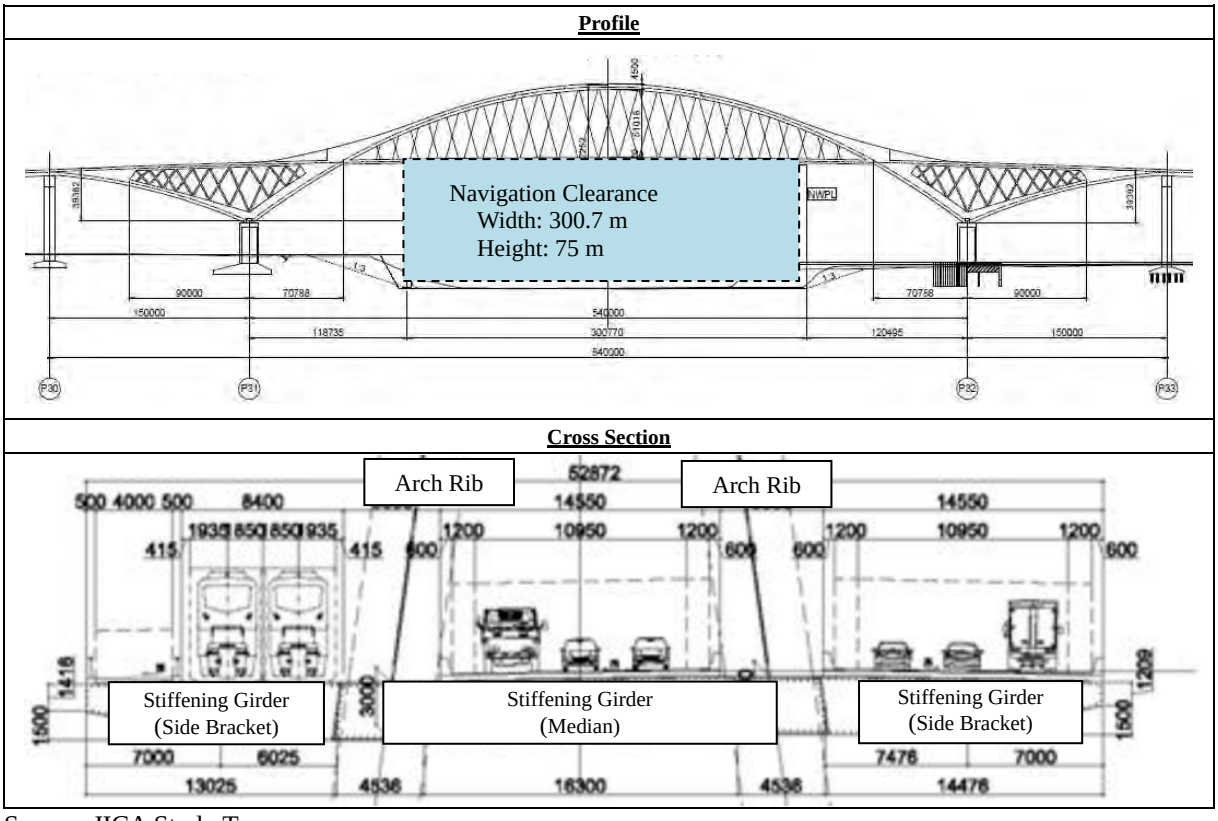
- Using the Navigation Channel
- Without Using the Navigation Channel

The superstructure erection method (main bridge of 4th Panama Canal Bridge) is shown in Table 15.3, and erection segment of superstructure is as shown in Figure 15.2.

Table 15.3 Superstructure Erection Method (Main Bridge of 4th Panama Canal Bridge)

No.	Erection Segment of Superstructure			Erection Method	
				Using Navigation Channel	Without Using Navigation Channel
1	Outside of Canal (Side Span, Part of Main Span)			Crane Erection with Bent	
2	Inside of Canal (Main Span)	Arch Rib		Lifting Erection from Deck Barge	Cable Erection with Oblique Hang
3		Stiffening Girder	Median	Cantilever Erection (Slewing Jib-crane)	
4			Side Bracket	Cantilever Erection (Gantry)	

Source: JICA Study Team

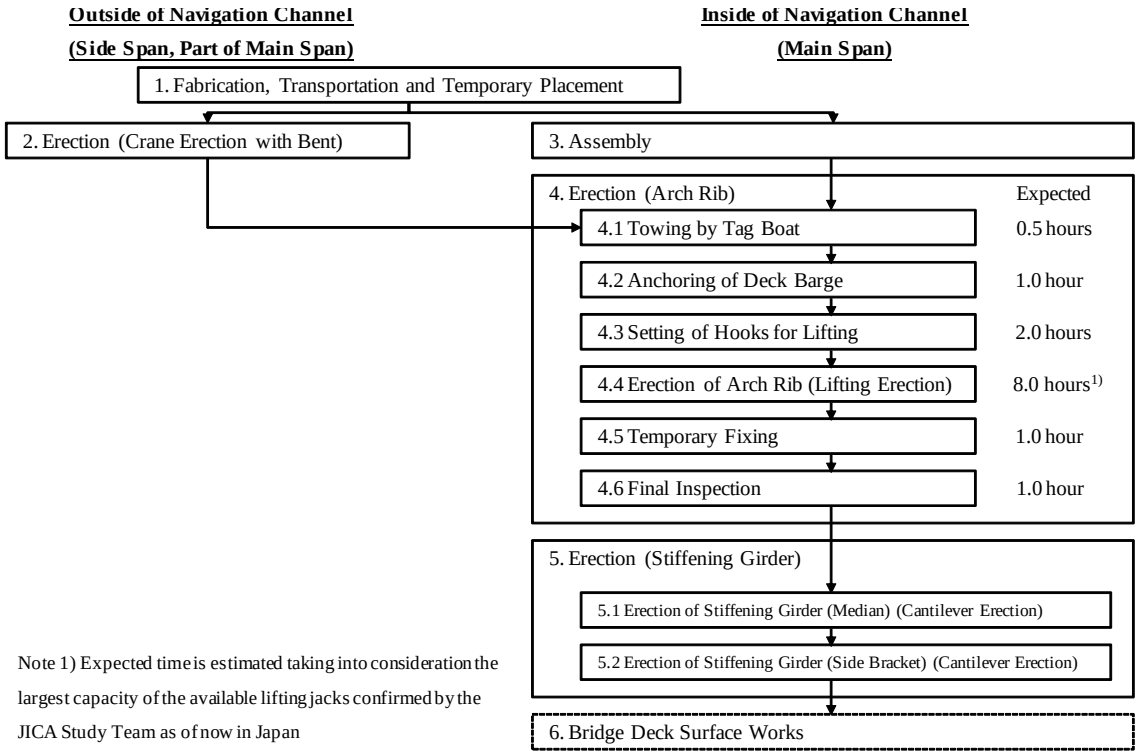


Source: JICA Study Team

Figure 15.2 Erection Segment of Superstructure (Main Bridge of 4th Panama Canal Bridge)

a) Using the Navigation Channel

The procedure for erecting the main bridge of the 4th Panama Canal Bridge using the navigation channel in the erection works is shown in Figure 15.3 and explained in the subsequent sections.



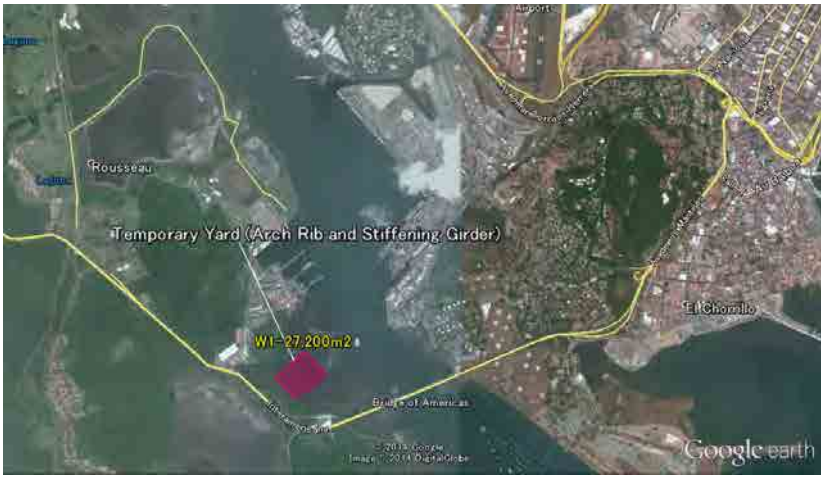
Source: JICA Study Team

Figure 15.3 Erection Procedure of Main Bridge of 4th Panama Canal Bridge with Using Navigation Channel

1. Fabrication, Transportation and Temporary Placement

The arch rib and stiffening girders (arch rib: 4.5m*10m, stiffening girder: 14.55m*3m) are fabricated in a foreign country, transported by sea and are to be placed in a temporary yard along the Panama Canal.

The supposed location of the temporary yard (for the arch rib and stiffening girders) is shown in Figure 15.4.



Source: JICA Study Team

Figure 15.4 Location of Expected Temporary Yard (Arch Rib and Stiffening Girders)

2. Erection (Crane Erection with Bent)

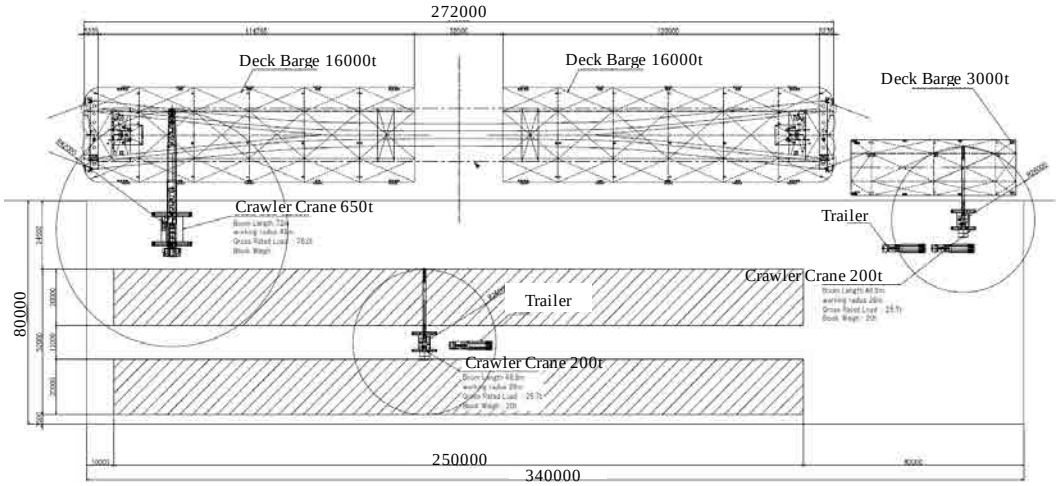
The side span and part of the main span (outside the navigation channel) are constructed by the crane erection method. A temporary peninsula by embankment is constructed inside the canal (outside the navigation channel) on the west side.

3. Assembly

The arch rib and stiffening girders (main span) are assembled in the following locations during the erection of the side span and part of the main span (outside the navigation channel).

- Arch Rib: On a deck barge (alongside the temporary yard)
- Stiffening Girder : In the temporary yard

The assembling plan (arch rib: on a deck barge) is shown in Figure 15.5.



Source: JICA Study Team

Figure 15.5 Assembling Plan (Arch Rib: On a Deck Barge)

4. Erection (Arch Rib)

4.1 Towing by Tug Boat

After completing the erection works (outside the navigation channel) and assembling the arch rib segment (on a barge inside the canal but outside the navigation channel), the arch rib segment is towed to the erection site by tug boat. The time for the towing is expected to be about 0.5 hours, according to past construction experiences.

4.2 Anchoring of Deck Barge

After arriving to the erection site, the deck barge is anchored precisely utilizing the GPS system. The time for anchoring is expected to be about 1.0 hour, according to past experiences.

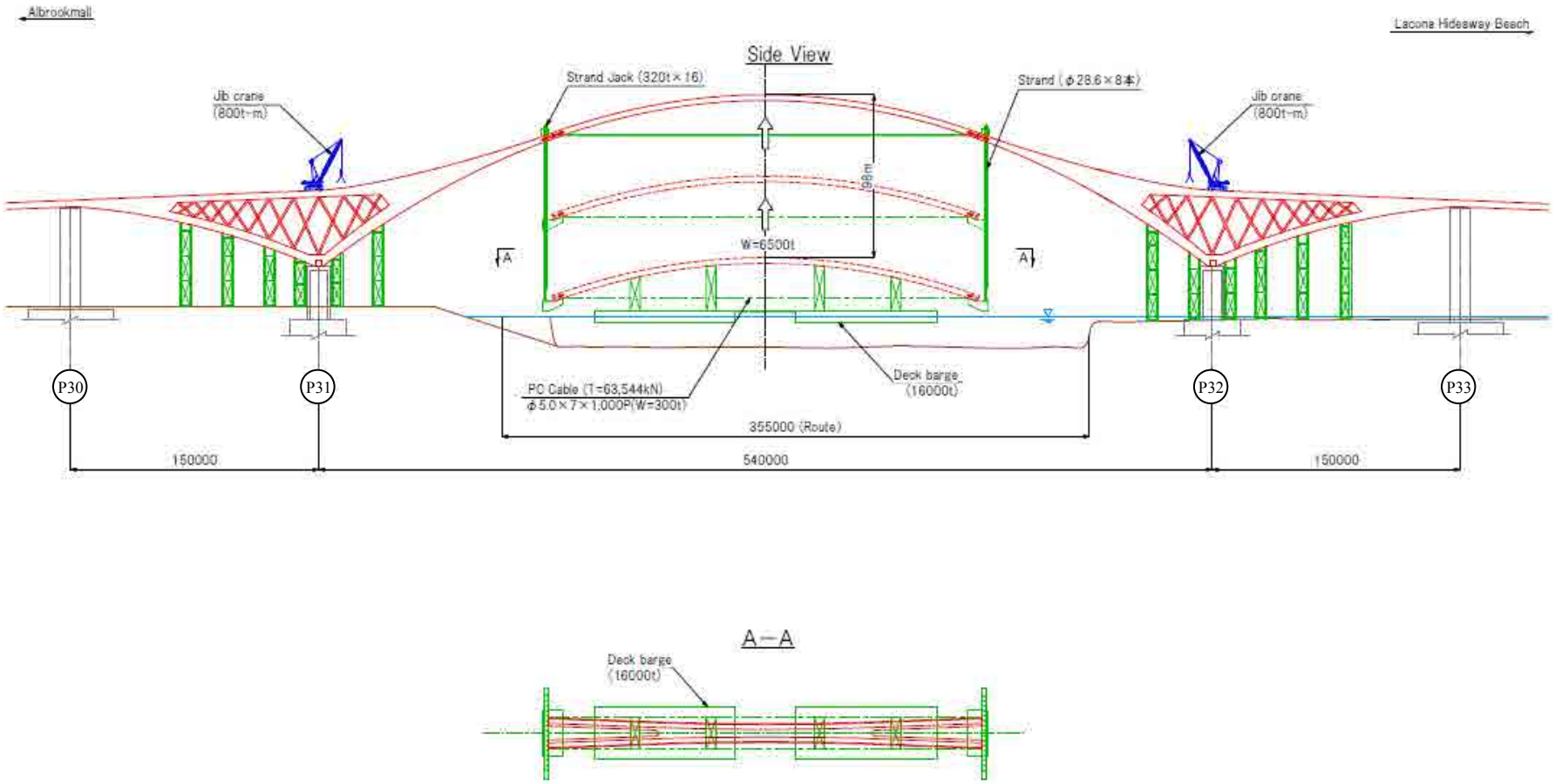
4.3 Setting of Hooks for Lifting

After anchoring of deck barge, the wire strands are hooked on the arch rib for lifting. The time for anchoring is expected to be about 2.0 hours, according to past experiences.

4.4 Erection of Arch Rib (Lifting Erection)

After anchoring the deck barge, the pre-installed wire strands are attached to the arch rib and the arch rib is erected utilizing the lifting method. Temporary cross beams are installed at the lifting points in order to ensure the balance of arch rib during the lifting operation. The time for the lifting operation is expected to be about 8.0 hours, according to the capacity of the hydraulic pumps.

The erection plan of the arch rib (lifting method) is shown in Figure 15.6.



Source: JICA Study Team

Figure 15.6 Erection Plan of Arch Rib (Lifting Method) (With Using the Navigation Channel)

4.5 Temporary Fixing

After the lifting operation, the arch rib is temporary fixed by temporary shear pins. The time for the temporary fixing of the arch rib is expected to be about 1.0 hour, according to past experiences.

4.6 Final Inspection

After fixing the arch rib segment, the final inspection is conducted before the re-operation of the Panama Canal. The time for the final inspection is expected to be about 1.0 hour, according to past experiences.

5. Erection (Stiffening Girder)

5.1 Erection of Stiffening Girder (Median) (Cantilever Erection)

After completing the arch rib structure, stiffening girders (median) are constructed by cantilever erection (slewing jib-crane) in order to reduce the horizontal force at the piers.

The stiffening girders are lifted at the piers and transported on the bridge deck; therefore, the erection of the stiffening girders does not use the navigation channel.

The erection plan of the stiffening girders (median) (cantilever erection) is shown in Figure 15.7.

5.2 Erection of Stiffening Girder (Side Bracket) (Cantilever Erection)

After completing the stiffening girders (median), the stiffening girders (side bracket) are constructed by cantilever erection (gantry).

This erection work also does not use the navigation channel.

The erection plan for the stiffening girders (side bracket) (cantilever erection) is shown in Figure 15.8.

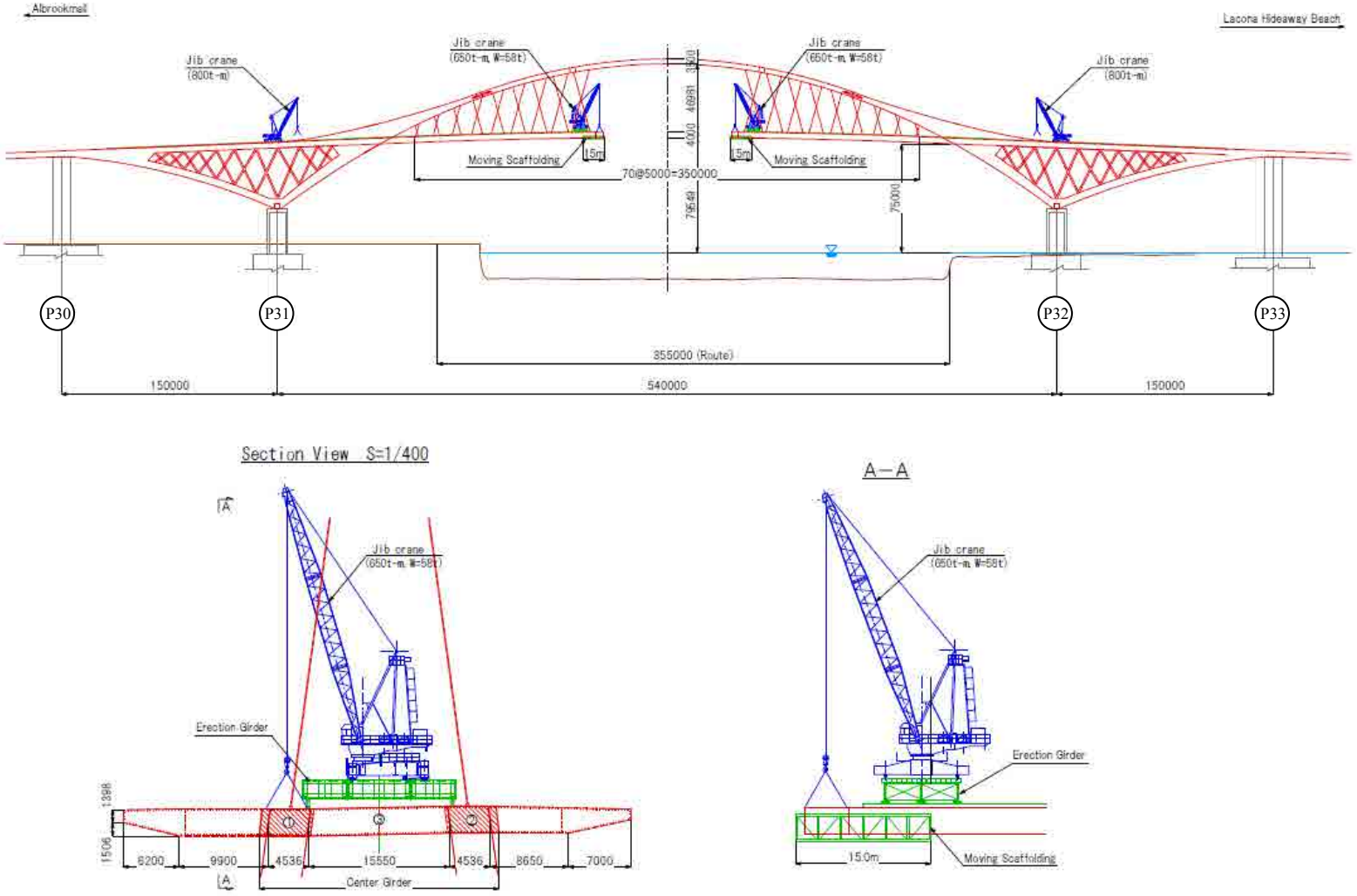
b) Without Using the Navigation Channel

In the case of not using the navigation channel, the followings points are different from the erection procedure shown in Figure 15.3:

- 2. Assembly: Assembled at the temporary yard (Length of arch rib block: 5m only).
- 4. Erection (Arch Rib): Constructed by cable erection with oblique hang.

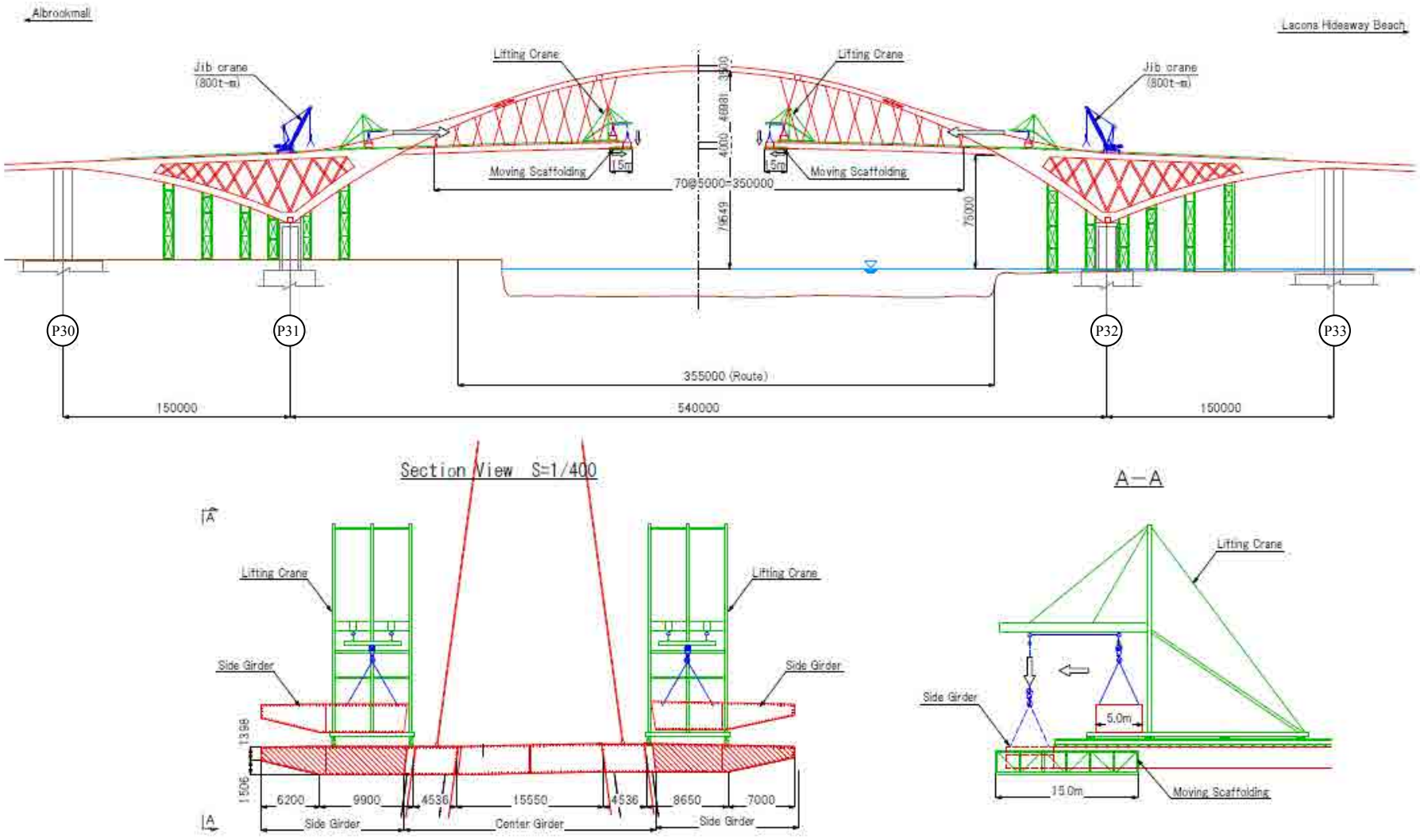
The other erection procedures and methods are the same as those in Figures 15.7 and 15.8.

The erection plan of the arch rib (cable crane with oblique hang) is shown in Figure 15.9.



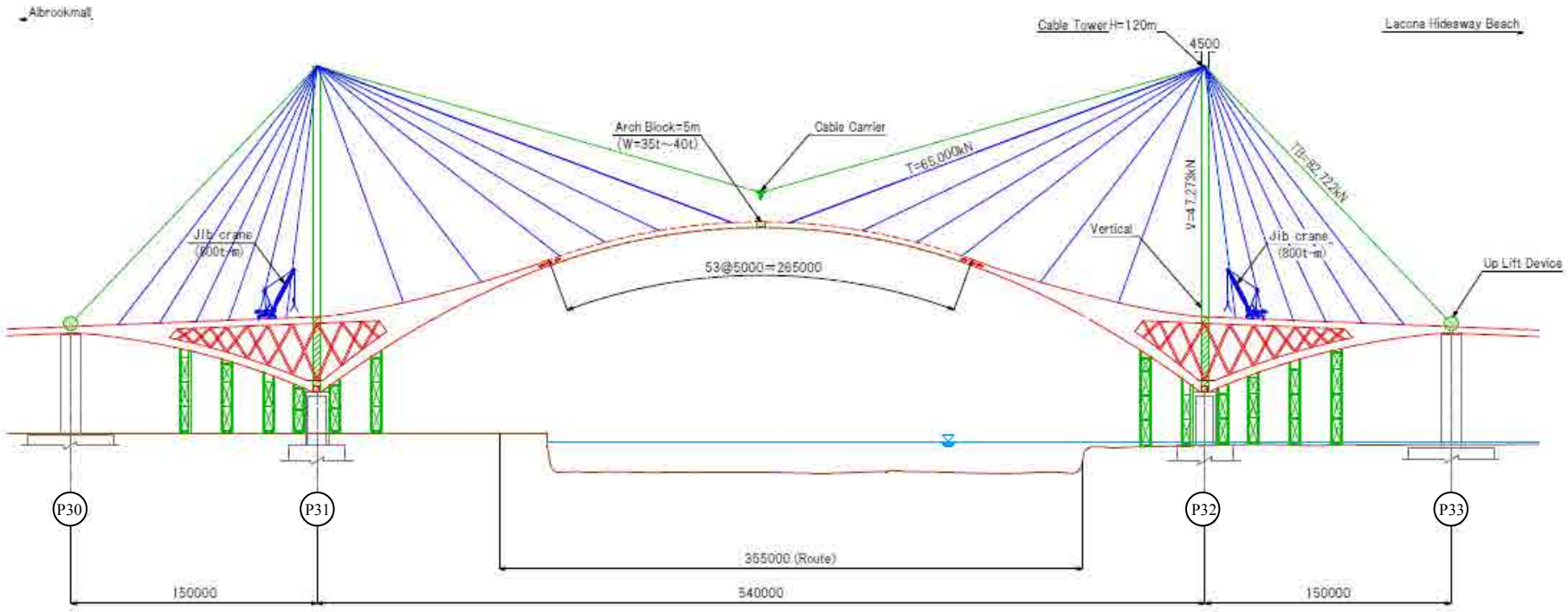
Source: JICA Study Team

Figure 15.7 Erection Plan of Stiffening Girder (Median) (Cantilever Erection)



Source: JICA Study Team

Figure 15.8 Erection Plan of Stiffening Girder (Side Bracket) (Cantilever Erection)



Source: JICA Study Team

Figure 15.9 Erection Plan of Arch Rib (Cable Crane with Oblique Hang) (Without Using the Navigation Channel)

c) Technical Risk Analysis

The technical risks involved in erecting the superstructure for the 4th Panama Canal Bridge are concentrated in the erection of the arch rib.

A technical risk analysis of the superstructure erection (main bridge of the 4th Panama Canal Bridge (arch rib)) is shown in Table 15.4.

Table 15.4 Technical Risk Analysis of the Superstructure Erection (Main Bridge of 4th Panama Canal Bridge (Arch Rib))

No.	Erection Conditions	Risk Item	Risk and Mitigation Measure	Rremaining Risk
1	Using the Navigation Channel	Inclement Weather	In the case of inclement weather (strong wind, heavy rain), the lifting operation can not be carried out from the viewpoint of safety of operation. Change of weather after commencing the erection works can be avoided by monitoring the weather forecast in advance of the erection works. On the other hand, in case the erection works are cancelled in accordance with the weather forecast, the use of the navigation channel needs to be recoordinated among the stakeholders.	Delay of work by inclement weather
2		Lifting Jack (Failure)	In case of failure of the lifting jacks, the arch rib stops in the navigation space due to insufficient capacity of the lifting jacks. The failure of lifting jacks has not occurred in past experiences; however, a 2.0 safety factor is applied to the lifting jack capacity to avoid the above trouble by ensuring the appropriate lifting capacity. Futhermore, expert mechanics are on standby at the site to minimize the time for replacing a lifting jack in trouble. (Replacement time of lifting jack: 1.0 hour)	Mostly mitigated
3		Lifting Jack (Slipping off of Wire Strands)	In case wire strands slip off from the lifting jack, the strands may be broken off due to insufficient lifting capacity. The slipping off of strands can be avoided by using lifting jacks with the multi-layers of safety devices.	Mostly mitigated
4		Wire Strands (Breakage)	In case of losing balance during the lifting operation, the wire strands may be broken off by unbalanced loads. Unbalanced load conditions can be avoided by using the established computer control system. Furthermore, a 4.0 safety factor is applied to the wire strand capacity to avoid the breaking off of the wire stands even if unbalanced load conditions occur.	Mostly mitigated
5	Without Using the Navigation Channel	Instability of Structure	The structure is not stable during the cable erection works by reason of oblique hanging conditions. By applying a large-scale temporary structure, the unstable conditions can be improved partially; however, it is costly and the unstable conditions still remain in strong wind and earthquake. Some bridges have collapsed in past experiences.	Risk of collapse by improper tension control and inclement weather
6		Hanging Cable (Tension Control/Capacity)	Tension control is difficult by reason of the huge tension force and the critical hanging cables that vary step by step. Regarding the unbalanced loading conditions, cable by cable, the capacity of the existing hanging cables might not withstand the loading conditions. Regarding the application of the hanging cables, it cannot be denied that they could collapse due to improper control of tension force.	Risk of collapse by improper tension control and inclement weather

Source: JICA Study Team

d) Risk Analysis by Panama Side

The risk analysis for arch rib erection (with using navigation channel in erection works) was conducted by Panama side (see Section 15.1.5(1)1) i. to iii.).

The risk analysis report (main bridge of 4th Panama Canal Bridge) is shown in Appendix 10.

The summary of risk analysis results and the additional study results by the JICA Study Team are described below.

1. Pre-conditions of Risk Analysis

a. Timing of Arch Rib Erection Works

The timing of arch rib erection works in the risk analysis was supposed in June, 2019 according to the work schedule prepared by the JICA Study Team (see Section 15.1.7).

b. Expected Time for Using Navigation Channel in Erection Works

The expected time for arch rib erection works was estimated about 135 hours by the JICA Study Team (see 15.1.5(1)1)i.). Based on this standard time, the maximum time was expected as 24 hours by Panama side in the risk analysis.

2. Summary of Risk Analysis Results

a. Maximum Duration of Channel Closure

In case of falling arch rib into the canal water, the channel closure will be required more than the maximum time for arch rib erection works (expected 24 hours). As the results of operational simulation by ACP, the maximum backlog is not acceptable to over 100 vessels in consideration of revenue and work volume of incremental work to reduce the backlog. In accordance with this requirement, the maximum duration of channel closure in the accident was concluded 3 days in the risk analysis by Panama side.

b. Risk Items and Countermeasures

The risk items and countermeasures in the risk analysis results are shown in Table 15.5.

Table 15.5 Risk Items and Countermeasures

No.	Risk Items		Countermeasures
1	Closure of Pacific Approach Channel and Special Prevention Measures	Compansation of neighbouring business (revenue, incremental works)	Direct Compensation Cost
2		Standby equipment, test simulation cost	Construction Cost
3	Short Notice Postponement of Pacific Approach Channel Closure Date	Compansation of neighbouring business (revenue, incremental works)	Risk Contingency[1)]
4	Rib Arch Sgment Falling	Compansation of neighbouring business (revenue, incremental works)[2)]	CGL Insurance
5		Compansation of additional project cost and delayed start-up in Metro Line 3 by extension of construction period	ALOP Insurance
6		Cost for removal of arch rib and additional project cost in 4th Panama Canal Bridge Project by extension of construction period	CEAR Insurance

Source: JICA Study Team
Red: Studied by the JICA Study Team in accordance with the request by Panama side
CGL : Comprehensive General Liability
ALOP : Delayed Start-Up
CEAR : Construction/Erection All Risks
1) Project Cost: 100%, Comparison of Main Bridge Type: 50%
2) Limit of Indemnity: Assumed 100 Mil.USD (practice in the 3rd Panama Canal Bridge) according to the discussion results on the Draft Final Report

3. Additional Study Results by the JICA Study Team (Erection Works)

In accordance with the request by Panama side, the following additional study related to the erection works was conducted by the JICA Study team.

This study result was reflected in the risk cost estimate.

a. Expected Extension of Construction Period by Arch Rib Falling

In case of falling the arch rib, the extension of construction period was expected about 9 months by the JICA Study Team to re-fabrication and erection works. In the risk cost estimate, the extension of construction period was considered 1 year.

The work schedule of re-fabrication and erection of arch rib is shown in Table 15.6.

Table 15.6 Work Schedule of Re-fabrication and Erection of Arch Rib

Work Items	1st Month	2nd Month	3rd Month	4th Month	5th Month	6th Month	7th Month	8th Month	9th Month	10th Month
Removal of Arch Rib										
Arch Rib Falling										
Removal of Arch Rib										
Site Inspection										
Landing and Scrapping of Arch Rib										
Re-fablication/Erection of Arch Rib										
Procurement of Materials										
Fablication										
Transportation										
Assembling										
Erection										
Investigation of Cause of Accident										

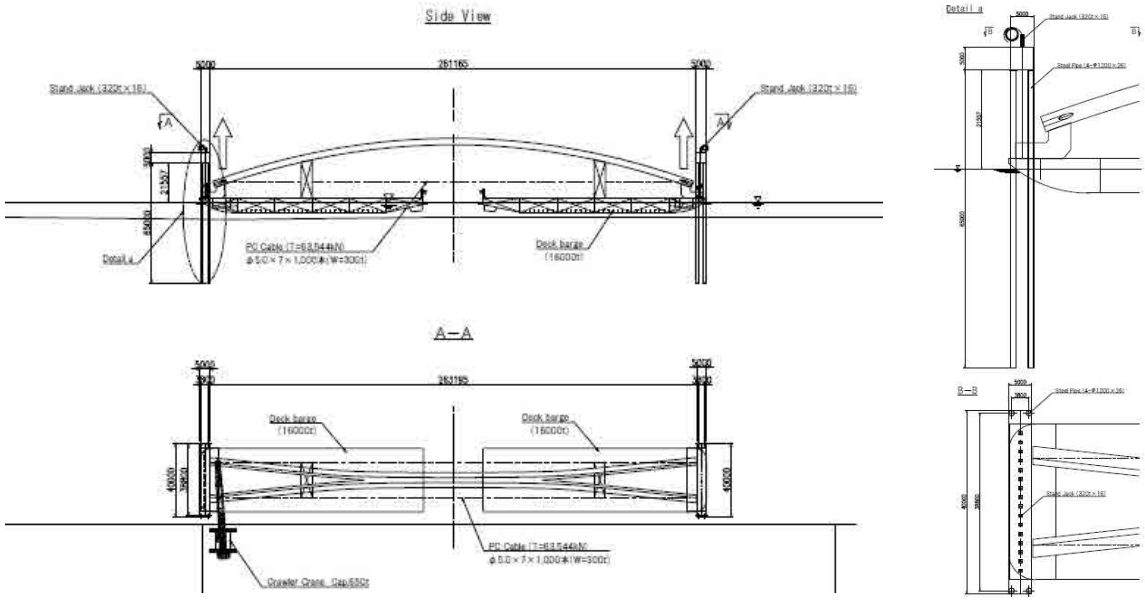
Source: JICA Study Team

b. Lifting Test (Simulation) of Arch Rib

The following lifting test (simulation) was planned by the JICA Study Team.

- Structural analysis and simulation by 3D frame program
- Test lifting at the assembling yard

The plan of lifting test (arch rib) is shown in Figure 15.10.



Source: JICA Study Team

Figure 15.10 Plan of Test Lifting (Arch Rib)

c Removal of Arch Rib

In case of falling the arch rib into the canal water, it will be removed to the edge of canal by towboats and pusher boats. The removal works was planned to complete within the maximum duration of channel closure (3 days).

The work items and duration (removal of arch rib), the list of labors and equipment (removal of arch rib) are shown in Tables 15.7 to 8, respectively.

Table 15.7 Work Items and Duration (Removal of Arch Rib)

No.	Work Items	Expected Duration
1	Site Inspection	12 hours
2	Installation of Lift-bags and rubber tubes by Divers (1 hour*3 cycles)	3 hours
3	Inflating Lift-bags by Air Compressor (3 hours*3 cycles)	9 hours
4	Removing the Arch Rib by Towboats and Pusher Boats	2 hours
Total		**26 hours**

Source: JICA Study Team

Table 15.8 List of Labors and Equipment (Removal of Arch Rib)

No.	Items	Quantities	Remark
1	Barge	2 nos.	500 ton
2	Tug Boat	4 nos.	4,000 PS
3	Lift Bag	74 sets	35 ton (77,000 lbs)
4	Rubber Tube	800 m	400m per one side
5	Compressor	6 sets	3,700 litters/minutes
6	Generator	2 sets	800 kVA, Diesel
7	Floating Crane	1 no.	Titan, ACP
8	Towboat	2 nos.	2,000 ton Class, ACP
9	Pusher Boat	2 nos.	High Powered
10	Diver	72 person-day	2 person/team*12 teams*3 days

Source: JICA Study Team

2) Substructure and Foundation

The following construction method is assumed for the substructures and foundations of the main bridge of the 4th Panama Canal Bridge.

East Side (on land): Spread Foundation (P30,P31)

The standard method for the substructures on land is a spread footing, which carries out intrusion without auxiliary method to the rock formation in this area. Construction procedures for the substructures consist of earth retention by steel sheet-pile, excavation, and the construction of the structure. The preliminary construction planning and procedures are as follows:

1) Existing Structure Removal and Ground Leveling

   The existing structure in the construction area is removed and leveled to form a work base and temporary road.

2) Steel Sheet Pile Driving

   Before the footing is constructed, the pile driving of steel-sheet-piles is carried out in the periphery of the footing to prevent the inflow of ground-water, and to stabilize the work.

3) Excavation in Sheathing

   The inside of the sheathing is excavated by backhoe and clamshell. Sheathing is carried out by strut and waling, or by ground anchor unit if needed.

4) Reinforcement Work and Concrete Work of Footing

   After pile-head disposal, reinforcement work and concrete work of the footing are carried out by a concrete pump.

5) Reinforcement Work and Concrete Work of Pier Pillar

   The concrete pier pillar is constructed by assembled formwork, and an elevator is installed for the work.

6) Filling and Removal of Steel Sheet-pile

   After the pier pillar is constructed to a certain height, filling and compaction in the footing are carried out and the steel sheet-pile is removed.

7) Reinforcement Work and Concrete Work for the Pier Beam

   Since the scale of the component is large, the supporting work for concrete loading is assembled from the ground.

West Side (in the Canal): Steel-pipe-sheet-pile Foundation(P32) and Cast in Place Pile(P33)

There are many experiences in the construction of a bridge foundation in water, which are applicable to the substructures for an arch bridge in a canal. High construction safety can be expected from the use of the steel-pipe-sheet-pile construction method, without a cofferdam. The preliminary construction planning and procedures are as follows:

1) Temporary Peninsula Construction by Embankment

   Since the water depth of the construction location is shallow, temporary peninsula (jetty) is constructed as a work base by the embankment of earth and sand from the land side.

2) Rock Excavation inside Steel pipe sheet pile foundation and Sand Replacement

   Since the bearing layer at the construction site is base rock, rock excavation and sand replacement are carried out earlier for fixing the tip of the steel pipe sheet pile to the base rock layer.

3) Cast-in-Place Pile

   A cast-in-place pile is constructed using a specialized machine, a machine for disposing excavated earth and sand, and a crawler crane.

4) Steel Pipe Sheet Pile Driving

   Pile driving of the steel pipe sheet pile is carried out by a crawler crane, vibratory hammer, and hydraulic hammer.

5) Excavation of the inside of the Steel Pipe Sheet Piling

   The sheet-piling joint is waterproofed and the inside of the steel pipe sheet pile is excavated by a backhoe and clamshell.

6) Concrete Work of Footing

   The concrete work of the footing inside the steel-pipe-sheet-pile is carried out by a concrete pump.

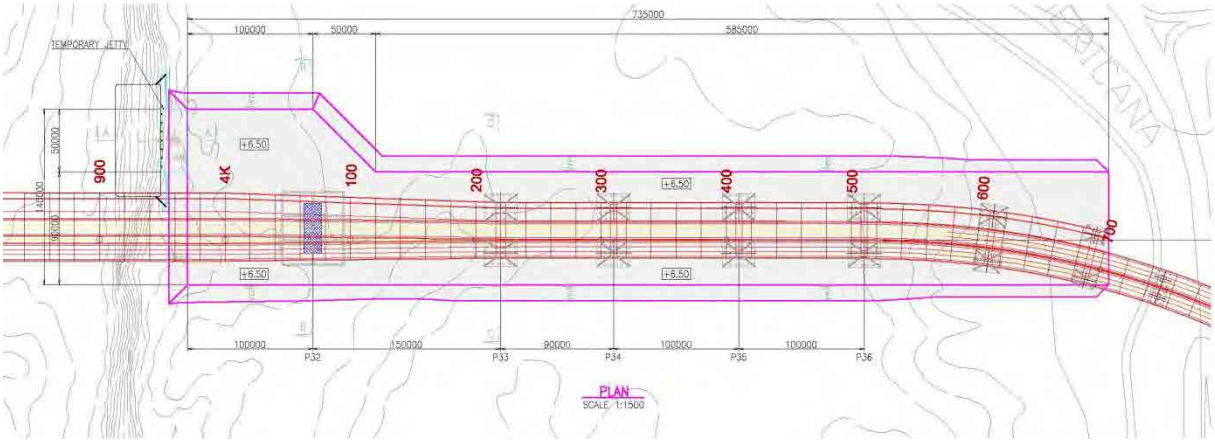
7) Reinforcement Work and Concrete Work of Pier Pillar

   The concrete of the pier pillar is constructed one by one by assembled formwork, and an elevator is installed at the same time for the work.

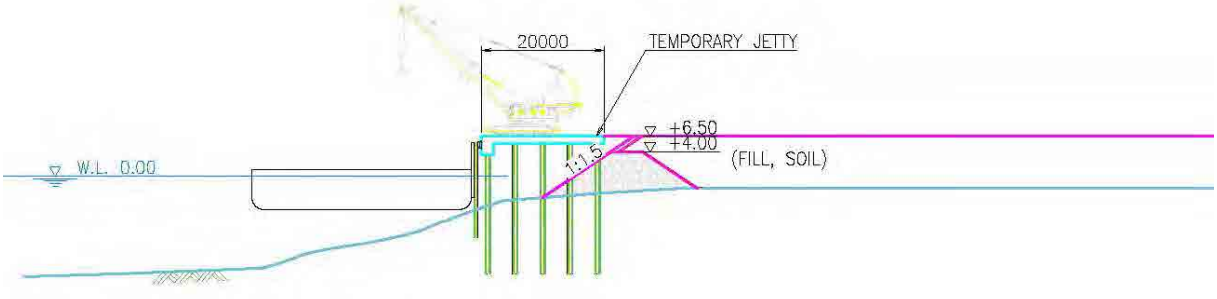
8) Reinforcement Work and Concrete Work of Pier Beam

   Since the scale of the component is large, the supporting work for concrete loading is assembled from the ground.

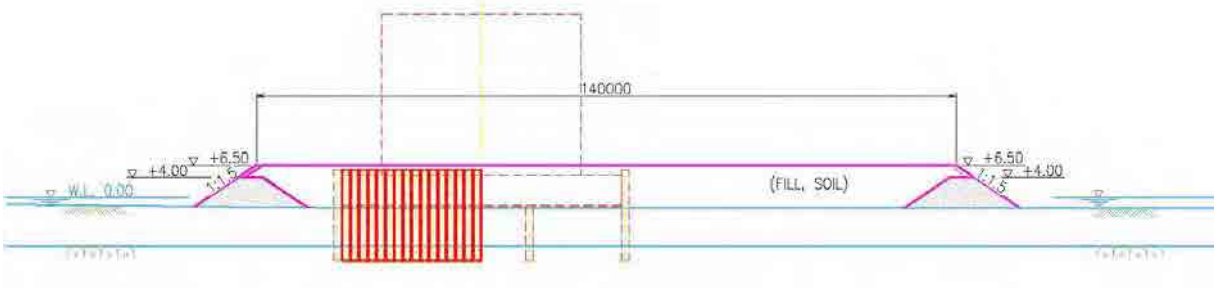
The construction plan of substructures and foundations (west side: in the channel) is as shown in Figures 15.11 to 15.14.



a) West Side: Plane on Canal



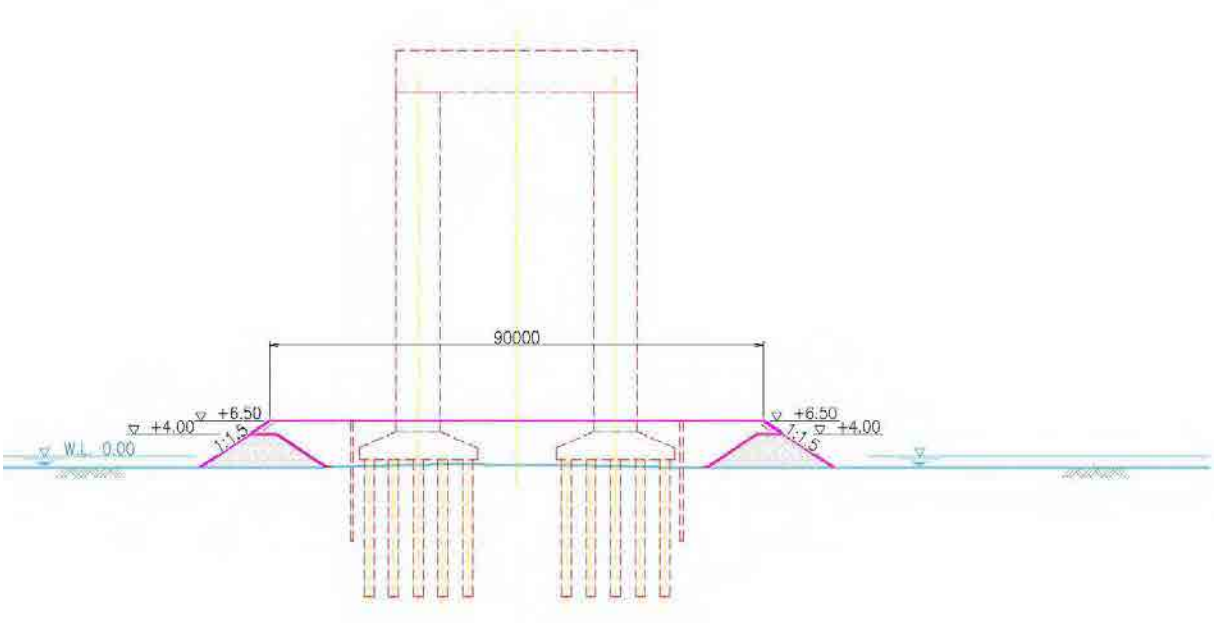
b) Temporary Road (A-A)



c) Temporary Road (B-B: P32 Pier)

Source: JICA Study Team

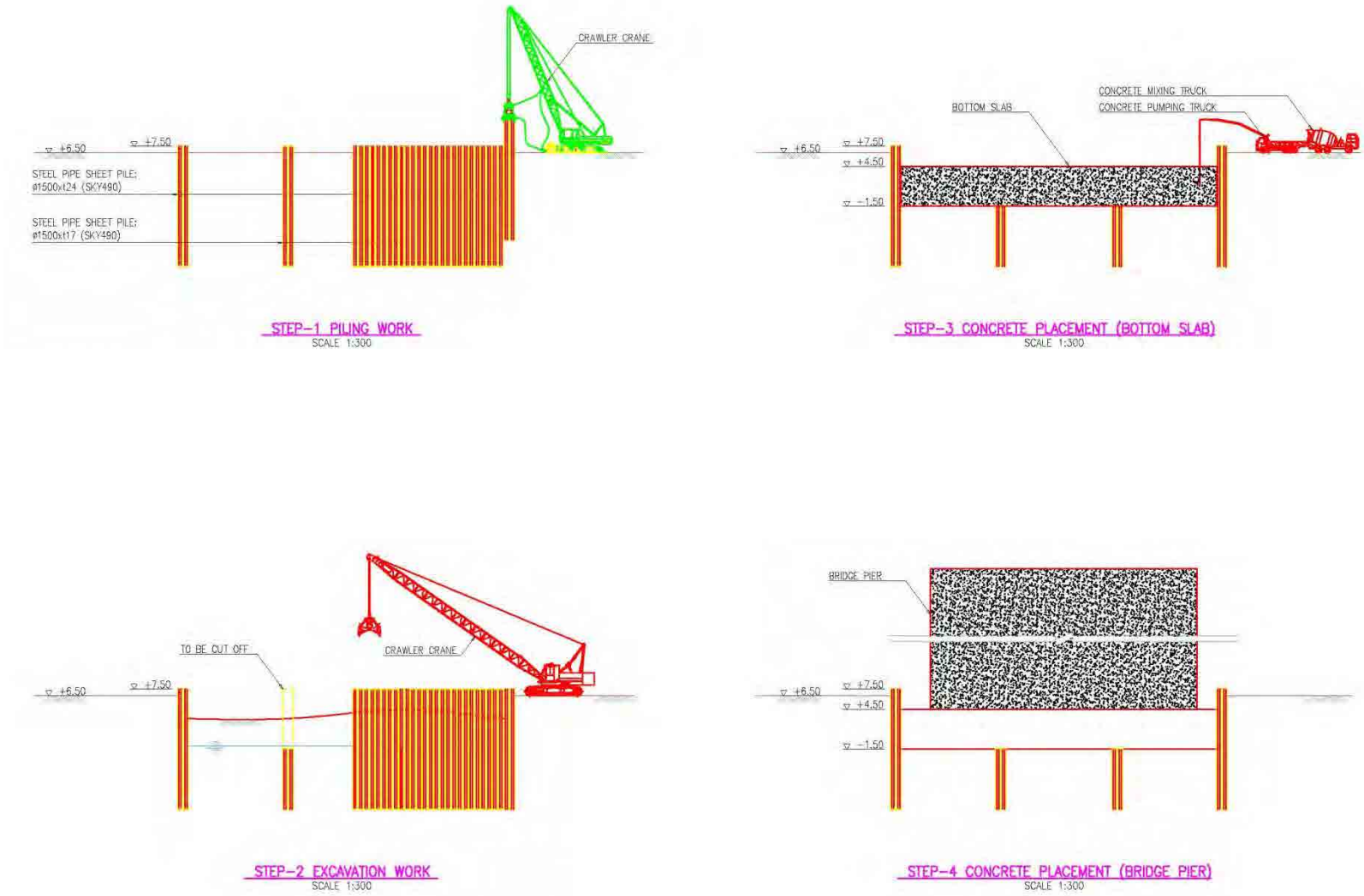
Figure 15.11 Construction Plan of Substructure and Foundation (West Side: in the Canal) 1/2



d) Temporary Road (C-C; P33 Pier)

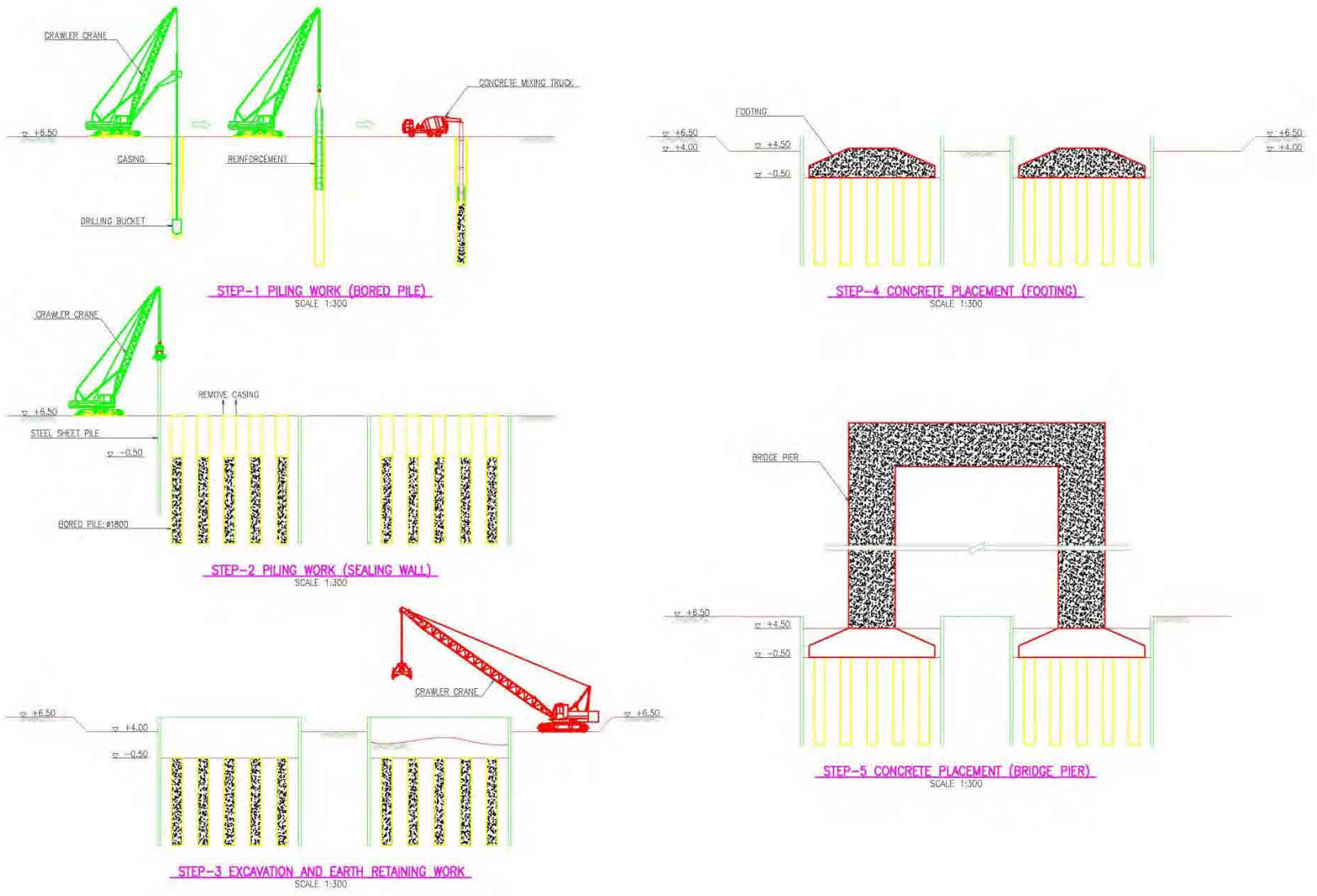
Source: JICA Study Team

Figure 15.12 Construction Plan of Substructure and Foundation (West Side: in Canal) 2/2



Source: JICA Study Team

Figure 15.13 Construction Plan of Substructure and Foundation (Procedure for P32 Pier)



Source: JICA Study Team

Figure 15.14 Construction Plan of Substructure and Foundation (Procedure for P33 Pier)

(2) Construction Method of the Approach Road

1) Substructure

The approach road section is constructed on land and can be transported from existing roads. The foundation type is the cast-in-place pile which has few construction impacts (noise and vibration) for the structure scale. The substructure in the low-elevation approach sections is the commonly used reinforced concrete, and does not require a special construction method. In the section near the main bridge, lifting type falsework is recommended for piers over 30m high. In the eastern section, when constructing piles and lifting materials, the construction methods should take in full consideration the obstacle limitation surfaces for being near an airport. Parallel to the construction of the approach road, improvements will be made to the Omar Torrijios intersection. Schedule management, such as traffic detours and construction procedures, should be coordinated between both constructions.

Construction procedures for the pile foundation and substructure are shown in Table 15.9.

Table 15.9 Construction Procedures of Pile Foundation and Substructure

Pile Foundation Work	Substructure (Footing)	Substructure (Beam/Pillar)
1. Casing installation	1. Structural excavation	1. Falsework assembling
2. Excavation	2. Levelling concrete	2. Reinforcement assembling
3. Reinforcement cage installation	3. Reinforcement assembling	3. Formwork
4. Concrete work	4. Formwork	4. Concrete work
5. Casing extraction	5. Concrete work	5. Curing
	6. Curing	6. Formwork/Falsework removal
	7. Formwork removal	
	8. Filling	

Source: JICA Study Team

2) Superstructure (PC-I Girder)

For the fabrication of the PC-I Girders, precast segmental method at a construction yard is adopted. The segments are divided and fabricated in consideration of the transport size. The fabrication procedure is to carry the segments to the assembly base at the erection point, where they are unified by gluing and pre-stressing.

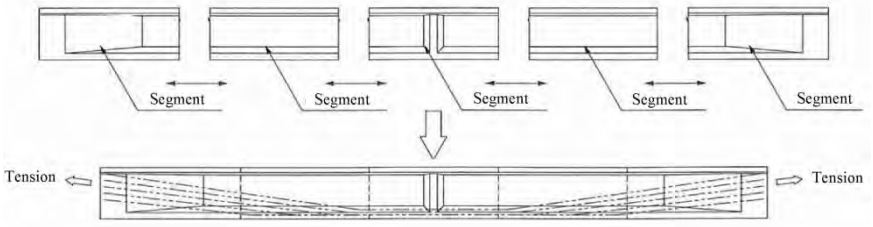
For raising the girders, the truck-crane erection method is adopted. A truck crane is set on the ground at the erection point, and a unified PC girder is lifted and installed. Coordinated lifting by two cranes is assumed as the PC girder's length and weight are 40 m and about 100t.

In the eastern approach road, for flyovers No.1 and No.2, crane work should take into consideration the airspace restrictions near the airport. The construction procedure for the PC I-girders is as follows:

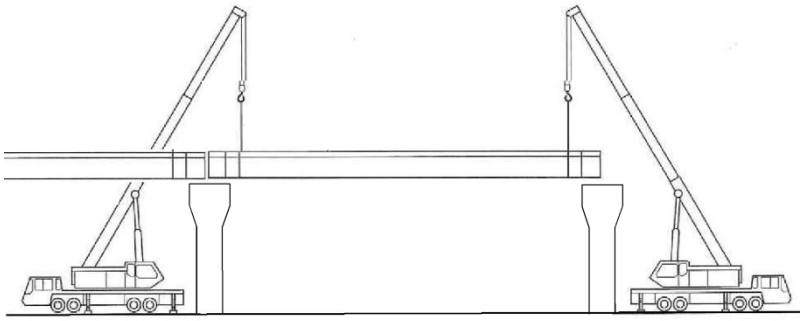
1. Carrying segments to the erection point
2. Join segments on the assembly table
3. Main girder erection by coordinated lifting by two cranes
4. Installation of falsework
5. Construction of cross beams, floor slab, and bridge surface, and
6. Proceed to next span

The precast segment method and truck-crane erection method are shown in Figure 15.15.

Segment Girder



Truck Crane Erection Method



Source: JICA Study Team

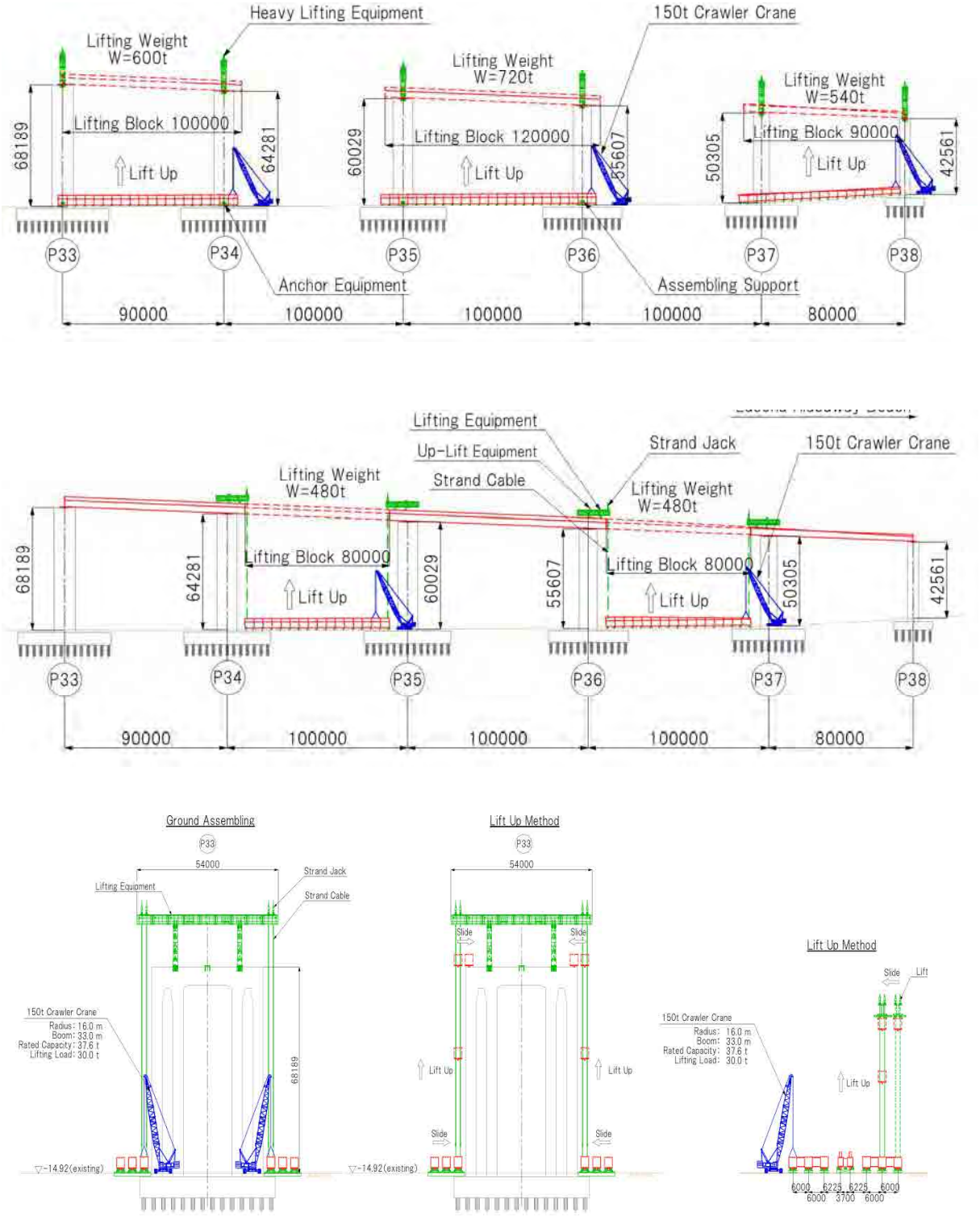
Figure 15.15 Precast Segment Method and Truck-crane Erection Method

3) Superstructure (Steel Box Girder)

For the Steel Box-girder Bridge, the truck-crane erection method and the large block erection method with winch is adopted. In the erection procedure of the large block erection method, the girder component block is carried to the erection point, and a girder for one span is assembled on the ground. A winch is installed on top of a pier or constructed girder, and an assembled girder for one span is placed by tandem lifting. For the floor slab, precast RC floor slab is adopted. Slab blocks are installed on constructed girder, and then unified.

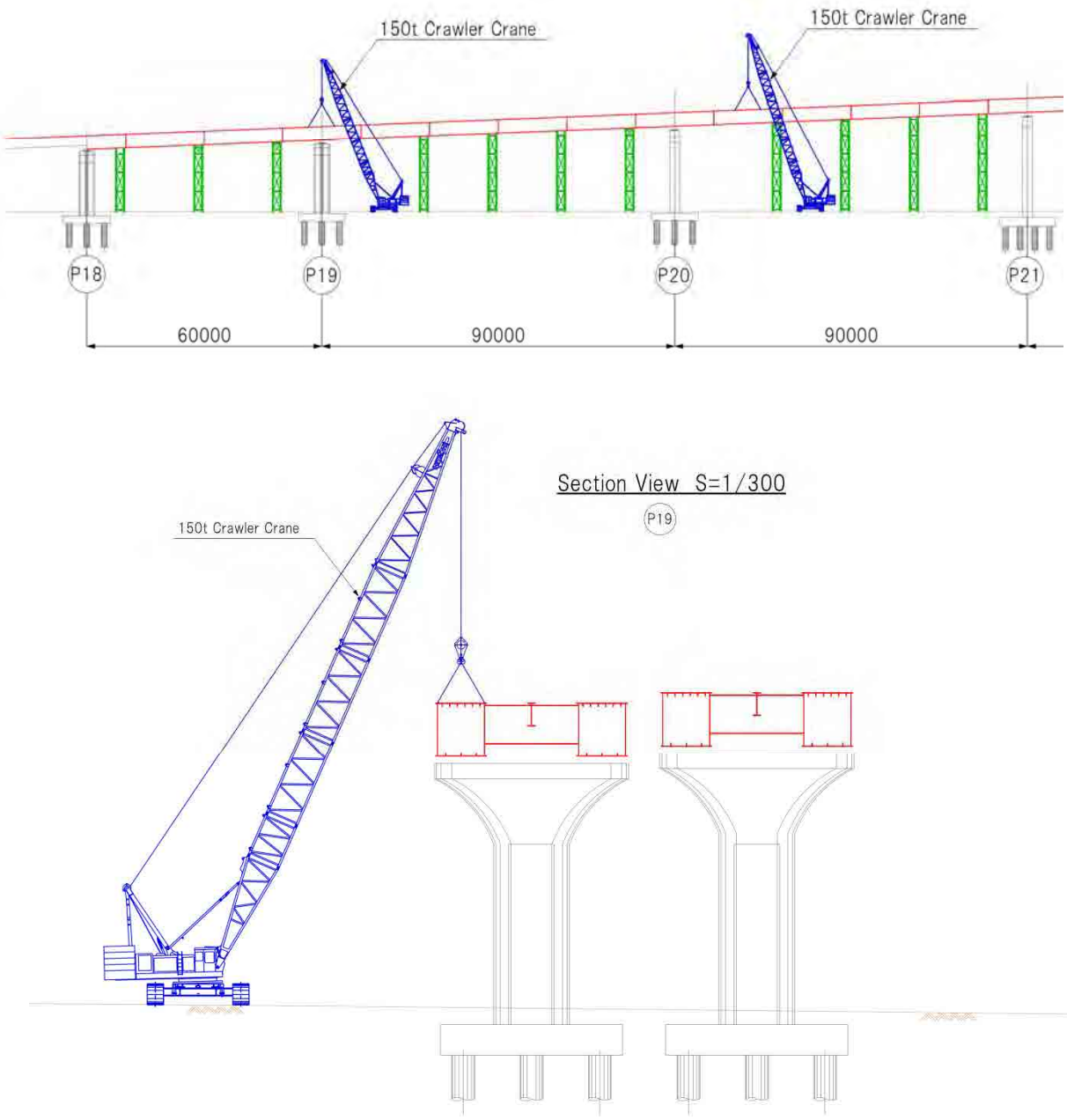
1. Assembling of lifting machine and winch
2. Carrying and assembling of girder at erection point
3. Girder erection
4. Removal of lifting machine and winch (to next span), and
5. Carrying and erection of precast floor slab

The large block erection method with winch is as shown in Figure 11.16. The track crane erection method is as shown in Figure 15.17.



Source: JICA Study Team

Figure 15.16 Large Block Erection Method with Winch



Source: JICA Study Team

Figure 15.17 Track Crane Erection Method

15.1.6 Temporary Facilities

(1) Construction Yard Area

When constructing the 4th Panama Canal Bridge, a construction yard is necessary for girder/floor-slab fabrication, stock, concrete manufacturing plant, material handling, temporary placement of excavation earth, and an office and worker camp. Since the eastern side does not have enough space, the construction yard will be minimal. Therefore, the yard for girder / floor-slab fabrication / stock will be located on the western side. According to the result of estimating the necessary yard area based on similar constructions from actual experience, about 270,000 square meters will be required.

The construction yard area is as shown in Table 15.10.

Table 15.10 Construction Yard Area

Item	East side	West side
Girder/floor-slab fabrication and stock	18,000m2	22,000m2
Reinforcement work, formwork fabrication, stock, and Temporary placement of false work	---	50,000m2
Temporary placement of machinery, office, parking, worker camp	13,000m2	17,000m2
Main bridge and approach bridge; temporary placement and arch assembling	---	134,000m2
Temporary placement of excavation earth	8,000m2	8,000m2
Subtotal	30,000m2	231,000m2
Total	270,000m2	

Source: JICA Study Team

(2) Candidate Locations of Construction Yard

The candidate locations of the construction yard are selected based on a survey of land use and interviews with related authorities. The concrete location should be confirmed in the future.

The candidate locations of construction yard are as shown in Figure 15.18.

Source: JICA Study Team

Figure 15.18 Candidate Locations of Construction Yard

(3) Construction Work Road and Temporary Pier

In order to construct a large-scale structure in a short period, many works should be carried out in parallel. A road for construction work should be secured on both sides for the smooth carrying of material and equipment to each work point.

Regarding the carrying of material between east and west, the use of the Pan-American Highway would impact work efficiency and traffic, as such, waterborne transportation by barge is recommended. Therefore, on the west bank, a peninsula will be constructed by embankment for the substructure work and girder erection, and a temporary jetty will be erected to serve as a dock for barge transport across the canal.

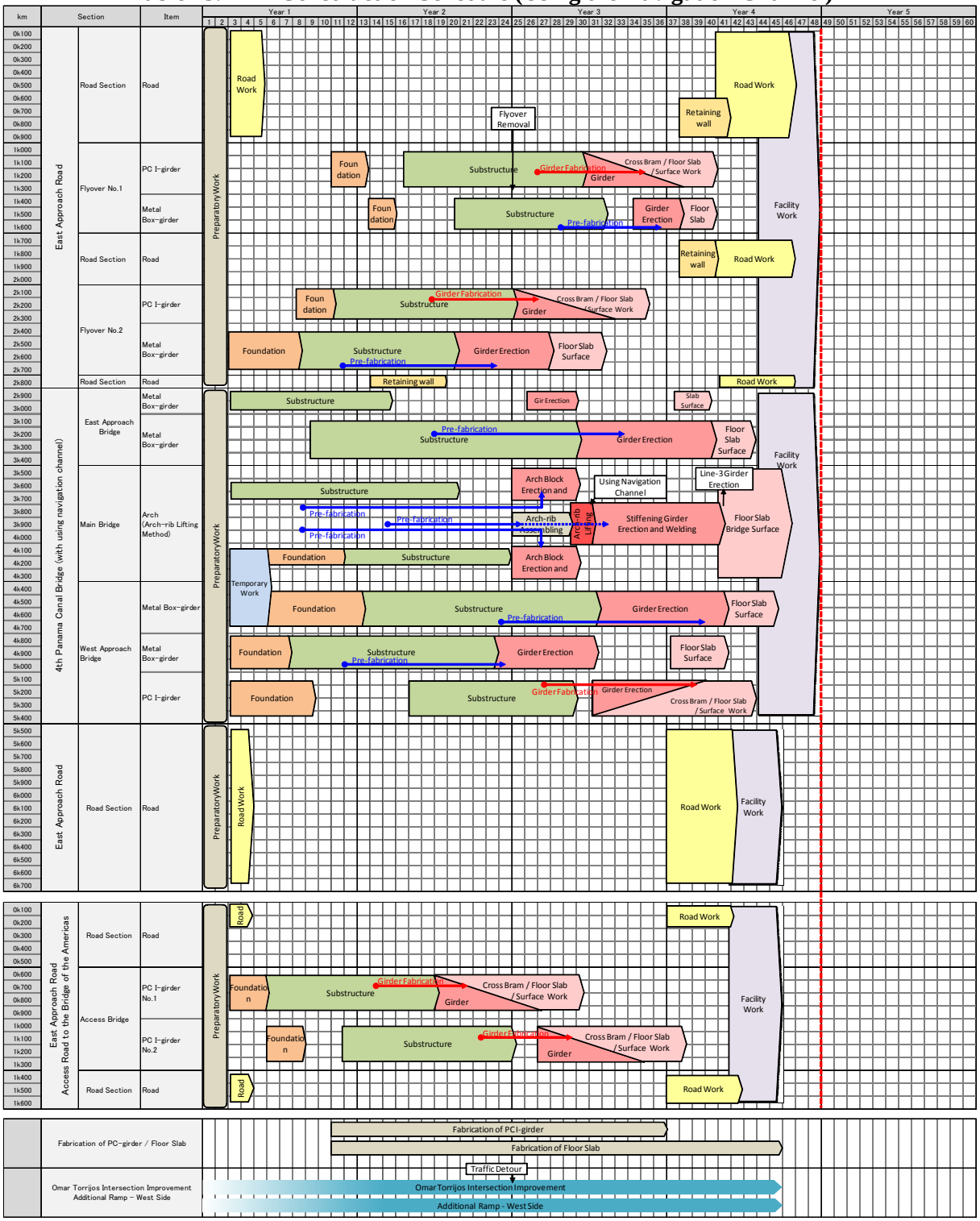
15.1.7 Construction Schedule

The construction schedule is planned in consideration of the construction methods, procedures, site characteristics, workload, and related constructions based on the designed quantities. The construction schedule is divided into 3 construction sections. For the erection of the main bridge, assessment was made for two cases: using/without using the navigation channel of the Panama Canal, with a construction period of 48 months and 60 months, respectively.

The construction scheduling is divided into 3 sections and it is assumed that each work is carried out in parallel. It is also assumed that the improvement of the Omar Torrijos intersection will be implemented at once. Traffic diversion at the intersection should be adjusted with that project during flyover removal and construction. Rail girder erection of Line-3 shall be started after the acceptance of the 4th Panama Canal Bridge is prepared.

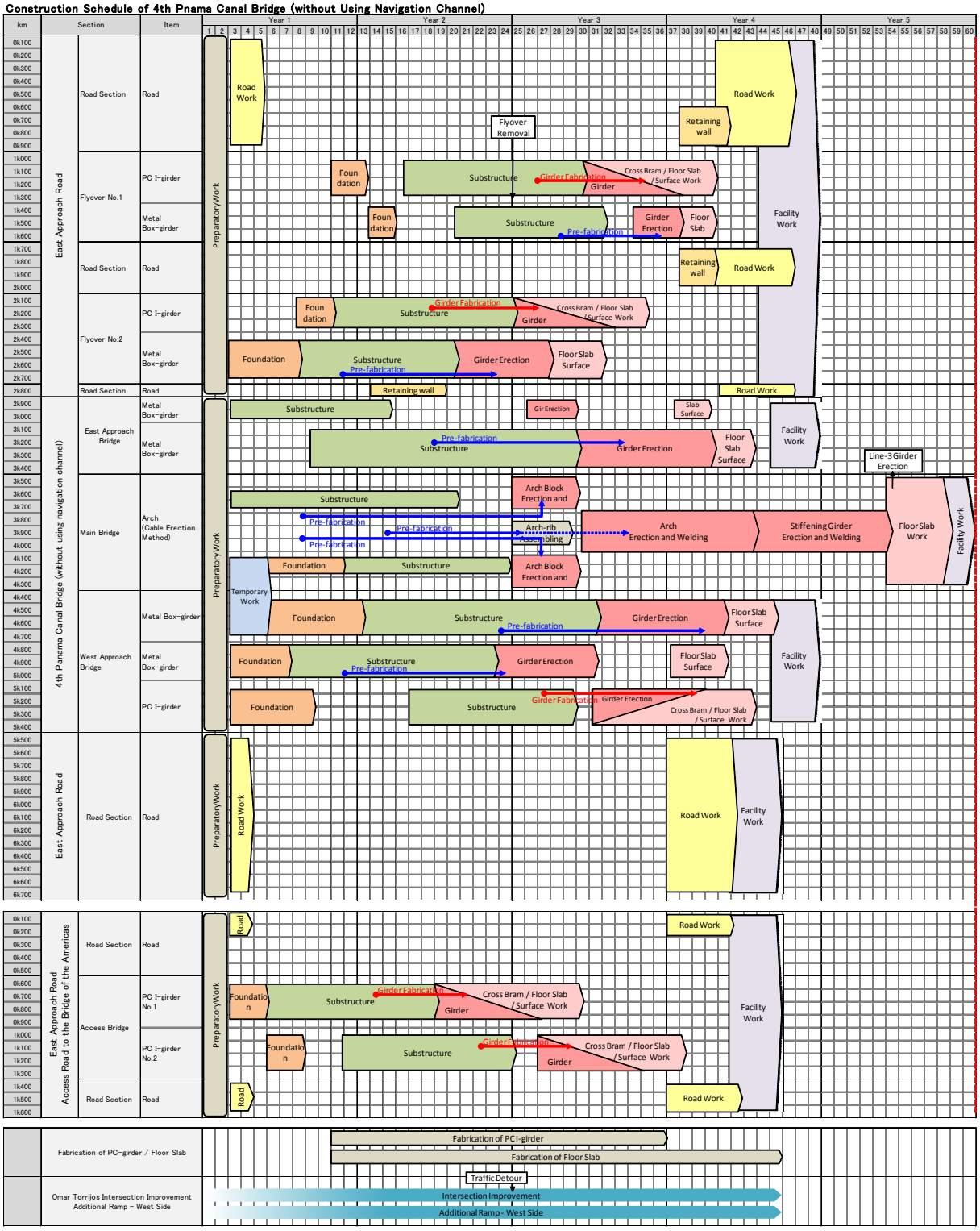
The construction schedules for the cases of using/without using the navigation channel are as shown in Tables 15.11 and 15.12, respectively.

Table 15.11 Construction Schedule (Using the Navigation Channel)



Source: JICA Study Team

Table 15.12 Construction Schedule (Without Using the Navigation Channel)



Source: JICA Study Team

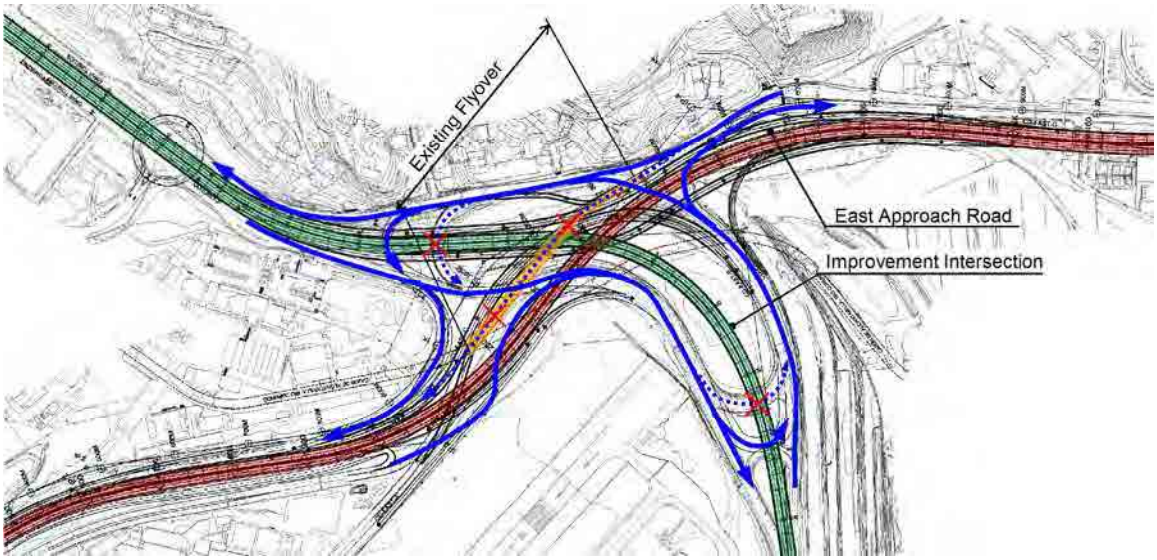
15.1.8 Traffic Management and Safety Management during Construction Period

(1) Traffic Management Plan

The 4th Panama Canal Bridge and approach roads are constructed in the location that avoids the existing road. Although impact on current traffic is comparatively small, the route has crossovers over existing intersections and roads. Traffic should be managed by providing detours and lane closure during the work of foundation and footing, and also during girder erection crane installation. As for the removal of the existing flyover at the Omar Torrijos intersection, the schedule for the new construction and intersection improvement should be adjusted accordingly.

Lane closure during construction and other aspects of the traffic management plan should comply with Panamanian law (Law 34 of the Land Transport and Transit Authority, ATTT). Permission is required from ATTT if the construction will affect road traffic, regardless of the scale of the construction.

Traffic detours at the time of removing the existing flyover are as shown in Figure15.19.



Source: JICA Study Team

Figure 15.19 Traffic Detours during Removal of Existing Flyover

(2) Safety Management Plan

Regulations related to construction safety management are indicated below. The 4th Panama Canal Bridge construction will conform to these regulations.

Safety, health, and hygiene during construction are secured in accordance with the "Executive Decree No.2 (of February 15, 2008) Whereby Safety, Health, and Hygiene of the Construction Industry are regulated" (*DECRETO EJECUTIVO No. 2 (de 15 de febrero de 2008) Por el cual se reglamenta la Seguridad, Salud e Higiene en la Industria de la Construcción*) maintained by MITRADEL (Ministry of Work and Labor Development). Regarding street safety regulations for road construction, the "Manual for the Control of Traffic during the execution of Construction and Maintenance Works in Streets and Roads" (*Manual para el Control de Transito durante la ejecution de Trabajos de Construcci[on y Mantenimiento en Calles y Carreteras)* maintained by MOP, is being enforced. In addition, in the construction of Line-1, SMP applied the OSG Act regulations established by OSHA (Occupational Safety & Health Administration), which is an organization under the U.S. Department of Labour.

Regarding safety management for constructions on water, deliberations were held in workshop with entities concerned. These deliberations should also be continued in the future.

15.1.9 Conclusion

The section for design quantities is divided into 3 taking into account the construction scale, structural characteristics, and on-site conditions. Regarding the construction contract, one construction contract package was assumed for this Study, since this would allow a joint schedule management for the control and implementation of a unified project. For the main bridge erection, the large block erection method using the navigation channel is proposed by reason of shorten construction period in the result of a comparison study. For the other bridges, suitable construction methods are proposed in consideration of the structural characteristics and site situation. A large construction yard is needed for girder and floor-slab fabrication, and the temporary placement of girder components and materials. Although candidate temporary yard locations are proposed, a concrete location should be selected in the future. For the construction schedule, the main bridge construction will take the longest, and it is assumed that the construction period is 4 years using the canal. Schedule management should be adjusted with Metro Line-3 construction project and Omar Torrijos intersection improvement.

15.2 Preliminary Project Cost Estimate

15.2.1 Summary

(1) Objective

The preliminary project cost for the 4th Panama Canal Bridge is estimated based on the results of preliminary design and preliminary construction planning.

(2) Study Items

The preliminary cost estimate is carried out by considering the condition, methodology, and unit costs, assuming that the 4th Panama Canal Bridge project is implemented as a Japanese yen loan project. The costs for Omar Torrijos Intersection and west additional ramp, which located in Concept Design Section, are estimated by using the similar scale project cost.

(3) Study Results

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 15.13 Preliminary Project Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(4) Conclusion

Because the project scale is extremely large, the project cost should be carefully determined through a more detailed survey and design, and discussed with the related organizations.

15.2.2 Related Laws and Regulations

There are no systematic laws and regulations for project cost estimating in Panama, the construction cost is estimated based on unit-prices from historical and market information.

15.2.3 Conditions of Cost Estimate

The conditions of cost estimate are as shown in Table 15.14.

However, the exchange rate, price escalation rate and contingency are values from the JICA study. The conditions of cost estimate will be presented by JICA at the appraisal.

Table 15.14 Conditions of Cost Estimate

Item	Remarks
Project Finance	Japanese yen loan
Base year of cost estimate	October 2013
Construction package	1 package
Currency	Foreign currency (FC):Japanese Yen (JPY) Local currency (LC):US Dollar (USD)
Exchange rate	USD 1.00 =JPY 99.7
Price escalation	FC : 1.3% LC : 3.1%
Physical contingency	Construction cost : 5% Consultant fee: 5%
Rate of interest during construction	Construction cost : 1.80% Consultant fee: 0.01%
Rate of front end fee	0.2%
Rate of tax	0.0%
Rate of administration cost	5.0%

Source: JICA Study Team

15.2.4 Methodology of Cost Estimate

(1) Cost Structure

The cost structure is as shown in Table 15.15.

The preliminary cost estimate of the 4th Panama Canal Bridge is divided to an eligible portion and a non-eligible portion.

The eligible portion consists of the construction costs for civil works, utilities, utilities relocation, environmental and mitigation compensation and risk cost, and consultant fee. The non-eligible portion consists of environmental compensation cost, and land acquisition and resettlement costs.

Moreover, the preliminary project cost estimate is divided to a foreign currency portion and a local currency portion.

Table 15.15 Project Cost Structure

A. ELIGIBLE PORTION
Ⅰ) Procurement / Construction
1)Temporary Works
2)East Approach Road
3)4th Panama Canal Bridge (A5 - A6 section)
4)West Approach Road (including Additional Ramp)
5)Omar Torrijos Intersection
6)Utilities
7)Public Utilities Relocation
8)Environmental Mitigation and Monitoring
9)Risk Cost
Base cost for JICA financing
Price escalation
Physical contingency
Ⅱ) Consulting services
1)Consulting services A
2)Consulting services B for Concept Design Section
Base cost
Price escalation
Physical contingency
Total (Ⅰ+Ⅱ)
B. NON ELIGIBLE PORTION
a Procurement / Construction
1)Environmental Compensation
Base cost
Price escalation
Physical contingency
b Land Acquisition and Resettlement
Base cost
Price escalation
Physical contingency
c Administration cost
d VAT
e Import Tax
Total (a+b+c+d+e)
TOTAL (A+B)
C. Interest during Construction
Interest during Construction(Const.)
Interest during Construction (Consul.)
D. Front End Fee
GRAND TOTAL (A+B+C+D)

Source: JICA Study Team

(2) Methodology

Costs for construction works and utilities are estimated based on the quantities calculated from the preliminary design and unit costs in the Panama market. Temporary works are considered in the construction cost estimate.

Consultant fees for the detailed design stage, contractor selection stage, and construction stage for a Japanese yen loan project are estimated based on inputs from the necessary specialists. The consultant's role is described in Chapter 17.

Public utilities relocation cost is estimated based on the quantities from the preliminary design and unit costs.

Costs for environmental mitigation and compensation are estimated based on the necessary actions taken during the construction stage.

Land acquisition and resettlement costs are estimated based on the Panama market cost.

The construction costs for Omar Torrijos Intersection and west additional ramp, which located in Concept Design Section, are estimated by using the similar scale project cost.

15.2.5 Unit Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

15.2.6 Preliminary Project Cost

The preliminary project cost and annual disbursement for the 4th Panama Canal Bridge are estimated for two cases, one using the canal in the main bridge construction, and the other not using the canal in the main bridge construction.

(1) Preliminary Construction Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 15.16 Preliminary Construction Cost (2013 price)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

*1) 4th Panama Canal Bridge section is including approach bridges as described in Chapter 15.1.13.
*2) West approach section is including west side additional ramps (excluding ramp X)
Source: JICA Study Team

(2) Preliminary Consultant Fee

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 15.17 Preliminary Consultant Fee (2013 price)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(3) Preliminary Cost for Environmental Compensation

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 15.18 Preliminary Cost for Environmental Compensation (2013 price)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(4) Preliminary Land Acquisition and Resettlement Costs

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 15.19 Preliminary Land Acquisition Cost (2013 price)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(5) Preliminary Project Cost and Annual Disbursement

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 15.20 Preliminary Project Cost and Annual Disbursement (Using the Navigation Channel)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 15.21 Preliminary Project Cost and Annual Disbursement (Without Using the Navigation Channel)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

15.3 Preliminary Operation and Maintenance Cost

15.3.1 Objective

The preliminary operation and maintenance cost for 100 years after the opening of the 4th Panama Canal Bridge are estimated based on operation and maintenance planning.

15.3.2 Preliminary Operation and Maintenance Cost

Table 15.22 shows the preliminary operation and maintenance cost. Details are as shown in Appendix 8.

Table 15.22 Preliminary Operation and Maintenance Cost

Item	Preliminary Operation and Maintenance Cost(mil.JPY)
Civil works	33,451
Utility	7,453
Concept Design Section (Omar Torrijos Intersection and West Side Additional Ramp)	11,663
Total	52,567

Source: JICA Study Team

15.3.3 Environmental Monitoring Cost

SMP should carry out the monitoring on air quality, noise, vibration, water quality, soil quality, and waste water during the first three years of the operation stage. The monitoring cost during operation stage is estimated at US$ 225,900 according to the EIA.

15.3.4 Conclusion

The preliminary operation and maintenance costs for 100 years after the opening of the 4th Panama Canal Bridge are estimated to be 52.6 billion JPY (527 million USD).

During the first three years of the opening stage, environmental monitoring will be required.

Chapter 16 Comparison Study between the Pre-F/S Option and the JICA Study Option

16.1 Objective

As described in Section 10.1, the screening of the main bridge type for the 4th Panama Canal Bridge was conducted at the beginning of the JICA Study (November, 2013). In the screening, the cable-stayed bridge and arch bridge were selected as the alternative bridge types and it was decided that these two alternatives would be compared again to select the optimum bridge type in accordance with the preliminary design results. In the Pre-F/S, the preliminary design was made for the cable-stayed option; therefore, the preliminary design of the arch bridge was conducted in the JICA Study.

The objective of this chapter is to conduct a comparison study between the Pre-F/S option and the JICA Study option in accordance with the preliminary design results and to recommend the optimum bridge type for the main bridge of 4th Panama Canal Bridge.

16.2 Summary of Preliminary Design Results

16.2.1 JICA Study Option

The following 2 cases of the preliminary design (arch bridge) were conducted in the JICA Study:

- With using the navigation channel in the erection works of the main span
- Without using the navigation channel in the erection works of the main span

The summary of the preliminary design results of the arch bridge is shown in Table 16.1.

The “With” case was selected as the JICA Study option for the following reasons:

Construction Duration

In the “With” case, the navigation channel needs to be used one time (expected period: 13.5 hours) in the erection works of the arch rib; however, the construction duration can be shortened by 1 year in comparison to the “Without” case.

Initial Construction Cost

The initial construction cost of the “With” case can be reduced by about 3.2Bil.JPY (32Mil.USD) in comparison to the “Without” case due to the shorter construction period and the smaller scale of temporary structures used in the erection works of the arch rib.

Technical Risks (Erection Works)

In the “With” case, it is important to ensure safety in the erection works of the arch rib; however, the technical risks are expected to be minimized by applying mitigation measures (see Section 15.1.5(1)1)iii.).

16.2.2 Pre-F/S Option

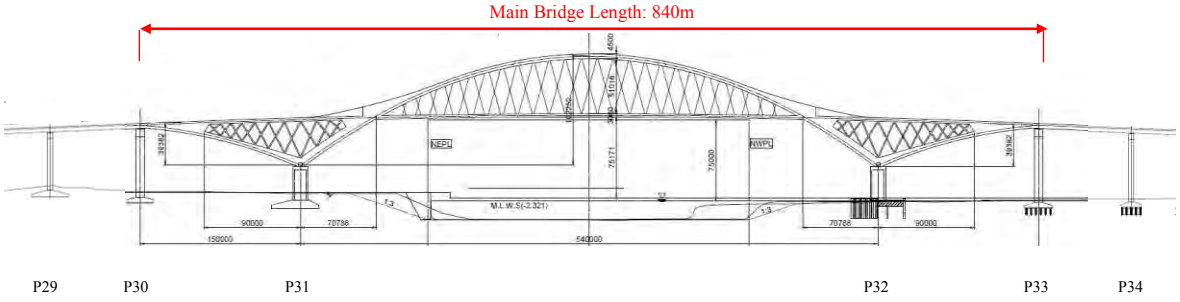
The preliminary design of the cable-stayed bridge was conducted in the Pre-F/S and its results are described in the Draft Final Report (November, 2013).

A summary of the preliminary design results of the cable-stayed bridge is shown in Table 16.2.

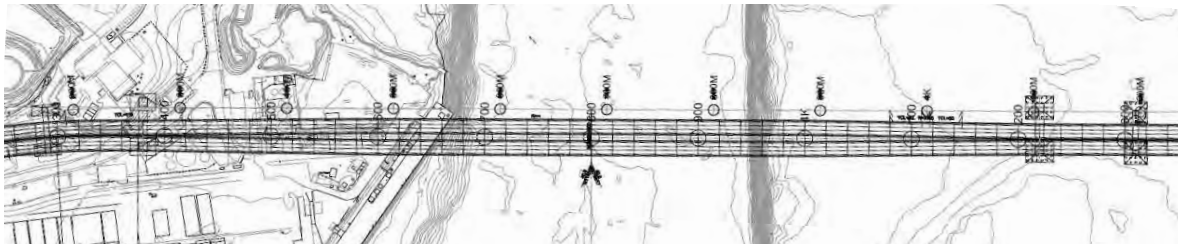
Table 16.1 Summary of Preliminary Design Results of Arch Bridge (JICA Study)

No.	Item		Preliminary Design Results	
			With Using Navigation Channel (Option by the JICA Study)	Without Using Navigation Channel
1	Bridge Length		840m	
2	Span Arrangement		150m+540m+150m	
3	Total Bridge Width		48.742m~52.872m	
4	Metro Line 3		Monorail (Width: 8.4m)	
5	Erection Method (Main Span)	Arch Rib	Lifting from Deck Barge	Cable Erection with Oblique Hang
		Stiffening Girder	Cantilever Erection (Slewing Jib-crane, Gantry)	
		Using Navigation Channel	1 time (expected 13.5 hours)	Not use
		Technical Risks	Refer to 15.1.5(1)1)c)	
6	Construction Duration		4 years	5 years
7	Initial Construction Cost (Civil Works (Bridge) only)		**To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.**	
8	Maintenance Cost (100 Years)		8.8 Bil.JPY (88 Mil.USD) (Discount Rate: 0%)	

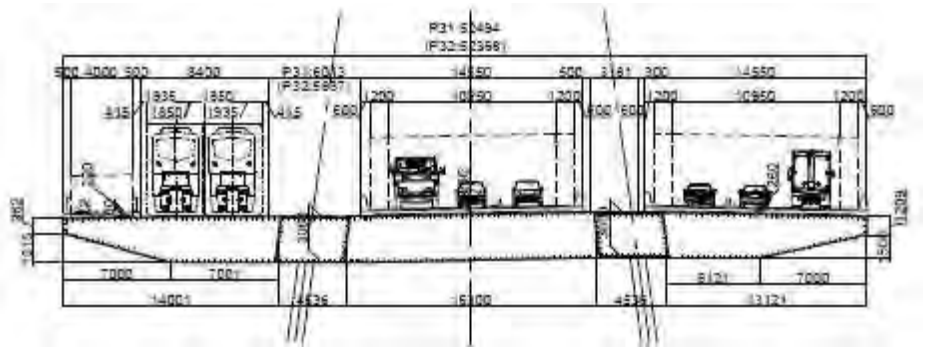
Side View



Plan



Cross Section (At Piers P31 and P32)

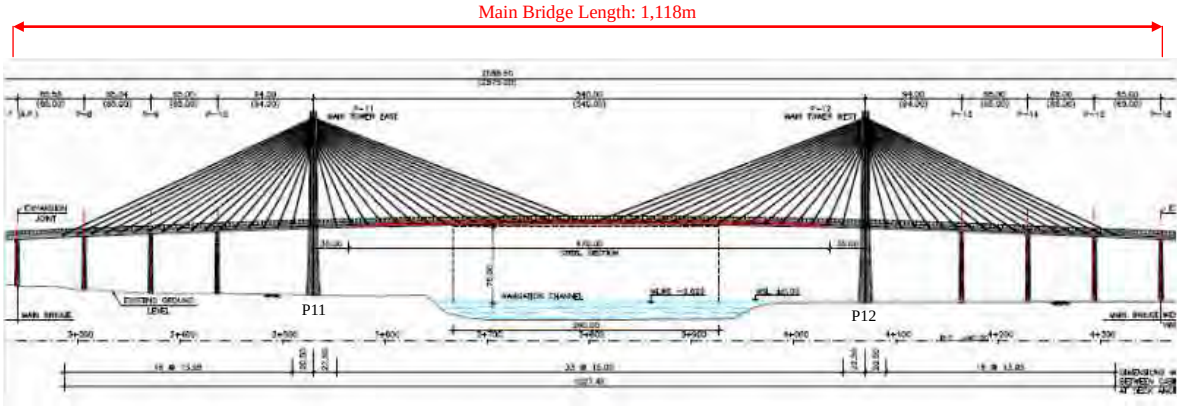


Source: JICA Study Team

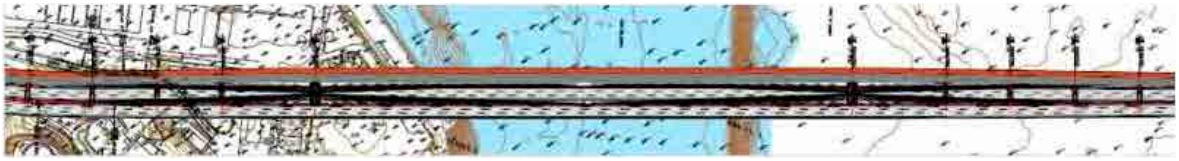
Table 16.2 Summary of Preliminary Design Results of Cable-stayed Bridge (Pre-F/S)

No.	Item		Preliminary Design Results
1	Bridge Length		1,118m
2	Span Arrangement		3@65m+94m+540m+94m+3@65m
3	Total Bridge Width		51.9m
4	Metro Line 3		Linear Metro (Width: 9m)
5	Erection Method (Main Span)	Erection Method	Cantilever Erection
		Using Navigation Channel	Not use
6	Construction Duration		4 years
7	Initial Construction Cost		**To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.** (Civil/E&M Works (Bridge), Track Beam/E&M Works (Metro Line 3)
8	Maintenance Cost (100 Years)		146 Mil.USD (14.6 Bil.JPY) (Discount Rate: 0%) (Civil/E&M Works (Bridge), Track Beam/E&M Works (Metro Line 3)

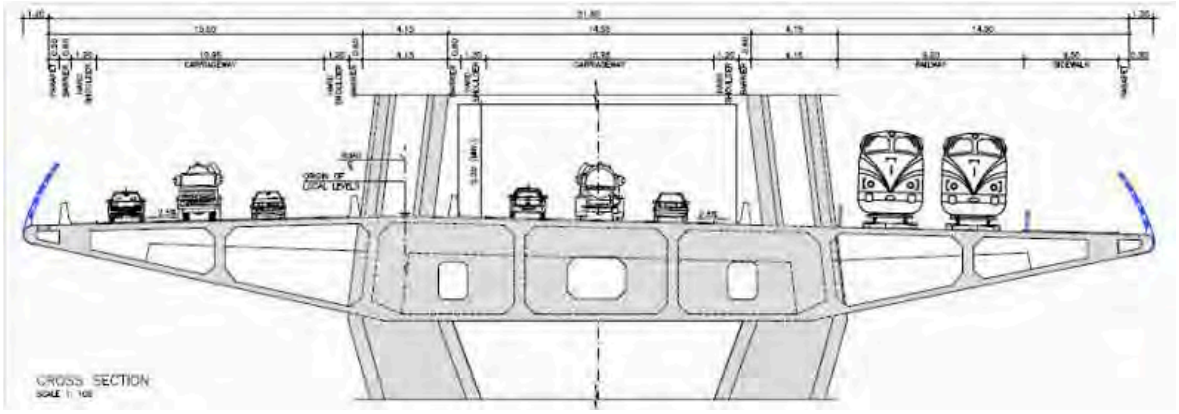
Side View



Plan



Cross Sections (At Pylons P11 and P12)



Source: ACP (Pre-F/S (Draft Final Report (November, 2013)))

16.3 Comparison Study between the Pre-F/S Option and the JICA Study Option

16.3.1 Study Method

Based on the screening result of the main bridge type for the 4th Panama Canal Bridge (see Section 10.1), a comparison study was made between the Pre-F/S option and the JICA study option in the following manner:

- Evaluation results, other than the cost item, were no different between the screening results and the preliminary designs; therefore, only the cost evaluation was updated.
- The cost evaluation was updated in accordance with the preliminary design results.
- The cost was included the risk cost for construction of main bridge in accordance with the risk analysis results conducted by Panama side.
- The cost was evaluated by life-cycle cost (discount rate: 4% (JICA's policy)).

(1) Adjustment of Comparison Conditions

The Draft Final Report of the Pre-F/S (Nov. 2013) was reviewed and some differences in the planning and design conditions were identified between the two Options (see Appendix 9).

Therefore, the following items were adjusted to make fair comparison under the same conditions:

JICA Study Option: Bridge Length

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Pre-F/S Option: Items in Initial Construction Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Pre-F/S Option: Effective Width

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Pre-F/S Option: Maintenance Item and Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

(2) Risk Cost

The risk analysis was conducted by the Panama side based on the erection plan of arch rib (main bridge of 4th Panama Canal Bridge) prepared by the JICA Study (see 15.1.5(1)1)d)).

The risk cost estimated in the risk analysis was included in this comparison study.

The risk cost (main bridge of 4th Panama Canal Bridge) is shown in Table 16.3.

Table 16.3 Risk Cost (Main Bridge of 4th Panama Canal Bridge)

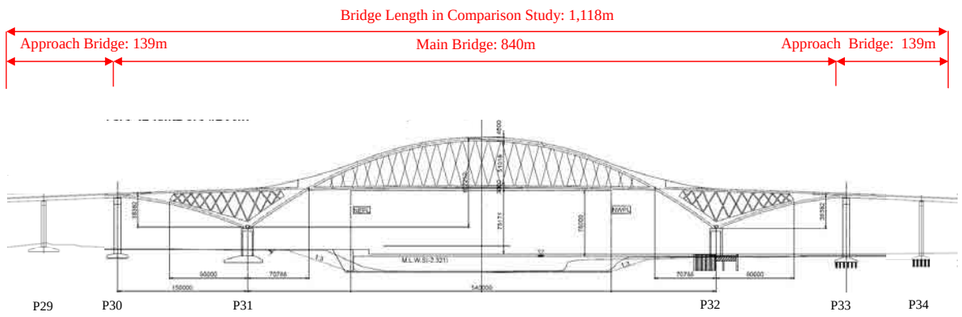
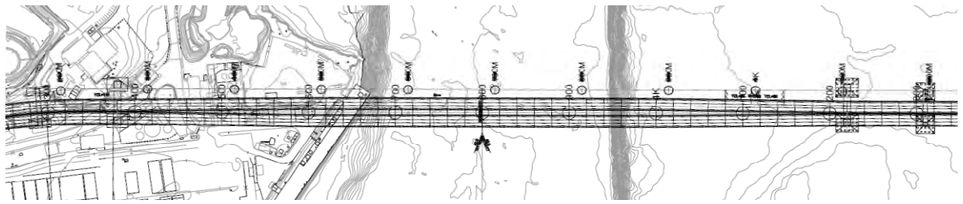
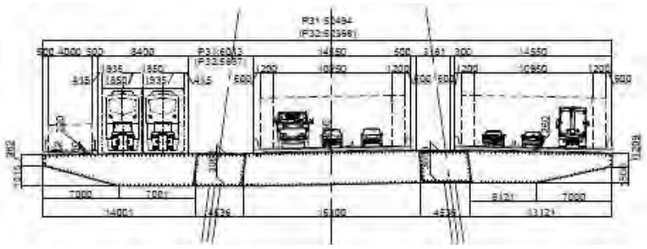
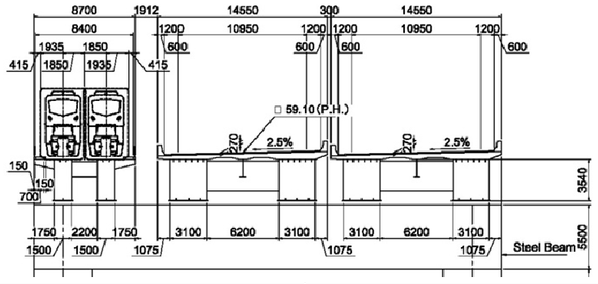
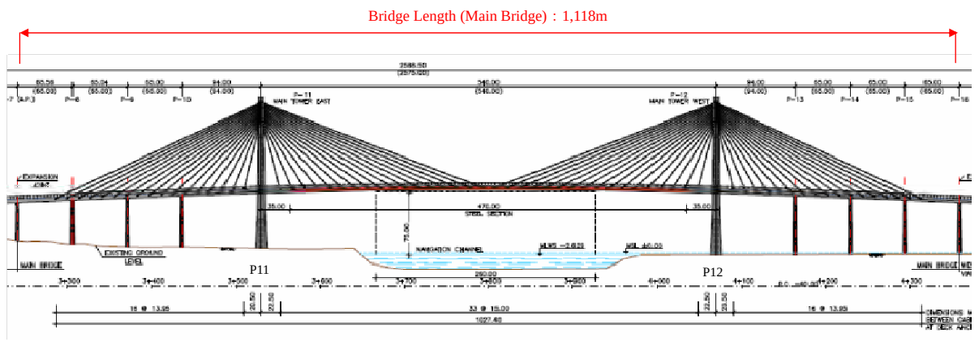
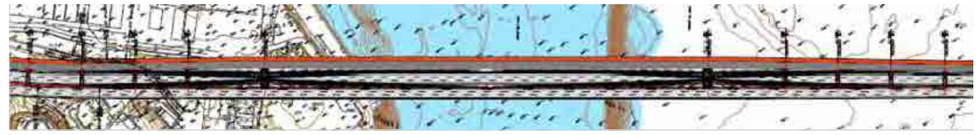
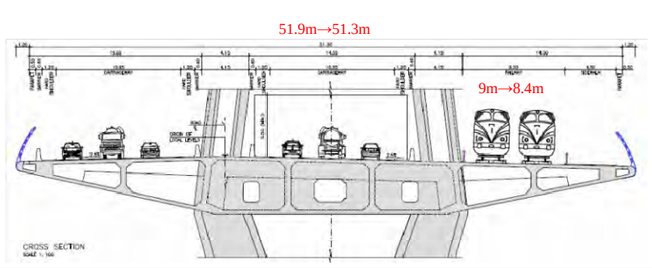
No.	Item		Risk Cost	
			Option by the Pre-F/S (Cable-stayed Bridge)	Option by the JICA Study (Arch Bridge) (Using Navigation Channel in Erection Works)
1	Cost for Closure of Pacific Approach	Direct Compansation Cost		1.9 Mil.USD
2	Channel and Special Prevention Measures	Standby Equipment, Test Simulation Cost		3.6 Mil.USD
3	Risk Contingency for Short Notice Postponement of Pacific Approach Channel Closure Date[1)]			0.4 Mil.USD
4	Insurance Premium for	CGL Insurance Premium[2)]		0.5 Mil.USD
5	for Rib Arch Segment Falling	ALOP Premium		0.4 Mil.USD
6		CEAR Insurance Premium	2.0 Mil.USD	2.1 Mil.USD
Total			2.0 Mil.USD	8.9 Mil.USD

Source: JICA Study Team
CGL: Comprehensive General Liability
ALOP: Delayed Start-Up
CEAR: Construction/Erection All Risks
1) Project Cost: 100%, Comparison of Main Bridge Type: 50%
2) Limit of Indemnity: Assumed 100 Mil.USD (practice in the 3rd Panama Canal Bridge) according to the discussion results on the Draft Final Report

(3) Options after Adjustment

The options after the adjustment made for comparison purpose are shown in Table 16.4.

Table 16.4 Options after Adjustment of Comparison Conditions

Item		Option by the JICA Study: Arch Bridge (Using Navigation Channel in Erection Works)	Option by Pre-F/S: Cable-stayed Bridge
General View		**Side View**  **Plan**  **Cross Section** Main Bridge (At P31 and P32 Piers)  Approach Bridge (At P29, P30, P33 and P34 Piers) 	**Side View**  **Plan**  **Cross Section** At P11 and P12 Pylons 
Bridge Length in Comparison Study		1,118m	1,118m
Span Arrangement		139m+150m+540m+150m+139m	3@65m+94m+540m+94m+3@65m
Total Bridge Width		Main Bridge: 48.742m~52.872m, Approach Bridge: 29.400m (at A6 Abutment) ~ 50.235m (at P30 Pier)	51.3m
Metro Line 3		Monorail (Width: 8.4m)	Linear Metro (Width: 8.4m)
Erection Method		Arch Rib: Lifting Erection, Stiffening Girder: Cantilever Erection (Slewing Jib-crane, Gantry), Approach Bridge: Large Block Erection	Cantilever Erection
Using Navigation Channel		Arch Rib: 1 Time (Expected 13.5 hours)	Not Use
Construction Duration		4 years	4 years
Initial Construction Cost	Const. Cost	**To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.**	
	Risk Cost		
	Total		
Maintenance Cost (100 Years)	DR = 0%	10.6 Bil.JPY (106 Mil.USD)	150 Mil.USD
	DR = 4%	1.6 Bil.JPY (16 Mil.USD)	24 Mil.USD
Life-cycle Cost	DR = 0%	**To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.**	
	DR = 4%		

Source: JICA Study Team
Exchange Rate: 1 USD = 99.7 JPY

16.3.2 Study Results

The life-cycle cost (discount rate = 4%) was evaluated by the following formula:

Score of Cost Evaluation = Weight - 2 * Weight * (Ratio – 1.0)

Ratio: Ratio to the Option of lower life-cycle cost (lower option: 1.0)

The comparison study results are shown in Table 16.5.

Table 16.5 Comparison Study Results

No.	Evaluation Item	Weight (Points)	JICA Study Option	Pre-F/S Option
			Arch Bridge (With Using Navigation Channel)	Cable-stayed Bridge (Without Using Navigation Channel)
1	Structure	25	16.00	15.00
2	Constructability	13	9.00	8.80
3	Maintainability	15	11.00	11.00
4	Landscaping	14	12.60	6.40
5	Cost	33	32.54	33.00
Total		**100**	**81.14**	**74.20**

Source: JICA Study Team

16.4 Conclusion

The following 2 cases of the preliminary design (arch bridge) were conducted in the JICA Study:

- With using the navigation channel in the erection works of the main span
- Without using the navigation channel in the erection works of the main span

The “With” case has an advantage to the “Without” case in construction duration and initial construction cost. On the other hand, it is important to ensure safety in the erection works of the arch rib; however, the technical risks are expected to be minimized by applying mitigation measures. Therefore, the JICA Study Option selected the “With” case.

Based on the screening result for the main bridge type of the 4th Panama Canal Bridge (see Section 10.1), a comparison study was made between the Pre-F/S Option and the JICA study Option, and the JICA Study Option (81.14 points) exceeded the Pre-F/S Option (74.20 points).

In addition to the screening results, the arch bridge has advantages to the cable-stayed bridge in the point of rigid structure and distinctive architectural features; therefore, the JICA Study Team recommends the JICA Study Option as the optimum main bridge type for the 4th Panama Canal Bridge.

“With” case is not approved yet by ACP at the time and it is necessary to obtain the approval based on this Draft Final Report.

Chapter 17 Implementation Plan

17.1 Project Components

The Project for the 4th Panama Canal Bridge consists of the following components:

- Procurement of the Consultant
- Detailed Design and Construction Supervision
- Land Acquisition and Compensation
- Relocation of Public Utilities and Underground Utilities
- Procurement of the Construction Contractor
- Construction (Except Additional Ramp X in West Area)
- Defects Liability
- Operation and Maintenance

17.1.1 Scope of Construction Works

Table 17.1 shows the scope of the construction works.

Table 17.1 Scope of Construction Works

No.	Route	Segment		Item	Description
1	4th Panama Canal Bridge (Construction)	Whole segment			Road Length: 6,720.212m (-KM0+020.975 to KM6+699.237) No. of Lanes: 6 lanes (2*3 lanes) (BP～Omar Torrijos Roundabout: 4 lanes (2*2 lanes)) Metro Line-3: South Side (Combined Section: 2,183m (KM2+847(A5) to KM5+030(P44)))
		Break-down	Civil	East Approach Road (-0+020.975～2+847)	Road Length: 2,867.975m Flyover No.1: PC-I/Steel Box (L=520m) Flyover No.2: PC-I/Steel Box (L=740m)
				4th Panama Canal Bridge (2+847～5+390)	Road Length: 2,543m East Approach Viaduct: Steel Box (L=533m) Main Bridge: Steel Arch (L=840m) West Approach Viaduct: Steel Box/PC-I (1,170m)
				West Approach Road (5+390～6+699.237)	Road Length: 1,309.237m
			Utilities	Whole Section	Electrical, communication and mechanical facilities
2	East Side Connection Road (Construction)	Whole segment			Road Length: 1,025.19m No. of Lanes: 1 way, 2 lanes
		Break-down	Civil	Additional Ramps	On Ramp: 400.2m Off Ramp: 624.99m
			Utilities	Whole Section	Electrical facilities (road lighting)
3	Access Roads to the Bridge of the Americas (Reconstruction)	Whole segment			Road Length: 3,170.4m Nos of Lanes: 4 lanes (2*2 lanes)
		Break-down	Civil	East, to Panama City	Road Length: 1,582.4m Access bridge to the Bridge of the Americas: PC-I (760m)
				West, to Arraijan	Road Length: 1,588m
			Utilities	Whole Section	Electrical facilities (road lighting)
4	Omar Torrijos Roundabout (Improvement)	Whole segment			Road Length: 5,690m No. of Lanes (Additional Ramp): 1 way, 1 or 2 lanes No. of Lanes (Underpass): 4 lanes (2*2 lanes)
		Break-down	Civil	Additional Ramps	Additional Ramp: Additional ramps A to I, Omar Torrijos Road Flyover: Additional ramps B, C (partial)[1)] Widening of Flyover No.2: Additional ramps F and G (partial)[1)] Underpass: Additional ramps F and G, Omar Torrijos Road
				Existing Roundabout	Widening of existing roundabout
			Utilities	Whole Section	Electrical facilities (road lighting)
				Add. Ramps F, G, Omar Torrijos Rd.	Mechanical facilities (drainage pump)
5	West Side Additional Ramps[2)] (Reconstruction)	Whole segment			Road Length: 1,130m No. of Lanes: 1 way 2 lanes
		Break-down	Civil	Additional Ramps	Additional Ramp: Additional ramp Y and ramps a to i
			Utilities	Whole Section	Electrical facilities (road lighting)

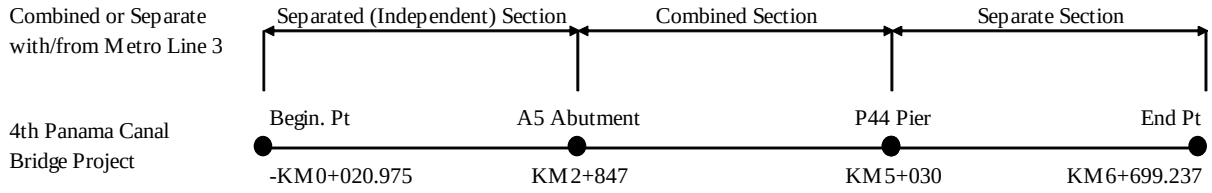
1) Assumption
2) Except Additional Ramp X (For the future)
Source: JICA Study Team

17.1.2 Relocation of Existing Utilities

The relocation of existing utilities is essential and necessary for construction in urban areas, especially on the east side of the 4th Panama Canal Bridge. Accordingly, all relocation works are planned to be completed before the commencement of construction works.

17.2 Demarcation between Metro Line-3 and 4th Panama Canal Bridge

As the alignment of the 4th Panama Canal Bridge runs parallel to that of Metro Line-3, the structures for some stretches of the road will carry both the Line-3 tracks and the carriageway of the 4th Panama Canal Bridge. The following diagram and chart were made to establish a clear demarcation between the two projects.



Civil Works	Independent	4th Panama Canal Bridge Project	Independent
Civil Works (Rail)	Metro Line 3 Project		
Utilities	Independent		
Land Acquisition/ Compensation	4th Panama Canal Bridge Project		
Relocation Works of Existing Utilities	4th Panama Canal Bridge Project		

A5 Abutment and P44 Pier: Included 4th Panama Canal Bridge Project
Source: JICA Study Team

Figure 17.1 Demarcation between the two Projects (Metro Line-3 Project, 4th Panama Canal Bridge Project)

17.3 Fund Procurement Plan

The following fund procurement plan was assumed in this Study:

- Japanese Yen Loan: 70% of Total Project Cost
- Panamanian State Budget: 30% of Total Project Cost

The ceiling of Japanese Yen Loan was assumed 70% of Total Project Cost in the above fund procurement plan and it will be finalized between the Government of Panama and JICA during the appraisal stage.

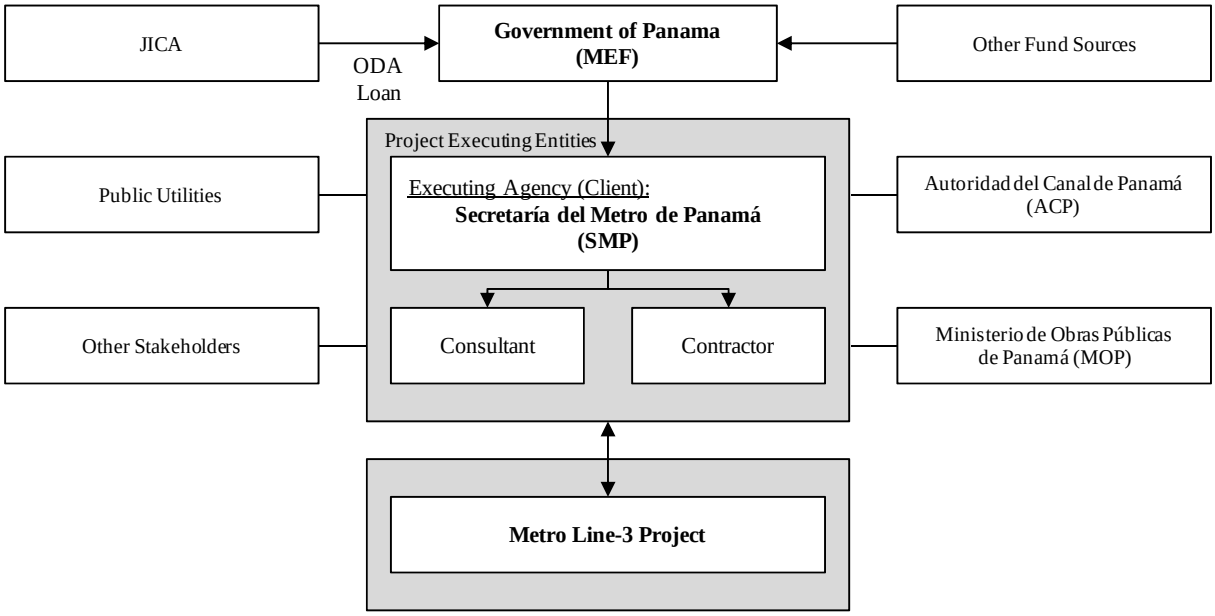
17.4 Project Implementation Structure

17.4.1 Project Implementation Organizations

It was assumed that the executing agency (the Client: SMP) shall procure the consultant for design and construction supervision, and shall procure the construction contractor(s) through a traditional contract where the detailed design is prepared by the Client following the outcomes of the consultation. As explained in previous chapters, ACP will collaborate with SMP to analyze the impacts and risks from using the navigation channel in the implementation stage. In addition, MOP, which prepares the design standards and guidelines in Panama, shall collaborate with SMP during the Project.

In the implementation stage of the Project, stakeholders such as the institutions in charge of the overhead cables and underground utilities, ACP, port companies and transport operators will become involved. Moreover, the implementation of the Metro Line-3 Project needs to progress in parallel with the 4th Panama Canal Bridge Project, as such, close coordination between the two projects will be very important.

The organizational scheme for the implementation of the Project is shown in Figure 17.2.



Source: JICA Study Team

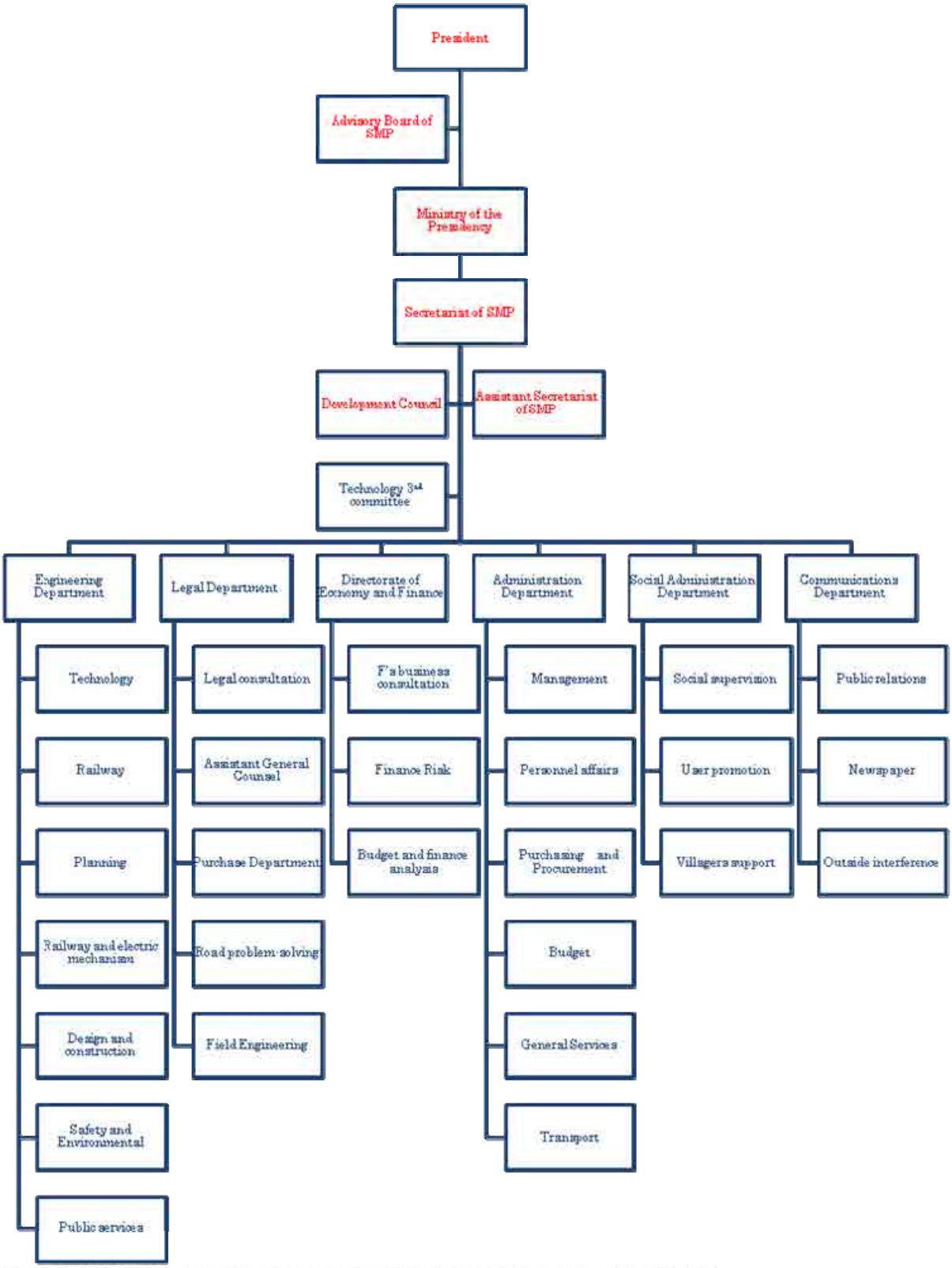
Figure 17.2 Project Implementation Scheme

17.4.2 Financial and Budgetary Status and Technical Level of the Executing Agency

(1) Organizational Structure of SMP

The executing agency of Metro Line-3 Project is SMP, which is also the executing agency of the 4th Panama Canal Bridge Project. SMP, as the Client, along with the consultant and the contractor(s), will have to organize the implementation scheme. It should be noted that in 2014, SMP will be transferred to a limited liability state company, called “Metro de Panama S.A.”.

Figure 17.3 shows the organizational chart of SMP.



Note: Red character shows management division, Blue one shows operation division
Source: Study Team referring to material of SMP web site

Source: JICA Study Team taken from the SMP website

Figure 17.3 Organization of SMP

(2) Financial and Budgetary Status

The Ministry of the Presidency of Panama controls SMP and two other organizations together in its general accounting budget management. The Study Team could not obtain separate data regarding the financial and budgetary status of SMP.

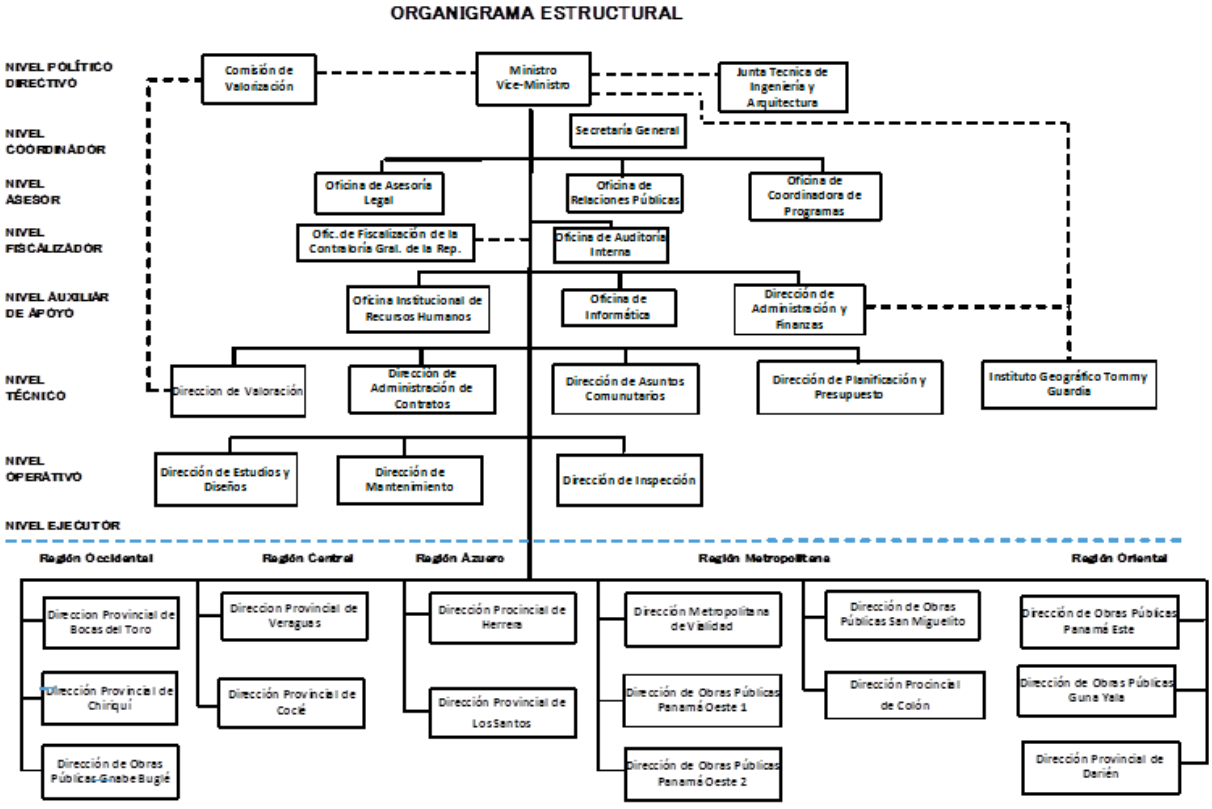
(3) Technical Level

The Bridge of the Americas is built as a braced-rib arch, the 2nd Panama Canal Bridge, the Centenario bridge, is built as a PC cable-stayed girder, and now the construction of the 3rd Panama Canal Bridge is underway by ACP. Accordingly, the technical level of bridge engineering is regarded to be high.

17.4.3 Financial and Budgetary Status and Technical Level of the Maintenance Agency

(1) Organizational Structure of MOP

As with the Bridge of Americas and the 2nd Bridge, or the Centenario Bridge, the Maintenance Department of MOP (Ministry of Public Works of Panama） will be responsible for the future maintenance of the 4th Panama Canal Bridge.



Source: JICA Study Team taken from the MOP website

Figure 17.4 Organization of MOP

(2) Financial and Budgetary Status

In order to keep the urban road networks as well as intra urban highways in good conditions, the following works are scheduled for the short term:

- A road construction program is scheduled to cover 2,500 miles (4,000km) of the inter-city road network, which represents a USD45 billion investment.
- Maintenance of about 200 miles (320km) of the inter-city road network for a total cost of USD28 million.
- Restoration of the intra-urban roads, where MOP plans to invest USD25 million in surface repaving.
- Maintenance work for cleaning side ditches and drainage systems, clearing roads, maintenance and re-painting of bridges, among other works.

(3) Technical Level of MOP

At present, the Maintenance Department of MOP has 2,000 staff and 1,340 units of light and heavy equipment with which it conducts maintenance on the following structures:

- 7,000km. of Urban Road Network (streets)
- 15,000km. of Inter City Road Network (roads)
- 1,800 Vehicular Bridges
- 214 Pedestrian Bridges

MOP provides construction and maintenance works to the above roads in Panama. These works has been carried out by private company through public tender. The company that constructs the works should carry out their maintenance for a period of two to three years after their completion. Therefore, the technical level of maintenance companies is regarded to be high through the technical transferring by the construction contractors. In addition, MOP's performance in maintaining the Bridge of the Americas and the Centenario Bridge is well and gives it a technical level high enough to maintain the completed 4th Panama Canal Bridge in the future.

17.5 Procurement Plan

17.5.1 Procurement of the Consultant

(1) Procurement Method

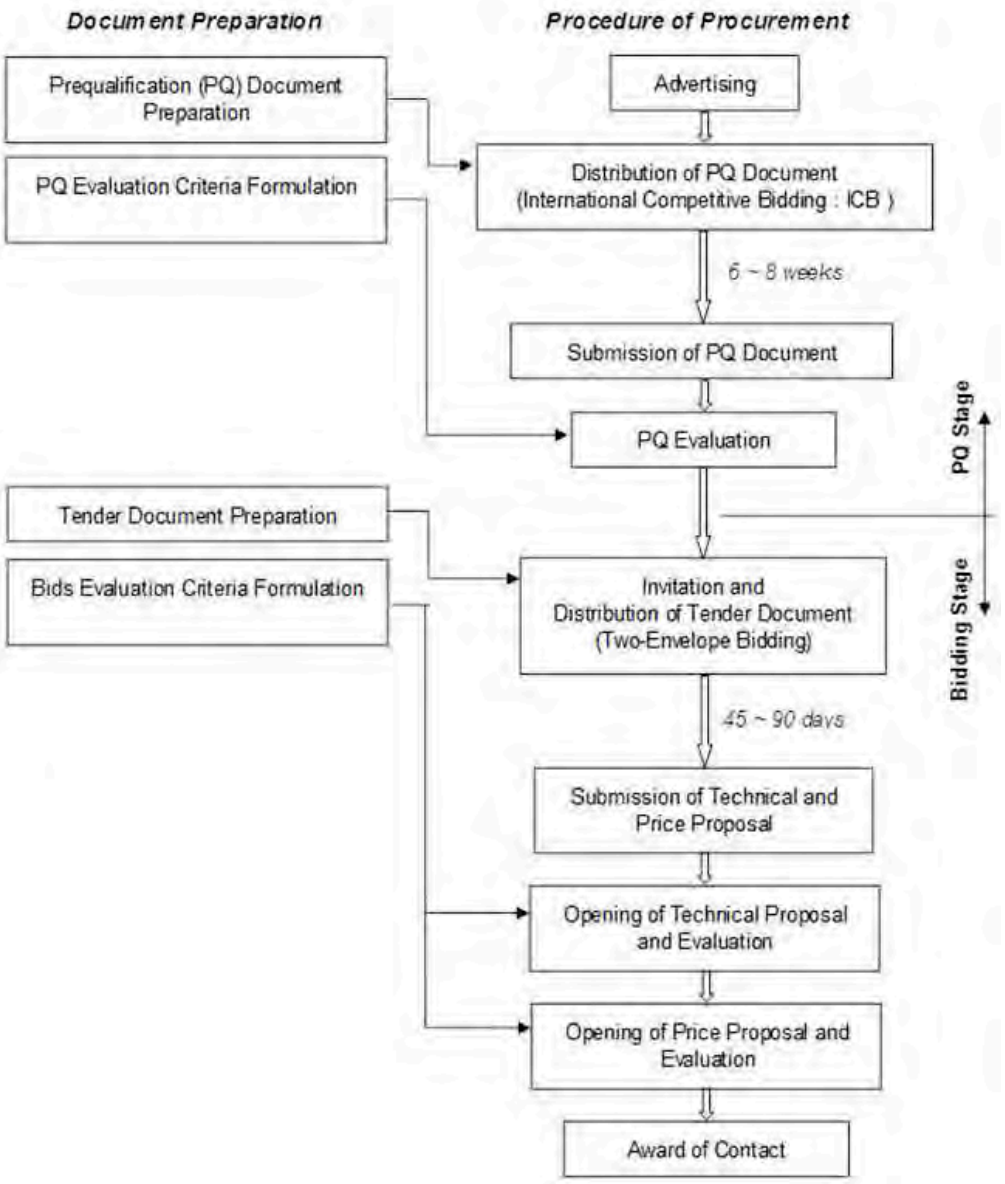
Design-build scheme will be applied in the Metro Line-3 Project (see Section 8); therefore, the detailed design works in the 4th Panama Canal Bridge shall be conducted by a consultant in consideration adjustment between two projects.

Although the implementation of the Project will progress in parallel with the Metro Line 3 Project, the bridge deck works of the Project need to be completed before work can begin on the installation of the beams and signal system of Metro Line-3.

The adjustment between two projects is not easy; therefore, the consultant services include both the detailed design and construction supervision. Accordingly, the procurement plan considers a single procurement for the consultant services.

An International Competitive Bidding (ICB) is recommended according to the JICA Procurement Guideline taking into consideration the size and engineering level of the Project.

Figure 17.5 shows an example of an ICB procurement following JICA Guideline.



Source: JICA Study Team

Figure 17.5 Example of an ICB Procurement following the JICA Guideline

(2) Scope of Consultant Services

- Detailed Design (Structural Analyses, Design, Preparation of Drawings, Quantity Calculation, Preparation of Technical Specifications, Construction Planning, Cost Estimate), Pre-qualification Document Preparation, Bid Document Preparation: 18 months
- Pre-construction Stage Services including assistance to the Client for Procurement of Construction Contractor(s) (Pre-qualification Assistance, Bid Assistance, Contracting Assistance, etc.): 15 months, 5 months overlap with the above Detailed Design
- Construction Supervision (Inspection and Recording of Quality Assurance/Control, Inspection and Recording of Work Progress, Inspection and Recording of the Completion of Facilities, Checking of Safety): 48 months (Arch-Rib Lifting Method), 60 months (Cable Erection Method)
- Defects Liability Inspection (1 Year): 12 months

17.5.2 Procurement of the Construction Contractor(s)

(1) Procurement Method

Procurement of contractor is recommended to apply an ICB procedure without pre qualification in order to perform efficient procurement procedures. The bidders should be submitted qualification documents, technical bids and financial bids simultaneously.

(2) Scope of the Construction Contractor(s)

- Construction of Facilities based on the Contract Documents, (Quality Assurance/Control, Work Progress Control, Control and Management of Physical and Monetary Progress, Safety Control): 48 months (Arch-Rib Lifting Method), 60 months (Cable Erection Method)
- Defects Liability (1 year): 12 months

17.6 Implementation Schedule of the 4th Panama Canal Bridge Project

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

17.7 Other Items to be Implicated

(1) Ownership and Responsibility of Future Maintenance

Although the Project Costs between Metro Line-3 and 4th Panama Canal Bridge should correspond to the Sub-Section “17.1.1 Scope of the Project” and Section “17.2 Demarcation between Metro Line-3 and 4th Panama Canal Bridge”, ACP will be the owner of the bridge and responsible for its future maintenance, and Metro Line-3 will be entitled to use the bridge infrastructure free-of-charge for its operation.

The future maintenance of facilities other than the 4th Panama Canal Bridge should be conducted as already discussed in “Chapter 14: Operation and Maintenance Plan”.

(2) Approval of EIA Report

During this feasibility study, the JICA Study Team supported SMP in carrying out the EIA studies and preparing the draft EIA report, in accordance with the Panamanian legal framework and JICA’s Guidelines for Environmental and Social Considerations (2010).

In the months ahead, ANAM will review the EIA report. It should be noted by all parties that if ANAM requires any additional work, report revisions, or other conditions for approval of the EIA report, the Panamanian Government will be responsible for complying with ANAM and carrying out any additional work.

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Figure 17.6 Project Implementation Schedule for the Case of "Using" the Navigation Channel (Arch-Rib Lifting Method)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Figure 17.7 Project Implementation Schedule for the Case of "Without" Using the Navigation Channel (Cable Erection Method)

Chapter 18 Project Impacts

18.1 Greenhouse Gas Emissions Reductions

18.1.1 Methodology

The Line-3 Project will reduce CO_2 emissions by reducing the number of vehicles used for passenger transport, and will increase CO_2 emissions from power plants by using electricity for the Line-3 operation. Since the former reduction volume is larger than the latter, the Line-3 Project will reduce CO_2 emissions in total.

To estimate the volume of the CO_2 reductions by the Project, JICA Climate Finance Impact Tool for Mitigation (JICA-FIT) was used in the Study. The JICA-FIT covers various infrastructure projects, containing methodology and calculation sheets for 25 subsectors, and one of which is for LRT and monorail systems.

The basic formula for the calculation of the CO_2 emissions from mass transit project in JICA-FIT is:

$$ER_y = BE_y - PE_y \ (t\text{-}CO_2/y)$$

$$BE_y = \sum_i \left(BPKM_y \times MS_{i,y} \times EF_{PKM,i}\right) = \sum_i \left(P_y \times BTDP_y \times MS_{i,y} \times EF_{PKM,i}\right)$$

$$PE_y = EC_{PJ,y} \times EF_{elec}$$

where,

ERy :	GHG emissions reduction due to project activity in year y (t-CO_2e/y) *
BEy :	GHG emissions with existing transport systems in year y (t-CO_2e/y) (Baseline emissions)
PEy :	GHG emissions after the success of modal shift to the mass transit from the existing transport systems in year y (t-CO_2e/y) (Project emissions)
$EF_{PKM,i}$:	CO_2 emission factor per passenger for vehicle category i (gr-CO_2/passenger)
$BPKM_y$:	Passenger-km of the mass transit in year y (passenger-km/year)
$MS_{i,y}$:	Modal share of transport mode i in year y (%)
$EF_{PKM,i}$:	Annual number of passengers transported by vehicle category i
$EC_{PJ,y}$:	Total annual electricity consumption of the mass transit after the project has completed (kWh/y)
EF_{elec} :	CO_2 emission factor of electricity (t-CO_2/kWh)

*: CO_2e = Equivalent Carbon Dioxide

Although JICA-FIT states that “official values” in the country or the city, if available, should be used for the emission rate (g-CO_2/passenger or g-CO_2/km or g-CO_2/L), there is no official value for these rates, so the emission rates are estimated in this study.

As described in JICA-FIT, “carbon leakage” such as energy consumption from rolling stock manufacturing and transportation of construction materials need not to be considered in the calculation because the amount of GHG emission by carbon leakage is very small compared to the reduction in GHG in case of mass transit project.

18.1.2 Base Line Emissions

(1) Fuel Consumptions

According to an ATTT's study in 2009, the fuel consumption rate of "Dablo Rojo" was calculated at 7.81 kilometers per gallon (2.06 km/litter or 0.485litter/km). The fuel efficiency of Metrobus fleet is only 6.8km/gallon (1.8km/L) due to traffic congestion (SMP). On the other hand, the fuel efficiency of modern bus is approximately 4.6km/L[1]. In the Study, it was assumed that the fuel consumption rate of buses will become the latter one due to the modernization of bus fleet.

Passenger cars for private use in Panama consist of imported cars from Japan, United States, Korea, Thailand, and other countries. Although used cars account for a large part of the imported cars, fuel consumption rate of cars in Panama is not different from that of developed countries because Japan and United States are the major countries for the import and car age is not so old. It is observed that small size cars (compact cars) account for a large share on the streets in Panama, which is similar to Japanese car market. The actual fuel consumption rate in Japan is approximately 10km/litter, which is calculated from energy statistics and transportation statistics. Since this is the average rate in Japan, the fuel consumption rate in urbanized area is expected to be lower than the rate. On the other hand, the actual fuel consumption rate in Panama cannot be calculated because statistics of vehicle-kilometers is not available. In this study, the fuel consumption rate for private passenger cars is assumed to be 7 km/litter.

Table 18.1 Fuel Consumption Rate

Unit	Car	Diablo Rojo	Metrobus/ Other buses
km/L	7 km/L	2.06 km/L	4.6 km/L
litter/km	0.143 litter/km	0.485 litter/km	0.217 litter/km

Source: ATTT's study and JICA Study Team

(2) CO_2 Emissions per Fuel Consumption

CO_2 emission rates of vehicles were calculated using assumptions on energy characteristics of diesel and gasoline as shown in Table 18.2. The calculated CO_2 emission rates are 0.232 kg-CO_2/km for cars, 1.25 for "Diablo Rojos", and 0.56 for other buses.

Table 18.2 CO_2 Emission Rate

	Energy density (MJ/L) * (a)	Carbon emission rate (kg-C/MJ) * (b)	CO_2 emission rate (per MJ) (kg-CO_2/MJ) (c)=(b)*44/12	CO_2 emission rate (per L) (kg-CO_2/L) (d)=(a)*(c)	CO_2 emission rate (per km) kg-CO_2/km
Gasoline	34.6	0.0183	0.0671	2.32	0.331 (car)
Diesel	37.7	0.0187	0.0686	2.58	1.25 (Diablo Rojo) 0.560 (Other buses)

Source: * Order of Law Concerning the Promotion of the Measures to Cope with Global Warning, Japan (2010)

Since JICA-FIT uses the emission rate in terms of t-CO_2/passenger-km, the above values are converted by applying the vehicle occupancy rate of 1.5 for cars and 35.9 for buses. The result of the calculation is: 221 g-CO_2/passenger-km for car, 34.8 for Diablo Rojo, and 15.6 for other buses.

[1] Best Operational Practices for City Bus Fleets to Maximize Fuel Economy, Energy Sector Management Assistance Program, World Bank 2010

(3) Baseline Traffic and Emission

The baseline traffics for with and without cases are calculated in Chapter 4. In the demand forecast, the share of "Diablo Rojo" to buses is not estimated because the difference between "Diablo Rojo" and other types of buses is not used in the demand forecast model. However, as seen in Table 18.2, the difference in the CO_2 emission rate between "Diablo Rojo" and other buses is large.

In Panama City, most of "Diablo Rojos" have been replaced with Metrobus vehicles, while "Diablo Rojo" is the dominant bus in Ararijan and La Chorrera Districts. It is expected that the number of "Diablo Rojos" will gradually decrease as the number of modern type buses increases. However, it is expected that "Diablo Rojos" will remain in 2022 when Line-3 is planned to start its operation. On the other hand, if some bus improvement programs such as the introduction of Metrobus in Panama City are done, "Diablo Rojos" would disappear in short periods. This study assumes the proportion of "Diablo Rojos" in buses as shown in Table 18.3. It is assumed that "Diablo Rojos" will disappear after 2030.

Table 18.3 Share of "Diablo Rojo"

2020	2025	2030	2035	2040	2045	2050
50%	25%	0%	0%	0%	0%	0%

Source: Assumption by JICA Study Team

In JICA-FIT, the "baseline traffic" is calculated in terms of passenger-km of the mass transit system. The necessary data are calculated in Chapter 3 and summarized in Table 18.4. The baseline CO_2 emission is calculated as shown in the table.

Table 18.4 Passenger-km and Modal Share for Baseline Traffic Calculation

Year		2020	2025	2030	2035	2040	2045	2050	
No. of passengers per year (million)		54.11	59.08	62.67	66.15	68.93	71.81	72.88	P_y
Average travel distance (km)		19.36	19.22	19.06	18.93	18.83	18.74	18.67	$BTDP_y$
Passenger-km per year (million)		1,048	1,136	1,195	1,252	1,298	1,346	1,361	$BPKM_y$
Modal Share	Diablo Rojo	45	45	0	0	0	0	0	MS_{1y}
	Bus	45	45	90	90	90	90	90	MS_{2y}
	Car	10	10	10	10	10	10	10	MS_{3y}
t-CO_2 per year		40,000	43,355	35,287	36,991	38,342	39,754	40,194	BE_y

Source: JICA Study Team

18.1.3 Project Emissions

(1) CO_2 Emission Factor of Electricity

The emission factor of electricity in Panama was estimated by IDB in 2008 for Clean Development Mechanism (CDM) based on AMC0002 Version 9 (Consolidated baseline methodology for grid-connected electricity generation from renewable sources). The report is available in the web page of the Secretary of National Electricity.

There are two kinds of emission factor in the baseline scenario for grid-connected renewable power plant projects. Emission Factor of Build Margin, which is calculated from recently constructed power plants, is used to estimate the future emissions from power plants which will be constructed in the future. This is applied to the calculation of the reduction in emissions by renewable power plant projects. Emission Factor of Operating Margin, which

is calculated from existing power plants, is used to evaluate the short term impact of renewable power plant projects. For the Line-3 project, increase in CO_2 emission from using electricity should be calculated, and identification of which power plants are used for the Line-3 operation is not necessary. Therefore, Emission Factor of Build Margin cannot be used. In addition, since hydro power is excluded from the calculation because of the evaluation method of renewable sources, Emission Factor of Operating Margin in the above repot cannot be used.

There is another estimation of the emission factor relating to CDM scheme in Panama. In "CEMEX Panama: Bayano cement plant Alternative fuels project", the emission factor of Operating Margin are calculated from the estimation of the total CO_2 emission and the total power generation. CO_2 Emission Factor was calculated by averaging three years (2005, 2006, and 2007) factors (t-CO_2/GWh). Table 18.5 shows the calculation of CO_2 Emission Factor applying the same method in the project to recent updated statistics. Taking three years (2009, 2010, and 2011), the CO_2 Emission Factor is calculated at **238.4 t-CO_2/GWh.**

Table 18.5 Calculation of CO_2 Emission Factor

		2006	2007	2008	2009	2010	2011
Bunker (000 Gallon)	(a)	103,902	96,794	86,938	112,592	110,586	103,716
Bunker, isolation (000 Gallon)	(b)	856	931	1,057	1,221	1,188	1,602
Bunker total (000 Gallon)	(c)	104,758	97,725	87,995	113,813	111,774	105,318
Diesel (000 Gallon)	(d)	15,175	44,671	31,619	34,352	50,405	67,590
Bunker (000 kg)	(e)	356,858	332,900	299,755	387,704	380,758	358,766
Diesel (000 kg)	(f)	51,694	152,172	107,710	117,020	171,705	230,245
Emission-Bunker (tCO2)	(g)	1,115,881	1,040,966	937,322	1,212,335	1,190,615	1,121,846
Emission-Diesel (tCO2)	(h)	164,711	484,865	343,197	372,861	547,102	733,631
Emission-Total (tCO2)	(i)	1,280,593	1,525,831	1,280,519	1,585,196	1,737,718	1,855,477
Generation (GWh)	(j)	5,910.3	6,325.0	6,313.0	6,784.5	7,258.4	7,658.4
tCO2/GWh	(k)	216.7	241.2	202.8	233.6	239.4	242.3

Note: (c)=(a)+(b)
(e)=(c)*0.9kg/L*3.785L/gallon, (f)=(d)*0.9kg/L*3.785L/gallon
(g)=(e)*40.4TJ/Gg*77.4tCO2/TJ*0.001, (h)=(f)*43TJ/Gg*74.1tCO2/TJ*0.001, (i)=(g)+(h)
(k)=(i)/(j)

(2) Electricity Consumption and CO_2 Emission by the Project

The electricity consumption by the Project is estimated in the operation and maintenance plan in Chapter 8. Traction power and station operation are the source of the electricity consumption by the Project. The project will consume 70.7 GWh in 2020, 73.6 GWh in 2035, and 77.2 GWh in 2050.

From the projection of the electricity consumption, CO_2 emission by the Project was estimated as shown in Table 18.6. The increase in CO_2 emission by the Project will be 16,845 t-CO_2 in 2025, 17,545 in 2035, and 18,415 in 2050.

Table 18.6 CO_2 Emission by the Project

Year	2020	2025	2030	2035	2040	2045	2050
MWh/y	67,158	70,658	73,334	73,594	73,594	75,438	77,244
GWh/year	67.2	70.7	73.3	73.6	73.6	75.4	77.2
t-CO_2/year	16,010	16,845	17,483	17,545	17,545	17,984	18,415

Source: JICA Study Team

18.1.4 Reduction in CO_2 Emission

Reduction in CO_2 emission was calculated from Table 18.4 and Table 18.6.

Table 18.7 CO_2 Reduction by the Project

Year	2020	2025	2030	2035	2040	2045	2050
t-CO_2/year	23,989	26,510	17,804	19,446	20,798	21,770	21,779

Source: JICA Study Team

18.2 Operation and Effect Indicators

Operation indicators are numerical values to monitor whether or not (or how much degree) 4th Bridge and Line-3 developed in the Project are operated as expected in the project plan. On the other hand, effect indicators are used to monitor whether or not (or how much degree) the Project achieves its purpose. These indicators will be evaluated few years after the transport system starts its operation. Operation and effect indicators should be measurable values, and their validity, reliability and accessibility are important for the monitoring.

In this study, 4th Bridge is assumed to open in 2022 and Line-3 is assumed to start its operation in the same year, and indicators for the ex-post evaluation in 2025 (3 years after the operation start) were identified.

18.2.1 Operation Indicators

The operation indicator of the 4th Bridge Project is the daily traffic of the bridge. Since the peak hour traffic is used for the decision of the number of lanes and the traffic of heavy vehicles is used for the decision of the depth of the pavement, these data are also employed for operation indicators.

Since the basic operation indicators are passenger transport volume and operation volume of trains, the average number of passengers per day and the average train-kilometers per day were employed, respectively. Rolling stock operating rate was also employed to evaluate whether the rolling stock purchased in the Project is sufficiently used. Because of the importance of transport service for the peak hour commuter demand, the capacity in peak hours is necessary for the operation indicators, and the number of trains in the peak hour was employed for this. Although the average number of train operations per day can be a operation indicator for the density of transport services, it was excluded because it can be calculated by dividing train-kilometers by the route length. The table below shows the operation indicators proposed in the Study.

Table 18.8 Operation Indicators

Project	Purpose of Indicators	Indicator	Target (2025)
Bridge	Traffic	Daily traffic	34,700
	Peak hour traffic	Peak hour traffic for the peak direction	1,800
	Heavy vehicle traffic	Daily traffic of heavy vehicles	1,300
Line-3	Transport Volume	No. of passengers per day	172,200
	Total amount of services provided	Train-km per day	9,719
	Peak hour capacity	No. of train operations in the peak hour	19
	Efficient use of rolling stock	Rolling stock operating rate *1	90%

*1: Cumulative operating days per year per train /361 (average inspection days=4 days/year)
Source: JICA Study Team

18.2.2 Effect Indicators

The Project is expected to generate effects such as tourism and regional development as described in 10.3, in addition to travel time saving, VOC saving, reduction in vehicle emissions and CO_2. However, it is difficult to apply these effects as effect indicators because some of them are qualitative, need to rely on "estimation", require a large scale traffic surveys, and so on. Because of this, most railway projects using JICA Loan apply the number of passengers and revenue. No. of passengers is included in operation indicators. Since the revenue is not the purpose of this project, it was not employed in the Project.

18.3 Qualitative Impacts

(1) Improved image of Panama City

Metro Line-3 will pass over the new bridge across the Panama Canal and is certain to become an internationally symbolic project. Furthermore, the monorail system will be only the second of its kind, after Brazil (operation to start in 2014), in all Central and South America. Combined with the Line-1 and Line-2 MRT systems, Panama City will be seen as the city with the most complete public transportation network in the region.

(2) Development of tourism

The number of tourists visiting Panama continues to grow year after year. It is anticipated that a monorail ride over the world renowned Panama Canal will be an attraction to tourists contributing to tourism development.

(3) Environmentally friendly transportation system

Currently, buses and cars are the only transportation modes available and they emit exhaust gases that cause air pollution. The introduction of a public transportation system will allow car and bus riders to switch to the monorail reducing the number of vehicles and the emission of greenhouse effect gases.

(4) More efficient travel

Taxis are often shared with other passengers and service is refused to passengers who wish to go to areas that are often congested or outside the driver's direction. Also, taxi fares need to be negotiated with the driver. A public transit system that is operated under fixed rate and time schedule would make reliable and efficient travel possible for citizens.

(5) Urban and industrial development

The increase in commercial installations around the metro stations will contribute to the region's economic growth. One third of the nation's population live in Panama City and approximately 40% of its employees work on the east side of the Canal. The project will also contribute to the Panama Pacifico development, that is currently underway, and to the economic development on the western side of the Canal, creating more employment and opportunities for people's livelihood.

(6) Safe access to educational institutions in any weather

The main universities in Panama Province are concentrated in Panama City. Students living on the west side of the Canal will be able to commute safely by monorail at all times to their

universities without delays from traffic congestion.

18.4 Economic Analysis

18.4.1 Methodology

(1) Evaluation Period

The evaluation period assumed for the appraisal of the Project starts in 2015, when the process of acquiring land and paying compensation to project affected persons must commence in order to allow construction to proceed, and ends in 2050, which is the last year of the demand forecast. The construction period (2016-2021) forms part of the evaluation period, as does the operating period (2022-2050).

(2) Asset Lives

The asset lives assumed for the analysis are as follows:

Civil structures (including elevated structures, stations and depot/workshop)	50 years
Electrical and mechanical (E&M) equipment, including system control, telecommunications and signaling, power distribution and AFC	20 years
Rolling-stock (A large scale rehabilitation is scheduled 25 years after the purchase)	40 years

These asset lives were used as a basis for calculating residual values at the end of the evaluation period.

(3) Day to Year Conversion

The demand forecast provides a projection of daily demand. The result of the demand forecast represents the traffic in a typical weekday. In order to convert the projection from a daily to an annual basis, a conversion factor of 330 was used.

(4) Conversion from Financial Cost to Economic Cost

The capital and operating and maintenance (O&M) costs of the Project are estimated in Chapters 7 and 8 for Line-3, and Chapter 14 and 15 for 4th Bridge.

These estimates are valued in financial terms and are suitable as a basis for the financial appraisal. For the economic appraisal, however, all project costs and benefits must reflect values relevant to the wider economy. The main characteristic of the values is that they exclude government taxes, charges, and transfer payments, as well as the effect of any distortions of prices from market determined values. They may be estimated by adjusting financial costs by shadow pricing factors (SPF's) which exclude the "non-economic" cost elements.

The relevant tax rates and resulting SPFs applicable for the economic appraisal of this project are given in Table 18.9.

Table 18.9 Relevant Tax and Shadow Pricing Factors

Cost element	Applicable type of tax	Tax Rate	SPF
Labour	Average rate of income tax for persons earning B.11,000 – B.50,000 per year	15%	0.85
Materials (including electricity, but excluding fuel)	Value added tax	7%	0.93
Petroleum fuel	Fuel tax per US gallon: Diesel Gasoline 87 octane Gasoline 95 octane	 B.0.25 B.0.60 B.0.60	 0.72 [1] 0.68 [1] 0.67 [1]
Equipment	Value added tax	7%	0.93
Other (e.g. services such as insurance)	Value added tax	7%	0.93

Source: Tax research by JICA Study Team

It is understood that any equipment imported for this project (including rolling stock) would not be subject to the payment of import duty. No examples of market distortions in factor prices (such as the effect of subsidies) were identified by the JICA Study Team, so that SPF's were computed only on the basis of the tax components of retail prices.

The SPF computed for the project's capital costs (comprising civil works, E&M system and rolling stock costs) is 0.93 and for the project's O&M costs, 0.93

(5) With and Without Case Definition

The following three economic analyses were carried out in the Study: (a) 4th Bridge and Line-3, (b) 4th Bridge, and (c) Line-3. "With" and "Without" cases of them are as summarized in the table below. Numbers 1)-3) correspond to the number of the network scenario in Chapter 3.

Table 18.10 Targets of Economic Analysis

Targets of Economic Analysis	With Case	Without Case
(a) 4th Bridge and Line-3	3) 4th Bridge & Line-3	1) Present
(b) 4th Bridge	2) 4th Bridge	1) Present
(c) Line-3	3) 4th Bridge & Line-3	2) 4th Bridge

Source: Setting by the JICA Study Team

For the economic analysis of (c) Line-3, the "Without Case" is the case when the 4th Bridge is constructed without Line-3, while the "With Case" is the case when both the 4th Bridge and Line-3 projects are implemented as shown in the above table. The reason is that the Study of Line-3 is based on the assumption that Line-3 will be constructed on the 4th Bridge.

It is assumed that no public transport improvement projects are taken place for the "Without Case" except for the construction of Line-2. "With Case" is the case of "Without Case" plus Line-3 project. However, express bus services are assumed to be operated through the 4th Bridge for both "With" and "Without" cases.

(6) Economic Benefit

The economic benefit of the Project is composed of travel time reduction and vehicle operating cost (VOC) saving. Travel time reduction is the direct benefit that Line-3 passengers and 4th Bridge users can experience.

The 4th Bridge Project will generate the economic benefit of reduction of the travel time of cars by shortening the route and by reducing traffic congestion. In addition, VOC of cars will be reduced by shortening of the travel distance.

The Line-3 Project will provide a faster transport system than buses and the passenger of Line-3 can reduce their travel time. The operation speed of Line-3 is expected to be 40km/h in average, while that of buses would be 10-20km/h in general conditions. VOC saving is one of the significant benefits of a mass transit system. Monorail and other mass transit system can carry a large number of passengers, which achieve lower operating cost per passenger than other transport mode.

The travel time reduction and VOC saving can be valued as monetary term and its methodology is widely used in transport sector projects in the world.

The project will bring about other benefits such as safe and comfortable transportation, improvement of the city image, promoting tourism, balanced regional development, reduction in CO_2 and other vehicle emissions, and so on. However, it is difficult to value these benefits in monetary term and there are no stable methodologies which are accepted in transport sector projects to estimate these benefits in monetary term. Therefore, these benefits were excluded from the calculation of the economic analysis.

The project will generate the same benefits for 6 months before the completion of the construction because of its advanced opening in the section to the west of Panama Paficifo. However, the benefits during the advanced opening are excluded because the demand forecast and the operation plan for the advanced opening are not included in the Study. The impact of the benefits on the result of the economic analysis is positive although it would be small and not affect the conclusion.

18.4.2 Project Cost

(1) Conversion to Economic Costs

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.11 Cost Classification for Economic Analysis

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 18.12 Financial Cost to Economic Cost (Line-3)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 18.13 Financial Cost to Economic Cost (4th Bridge)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(2) Line-3 Cost in 4th Bridge Project Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.14 Line-3 Cost in 4th Bridge Project Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(3) 4th Bridge & Line-3

The economic cost of the initial investment for the economic evaluation for "4th Bridge & Line-3" is the sum of

Table 18.12 and Table 18.13.

Table 18.15 Economic Cost of Initial Investment (4th Bridge & Line-3)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(4) Line-3

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.16 Economic Cost of Initial Investment (Line-3)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(5) 4th Bridge

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.17 Economic Cost of Initial Investment (4th Bridge)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

18.4.3 O&M Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

18.4.4 Reinvestment and Additional Investment Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

18.4.5 Vehicle Operating Cost

The SMP Study 2011[2] estimated the vehicle operating cost (VOC) of a car, bus, and taxi at USD 0.24, 1.68, and 0.31 per vehicle-kilometer, respectively; although these values included travel time cost of passengers. HDM III model was used to calculate these VOCs. The VOC without travel time cost in the SMP Study 2011 is calculated at USD 0.24, 1.02, and 0.29 for a car, bus and taxi, respectively.

(1) Unit Prices

The market prices include tax (USD 0.6 per gallon for gasoline and USD 0.25 per gallon for diesel), which should be excluded from the economic prices because tax is a transfer cost in a country. The taxes are calculated at USD 0.159 per litter and USD 0.066 per litter, respectively, using 1 gallon=3.785 litter. Import tax is not charged to gasoline and diesel in Panama.

There are super (95 octane) and regular (91 octane) gasoline in Panama. The consumption of gasoline in 2012 was 87.1 million gallon of super gasoline and 128.7 million gallon of

[2] Actualización de la Demanda, Costos de Operación e Indicadores Varios requeridos por el BEI para la nueva configuración de la Línea 1 del Metro de Panamá. Informe de Final

regular gasoline[3]. The ratio of the consumption of super and regular gasoline is calculated at 40:60. The average prices of gasoline and diesel per litter in 2013 (from December 15, 2012 to December 13, 2013) are calculated at USD 1.113 for super gasoline, USD 1.031 for regular gasoline, and USD 0.991 for diesel. The average fuel price for cars is calculated at USD 1.064 (1.113*0.4+1.031*0.6). In the calculation above, the prices are converted from per gallon to per litter (1 gallon = 3.785 litter).

Lubricant cost was assumed to be USD 4 per litter in market price. The average vehicle price in Panama in 2012 was estimated at USD 20,144, based on "Automobile Market Outlook Panama, 2012, BBVA Research", while it was assumed at USD 15,000 in the SMP Study 2011. The former price represents the new vehicle price while the latter can be regarded to represent the price of existing vehicles. For the economic analysis, the latter price should be used as the present value because the benefit from VOC saving is generated from not only new vehicles, but also existing vehicles.

Unit prices used in this study are summarized in Table 18.18.

Table 18.18 Unit Prices for VOC Calculation

Items	Financial Cost		Economic Cost	
	Car	Bus	Car	Bus
Vehicle price (USD per vehicle)	15,000	160,000	13,950	148,800
Fuel price (USD per L)	0.94	0.95	0.78	0.89
Lubricant price (USD per L)	4.00	4.00	3.72	3.72
Tyre price (USD per no)	75	350	69.8	325.5
Crew cost (USD per hour)	0.00	5.97	0.00	5.37
Maintenance labour cost (USD per hour)	6.00	6.00	5.40	5.40

Source: Estimation by JICA Study Team (Financial costs are as same as that of the SMP Study 2011)

(2) Assumptions of Vehicle Utilization

Vehicle utilization, which is used to calculate depreciation cost, is assumed as the same as that in the SMP Study 2011 except for operating speed, as shown in Table 18.19. Operating speed is used to calculate crew hours for drivers' cost.

Table 18.19 Vehicle Utilization

		Car	Bus	Remark
Annual kilometers (km)	(a)	20,000	70,000	SMP Study 2011
Vehicle Life (Years)	(b)	12	10	SMP Study 2011
Operating Speed (km/h)	(c)	25	15	Assumption in this study

Source: Described in Remark

(3) Consumptions per 1000 Vehicle-Kilometer

Lubricant oil, tyres, parts, and labor consumptions by vehicle operation were estimated by using HDM IV model as shown in Table 18.20. For the fuel consumption rates, the rate used in 10.1 is used to keep consistency between the estimation of CO_2 reduction and the calculation of VOC, although the rate calculated by HDM IV is 10 km/L for cars and 3.4 km/L for buses.

[3] Statistic data in http://www.energia.gob.pa/

Table 18.20 Consumption Rate per1000 Vehicle Kilometers

	Car	Bus	Remark
Fuel (km/L)	10.0	4.6	Table 18.1
Lubricant Oil (L/1000km)	0.70	2.00	HDM IV model
Tyre (no. /1000km)	0.033	0.022	HDM IV model
Parts (% to vehicle price /1000km)	0.210	0.103	HDM IV model
Crew hours (hours /1000km)	40.00	66.67	1000/(c)
Maintenance hours (hours/ 1000km)	2.65	8.38	HDM IV model
Depreciation (% to vehicle price/ 1000km)	0.354%	0.121%	0.85/(a*b)*1000

Source: Remark

(4) VOC per 1000 km

VOC was calculated from the estimated unit costs and consumption rates as shown in Table 18.21. Economic costs were used for the economic analysis while financial costs are not used. VOC of the economic cost was calculated at USD 236.47 per 1000 vehicle-km for a car, and USD 1,267.95 per 1000 vehicle-km for a bus.

Table 18.21 VOC per1000 Vehicle Kilometers

Unit: USD per 1000 vehicle-km	Financial Cost		Economic Cost	
	Car	Bus	Car	Bus
Fuel	133.61	462.99	110.96	430.93
Lubricants	2.80	8.00	2.60	7.44
Tyres	2.48	7.70	2.30	7.16
Auto parts	31.50	164.80	29.30	153.26
Crew	0.00	398.00	0.00	358.20
Maintenance labour	15.87	50.27	14.29	45.24
Depreciation	53.13	194.29	49.41	180.69
Interest	30.00	91.43	27.90	85.03
Taxes (incl. licences and reg.)	2.82	2.82	0.00	0.00
Total	272.20	1,380.29	236.76	1,267.95

Source: Estimation by JICA Study Team

(5) Estimation of Vehicle-Kilometers

VOC reduction is calculated from the VOC per 1000km calculated above and vehicle-km that is estimated from the demand forecast. Since the operating cost of Line-3 is estimated as O&M cost, the vehicle-km was calculated for cars and buses. Passenger-km, which is one of the outputs of the Transit Assignment, was used calculate the vehicle-km of buses, while the vehicle-km was directly calculated from the result of the Traffic Assignment of the demand forecast. The calculated reduction in vehicle-km is shown in Table 18.25.

18.4.6 Travel Time Cost

(1) Value of Time Estimation in the SMP Study

The benefit from reduction in travel time is calculated from the reduction in travel hours and the value of time. In the SMP Study 2011, the value of time is estimated by trip purpose as shown in Table 18.22, while the METI Study 2012 estimated the value of time at USD 3.63 and USD 1.71 per person per hour for car users and bus passengers, respectively.

Table 18.22 Value of Time in SMP Study 2011

Trip Purpose	Value of Time (USD per hour)
Commercial	1.03
Education	0.63
Work of Low Income Group	1.25
Work of Medium Income Group	2.38
Work of High Income Group	5.75

Source: SMP, April 2010. "ESTUDIO DE DEMANDA PARA LA LÍNEA 1 DEL SISTEMA DE TRANSPORTE MASIVO DE LA CIUDAD DE PANAMÁ. INFORME FINAL"

(2) Value of Time of Car Passengers

Since the OD matrix represents the total trips of all trip purposes and the breakdown of the trips into matrices by trip purpose is not available, this Study employed a value of time that is estimated from the average of household income. The average household income in Panama Province in 2010 was USD 803 per month according to Census 2010.

The value of time of car passengers for business trips is estimated from household income statistics, i.e. value of time (business) = monthly income divided by monthly working hours. The value of time for all trips is assumed as 50% of that of business trips because various studies show that the value of time on no-business trips is approximately 50% of that of business trips. According to "Automobile Market Outlook Panama 2013, BBVA", households in Panama own one or more cars when the household income exceeds USD 1,100 per month. Table 18.23 shows the calculation of the value of time on business trips. It is assumed that monthly working hour is 168 hours (21days*8hours). The number of workers is estimated at 1.55 per household based on the Census statistics. From this, the value of time per person was calculated at USD 4.38 (USD 8.76*0.5) and that per car is calculated at USD 2.92 (assuming 1.5 passengers per car).

Table 18.23 Monthly Income and Value of Time for Business Trips (Car)

Income Range USD / Month	Median (a)	No. of Households (b)	% Total (c)	(a)*(c)	Value of Time per hour
1,000 - 1,500	1,250	74,226	38.9%	486	
1,500 - 2,000	1,750	39,082	20.5%	359	(d)/1.55
2,000 - 2,500	2,250	22,495	11.8%	265	/168days
2,500 - 3,000	2,750	13,574	7.1%	196	
3,000 - 4,000	3,500	15,921	8.3%	292	
4,000 - 5,000	4,500	8,630	4.5%	204	
5,000 -	5,500	16,813	8.8%	485	
Total		190,741	100.0%	2,287	USD 8.76

Source: Calculated from INEC statistics

(3) Value of Time of Bus Passengers

The value of bus passengers can be estimated as the same method as that of car passengers using household income. Table 18.24 shows the calculation of the value of time for the business trips of bus passengers. Although the income range of bus passengers is not clear, it was assumed that the income range of 1,000-1,500 was the upper level of bus passengers.

Table 18.24 Monthly Income and Value of Time for Business Trips (Bus)

Income Range USD / Month	Median (a)	No. of Households (b)	% Total (c)	(d)= (a)*(c)	Value of Time per hour
	50	24,276	6.9%	3	
100 - 125	112.5	9,045	2.6%	3	(d)/1.55
125 - 175	150	9,352	2.7%	4	/168days
175 - 250	212.5	17,969	5.1%	11	
250 - 400	325	41,477	11.8%	38	
400 - 600	500	73,455	21.0%	105	
600 - 800	700	53,827	15.4%	108	
800 - 1,000	900	46,844	13.4%	120	
1,000 - 1,500	1250	74,226	21.2%	265	
		350,471	100%	657	USD 2.52

Source: Calculated from INEC statistics

(4) Travel Time Reduction

Travel time reduction was calculated from passenger-hours of private and public modes with and without cases. The result of the Transit Assignment of JICA-STRADA was used to calculate passenger-hours of public modes, while that of the Traffic Assignment was used for passenger-hours of private modes. Since the demand forecasts were done for the peak hours, a peak rate of 12% was used to estimate the daily travel time reduction.

18.4.7 Economic Internal Rate of Return (EIRR)

(1) VOC Saving and Travel Time Reduction

The benefit flows (2022-2050) of VOC saving and travel time reduction were calculated as shown in Table 18.25.

Table 18.25 Travel Time Reduction and VOC Saving (4th Bridge & Line-3)

Year	Travel Time Reduction									VOC Saving				
	Passenger-Hours per day (000)				Reduction in Passenge Hours per day (Without-With)		Value of Time Saving Saving (B. Million per year)			Reduction in Veh-km per day		VOC Saving (B. Million per year)		
	Without		With											
	Private	Public	Private	Public	Private	Public	Private	Public	Total	Bus	Car	Bus	Car	Total
2020														
2021														
2022	373	1,346	347	1,218	25.6	127.6	37.1	53.1	90.1	140,669	329,156	58.9	25.7	84.6
2023	386	1,364	358	1,234	28.2	129.7	40.8	53.9	94.7	142,516	351,644	59.6	27.5	87.1
2024	400	1,381	369	1,249	30.8	131.7	44.6	54.8	99.3	144,363	374,132	60.4	29.2	89.6
2025	414	1,398	380	1,265	33.4	133.7	48.3	55.6	103.9	146,210	396,620	61.2	31.0	92.2
2026	430	1,412	392	1,277	37.9	134.9	54.8	56.1	110.9	147,088	414,014	61.5	32.3	93.9
2027	447	1,425	404	1,289	42.5	136.0	61.4	56.5	117.9	147,966	431,408	61.9	33.7	95.6
2028	463	1,438	416	1,300	47.0	137.1	67.9	57.0	124.9	148,845	448,802	62.3	35.1	97.3
2029	480	1,451	429	1,312	51.5	138.3	74.4	57.5	131.9	149,723	466,196	62.6	36.4	99.1
2030	497	1,464	441	1,324	56.0	139.4	81.0	58.0	138.9	150,601	483,590	63.0	37.8	100.8
2031	517	1,476	453	1,335	63.6	140.6	92.0	58.5	150.4	151,482	500,591	63.4	39.1	102.5
2032	537	1,488	465	1,346	71.2	141.8	103.0	59.0	161.9	152,362	517,592	63.8	40.4	104.2
2033	557	1,500	478	1,357	78.8	143.1	114.0	59.5	173.4	153,243	534,593	64.1	41.8	105.9
2034	577	1,512	490	1,368	86.4	144.3	125.0	60.0	184.9	154,123	551,594	64.5	43.1	107.6
2035	597	1,524	503	1,378	94.1	145.5	136.0	60.5	196.5	155,004	568,595	64.9	44.4	109.3
2036	626	1,533	519	1,387	106.8	146.2	154.3	60.8	215.1	152,373	601,518	63.8	47.0	110.8
2037	656	1,542	536	1,395	119.5	146.9	172.7	61.1	233.8	149,742	634,442	62.7	49.6	112.2
2038	685	1,551	553	1,403	132.2	147.5	191.1	61.3	252.4	147,112	667,365	61.6	52.1	113.7
2039	714	1,559	569	1,411	144.9	148.2	209.5	61.6	271.1	144,481	700,288	60.5	54.7	115.2
2040	744	1,568	586	1,419	157.6	148.9	227.8	61.9	289.7	141,850	733,211	59.4	57.3	116.6
2041	776	1,577	601	1,427	175.0	149.5	252.9	62.2	315.0	144,994	759,196	60.7	59.3	120.0
2042	808	1,586	615	1,435	192.3	150.1	277.9	62.4	340.4	148,138	785,180	62.0	61.3	123.3
2043	840	1,594	630	1,443	209.6	150.8	303.0	62.7	365.7	151,281	811,164	63.3	63.4	126.7
2044	872	1,603	645	1,451	226.9	151.4	328.0	62.9	391.0	154,425	837,149	64.6	65.4	130.0
2045	904	1,611	659	1,459	244.3	152.0	353.1	63.2	416.3	157,569	863,133	65.9	67.4	133.4
2046	940	1,616	676	1,464	263.6	152.1	380.9	63.3	444.2	157,373	878,750	65.8	68.7	134.5
2047	976	1,621	693	1,468	282.8	152.3	408.8	63.3	472.1	157,178	894,368	65.8	69.9	135.6
2048	1,012	1,625	710	1,473	302.1	152.4	436.7	63.4	500.1	156,982	909,986	65.7	71.1	136.8
2049	1,048	1,630	727	1,477	321.4	152.6	464.6	63.4	528.0	156,786	925,603	65.6	72.3	137.9
2050	1,084	1,635	743	1,482	340.7	152.7	492.4	63.5	555.9	156,590	941,221	65.5	73.5	139.1

Source: JICA Study Team

Table 18.26 Travel Time Reduction and VOC Saving (Line-3)

Year	Travel Time Reduction									VOC Saving				
	Passenger-Hours per day (000)				Reduction in Passenge Hours per day (Without-With)		Value of Time Saving Saving (B. Million per year)			Reduction in Veh-km per day		VOC Saving (B. Million per year)		
	Without		With											
	Private	Public	Private	Public	Private	Public	Private	Public	Total	Bus	Car	Bus	Car	Total
2020														
2021														
2022	359	1,283	347	1,218	12.4	64.8	17.9	27.0	44.8	110,950	242,478	46.4	18.9	65.4
2023	372	1,300	358	1,234	13.7	65.7	19.8	27.3	47.1	112,307	256,039	47.0	20.0	67.0
2024	384	1,316	369	1,249	15.0	66.6	21.8	27.7	49.4	113,664	269,600	47.6	21.1	68.6
2025	397	1,332	380	1,265	16.4	67.5	23.7	28.1	51.7	115,022	283,161	48.1	22.1	70.3
2026	411	1,344	392	1,277	18.6	67.8	26.8	28.2	55.0	115,620	293,705	48.4	22.9	71.3
2027	425	1,357	404	1,289	20.7	68.1	30.0	28.3	58.3	116,217	304,248	48.6	23.8	72.4
2028	439	1,369	416	1,300	22.9	68.4	33.1	28.4	61.5	116,815	314,792	48.9	24.6	73.5
2029	454	1,381	429	1,312	25.1	68.7	36.2	28.6	64.8	117,413	325,336	49.1	25.4	74.5
2030	468	1,393	441	1,324	27.2	69.0	39.4	28.7	68.1	118,011	335,879	49.4	26.2	75.6
2031	483	1,405	453	1,335	30.4	69.6	44.0	28.9	72.9	118,588	358,657	49.6	28.0	77.6
2032	499	1,416	465	1,346	33.6	70.1	48.6	29.1	77.7	119,166	381,435	49.9	29.8	79.7
2033	515	1,427	478	1,357	36.8	70.6	53.2	29.4	82.6	119,744	404,212	50.1	31.6	81.7
2034	530	1,439	490	1,368	40.0	71.2	57.8	29.6	87.4	120,321	426,990	50.3	33.4	83.7
2035	546	1,450	503	1,378	43.2	71.7	62.4	29.8	92.2	120,899	449,768	50.6	35.1	85.7
2036	568	1,458	519	1,387	48.9	71.7	70.7	29.8	100.5	121,006	469,398	50.6	36.7	87.3
2037	591	1,467	536	1,395	54.6	71.8	79.0	29.8	108.8	121,113	489,028	50.7	38.2	88.9
2038	613	1,475	553	1,403	60.4	71.8	87.2	29.9	117.1	121,221	508,658	50.7	39.7	90.5
2039	635	1,483	569	1,411	66.1	71.8	95.5	29.9	125.4	121,328	528,288	50.8	41.3	92.0
2040	658	1,491	586	1,419	71.8	71.9	103.8	29.9	133.7	121,435	547,918	50.8	42.8	93.6
2041	677	1,499	601	1,427	76.6	72.0	110.8	30.0	140.7	121,474	557,612	50.8	43.6	94.4
2042	697	1,508	615	1,435	81.5	72.2	117.7	30.0	147.8	121,513	567,305	50.8	44.3	95.2
2043	716	1,516	630	1,443	86.3	72.4	124.7	30.1	154.8	121,552	576,999	50.9	45.1	95.9
2044	736	1,524	645	1,451	91.1	72.5	131.7	30.2	161.8	121,591	586,692	50.9	45.8	96.7
2045	755	1,532	659	1,459	95.9	72.7	138.7	30.2	168.9	121,631	596,385	50.9	46.6	97.5
2046	779	1,536	676	1,464	102.8	72.5	148.6	30.2	178.8	121,245	616,672	50.7	48.2	98.9
2047	803	1,541	693	1,468	109.7	72.4	158.6	30.1	188.7	120,859	636,958	50.6	49.8	100.3
2048	826	1,545	710	1,473	116.6	72.2	168.6	30.0	198.6	120,473	657,244	50.4	51.4	101.8
2049	850	1,549	727	1,477	123.5	72.0	178.5	30.0	208.5	120,087	677,530	50.2	52.9	103.2
2050	874	1,554	743	1,482	130.4	71.9	188.5	29.9	218.4	119,701	697,816	50.1	54.5	104.6

Source: JICA Study Team

Table 18.27 Travel Time Reduction and VOC Saving (4th Bridge)

Year	Travel Time Reduction									VOC Saving				
	Passenger-Hours per day (000)				Reduction in Passenge Hours per day (Without-With)		Value of Time Saving Saving (B. Million per year)			Reduction in Veh-km per day		VOC Saving (B. Million per year)		
	Without		With											
	Private	Public	Private	Public	Private	Public	Private	Public	Total	Bus	Car	Bus	Car	Total
2020														
2021														
2022	373	1,346	359	1,283	13.3	62.8	19.2	26.1	45.3	29,720	86,678	12.4	6.8	19.2
2023	386	1,364	372	1,300	14.5	63.9	21.0	26.6	47.6	30,209	95,605	12.6	7.5	20.1
2024	400	1,381	384	1,316	15.8	65.1	22.8	27.1	49.9	30,698	104,532	12.8	8.2	21.0
2025	414	1,398	397	1,332	17.0	66.2	24.6	27.5	52.2	31,188	113,459	13.0	8.9	21.9
2026	430	1,412	411	1,344	19.4	67.0	28.0	27.9	55.9	31,468	120,309	13.2	9.4	22.6
2027	447	1,425	425	1,357	21.7	67.9	31.4	28.2	59.6	31,749	127,160	13.3	9.9	23.2
2028	463	1,438	439	1,369	24.1	68.7	34.8	28.6	63.4	32,029	134,010	13.4	10.5	23.9
2029	480	1,451	454	1,381	26.4	69.5	38.2	28.9	67.1	32,310	140,861	13.5	11.0	24.5
2030	497	1,464	468	1,393	28.8	70.4	41.6	29.3	70.8	32,591	147,711	13.6	11.5	25.2
2031	517	1,476	483	1,405	33.2	71.1	48.0	29.5	77.5	32,893	141,934	13.8	11.1	24.9
2032	537	1,488	499	1,416	37.6	71.7	54.4	29.8	84.2	33,196	136,158	13.9	10.6	24.5
2033	557	1,500	515	1,427	42.0	72.4	60.8	30.1	90.9	33,499	130,381	14.0	10.2	24.2
2034	577	1,512	530	1,439	46.5	73.1	67.1	30.4	97.5	33,802	124,604	14.1	9.7	23.9
2035	597	1,524	546	1,450	50.9	73.8	73.5	30.7	104.2	34,105	118,827	14.3	9.3	23.6
2036	626	1,533	568	1,458	57.9	74.4	83.6	31.0	114.6	31,367	132,121	13.1	10.3	23.4
2037	656	1,542	591	1,467	64.8	75.1	93.7	31.2	125.0	28,629	145,414	12.0	11.4	23.3
2038	685	1,551	613	1,475	71.8	75.7	103.8	31.5	135.3	25,891	158,707	10.8	12.4	23.2
2039	714	1,559	635	1,483	78.8	76.4	113.9	31.8	145.7	23,153	172,000	9.7	13.4	23.1
2040	744	1,568	658	1,491	85.8	77.0	124.0	32.0	156.1	20,415	185,293	8.5	14.5	23.0
2041	776	1,577	677	1,499	98.3	77.5	142.1	32.2	174.3	23,520	201,584	9.8	15.7	25.6
2042	808	1,586	697	1,508	110.8	77.9	160.2	32.4	192.6	26,625	217,875	11.1	17.0	28.2
2043	840	1,594	716	1,516	123.3	78.4	178.3	32.6	210.9	29,729	234,166	12.4	18.3	30.7
2044	872	1,603	736	1,524	135.8	78.8	196.3	32.8	229.1	32,834	250,457	13.7	19.6	33.3
2045	904	1,611	755	1,532	148.3	79.3	214.4	33.0	247.4	35,938	266,747	15.0	20.8	35.9
2046	940	1,616	779	1,536	160.7	79.6	232.3	33.1	265.4	36,129	262,079	15.1	20.5	35.6
2047	976	1,621	803	1,541	173.1	79.9	250.2	33.2	283.4	36,319	257,410	15.2	20.1	35.3
2048	1,012	1,625	826	1,545	185.5	80.2	268.1	33.4	301.5	36,509	252,742	15.3	19.7	35.0
2049	1,048	1,630	850	1,549	197.9	80.5	286.0	33.5	319.5	36,700	248,073	15.4	19.4	34.7
2050	1,084	1,635	874	1,554	210.3	80.8	303.9	33.6	337.5	36,890	243,405	15.4	19.0	34.5

Source: JICA Study Team

(2) Social Discount Rate

A social discount rate is an indicator to estimate the present value in economic analyses. In Panama, there is no official value of the social discount rate. In the Study, the value of 5.75% was employed for the social discount rate in Panama based on the interest rates of Global Bond in Panama.

(3) EIRR Calculation

1) 4th Bridge & Line-3

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.28 Cash Flow of Economic Benefit and Cost (4th Bridge & Line-3)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

2) Line-3

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.29 Cash Flow of Economic Benefit and Cost (Line-3)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

3) 4th Bridge

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.30 Cash Flow of Economic Benefit and Cost (4th Bridge)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

18.4.8 Sensitivity Analysis

1) 4th Bridge & Line-3

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.31 Sensitivity Analysis of EIRR (4th Bridge & Line-3)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

2) Line-3

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.32 Sensitivity Analysis of EIRR (Line-3)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

3) 4th Bridge

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.33 Sensitivity Analysis of EIRR (4th Bridge)

To ensure fairness of procurement process as well as project implementation,
information should not be disclosed for a fixed period.

Source: JICA Study Team

18.5 Financial Analysis

18.5.1 Objectives

The present financial analysis of the Metro Line-3 project has the following objectives:

- Evaluate financial viability of the project by estimating the project financial internal rate of return (FIRR);
- Estimate the government's financial burden incurred by the project implementation by projecting the life cycle cost of the project; and
- Estimate the Value for Money (VFM) of each PPP scheme alternative presented in Chapter 8 (Section 8.6).

18.5.2 Methodology

(1) Project FIRR

Project FIRR is calculated based on the discounted cash flow projection expressed in constant price (year 2013) to evaluate the project's overall profitability. The cash flow does not distinguish the ownership of revenue or cost stream and does not include the financing cash flow. FIRR is a discount rate when net present value (NPV) of the discounted cash flow equals to zero and defined in the following equation:

$$\mathrm{NPV} = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 0$$

Where: NPV = Net present value
n = Year
N = Total number of years
Cn = Annual net cash flow in year n
r = Discount rate = Internal rate of return (IRR)

The FIRR will be evaluated by comparing weighted average cost of capital (WACC) estimated for the project's funding structure. Both project FIRR and WACC are expressed in real terms.

(2) Life Cycle Cost of Public Investment and Operation Case

In the public investment and operation case, the government will bear the construction and reinvestment costs and debt services besides the operational cash inflow. The life cycle cost (LCC) to be borne by the government is estimated by acquiring present value of the net cash flow discounted by the public funding cost. LCC of the public investment and operation case is used as the public sector comparator (PSC) to estimate Value for Money (VFM) of each project scheme alternative with private sector participation. LCC and VFM as well as the cash flow projection thereof are expressed in nominal price.

(3) Value for Money of Project Scheme Alternatives

LCC of the government will be estimated for each project scheme alternative with private sector participation as presented in Chapter 8 (Section 8.6). Since full-scale market sounding and owner's estimate for PPP alternatives are not implemented in the present survey, it is not possible to estimate the operational and investment efficiency achieved by the private sector participation. Alternatively, the present analysis will estimate the cost reduction and revenue increase required to acquire VFM through the PPP scheme alternative based on the same revenue and cost estimation applied to the public implementation LCC.

18.5.3 Assumptions

Basic assumptions applied in the analysis are presented in the table below.

Table 18.34 Basic Assumptions of Financial Analysis

	Item	Assumption	Source / Remarks
1	Project lifetime	30 years of operation after seven-year construction period	JICA Study Team assumption
2	Exchange rates	USD 1.00 = JPY 99.7	Equivalent to JICA Study Team assumptions in cost estimates (See Chapter 8). Cash flows are expressed in USD.
3	Inflation rates (Price escalation rates)	Foreign Currency (FC): 1.3% Local Currency (LC): 3.1 %	
4	Taxation	(i) Construction: ITBMS and Import Tax are exempted. (ii) Public operation: Metro de Panamá, S.A. is exempted from corporate income tax, etc. (iii) Private operation: 25% income tax is partially exempted in the following schedule: - 100% during first five years of concession - 75% during the following five years - 50% during the remaining concession period	(i) See Chapter 8 for tax on construction cost. (ii) Law 109 of 2013 (iii) Law 5 of 1988 as amended
5	Physical contingency	(i) Procurement & construction: 5% (ii) Consulting services: 5%	See Chapter 8.
6	Administration cost	5%	See Chapter 8.

Source: Various sources

18.5.4 Cost Projection

(1) Initial Investment Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.35 Initial Investment Cost (Constant Price)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 18.36 Initial Investment Cost (Nominal Price)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(2) Operation and Maintenance Cost

Annual operation and maintenance (O&M) cost of the project estimated in Chapter 8 is used for the cost projection. See table below for the estimation in constant price and nominal price (See Section 8.5 for details). The same O&M cost amount as in 2050 is applied for that of 2051.

Table 18.37 Annual O&M Cost

Unit: USD million

Item	2022	2025	2030	2035	2040	2050-51
O&M Cost in Constant Price (2013)	**36.61**	**40.37**	**41.36**	**41.72**	**41.72**	**42.91**
Personnel	6.92	7.69	7.85	7.93	7.93	8.11
Electricity	10.77	11.31	11.73	11.78	11.78	12.36
Maintenance	6.36	6.84	7.00	7.15	7.15	7.31
Others	12.56	14.54	14.78	14.86	14.86	15.13
O&M Cost in Nominal Price	**47.62**	**55.97**	**64.26**	**72.68**	**81.68**	**107.04**
Personnel	9.98	12.15	14.46	17.01	19.82	27.50
Electricity	15.54	17.87	21.61	25.26	29.43	41.91
Maintenance	7.43	8.30	9.06	9.88	10.54	12.26
Others	14.67	17.65	19.13	20.52	21.89	25.37

Source: JICA Study Team

(3) Reinvestment and Additional Investment Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.38 Reinvestment and Additional Investment Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

18.5.5 Revenue Projection

Law 109 of 2013 on the regulatory framework of Metro system stipulates that one of the functions of Metro de Panamá, S.A. is to recommend the passenger fare system to the Executive Branch of the government (Article 5). However, according to SMP officials, there is no predetermined regulation or mechanism for the government to follow on the tariff setting and adjustment of the Metro system and many other public transportation systems. The government shall determine the tariff system of Metro in accordance with stipulation of the Constitution[4]. Due to the lack of such passenger fare setting mechanism for the present analysis to follow, distance-based fare system (Fare = 0.65 + 0.042X) [5] is applied in

[4] Article 284 of the Republic's Constitution reads: "The State shall intervene in all the companies within the regulations established by law, to enforce social justice referred to in this Constitution and in particular for the following purposes: 1. To regulate through special agencies the tariffs, services and prices of any kind, especially of staples …"

[5] $\text{Fare} = F + R \times \text{Max}(\text{Distance} - X, 0)$, where: Fare = passenger fare, F = fixed rate (B/. 0.65 per person-trip), R = variable rate (B/. 0.042 per km), Distance = destination station's distance from origin (km), and X = fixed rate threshold (18 km). See Chapter 4 for details.

accordance with the demand projection scenario presented in Chapter 4 and SMP's suggestion. The fare revenue has been projected on five- to ten-year interval during the operation period in the demand analysis. The present financial analysis estimates annual revenue cash flows by making linear projection between these milestone years. The same revenue amount as in 2050 is assumed for that of 2051. Non-fare revenue is assumed to be 3% of the fare revenue according to international experience in similar projects as well as the assumption applied to the Line-1 project analysis indicated by the SMP officials.

Two cases are assumed for the revenue expressed in nominal price. The yearly adjustment case is the revenue projection based on the assumption that the passenger fare is adjusted annually in line with the price escalation (3.1% per annum); whereas the stepwise adjustment case is that of the assumption that the passenger fare is only adjusted to price escalation every five years reflecting actual experience in urban public transport tariffs in Panama[6].

Table 18.39 Revenue Projection

Year		Constant Price (2013)					Nominal Price (Yearly Adjustment)			Nominal Price (Stepwise Adjustment)			Remarks
		Daily Fare Revenue /1	Straight Line Fitting /2	Annual Fare Revenue /3	Non Fare Revenue /4	Total	Annual Fare Revenue /5	Non Fare Revenue /4	Total	Annual Fare Revenue /6	Non Fare Revenue /4	Total	
		USD	USD	USD million	USD million	USD million	USD million	USD million	USD million	USD million	USD million	USD million	
2020	Not in	**131,157**	**131,157**	43.28	1.30	**44.58**	53.59	1.61	**55.20**	**53.59**	1.61	**55.20**	Revenue is not recognized before operation
2021	Operation		132,706	43.79	1.31	**45.11**	55.91	1.68	**57.59**	54.23	1.63	**55.85**	
2022			134,256	44.30	1.33	**45.63**	58.31	1.75	**60.06**	54.86	1.65	**56.51**	
2023			135,805	44.82	1.34	**46.16**	60.82	1.82	**62.64**	55.49	1.66	**57.16**	
2024			137,354	45.33	1.36	**46.69**	63.42	1.90	**65.32**	56.13	1.68	**57.81**	
2025		**138,903**	**138,903**	45.84	1.38	**47.21**	66.12	1.98	**68.10**	**66.12**	1.98	**68.10**	Adjusted to 2025 price level in the stepwise adjustment case
2026			140,070	46.22	1.39	**47.61**	68.74	2.06	**70.80**	66.67	2.00	**68.68**	
2027			141,237	46.61	1.40	**48.01**	71.46	2.14	**73.61**	67.23	2.02	**69.25**	
2028			142,403	46.99	1.41	**48.40**	74.29	2.23	**76.52**	67.79	2.03	**69.82**	
2029			143,570	47.38	1.42	**48.80**	77.22	2.32	**79.53**	68.34	2.05	**70.39**	
2030		**144,737**	**144,737**	47.76	1.43	**49.20**	80.26	2.41	**82.67**	**80.26**	2.41	**82.67**	Adjusted to 2030 price level in the stepwise adjustment case
2031			145,818	48.12	1.44	**49.56**	83.36	2.50	**85.87**	80.86	2.43	**83.28**	
2032			146,899	48.48	1.45	**49.93**	86.59	2.60	**89.18**	81.46	2.44	**83.90**	
2033			147,980	48.83	1.47	**50.30**	89.93	2.70	**92.63**	82.06	2.46	**84.52**	
2034			149,062	49.19	1.48	**50.67**	93.39	2.80	**96.19**	82.66	2.48	**85.14**	
2035		**150,143**	**150,143**	49.55	1.49	**51.03**	96.99	2.91	**99.90**	**96.99**	2.91	**99.90**	Adjusted to 2035 price level in the stepwise adjustment case
2036	Operation		151,203	49.90	1.50	**51.39**	100.70	3.02	**103.72**	97.67	2.93	**100.60**	
2037	Period		152,264	50.25	1.51	**51.75**	104.55	3.14	**107.69**	98.36	2.95	**101.31**	
2038			153,324	50.60	1.52	**52.11**	108.54	3.26	**111.80**	99.04	2.97	**102.01**	
2039			154,385	50.95	1.53	**52.48**	112.68	3.38	**116.06**	99.73	2.99	**102.72**	
2040		**155,446**	**155,446**	51.30	1.54	**52.84**	116.97	3.51	**120.48**	**116.97**	3.51	**120.48**	Adjusted to 2040 price level in the stepwise adjustment case
2041			156,501	51.65	1.55	**53.19**	121.42	3.64	**125.06**	117.76	3.53	**121.30**	
2042			157,557	51.99	1.56	**53.55**	126.02	3.78	**129.80**	118.56	3.56	**122.12**	
2043			158,613	52.34	1.57	**53.91**	130.80	3.92	**134.73**	119.35	3.58	**122.93**	
2044			159,668	52.69	1.58	**54.27**	135.75	4.07	**139.83**	120.15	3.60	**123.75**	
2045			160,724	53.04	1.59	**54.63**	140.89	4.23	**145.11**	**140.89**	4.23	**145.11**	Adjusted to 2045 price level in the stepwise adjustment case
2046			161,780	53.39	1.60	**54.99**	146.21	4.39	**150.60**	141.81	4.25	**146.07**	
2047			162,836	53.74	1.61	**55.35**	151.73	4.55	**156.28**	142.74	4.28	**147.02**	
2048			163,891	54.08	1.62	**55.71**	157.44	4.72	**162.17**	143.66	4.31	**147.97**	
2049			164,947	54.43	1.63	**56.07**	163.37	4.90	**168.27**	144.59	4.34	**148.93**	
2050		**166,003**	**166,003**	54.78	1.64	**56.42**	169.51	5.09	**174.60**	**169.51**	5.09	**174.60**	Adjusted to 2050 price level in the stepwise adjustment case
2051			166,003	54.78	1.64	**56.42**	174.77	5.24	**180.01**	169.51	5.09	**174.60**	

/1 Daily fare revenue estimates are generated through the demand analysis following Fare = 0.65 + 0.042 * Max (D - 18, 0) for 2020, 2025, 2030, 2035, 2040, and 2050.

/2 Straight line fitting made through the least square method for rest of the years

/3 Caculated through: Annual fare revenue = Daily fare revenue * 330 days.

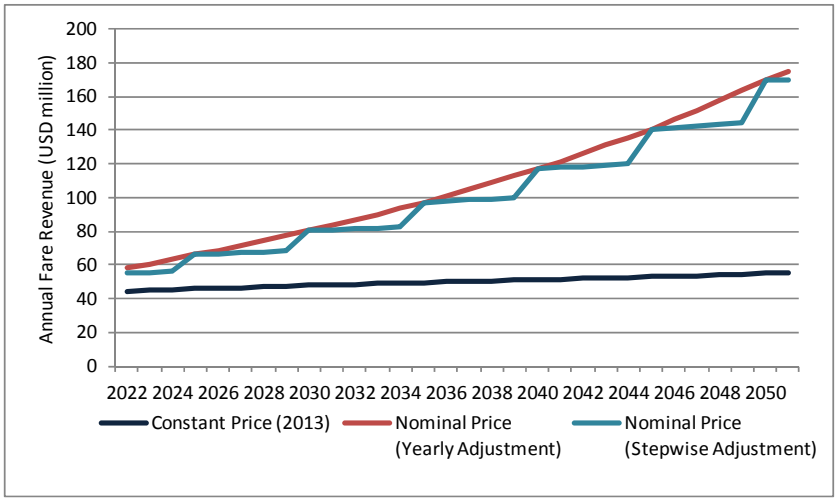
/4 3% of annual fare revenue

/5 Adjusted to price escalation in each year

/6 Stepwise adjustment to price escalation every five year

Source: JICA Study Team

[6] For instance, the metropolitan bus transport fare has not been adjusted over ten years, resulting in great amount of government subsidy (subsidy of B/. 0.324 per passenger for the standard fare value of B/. 0.25) to maintain the system. This indicates that the attempt for tariff adjustment often faces political challenges and may not be made frequently by the government.



Source: JICA Study Team

Figure 18.1 Fare Revenue Projection

18.5.6 Funding and Finance

(1) Assumptions on Financing for the Project

The table below shows the assumptions for the funding and financing conditions for the project applied to the public investment as well as the private investment cases. The government funding cost is assumed to be 5.75% per annum and will be used to estimate the present value of government financial burden in each project scheme alternative.

Table 18.40 Assumptions on Funding and Finance

	Item	Assumption	Source / Remarks
1	JICA ODA loan conditions (Standard conditions)	(i) Currency: JPY (ii) Financing ratio: 70% (base case)[7] (iii) Repayment period: 25 years including 7 year grace period (iv) Interest rate (construction): JPY 6 month LIBOR+35bp = 0.55% LIBOR = 0.2025% (v) Interest rate (consulting services): 0.01% (vi) Front end fee: 0.2%	(i) - (vi) ODA loan terms and conditions effective from Oct 1, 2013 (JICA website) (iii) JPY 6 month LIBOR rate as of Jan 31, 2014 (BBA website)
2	Government funding cost	5.75%	JICA Study Team assumption Global Bond 2034-53 yields range: 5.73% - 5.77% as of Feb 4, 2014 (MEF information)
3	Exchange risk premium	3.1%	JICA Study Team assumption Difference of Global Bond 2021 yield (4.31%) and Samurai Bond yield (1.21%) as of Feb 4, 2014 (MEF information)
4	Cost of private equity	13.5%	JICA Study Team assumption "Study on Financial Frameworks in Mass Transit System Project in Thailand" (Aug 2010)
5	Commercial loan conditions	(i) Currency: USD (ii) Debt ratio: 70% to total assets (iii) Interest rate: 6.5%	(i) – (iii) JICA Study team assumption (iii) Industrial loans average interest rate (ex. construction): 6.49% as of November 2013 (Superintendencia de Bancos de Panamá)

Source: Various sources

[7] Actual financing ratio applied to the project is subject to appraisal by JICA.

(2) Weighted Average Cost of Capital of Public Investment and Operation Case

Table 18.41 WACC of Public Investment Case

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

18.5.7 Project FIRR

(1) Project FIRR and NPV

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.42 Project FIRR and NPV

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 18.43 Project Cash Flow Projection (Constant Price)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(2) Sensitivity Test

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.44 Sensitivity Test (Project FIRR)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

18.5.8 Life Cycle Cost of PublicInvestment and Operation

(1) Life Cycle Cost of Public Investment and Operation

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.45 Life Cycle Cost of Public Investment and Operation Case

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 18.46 Cash Flow Projection (Public Investment and Operation)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(2) Sensitivity Test

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.47 Sensitivity Test (Revenue and Cost Changes)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 18.48 Sensitivity Test (JPY LIBOR Rate and Revenue/Cost)

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

18.5.9 Value for Money of Project Scheme Alternatives

(1) Assumptions on Value for Money Estimation

Value for Money (VFM) of each project scheme alternative presented in Chapter 8 (Section 8.6) is estimated as difference in LCC between the Public Investment and Operation case (Alternative 1) and each alternative based on the following assumptions. Efficiency derived from private investment and operation is not quantified in the base case scenario. The analysis will estimate the required efficiency by the private implementation instead in accordance with each scheme's setup.

Table 18.49 Assumptions on Value for Money Estimation

Item		Assumption
1	Project Scheme Alternatives	- Alternative 1: Public Investment and Operation (PSC: See Section 18.5.8) - Alternative 2-1: Concession Scheme (Fare-based) for 30-year operation - Alternative 2-2: Concession Scheme (Annuity-based) for 30-year operation - Alternative 3: BOT/BTO Scheme for 7-year construction and 30-year operation - Alternative 4-1: Vertical Separation (Fare-based) for 7-year construction and 30-year operation - Alternative 4-2: Vertical Separation (Annuity-based) for 7-year construction and 30-year operation - Alternative 5: Public Operation with Private Investment for 7-year construction and 30-year operation
2	Vertical Separation Project Scope	The private concessionaire undertakes the construction and procurement of rolling stock, power supply, signaling & telecommunication and AFC system. The public undertakes rest of the scope. Mobilization and detailed design costs are divided on a pro-rata basis.
3	Reinvestment and additional investment	Reinvestment and additional investment scheduled is undertaken by the private concessionaire. Residual value is reimbursed from the public side at the end of operation period.
4	Cash flow of the public side	Transactions with the private concessionaire are undertaken by Metro de Panamá, S.A. The company's net cash flow is maintained at zero by either transferring positive net cash to the government or subsidizing on construction/operation costs.

Source: JICA Study Team

(2) Adjustment Mechanism for Commercial Viability

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.50 Adjustment Mechanism for Commercial Viability

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Table 18.51 WACC of the Private Concessionaire

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

(3) Results

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Table 18.52 Value for Money of Project Scheme Alternatives

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

Source: JICA Study Team

Figure 18.2 Threshold to Achieve VFM

18.5.10 Implications from Financial Analysis

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

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Chapter 19 Environmental and Social Considerations

19.1 Introduction

The Metro Line 3 and 4th Panama Canal Bridge Projects will generate various positive and negative impacts on the environment and society. In order to avoid, mitigate, minimize and compensate for potential negative impacts, an Environmental Impact Assessment (EIA) was carried out. Also, a Strategic Resettlement Action Plan (SRAP) was prepared in parallel. A number of other peripheral investigations and studies have also formed part of the environmental and social investigations within the overall Feasibility Study.

This section summarizes the results of the EIA, SRAP and other environmental and social considerations activities.

19.2 Legal and Institutional Framework on Environmental and Social Considerations

19.2.1 Panamamian Legal Framework

The Constitution of the Republic of Panama and Law 41 of 1st July 1998 (Environmental Law) establishes that it is an obligation for the Panamanian government to protect, conserve and restore the environment.

The Environment Law also created the National Authority of Environment (ANAM) as the responsible agency for environmental issues. The same law obliges the proponent of all public or private projects to carry out an EIA before construction of the project.

Table 19.1 shows the national legislations related to environmental and social considerations.

Table 19.1 Legislation on Environmental and Social Considerations in Panama

Name of legal instrument	Main functions
Law 41 of 1st July 1998 "Environmental Law"	Created National Authority of Environment (ANAM) and defines their responsibility to evaluate EIA studies and issue respective resolutions. Also defines the criteria for project categorization.
Executive Decree 123 of 14th August 2009 with modification of Executive Decree 155 of 5th August 2011	Establishes the general frame work for environmental impact assessment process.
Law 01 of 3rd February 1994	Regulates forest management.
Resolution AG-0235-2003	Establishes ecological compensation cost for cutting trees, bushes and grasses.
Executive Decree 01 of 15th January 2004	Determines the noise level in residential and industrial area.
Executive Decree 58 of 16th March 2009	Establishes the environmental quality normative and permissible limit.
Resolution AG-0051-2008	Regulates threatened and endangered extension of species.
Executive Decree 02 of 14th January 2009	Whereby the Environmental Norm for Soil Quality is established for various uses.
Technical Regulation DGNTI 39-2000	Discharge of Liquid Effluents into Bodies of Surface Water and Groundwater.
Resolution AG-0026-2002	Schedule for the Characterization of Discharges and their Compliance
Resolution AG-0466-2002	Requirements for applying for permits or concessions for discharging wastewater or residual waters.

Name of legal instrument	Main functions
Law No. 35 of 22th September 1966	Water Use Law
Technical Regulation DGNTI-COPANIT 43-2001	"Hygiene and safety Conditions for controlling air pollution produced by chemical substances in the work area".
Technical Regulation DGNTI-COPANIT 45-2000	Industrial Hygiene and Safety in environments producing vibrations.
Resolution 506 of 6th October 1999 / Technical Regulation DGNTI-COPANIT 44-2000	Regarding Occupational Hygiene and Safety in work environment producing noise.
Executive Decree 306 of 4th September 2002	Adopts the regulation for controlling noise in public spaces, residential or inhabited areas, and work spaces.
Executive Decree 38 of 3th June 2009.	Emissions from mobile sources. Whereby the permissible limits for air emissions produced by motor vehicles are established in order to protect human health, natural resources, and environmental quality from air pollution.
Work Code (articles 126, 128, 134, Book II, Occupational hazards, Title I, Health and Safety in workplace Articles 282, 283 and 296)	Occupational Safety, Work Hygiene and Professional Risks.
Law 6, of 11th January 2007	Whereby the norms are dictated for the management of oily wastes derived from hydrocarbons or synthetic base.
Law N°66, of 10th November 1947, Sanitary Code	Whereby the Health Code of the Republic of Panama is approved.
Law 21 of 2nd July 1997	Approves regional plan of development in the inter ocean region and general plan for use, conservation, and development of the Panama Canal area.
Law 14 of 5th May 1983 with modification of Law 58 of 7th August 2003	Regulates historical monuments and protection of archaeological resources.
Resolution AG-0363-2005	Establishes measures to protect national historical monuments from impact generated by project activities.
Article 48 of Panamanian Constitutions	Establishes that expropriation can be carried out for public benefit, and the expropriation should be carried out with legal way and with previous payment of compensation.
Law 22 of 27th June 2006	Regulates that property assess must be carried out by Ministry of Economic and Finance (MEF) and Government Accounting Office (CGP).
Civil Code (Chapter 5)	Regulates use of right of way.

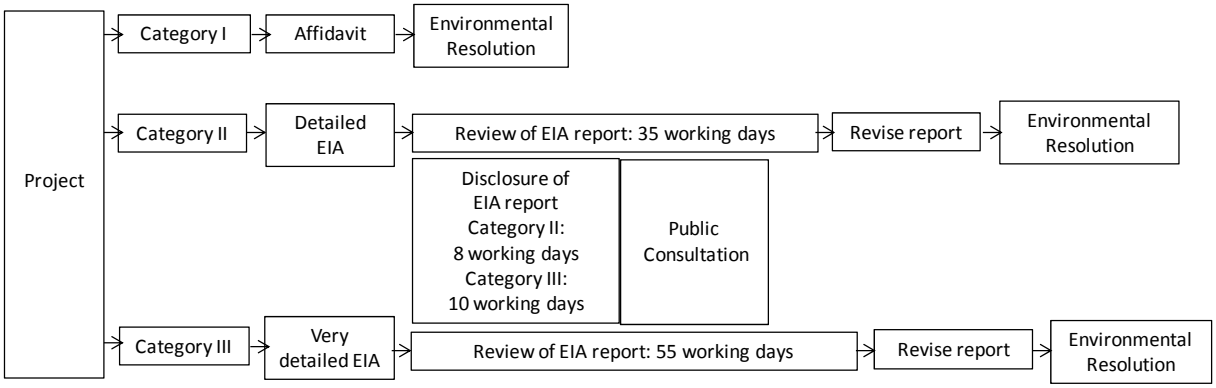
Source: JICA Study Team

19.2.2 Environmental Resolution

Article 3 of Executive Decree 123 of 4th August 2009 states that all project proponents must go through the EIA evaluation process before commencement of construction to obtain an Environmental Resolution issued by ANAM. The process to obtain an environmental resolution varies based on the category of the project.

Project proponents must screen and categorize their own project into Category I, II, or III, according to the ED 123 of 4th August 2009. A project with no or minor negative impact on the environment and/or society is categorized as Category I; a project with significant negative impacts which can be eliminated or mitigated with standard measures is categorized as Category II, and a project with accumulative and synergistic negative impacts on environment and social aspect which requires detailed analysis and mitigation measures is categorized as Category III.

Figure 19.1 shows the process to be followed for environmental resolution for each category. During the EIA process, the project proponent of Category II or III projects must disclose the report to the public and have one public consultation.



Source: JICA Study Team

Figure 19.1 Process to Obtain Environmental Resolution

19.2.3 JICA Guidelines for Environmental and Social Considerations (2010)

All JICA cooperation projects should apply the JICA Guidelines for Environmental and Social Considerations ("JICA Guidelines"). The JICA Guidelines state that it is the responsibility of the recipient country to manage environmental and social considerations. The objectives of the Guidelines are the following: 1) to encourage the project to have appropriate consideration for environmental and social impacts, and 2) to ensure that the recipient countries, supported by JICA, ensure that environmental and social issues are dealt with in a satisfactory manner.

JICA categorizes a project into four categories taking in to account the type and size of the project, and the characteristics of the project area. A project with possible significant negative impacts on environment and society is categorized into Category A. A project with less significant possible impacts compared to Category A is assigned to Category B. A project with little or no negative impact is designated as Category C. Finally, if JICA's funding of a project is provided to a financial intermediary or executing agency, or the sub-project cannot be specified prior to JICA's approval of funding/project appraisal, and those subprojects are expected to have a potential negative impact on the environment, the project is designated as Category FI.

19.2.4 Institutional Framework

The proponent of the Metro Line 3 and 4th Panama Canal Bridge Line-3 Projects is *the Secretaria del Metro de Panama* (SMP). SMP is responsible for ensuring that the project correctly undergoes the EIA process under the Panamanian regulations and JICA Guidelines, and to obtain an Environmental Resolution before construction. SMP must obtain other environmental permissions which the Environmental Resolution may require.

ANAM is responsible for reviewing the EIA report, and issuing the Environmental Resolution. Sector Environmental Units (UAS)[1] will be charged with the review of the EIA report.

ACP is the entity that regulates the land use of the Panama Canal area established in the Law 21 of 1997, which the project area crosses. SMP asked ACP to issue permission to enter the Canal area for the baseline studies for the EIA, and will ask ACP for permission for civil works during construction. Due to the national importance of the Canal, ACP is a very powerful organization.

[1] UAS (Unidad Ambiental Sectorial) is an organization within each ministry and municipality, whose responsibility it is to review and evaluate EIA reports and give comments to ANAM.

19.3 Categorization of the Projects

19.3.1 Categorization according to the Panamanian legislation

As described above, the project proponent is responsible for categorizing its own project. As the characteristics of the Metro Line 3 project (Monorail project) and the 4th Panama Canal Bridge project (Road Bridge with monorail line and the improvement work of the Omar-Torrijos Intersection) are different, the categorization was carried out separately for each project, according to the discussions with stakeholders such as SMP.

SMP classified both projects as Category III. Full EIA studies were therefore required for both projects, and SMP should obtain two environmental resolutions.

19.3.2 Categorization according to JICA Guidelines

The overall project (Metro Line 3 only) was originally designated as Category A by JICA. During the study, the scope was expanded to include the 4th Panama Canal Bridge project, and the mode for the Metro Line 3 project and its scale were determined. Following the repackaging of the overall project, and based on the available data and information in December 2013, JICA changed the categorization of the project to Category B.

The JICA study team is required to carry out an Initial Environmental Evaluation (IEE) according to JICA Guidelines for Category B projects, and to prepare a report taking into account the results of IEE. However as these projects are designated as Category III according to Panamanian law, which requires a full EIA, the JICA study team carried out full EIAs (and SRAPs) to support SMP.

19.4 Public Participation

The Public Consultation and Disclosure Plan (PCDP) was prepared in the early stages of the EIA/SRAP studies, and it set out the proposed planning and format of the consultation meetings, and identified the key affected people and other stakeholders. One public forum is required during the review of the draft EIA reports according to the Panamanian regulations, however the present projects have gone beyond the minimum requirement and has organized and carried out various public participation meetings in addition to the public forum.

The objectives of the public participation were to:

- Identify the different types of stakeholders, families and economic units to be directly affected by the project;
- Provide the public with information on the scope and operation of the project, including social and environmental potential impacts and the mitigation measures;
- Establish mechanisms for sharing information about the project;
- Provide an opportunity for stakeholders to express their concerns and points of view on various aspects of the project, to be taken into consideration during the preparation of the EIA/SRAP and during design and implementation of the project; and
- Establish a good relationship with the local community.

The mechanisms for public participation for this study were:

- Questionnaire surveys (400 samples for the Line 3 project, 164 for the 4th Panama Canal Bridge project);
- Interviews with stakeholders (political and governmental sector, economic sector, socio-cultural sector, environmental sector, and natural leaders);
- Focus group discussion (women, transportation sector, business sector, students, etc.);
- Community meetings;
- Public Visits (Distribution of pamphlets); and
- Public Forum.

19.4.1 Resume of the Community Participation Activities

Table 19.2 shows a record of all community participation activities carried out. The records (the minutes of meetings, photos, and attendance lists) of all community participation activities are attached to the EIA reports.

Table 19.2 Record of Community Participation Activities

Date	Time	Location	Activity	Number of participants (approx.)	Name of project
2014/02/17	16:00-17:30	Specialized University of Las Americas (Albrook)	Focus group discussion (Women)	7	Metro Line 3
2014/02/18	14:30-16:10	Specialized University of Las Americas (Albrook)	Focus group discussion (University students)	8 (*1)	Metro Line 3
2014/02/18	10:00-11:30	Specialized University of Las Americas (Albrook)	Focus group (Transportation sector)	2 (*2)	Metro Line 3
2014/02/19	17:30-20:00	Specialized University of Las Americas (Albrook)	Stakeholder meeting	21	Metro Line 3
2014/02/20	17:00-18:30	El Diamante, Burunga	Focus group discussion (Workers and Community Leaders of *Corregimiento* of Burunga)	10	Metro Line 3
2014/03/16	09:30-11:00	Super Xtra (Arraijan)	Public Visit (Distribution of 3,000 pamphlets approx.)	-	Metro Line 3
2014/03/17	10:00-11:30	Classroom of Panama International Maritime University (La Boca)	Focus group discussion (Transportation sectors)	6	Metro Line 3
2014/03/19	16:30-19:20	Auditorium of Panama International Maritime University (La Boca)	Community Meeting	28	Metro Line 3
2014/03/19	19:30-20:30	Auditorium of Panama International Maritime University (La Boca)	Stakeholder meeting	16	Metro Line 3
2014/03/20	17:00-18:00	Auditorium of Panama International Maritime University (La Boca)	Community Meeting	2 (*3)	4th Panama Canal Bridge
2014/03/21	15:00-16:10	Municipal gym of Arraijan (Regulo Sanchez Gym)	Focus group discussion (Community leaders and authorities of District of Arraijan)	12 (*4)	Metro Line 3
2014/03/21	16:30-18:00	Municipal gym of Arraijan (Regulo Sanchez Gym)	Community Meeting	25	Metro Line 3
2014/03/22	10:30-12:00	La Boca (close to Las Americas Bridge)	Stakeholders Meeting (Fishermen)	37	4th Panama Canal Bridge
2014/03/22	13:00-13:30	Albrook Bus Terminal	Public Visit (Distribution of 1,000 pamphlets approx.)	-	Metro Line 3 / 4th Panama Canal Bridge
2014/05/09	16:45-19:00	Auditorium of Panama International Maritime University (La Boca)	Community Meeting	84	4th Panama Canal Bridge

Date	Time	Location	Activity	Number of participants (approx.)	Name of project
To be determined (August, 2014)			Public Forum	-	Metro Line 3
To be determined (August, 2014)			Public Forum	-	4th Panama Canal Bridge

(*1): 23 students came to the meeting, however 15 students participated as observers because of the objective and methodology of focus group discussion.
(*2): Only 2 persons of alternative transportation "*piratas*" came to the discussion, so the meeting was postponed to March 17.
(*3): Many people invited to this meeting participated in the meeting on March 19. Another community meeting was carried out on the 9th of April or May, after determining the type of bridge and construction method.
(*4): Although 23 people came to this focus group, a total of 12 participated actively because of the objective and methodology of focus group discussion. Nevertheless, the other 11 people were invited to expose their opinion at the end of the activity.
Note: A public distribution of 5,000 Line 3 pamphlets, 2,500 Meetings Invitational flyers and 100 Posters were made from March 12 to March 19 from Arraijan to Hato Montaña and from Albrook to La Boca inviting to Public Meetings for Line 3 and 4th Panama Canal Bridge Project. From March 17 to March 22, pamphlets were distributed in each meeting. During the week of March 24 to March 28 a total of 8,000 pamphlets were distributed in local schools, Health Centers and Community centers of the district of Arraijan.
Source: JICA Study Team

(1) Results of questionnaire survey

A questionnaire survey was carried out to discover opinions on:

- Current problems of the transportation sector; and
- Opinions about the Metro Line 3 and the 4th Panama Canal Bridge projects and their likely positive and negative impacts.

The sample numbers were 400 persons for the Metro Line 3 Project and 167 for the 4th Panama Canal Bridge Projects. The questionnaire survey was carried out from January to March of 2014 in the project area.

84% of respondents supported the Metro Line 3 Project, and 3% did not. 98% of respondents supported the 4th Panama Canal Bridge Project, and 1% did not.

According to the questionnaire survey, the principal problems of the transport sector in the route from Panama to Arraijan are: lack of sufficient buses, bad quality of bus service, traffic jams, and lack of traffic management.

The respondents expect that the Metro Line 3 and the 4th Panama Canal Bridge Projects will improve the quality of transportation services, improve the quality of life of the local people, contribute to national development, and generate local employment. On the other hand, they foresee that the inconvenience of traffic jams will be temporarily increased, a negative impact on the environment will be generated, and the public services such as water and lighting will be affected during the construction phase.

(2) Interviews with Stakeholders

At the early stage of this feasibility study, SMP and the JICA Study Team confirmed the stakeholders for this project. The table below shows the main stakeholders for both projects.

Table 19.3 Project Stakeholders

Type of stakeholder	Details
Political and governmental actors	ACP, Panama Maritime Authority, ANAM, National Land Authority, Civil Aviation Authority, ARAP, Ministry of Finance and Economy, Ministry of Housing, Ministry of Public Works, Transit and Transportation Authority, Municipality of Panama, Municipality of Arraijan, Panama Pacifico Agency, 4 representatives of political parties
Economic and guild actors	Panama Port, Industrial Union of Panama, Chamber of Commerce of Panama, Panama Canal Railway Company, Select Transport Society of Vista Alegre, Union of United Taxies, Chamber of Construction of Panama, CANATRA, Society of Engineer and Architect of Panama, SUNTRACS, Albrook Transport Terminal, Entrepreneurs of Arraijan (Super Xtra, Arraijan Mall, Hato Montaña Complex), Entrepreneurs of Ancon and Panama (Albrook Mall, Nicos cafe), Artisanal fishermen
Social and cultural actors	Church, civil society, community leaders
Environmental actors	NGOs (ANCON, Alianza para la Conservación y Desarrollo de Panamá, Fundación Natura, Mar Viva, Panamanglar)
Natural leader	Community leaders

Source: JICA Study Team

The interviews were carried out with 85 stakeholders (15 political and governmental actors, 27 economic and guild actors, 20 social and cultural actors, 10 environmental actors, and 13 community leaders) for the Metro Line 3 and 4th Panama Canal Bridge Projects. The main opinions and recommendations which were heard in the interviews are:

- Most of the interviewees said that both projects are in the national / social interest, and will give huge benefit to the communities in the area. The projects will improve the traffic condition, generate local employment, improve the quality of life especially in the project area, and encourage national economic activities.
- Some stakeholders mentioned that the cost-benefit ratio must be sustained to implement the Projects. At the same time, they are concerned about the increasing external debt.
- Many stakeholders mentioned that it would be better to extend the Metro Line 3 to La Chorrera, to help solving traffic jams between Arraijan and La Chorrera. Moreover, many residents of La Chorrera go to Panama City to study or work every day.
- Some stakeholders expressed their concern of the potential negative impact on flora and fauna, and on the Canal operations. They strongly insisted to carry out all necessary studies such as EIA, and to ensure a robust environmental management plan to mitigate and minimize every negative impact.
- A respondent commented to provide spaces for *piratas* to integrate them into the transportation system formally.
- The stakeholders recommended to ensure to keep the local community informed about the Projects to avoid problems in the future. Also they mentioned to ensure employment of local people, and to implement the Projects as soon as possible.

(3) Results of Focus Group Discussion

A focus group discussion is an activity in which six to 12 people are gathered together and allowed free discussion on a specific theme, which permits to gather their opinions and information.

During this study, five focus group discussions were carried out. The discussion was started without any detailed information about Line 3 and the 4th Panama Canal Bridge projects. In the second half of the discussion, a brief explanation of the project were given to the participants with a pamphlet. The main three themes of the discussion were:

1) The problems in the transportation sector;
2) Opinions for Metro Line 3 and the 4th Panama Canal Bridge projects; and
3) Ideas on how to integrate the exiting transportation system and Metro Line 3 / the 4th Panama Canal Bridge projects.

The results of the focus group discussions of the users of bus, Metro Bus, and taxies show that people have been suffering from long journey times, troublesome travel (bad driving manners, lack of seats, no air-conditioning), high cost for transportation (bus plus taxi, or *piratas*). They consider that the bad transportation systems aggravate the quality of life. Some people prefer to use *piratas* though the fee is much higher than the Metro Bus or bus, because they can save travel time, or because there are some routes that only the *piratas* service. All participants welcome the Metro Line 3 and the 4th Panama Canal Bridge Projects.

The transportation sector (provider of services) also supported the Metro Line 3 and the 4th Panama Canal Bridge Projects, but without leaving the existing transportation services. They also mentioned that they can contribute to provision of information and ideas to integrate the Metro with the existing transportation services, and to improve the internal routes in Arraijan, so that small transportation services (taxis, mini buses) can pick up passengers in the internal area to bring them to the Metro stations.

The summaries of the four focus group discussions are shown in **Appendix 11-1**.

(4) Results of Community Meetings

A Community Meeting is an activity in which people who live, work, study, or have other interests in the project area are invited to hear project information, and also given the opportunity for questions and answers.

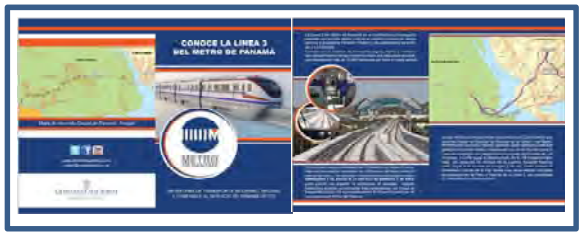
Two community meetings were held in March 2014 for the Metro Line 3 project in the eastern and western area of the canal. One community meeting was held for the 4th Panama Canal Bridge Project in May 2014 in La Boca. The community meeting was announced though posters, communication with community leaders, phone, verbal announcements during the field visits, etc.

In the community meetings, SMP gave a power point presentation of the project, and also made time for questions and answers. **Table 19.4** shows the main results of Q&A in the meetings.

Table 19.4 Main Questions and Answers of Community Meetings

Questions/Opinions	SMP Response
[Resident in the project area] Why the type of technology of Metro Line 3 is different from the Line 1?	Because of the difficulties in topography conditions (inclination and radius). We analyzed the options of system for the Metro Line 3, also considering the maintenance of the train. (Also show the results of alternative analysis of systems.)
[Resident of Diablo Heights] We know that Metro Bus places bus stops,	The study has been carried out, and JICA Study Team will do simulation for this.

Questions/Opinions	SMP Response
which made worse traffic jam. Now, is there any capacity to build new transportation system in the existing road? Do you have any plan for new structures related to Metro?	
[Resident of Diablo Heights] If the feasibility study has not completed yet, why are you carrying out EIA at this moment?	It is very important to take into consideration the environmental issues from this study stage to ensure that the project is environmentally feasible.
[Resident in the project area] Questions about the location of some stations.	Gave answers showing the map.
[Resident of Howard] Why the 4th Panama Canal Bridge will go for north side of The America Bridge, not for south?	ACP had carried out alternative analysis of the route of new bridge. They considered five alternatives including a tunnel option. Then the north route was selected as the most feasible one.
[President of Quarry Heights (residential area)] How much will be the fee of the Metro Line 3?	We are carrying out an investigation on this theme; we investigated in the case of Costa Rica. We will establish the fee for each section, not same fee for every transit.
[Resident in Ancon] We are very worried about the problem such as traffic jam during the construction phase which will last for four years. We also worried about the negative impact on fauna and flora in our area.	SMP implemented the Metro Line 1 Project in the area with many problems, especially management of traffic. However we completed well the work. Also I need to clarify that the construction period of the Project will be four years, but the construction in your area will be much less than four years.
[Resident and shop owner in Arraijan] I've heard that Av. Ascanio Villalaz will be widened, is it true? Also I've heard that there will be land expropriation. I have a shop along the alignment in Arraijan.	We do not have the plan to widen the Av. Ascanio Villalaz. The most part of the alignment will be within the RoW, and we have been working to minimize the affectation. *[Moderator of the meeting] Please contact us later to know the detail of your shop to be affected.*
[Resident] There are parts of the project that could affect the Airport. Have you considered moving the runway north to avoid the need to tunnel?	We have been seeking to solve this problem. What is being analyzed is the possibility of construction of intersection to help improve the roads and access to the West Panama. This will require generating a roundabout, probably three levels for cars, them one of them will provide access to the bridge. We think the moving the airport runway to north does not resolve the problem.
[Resident in Ancon] There is concern among the residents for their quality of life. We will not allow machinery passing in our area during construction. We are worried about noise and PM_{10}. Also it is important to plan and implement a Plan for Security in the area.	*[Moderator of the meeting] EIA studies have been carried out to evaluate all impacts, such as fauna, flora, air quality, noise and vibrations. The mitigation measures will be planned to mitigate and minimize such impact to not aggravate your quality of life.*

Questions/Opinions	SMP Response
	
March 19, 2014 at Auditorium of Panama International Maritime University (*1)	March 21, 2014 at Municipal gym of Arraijan (Regulo Sanchez Gym) (*1)
	
May 09, 2014 at Auditorium of Panama International Maritime University (*2)	Pamphlet provided in the Project Area

Source: JICA Study Team, (*1) JICA Study Team, (*2) URS Holdings, Inc.

(5) Public Visit

A Public Visit is an activity to give people project information and to collect opinions at a location within a project influence area where people come and go very frequently. A banner about the project is erected, pamphlets are handed out, and people can enquire about the project freely.

Two Public Visits were carried out for this project, one at Albrook Bus Terminal, the starting point of the Metro Line 3 in the east side of the Canal (on Saturday, March 22, 2014), and another at a big super market (Super Xtra) in Arraijan, on the west side of the Canal (on Saturday, March 15, 2014). A big expectation for the project was voiced by the community; who are generally looking forward to the new service very much. The main questions asked by the public were related to the location of stations, fare, and the starting time of the construction.

Source: JICA Study Team

Figure 19.2 At Arraijan (Super Xtra) March 16, 2014 (L) and Albrook Transportation Terminal, March 22, 2014 (R)

(6) Public Forum

A Public Forum is carried out by the project proponent (SMP) during the review of the EIA reports. The Public Forum for Metro Line 3 Project and the 4th Panama Canal Bridge Project will be carried out in August 2014. The EIA reports will be published and will be freely available to the public, who will also be able to give comments. All comments given during the Public Forum will be taken into consideration for the final version of the EIA report.

19.5 Analysis of Alternatives

It is usual within an EIA to consider alternatives, which may be alternatives of location, design, construction, and/or operation. In the case of the Metro Line 3 Project and the 4th Panama Canal Bridge Project, a large number of alternatives have been examined by various parties throughout the development of the projects. The alternatives considered include not only route and technology variants, but also the "no project" option.

19.5.1 "No Project"

The present situation of the project area (Panama City and the suburbs of Arraijan and La Chorrera) and its inhabitants can be summarised as follows:

- Traffic congestion along the Panamerican highway has been getting worse and worse because of lack of route which connects Panama City and Arraijan/La Chorrera.
- Due to population growth, urban development, and GDP growth, traffic congestion on the Panamerican highway is likely to worsen in the future;
- If no mass transit system or other alternative arrangement is developed, it is estimated that rush hour congestion at the Americas Bridge will be four to five hours by 2010 and seven hours by 2030; and
- The Metrobus system does not serve the western side of the canal. Normal buses run on the western side of the canal, but these serve the suburbs poorly, with infrequent services that are overcrowded, unpredictable journey times, and inconvenient stopping locations.

The government's development plans are likely to result in the following in the next 10 years:

- The *Panama Pacifico* development is set to provide an additional 20,000 homes and 40,000 jobs;

- The number of private housing developments that are currently being built elsewhere in the Arraijan and La Chorrera zone will continue to grow;
- Major maintenance[2] of the Americas bridge is overdue and would need to be carried out[3]; and
- Metro Lines 1 and 2 will become operational.

The objectives of the Metro Line 3 Project and 4th Panama Canal Bridge Project include:

- Alleviation of the present congestion problem in the Americas bridge area;
- Reduction of negative social impacts associated with the current journey times for residents of the Western suburbs;
- Economic development of the Western suburbs and of Panama as a whole;
- Air pollution / emission avoidance;
- Encouragement of planned urban development in the Western suburbs of Panama City; and
- Promotion / development of a sustainable urban public transport system.

Failure to implement some form of solution to the transport problems in the Western suburbs would be likely to result in the following environmental and social impacts:

- An increase in car usage;
- An increase in air pollution / emissions;
- An increase in journey times;
- Slowing of development in the Western suburbs; and
- Unplanned / uncontrolled development in eastern areas served by the Metro Lines 1 and 2 systems.

Considering the above observations and facts, the "no project" scenario is difficult to accept as a feasible option, whether economically, socially or environmentally. Economic development of the study area will inevitably suffer if transport links to the city are not improved. Furthermore, the negative social and environmental impact of not constructing some form of new transport project or projects is likely to far outweigh the potential negative impacts associated with the construction and operation of the same.

19.5.2 Metro Line 3 Project

The alternatives assessment for the Metro Line 3 Project has been an iterative process developed jointly by the JICA study team and SMP. The assessment included a detailed review of the various route options and transport technologies available, and an analysis of the suitability of these options with respect to technical feasibility, cost, schedule, demand, land availability/resettlement and potential environmental impact. The alternatives assessment procedure for Metro Line 3 is summarized below, but fully described in **Chapter 5** (including comparative tables).

(1) Route Selection

Based on field survey observations, maps, and satellite imagery, a comparative assessment of the two proposed route alternatives for Metro Line-3 (along Panamericana highway or "Autopista") from a point of view of environmental and social impact was carried out and is shown in **Appendix 11-2**. The assumption adopted for the assessment was that Metro Line 3 uses elevated railway and no fossil fuels use system.

[2] Requiring extended closure of the bridge

[3] The current strategy is to await completion of the Fourth Bridge prior to commencing the maintenance works

The results of the comparison show that there are relatively few fields in which a significant difference in impacts is likely to be experienced between the two route alternatives. The most significant areas of difference between the routes were:

- Resettlement and land acquisition;
- Local economy, employment & livelihoods;
- Air pollution;
- Noise and vibration;
- Safety; and
- Traffic.

The above fields, deemed to be the most significant in terms of route selection, were fed into the overall route selection matrix, which allocated weighted scores to different aspects to be considered (see **Chapter 5** of the present report) in a very comprehensive manner. Environmental and social considerations were allocated 20 of the possible 100 weighting points within the overall route assessment.

The result of the comprehensive analysis favoured the Panamerican route, and that route has now been fixed as the most suitable route for Metro Line 3.

(2) System Selection

The analysis for system selection of the Metro Line 3 Project was carried out during the first stage of this study (see **Chapter 5** of the present report). Initial performance-related screening removed a number of potential system options from consideration. One of the performance criteria considered was whether the system used fossil fuels. The systems screened out at the first stage were:

- Bus Rapid Transit (BRT) at grade;
- BRT using dedicated lane;
- Light Rail Transit (LRT) at grade;
- Hanging Monorail; and
- Maglev.

The environmental and social impacts of the remaining transport systems (LRT using dedicated lane; AGT (Automated Guideway Transit); Monorail Straddle Type; Liner Metro; MRT conventional; LRT/MRT for steep slope) being considered by the study team were then provisionally compared, as shown in **Appendix 11-3**. It was decided that, while some differences in likely impact levels do exist between the system options, these differences are not sufficiently significant to warrant consideration in the selection of system. Environmental impact was allocated 5 of the possible 100 weighting points and social impact (area of land acquisition and number of resettlement) was allocated 15 of the possible 100 weighting points within the overall system analysis.

The result of the comprehensive analysis favoured the monorail system, and that system has now been fixed as the most suitable technology for Metro Line 3.

19.5.3 The 4th Panama Canal Bridge project

A number of options for improving the crossing of the Panama Canal have been studied. The first stage of the options assessment was to decide between a bridge and a tunnel (or tunnels). A summary of the key advantages and disadvantages of the two technologies is presented in **Table 19.5** below. (See also **Chapter 2** of the present report).

Table 19.5 Comparison of Tunnel and Bridge Technologies

Comparison Factor	Technology	
	Bridge	**Tunnel(s)**
Cost	• USD 1.0 billion	• USD 1.5 billion
Location	• Design restricted by approach to airport • Construction could disrupt canal operations	• Problems associated with airport and shipping are avoided
Environmental / Social Impact	• Some negative impact to marine environment possible due to piling • Negative impact on mangrove area to west of canal • Landscape impact (whether positive or negative is subject)	• Construction will generate a huge amount of excavated material • Potential issues with vibrations, collapse, ingress. • No landscape impact
Operation	• Maintenance is periodic only	• Regular maintenance required • Auxiliary equipment also needed to be operated, e.g. lighting, ventilation, pumping. • Risk of catastrophe e.g. fire in tunnel is much higher than for bridge

Source: JICA Study Team

Although the tunnel option does offer some unique advantages over the bridge option, the bridge option is generally preferable, as can be seen in **Table 19.10** above. It was therefore decided that, due principally to prohibitive cost, the tunnel option would be rejected, and a bridge selected as the preferred solution.

Having determined that a bridge is the only viable crossing option, a number of sub-options were then assessed, namely the potential bridge locations / routes and the bridge design.

Prior to the incorporation of the bridge into the JICA Study, extensive preliminary feasibility studies were carried out on the bridge concepts by ACP. These preliminary studies included an Initial Environmental Examination (IEE)[4], which, *inter alia*, examined three potential route options, and proposed one route as the preferred route.

The bridge routing alternative assessment was mainly achieved with reference to the above IEE study; the key details of which have been summarised below.

Three potential route alternatives were developed, as follows:

- Alternative 1 (“La Boca – Balboa”) passes along Roosevelt Avenue from the road bridge located diagonally from McDonald’s restaurant (old railway station) in Balboa, passes over the corner of the port facilities and crosses over the canal to an area of mangroves located northwest of the Bridge of Americas.
- Alternative 2 (“Amador”) follows a route parallel to the Bridge of the Americas but 100 meters to the south.
- Alternative 3 (“Chorrillo-Barraza Amador”) begins from the 3rd section of the Coastal Beltway (Cinta Costera), crosses over Amador Avenue, and lands on the southern part of Farfan Hill.

The IEE went into considerable detail in considering the three route alternatives. The key advantages and disadvantages of the three alternatives have therefore been distilled for the present report, and are shown in **Table 19.6** below.

[4] ACP had carried out an IEE for the Fourth Panama Canal Bridge Project in 2013. The main objective of the IEE was an alternative analysis of the rout and location of the new bridge.

Table 19.6 Comparison of Tunnel and Bridge Technologies (Environmental and Social Aspects)

Comparison Factor	Route Alternative		
	1	2	3
Route options			
Land use	• Most of the area of direct impact belongs to the Panama Ports Company and the Panama Canal Authority, and the primary activities are related to the operation of the Canal. • To the west is an area of mangroves	• Most of the area of direct impact is occupied by El Chorrillo neighbourhood, consisting of multifamily apartment buildings up to 15 stories high, businesses, restaurants, etc.	• Most of the area of direct impact is urbanized alternating between low-density housing, as in Amador, Loma Terrace Street and Sadler Street with modern, recently constructed buildings, and high-density housing (Barraza and El Chorrillo neighbourhoods). • The area includes businesses, schools, health centres, sports complexes, etc. • Proposed land-reclamation areas, widening of Amador Causeway, and tourist development
Social Impacts	• Few negative social impacts associated with construction due to lack of local residents	• Some negative social impacts associated with construction	• Some negative social impacts associated with construction • Impact on tourism likely
Landscape	• Few negative impacts comparatively, due to existing port facilities	• Greater negative impacts due to presence of recreational and tourism zones	• Greater negative impacts due to presence of recreational and tourism zones
Erosion / Landslide susceptibility	• There are small slides on the sides of Cerro Sosa	• Not expected.	• Not expected.

Comparison Factor	Route Alternative		
	1	2	3
Flora and Fauna	• On Sosa Hill, a succession of secondary vegetation, with small patches of young secondary forest is present • Mangroves to the west. The dominant species are *Rhizophora mangle* and *Pelliciera Rhizophorae* • Fauna diversity and abundance likely to be high in mangrove ecosystem.	• Remnant of secondary forest 100m south of the Bridge of Americas that is fragmented by the road leading to Veracruz • Few fauna numbers sighted	• The vegetation is characterized by the presence of tall, introduced trees. • Fewest fauna numbers sighted
Cultural / archaeological resources	• No disturbance of cultural/archaeological resources is expected	• The western end touches the southern slope of Farfan Hill. There are archaeological reports indicating the existence of cultural resources in the area. On the flat land close to the beach pre-Colombian pots and shells were found. • If Alternative 3 were to be chosen, the impact on the heritage resource could be potentially significant	• No disturbance of cultural/archaeological resources is expected
Summary	• IEE identified 20 negative impacts and 2 positive impacts • Key potential negative impact is loss of mangrove ecosystem	• IEE identified 19 negative impacts and 2 positive impacts • Key potential negative impact is loss of archaeology	• IEE identified 20 negative impacts and 2 positive impacts • Key potential negative impact is on socioeconomics, mainly due to incompatibility with the present and future land use

Source: Adapted from Abenaki Consulting, S.A. 2012

Overall, the IEE found only minor differences between the three route options in terms of environmental and social issues, but proposed Alternative 1("La Boca – Balboa") as the most favourable from an environmental and social perspective.

Following the selection of the "La Boca - Balboa" route for the bridge, a study has been conducted to determine the bridge type.

A significant negative impact is foreseen for an arch bridge because of the construction method, which would require suspension of the canal operation for 24 hours maximum. However, this negative impact can be minimized and compensated for economically. There is not expected to be a significant difference between arch bridge and cable-stayed bridge in terms of negative environmental impacts.

19.6 Scoping

A scoping review was carried out for both the Metro Line-3 and 4th Panama Canal Bridge projects as part of the feasibility study. The objective of the review was to make a preliminary assessment of expected environmental and social impacts under each of the 29 environmental and social issues. The preliminary assessment explained the key expected impacts and assigned a simple-to-understand level of impact.

The Scope and ToR of the EIA studies was developed via an iterative process that involved the JICA Study Team, SMP, and JICA Head Office Staff. ANAM was also consulted during the scoping process, though, unusually, ANAM is not legally required to review or approve draft scopes of work. Following development of the ToR, a suitable consultant was engaged to carry out the EIA and SRAP studies via a transparent selection process.

Following the preparation of the EIA studies, the scoping review tables were updated to show the revised impact levels for each of the 29 areas of impact. The updated scoping review, now including the results of the two EIA studies, is provided in section **19.7.2**.

19.7 Results of Environmental Impact Assessments (EIAs)

The results of the two EIA studies are briefly summarized below. The EIA studies are very lengthy and detailed documents, so those requiring further information than is presented below should refer to the EIA Final Reports. The EIA work started on January 1st, 2014, and the final reports to be submitted to ANAM are due to be completed in the end of July 2014. The EIA reports will be submitted to ANAM by SMP then, the approval will be obtained in around three months after submission.

19.7.1 Current Conditions of Environmental and Social Aspects in the Study Area

(1) Physical environment

Geology, soils and seismology

The two projects traverse a total of four geological formations, as follows:

- *La Boca Formation* – a tertiary sedimentary formation at the east of the project area around Albrook and Balboa. Also found behind Rodman;
- *Río Hato Formation* - a quaternary sedimentary formation that belongs to the Aguadulce Group. Covering a small area around Rodman on the western bank of

the Panama Canal;

- *Panama-Fase Marina Formation* - a tertiary volcanic formation that intersects the alignment in two areas between Panamá Pacífico and Loma Coba, as well as in Nuevo Arraijan and San Bernardino.
- Tocué Formation – This tertiary volcanic formation belonging to the Cañazas Group is the dominant formation in the project area.

The above formations are shown in **Figure 19.3** overleaf.

According to a 2006 study on the Earthquakes of the Isthmus of Panama, seismicity in the project area is low. The Map of Seismic Threat for the Republic of Panama prepared by the geoscience department at the University of Panama indicates that the project area is considered of low seismic risk, with an acceleration between 2.6 and 3.0 m/s^2.

The dominant soil type in the direct area of influence are Utisols. These have an ochric surface layer with a deeper argillic layer below. As can be observed from the laboratory analysis, these soils are acidic with a low percentage of organic material and nutrients such as Phosphorus, Calcium, and Magnesium, and are up to six metres deep.

Soils at the eastern end of the project area are predominantly Entisols. These soils are deep and of recent deposition. As a result, they do not have an ochric layer but have a greater concentration of organic material than Utisols and are therefore more fertile.

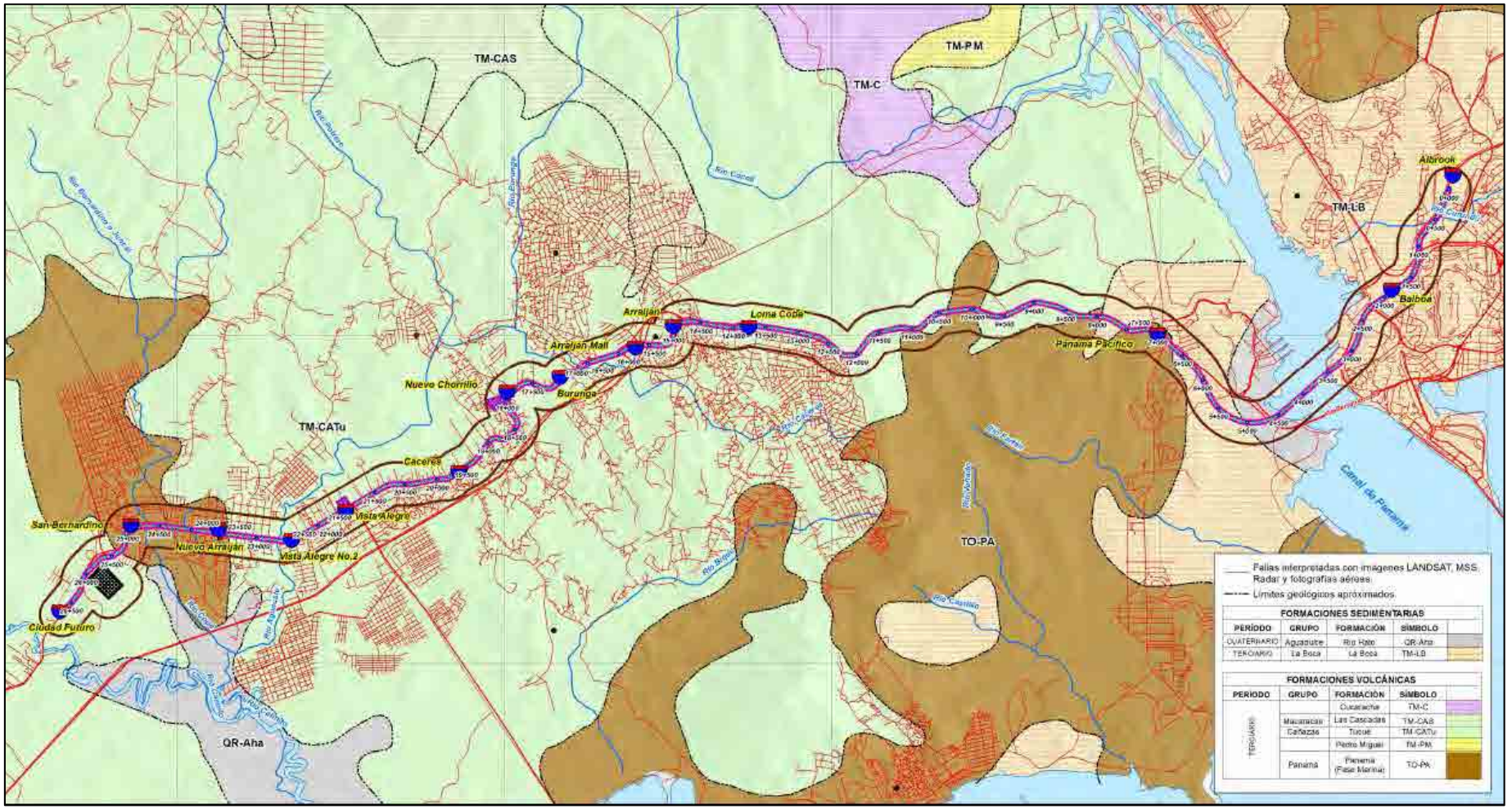
The "Farfan Deposit Area" to the west of the bridge landing point, where the Panama Canal Authority deposits sediments and materials removed via dredging of the Panama Canal, can be classified as having anthrosols due to the degree of alteration due to the anthropic activities. The site has been filled, shaped, and levelled numerous times to receive deposits, and probes established that fill material is found to a depth of 3.0 meters.

Soil and Sediment Quality

Extensive soil sampling and chemical analysis was carried out during the EIA studies. The results of the analyses showed low levels of PAHs and PCBs as well as nitrates / nitrites and most other major ions (with the exception of sulphate), but slightly elevated levels of certain heavy metals, including nickel and zinc, both of which exceeded the applied standards. The contamination is expected to be as a result of the transportation and light industry activities along the Panamerican Highway.

Marine sediments were also collected from sites up and down stream of the proposed bridge alignment, and in proximity to the mangrove area. Analysis showed the following characteristics:

- The substrate was dominated by fine to medium sandy substrate (0.125-0.500mm);
- Organic content was low in the centre of the canal (2-3%) due to the pull of passing ships and dredging. Away from the main channel and towards the mangrove area, organic content increased markedly to 10.5%;
- In terms of inorganic chemistry, all determinants tested for showed positive results, but none at particularly high levels. This is to be expected for an area that is both highly disturbed from shipping and other activities, but also very well flushed on a daily basis.



Source: URS Holdings, Inc. (2014)

Figure 19.3 Geological Map of the Project Areas

Land use

As can be seen in **Tables 19.7 and 19.8** below, land use in the direct area of influence is predominantly urban for the Metro Line 3 Project (67%) and predominantly Urban and "bare ground" in the case of the 4th Panama Canal Bridge Project (77%). Natural environments, including forest, grassland, and water bodies, make up far less significant proportions of the project areas, particularly with regards to the 4th Panama Canal Bridge Project, where natural environments make up less than 15% of the land use in the direct area of influence.

In terms of environment, the two most significant land use categories are mature secondary forest for the Metro Line 3 Project and mangrove for the 4th Panama Canal Bridge Project. The former is a total of around 15% of the area, and the latter is less than one percent of the direct area of influence.

Overall, it can be concluded that the majority land use for both project areas is one of anthropogenic influence, with comparatively little natural environment in the direct area of influence.

Table 19.7 Land Use in the Metro Line 3 Project Area

Category	Direct area of Influence		Indirect area of Influence	
	Area (Ha)	%	Area (Ha)	%
Mature Secondary Forest	24.146	15.026	316.446	19.203
Intermediate Secondary Forest	1.501	0.934	90.607	5.498
Young Secondary Forest	1.873	1.165	72.007	4.370
Grasslands/isolated trees	14.409	8.967	172.986	10.498
Mangroves	0.0	0.0	0.0	0.0
Forest Plantation	0.155	0.096	2.022	0.123
Urban area	107.751	67.053	882.864	53.576
Water bodies	5.649	3.515	63.939	3.880
Bare ground	4.729	2.943	39.243	2.381
Total	**160.213**	**100**	**1640.114**	**100**

Source: URS Holdings, Inc. (2014)

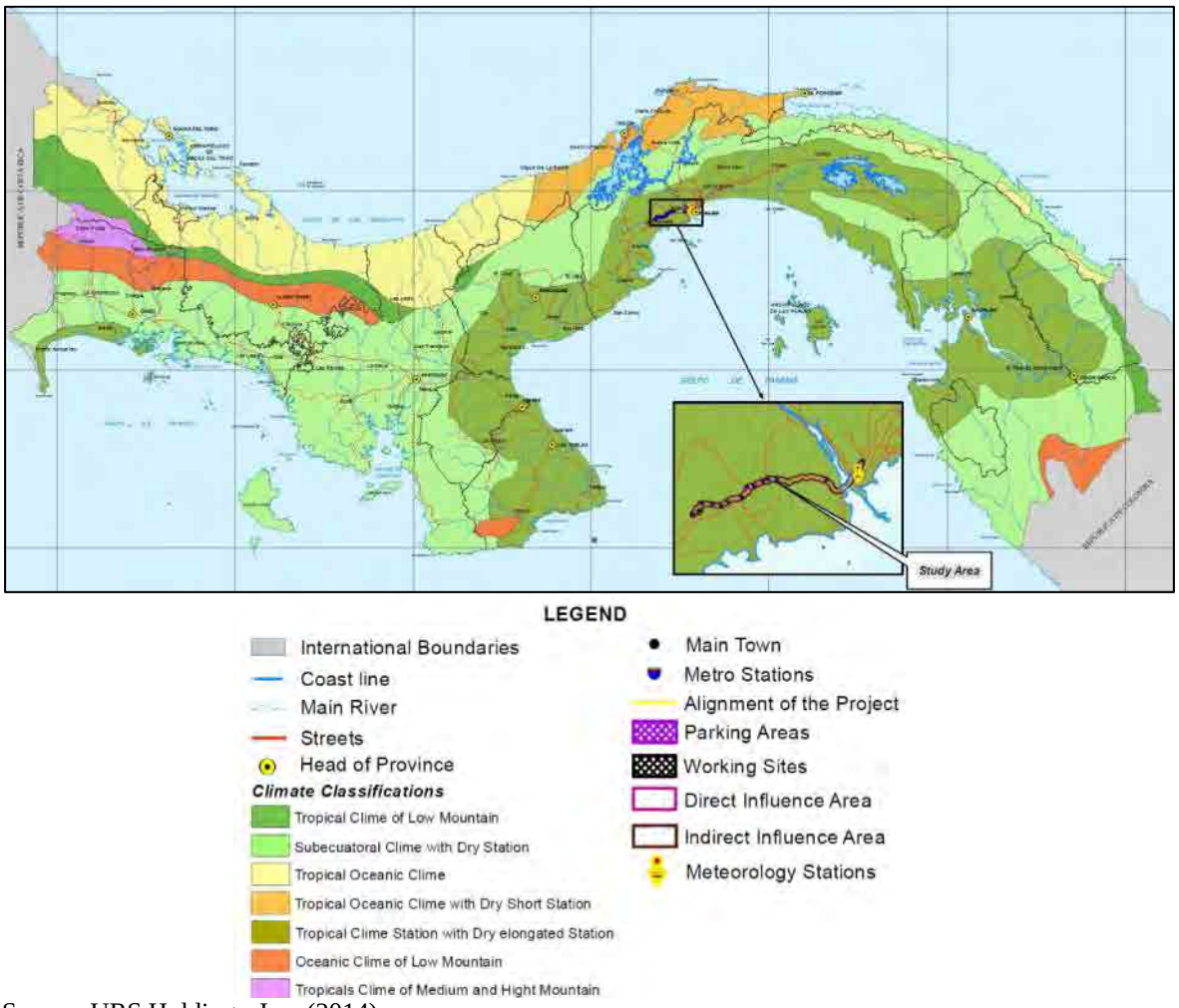
Table 19.8 Land Use in the 4th Panama Canal Bridge Project Area

Category	Direct area of Influence		Indirect area of Influence	
	Area (Ha)	%	Area (Ha)	%
Mature Secondary Forest	1.668	4.119	56.165	11.770
Intermediate Secondary Forest	0.240	0.594	8.082	1.694
Young Secondary Forest	0.607	1.500	9.110	1.909
Grasslands/isolated trees	1.655	4.086	20.268	4.247
Mangroves	0.483	1.189	7.617	1.596
Forest Plantation	0	0	2.033	0.426
Urban area	24.395	60.249	275.605	57.757
Water bodies	4.595	11.349	61.475	12.883
Bare ground	6.967	17.207	36.828	7.718
Total	**40.610**	**100**	**477.183**	**100**

Source: URS Holdings, Inc. (2014)

Climate

The Metro Line 3 and 4th Panama Canal Bridge Project areas are s characterized by a Tropical Climate[5] with a prolonged dry season, as shown in **Figure 19.4**. This climate category predominates in the Central-South and Southeast sectors of Panama and is characterized by average temperatures of 27 to 28 °C and a level of annual precipitation less than 2,500 mm. Strong winds are also common during the dry season, with a predominance of clouds, low relative humidity, and high evaporation.



Source: URS Holdings, Inc. (2014)

Figure 19.4 Climate Map for the Project Areas

Air quality

The results of the air quality survey show that air quality along the overall alignment of the Metro Line 3 project (including the bridge) is good to fair, depending on location. Highly trafficked areas, and those locations near to light industry, port operations or commerce, generally exhibit a deterioration in air quality. Although Panama does not yet have an official air quality standard, the EIA team compared the air quality survey results with the provisional Panamanian standard for air quality and with WHO Guidelines. Most results were below the limits of the standards, with the exception of:

[5] According to the classification of McKay

- NO_2 exceeded the WHO Guidelines at the extreme West of the Metro Line 3 alignment in the Puma fuel station (Arraijan), where fuel is dispatched and there is vehicle traffic.
- SO_2: exceeded the WHO Guidelines in the eastern sector of the alignment, specifically at Avenida Ascanio Arosemena, where there is a lot of vehicle traffic and heavy cargo, and at the entrance to Cocolí, where this is also a lot of car and truck traffic.
- CO_2 exceeded the provisional Panamanian standard at 4 sampling points in the extreme East of the alignment, where there is fairly intense commercial activity and vehicle traffic.

In addition to the instrumented air quality monitoring, an odour assessment was carried out. The assessment determined that bad smells resulting from untreated sewage, stagnant water, dredging of the Panama Canal, decomposing organic matter and waste, combustion gases and industry were fairly significant in certain locations.

Noise and vibration

Noise and vibration surveys were carried out in the project area. The noise surveys were conducted using Extech 407780 integrating sound level meters, which were calibrated and fitted with windshields. The vibration measurements were made using INSTATEL Minimate Plus meters. Surveys were carried out at numerous locations, and were repeated on both weekday and weekends, and both day and night.

Source: URS Holdings, Inc. (2014)

Figure 19.5 Noise (L) and Vibration (R) Surveys

The results of the noise survey were unambiguous; all readings at all locations and at all times were in excess of the national standards for ambient noise. This is due to the proximity of the road and other urban and suburban sources of noise. Panama does not yet have any legal limits for vibration, but the results of the survey were compared with both the draft Panamanian standard and Swiss standards. Nine of the readings exceeded the draft Panamanian standard, however the Swiss standard was also exceeded on occasion.

Water quality

Past studies carried out by ANAM showed that the Caimito River, which is the main source of water supply for the district of La Chorrera, had BOD values that widely exceeded the limits established in the relevant standard at the majority of sampling sites. The concentration of dissolved oxygen in the Caimito was found to be between 5.45 and 7.3 mg/l, exceeding the minimum recommended for water supply for human consumption and conservation of the aquatic life of 5 mg/l.

The surface water quality survey carried out as part of the present EIA studies found that faecal coliforms numbers were above the limit established by the *Continental Water Quality Standard* (250.0 UFC/100 m/l) in the Aguacate and Copé rivers, but not in the Velasquez River, which is farthest from urban centers. As with faecal coliforms, the presence of macrominerals (sodium, potassium, calcium, and magnesium) at elevated levels could be due to sewage contamination. No PAHs or pesticides were detected in any of the samples, except for a trace of the pesticide, gamma-chlordane in the Copé River.

The results of the groundwater surveys carried out during the EIA studies were largely as expected for most locations, with few notable results indicating particularly low or high values resulting from natural or anthropogenic causes. Several readings were, however, noteworthy.

The results obtained at San José exhibited levels of turbidity higher than that considered normal, possibly related to the construction activities nearby. In the interchange of Omar-Torrijos in Albrook, the waters also had high turbidity, but this is probably explained by the fact that the area formed part of a wetland before the existing road development. As a result, high levels of humic and fulvic acids (that colour the water) remain. The presence of odours associated with organic decay also correspond to the prior presence of mangrove swamps and a certain level of salinity, as well as the elevated concentration of chlorides, due to the marine influence of the area.

The groundwater quality results in the Albrook area also showed fairly high levels of heavy metals (such as arsenic, chromium, lead, nickel, sodium, and thallium) assumed to be as a result of the intense human activity and traffic present. In some cases the levels of these metals exceeded the established limits. It was interesting to find that none of the groundwater samples along the entire alignment of the Metro Line 3 and 4th Panama Canal Bridge contained detectable levels of PAH, PCBs, TPH or BTEX.

Marine/estuarine water quality results for the bridge area were as expected for such an environment. One biological and one chemical determinand were noted as being slightly high Faecal coliforms were somewhat elevated, possibly as a result of untreated or poorly treated municipal waste water or even possibly due to the very high level of marine traffic passing through the canal. The chemical determinand of note was thallium, a highly toxic metal, which was present in high concentrations. Possible sources of thallium include combustion of hydrocarbons, mining residues, and some illegal pesticides. It is not clear what the likely source is in this case, but it should be noted that a lack of detectable levels of thallium in the marine sediments suggests that the source is not historic pollution, but a recent release.

(2) Biological environment

The following surveys were conducted to identify the species and ecosystems present in the two project areas:

- General walkover and boat-borne surveys;
- Forest and flora inventory surveys;
- RSA transects for intertidal species;
- Trapping (for fish, small mammals, arachnids, amphibians, etc); and
- Bird surveys.

The results from the above surveys were combined the considerable amount of existing information available to generate a picture of the biological environment in the two project areas.

Terrestrial Ecology

Ecosystems

A number of main natural ecosystems were identified during the surveys, as follows:

Mature Secondary Forest

Firstly, it should be noted that no primary forest was identified in the direct or indirect project area for either project.

Mature secondary forest was found in the area of San Juan Hill in Rodman, in the areas of Howard and Loma Coba on both sides of the road leading to Arraijan from the Bridge of the Americas (Panamerican highway). This vegetation formation has diverse successional states advancing outward from the mature forest.

In general, emerging tree species reaching heights over 35 meters with trunk diameters over 40 cm are found in this forest type, including the following key species: Anacardium excelsum (Cashew), Luehea seemannii, Astronium graveolens (Glassywood), Copaifera aromatica and Spondias mombin.

Many palms are also present in the mature secondary forest, including Desmoncus orthocanthos, Bactris cf. coloniata, Attalea butyracea, Elaeis oleifera, Oenocarpus mapora and Cryosophila warscewiczii. In Loma Cobá area two species of tree fern of the genus Cyathea were found.

Source: URS Holdings, Inc. (2014)

Figure 19.6 General view of Typical Mature Secondary Forest (L) and Elaeis oleífera (R)

Under the canopy, other tree species are found, such as *Castilla eslastica, Dendropanax arboreus, Protium panamense, Cordia alliodora, Xylopia frutescens*, among others. Typical herbaceous species found in this forest type include *Costus villosissimus, Serjania* sp., *Heliconia latispatha* and *Carludovica palmata*.

The mammals *Didelphys marsupiales* (Opossum) and *Proechimys semispinosus* (Tome's spiny rat), were found in secondary forest areas, with some *Dasyprocta punctata* (Central American Agouti) also observed.

Intermediate Secondary Forest

The tree species of this type of forest have variable heights with some emergent trees reaching heights of 25 m or more. Pioneer species were dominant, but are mixed with few

mature specimens. Among the species identified in the upper stratum were *Pseudobombax septenatum, Anacardium excelsum, Leucaena multicapitua, Schefflera morototoni, Pittoniotis trichantha, and Sapindus saponaria.*

Notable shrub species in the intermediate secondary forest include *Alibertia edulis, Solanum sp., Palicourea guianensis, Piper reticulatum,* and *Capparis cf. frondosa.* Key herbaceous species include *Carludovica palmata, Heliconia platystachys,* and *Pharus latifolius*.

Young Secondary Forest

This ecosystem has the greatest diversity of species, and was identified mainly on Sosa Hill. This forest type also exhibits the greatest variety in height and diameter of trees, although they do not exceed 20 meters in height or have a DBH greater than 25 cm. Key species include Jobo (*Spondias mombin*), Toreta (*Annona purpurea*), the Marañon (*Anacardium occidentale*), Laurel (*Cordia alliodora*), Pava (*Schefflera morototoni*), *Pithecellobium unguis-cati,* and palms such as *Roystonea regia.* The presence of *Curatella americana* should be noted, as the species is an indicator of degraded soils and of dry forests degraded to savannas. It was recorded in the area of Sosa Hill.

Source: URS Holdings, Inc. (2014)

Figure 19.7 Curatella americana (L) and Pithecellobium unguis-cati (R)

Notable shrub species include Cochlospermum vitifolium, Vernonanthura patens, Tecoma stans, Thevetia peruviana, and Piper reticulatum. Key herbaceous species include Delilia biflora, Rootboellia conchinchinensis, Epihyllun pyllanthus, Heliconia latispatha, and Phoradendron piperoides.

Grasses with Dispersed Trees

Grassland ecosystem is found in small patches at the entrance toward Veracruz and along the right-of-way of the Panamerican highway leading to the Bridge of the Americas, adjacent to the site where the dredged material is disposed by ACP. Kans grass (Saccharum spontaneum) is the predominant species, and its aggressive growth impedes the establishment of other native species.

Forest Plantation

This type of ecosystem is found only in a reforested area on the Northeast slope of Sosa Hill. The plantation is principally made up of Tectona grandis (Teca). It covers a surface area of 0.155 hectares (0.086%) in the area of direct influence and 2.021 hectares in the area of indirect influence.

Mangroves

See description below under "Aquatic Environment".

Flora

Overall, the flora surveys identified a total of around 172 plant species, of which 15 are listed by Panamanian law as being locally endangered, and seven of which are listed by the IUCN Red List as internationally threatened[6]. **Appendix 11-4** lists the flora species identified during the surveys and lists all species considered locally or internationally threatened.

The surveys determined that, although some endangered species were identified, there is practically no habitat that could be considered to be critical for the conservation of these species. The majority of areas are degraded to some extent, and the diversity and abundance of species, for both flora and fauna, are comparatively low.

Fauna

The surveys identified at total of 27 bird species, 16 mammal species, 12 amphibians, and 12 reptiles. Of these, seven species are listed by Panamanian law as being locally endangered, with only one of the species encountered, (Crocodylus acutus, the American Crocodile) being listed by the IUCN Red List as internationally threatened. **Appendix11-5** lists the fauna species identified during the surveys.

The diversity of fauna species that were identified in the different types of vegetation are as follows: mature secondary forest, 13 species; intermediate secondary forest, 16 species; young secondary forest, 20 species; grassland, 10 species and mangroves, 13 species.

Mammals

The fauna surveys were carried out in the habitat of the secondary forest, grassland and wetland ecosystems, and recorded a total of 16 species of mammals contained within 11 families and 7 orders. Chiroptera (bats) contained the highest number of species.

Mammal diversity and numbers were low, but to be expected given how disturbed the ecosystems are in general. Among the species of mammals identified were the common opossum (Didelphys marsupiales) and the spiny rat (Proechimys semispinosus), species are usually found in secondary forest. Central American agouti (Dasyprocta punctate) were observed within the forest, and a raccoon (Procyon sp.) was recorded in the wetlands near Veracruz. An interesting rodent is the southern cotton rat (Sigmodon hirsutus). This species is common in grasslands, undergrowth, and clearings.

Birds

Of the 27 bird species identified during the EIA studies, the diversity amongst orders and families was quite high. The most species in any family was for Ardeidae (herons & egrets) and Columbidae (pigeons & doves) with three species each. In spite of the fact that the area is not very diverse with regards to habitat, the birds are the group with the largest number of species due to certain ecological characteristics, such as their wide range of adaptation to habitats and of feeding groups. According to the description of documented habits and customs of the birds of Panama by Ridgely and Gwynne (1993); many of the

[6] One further species, identified only to the genus level, may also be internationally threatened

species found in the study area prefer a habitat of the secondary forest type. They also show a great diversity in their feeding habits, for example, the survey identified fruit/grain eating families (Columbidae, Emberizidae), nectar-eating families (Trochilidae, Thraupidae), insectivore families (Picidae), fish-eating families (Phalacrocoracidae, Sulidae, Pelecanidae, Fregatidae,) and even scavenging birds (Cathartidae, Falconidae) were found.

Reptiles and Amphibians

In common with the mammals, relatively few species of reptiles were found during the field surveys, thought to be due to the general disturbance of the area of direct influence. Only 12 reptile species divided among ten families and three orders were identified.

Nine of the species were in the order *Lacertilia* including the common basilisk (*Basiliscus basiliscus*), the green iguana (*Iguana iguana*) and the Giant Ameiva (*Ameiva ameiva*). The green iguana was reported by the inhabitants of the area as a species very prized and hunted for its meat and eggs. The scarcity of permanent water streams in the habitat of secondary forest suggests that this species alternates its activities between the secondary forest and the areas of existing wetlands. Snakes identified include the common boa (*Boa constrictor*) and the Mexican vine snake (*Oxybelis aeneus).*

During the sampling, the presence of twelve species of amphibians was recorded. The low abundance of amphibian species recorded could be due to the disturbance of the site, but also could be due to the fact that the sampling was done in the middle of the dry season, which resulted in few wet areas in the study area. Twelve species were recorded, distributed among seven families belonging to the order *Anura* (frogs).

Habitat and Diversity

All fauna species recorded during the surveys were tabulated according to the habitats in which they were identified. The results are shown in **Table 19.9** below. The results show that, as would be expected, habitats with high numbers of trees have a larger diversity of species. Of the forest habitats, young secondary forest had the greatest animal diversity.

Table 19.9 Fauna Diversity according to Species

Group	Habitat				
	Mature Secondary Forest	**Intermediate Secondary Forest**	**Young Secondary Forest**	**Grassland**	**Mangrove**
Mammals	8	3	13	1	1
Birds	6	10	10	6	11
Reptiles	1	5	7	2	2
Amphibians	0	4	8	1	0
Total	**15**	**22**	**38**	**10**	**14**

Source: URS Holdings, Inc. (2014)

Overall, the studies concluded that in the area of direct influence of the projects, there is practically no habitat that could be considered as critical for the preservation of certain species; the majority of the areas are found to be highly disturbed and degraded.

Aquatic Ecology

The aquatic ecosystems in the vicinity of the 4th Panama Canal Bridge are dominated by fine to medium sandy substrate (0.125-0.500mm) and associated benthos. The level of organic material is fairly low towards the centre of the Canal / estuary, but this rises considerably towards the more productive intertidal zone.

The survey of the aquatic environment in the canal estuary near the proposed 4th Panama Canal Bridge alignment sampled flora and fauna species present via boat, visual survey and an intertidal transect survey.

Flora

The key habitat of interest is the intertidal mangrove ecosystem lying to the west of the proposed bridge alignment. The predominant mangrove species is Rhizophora mangle, (Red Mangrove), followed by the rarer Tea Mangrove, Pelliciera rhizophorae. Other plant species frequently associated with the mangrove environment were also found, such as Taliparitiliaceum, Matayba glaberrima, and Guazuma ulmifolia.

Source: URS Holdings, Inc.

Figure 19.8 *Rhizophora mangle* in the project area (L) and *Pellicera rizhophorae* (R)

Invertebrates

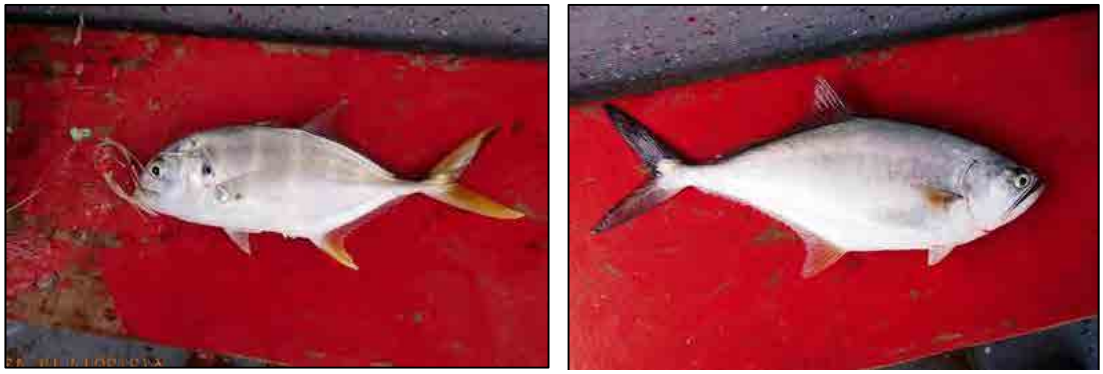
In this sandy and muddy environment, there are large numbers of bivalves and gastropods, such as the Mangrove Cockle, Anadara grandis, and the Onyx Slippersnail, Crepidula onyx. It should be noted that this zone is affected by the significant activities of the Panama Canal, including the frequent passage of ships, lock flushings with fresh water, and dredging operations. Examples of invertebrates identified during the surveys are shown in **Figure 19.9** below.

Source: URS Holdings, Inc

Figure 19.9 Melongena sp. (L) and Protothaca asperrima (R)

Vertebrates

The only vertebrates encountered during the surveys in addition to the birds already reported above were fish, of which 12 species were identified. No marine mammals were seen, nor were turtles. Examples of fish species identified during the surveys are shown in **Figure 19.10** below.



Source: URS Holdings, Inc. (2014)

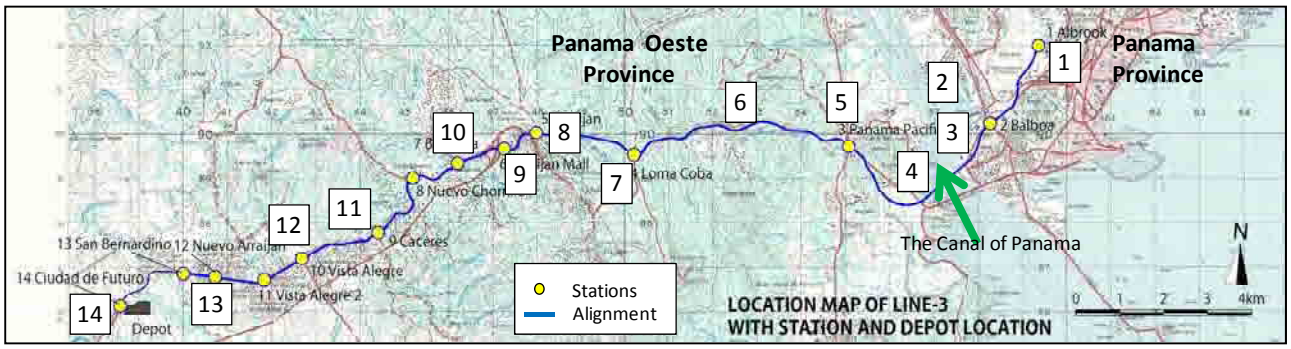
Figure 19.10 Pacific Crevalle Jack (*Caranx caninus*) (L) and Longjaw Leatherjacket (*Oligoplites altus*) (R)

A total of 63 aquatic species were identified. Of the species identified, none[7] are considered locally or internationally endangered. **Appendix 11-6** lists the species identified during the surveys.

(3) Social and cultural environment

General Landscape Characteristics of the Project Area

The Metro Line 3 / 4th Panama Canal Bridge will pass through two provinces, which are Panama Province located on the east bank of the Panama Canal, and Panama Oeste (Western Panama) Province[8] in the west bank (See **Figure 19.11** below).



Source: JICA Study Team

Figure 19.11 Alignment of the Project

Figure 19.12 shows examples of the typical landscapes in the project areas. The Metro Line 3 starts from Albrook Terminal, where is the biggest shopping mall in Panama and location of the national bus terminal and Metro Line 1 station. Commercial, institutional,

[7] *Crocodylus acutus* is included in the terrestrial list and has therefore not been duplicated in the aquatic list

[8] Panama Oeste Province was established on January 1st, 2014, which were former five districts (Arraijan, Capira, Chame, La Chorrera, and San Carlos) located in the western side of the Canal in the Panama Province.

and port activities are predominant from this area to the port area. There is no residential area in the immediate project area in this vicinity. After crossing the Canal, the Metro Line 3 alignment goes through a secondary forest area but the project area is restricted to within the existing road and RoW, where is no residential area. Then the Line 3 will enter into the urban area of Arraijan. From Arraijan to the end of the alignment, there are business activities and some housing along the existing Panamerican Highway.

1. Line 1 station at Albrook Terminal. Next to this station, the Metro Line 3 station will be installed.

2. Port Area (Balboa), view from Ancon Hill. Main land use is for port activities and institutional use for ACP & other governmental buildings.

3. Port area

4. Mangrove area, the west bank of the Canal

5. Intersection of Panamerican Highway and the road to *Panama Pacifico*. There is a military base close to this intersection.

6. Young and Mature Secondary Forest section. There are no housing or commercial buildings. There are trees within the RoW in some sections.

7. *Loma Coba*. There is a spread residence area with low density in Loma Coba, but not very close to the Panamerican Highway.

8. Arraijan, near to big supermarket (Super Xtra). There is a bus terminal behind the supermarket, and there are commercial buildings and housing with high density in this area.

9. Detour to future "Arraijan Mall". There are some small shops and housings along the road.

10. Urban area. There are commercial buildings close to the Panamerican Highway, some housings, too.

11. Nuevo Chorrillo. There are municipality and fire station close to Panameritan Highway.

12. Vista Alegra. There are many shops, offices, supermarkets along the Panamerican Highway.

13. Nuevo Arraijan. There are some institutional buildings located close to the Panamerican Highway.

14. Depot at Hato Montaña.

Source: JICA Study Team

Figure 19.12 Typical Landscape in the Project Area

Demographics

The total population of the Corregimientos (Ancon in Panama District, Arraijan Cabecera, Burunga, Cerro Silvestre, Juan Demostenes Arosemena, Veracruz and Vista Alegre in Arraijan District) where Line 3 passes is 244,498 (Census 2010). 51 % of the population is male, and 49% is female.

One of the significant characteristic of the population in the project area is that there is a high percentage of migrants who originally lived in Panama District and came to live in Arraijan and La Chorrera Districts. The economic activities in the Province of Panama Oeste, especially in Arrajan and La Chorrera, have expanded. However, many people go to work to Panama from Arraijan and La Chorrera.

Table 19.10 shows the population, area, and population density of the *corregimiento* in the project area. The population density is low in Ancon, because this area is mainly for port industries/activities, and institutional use. On the other hand, the population density is higher in Vista Alegre and Cerro Silvestre compared with other *corregimientos*.

Table 19.10 Population of Corregimientos in the Project Area

Province	District	*Correginimiento*	Population	Area (km^2)	Population density (person/km^2)
Panama	Panama	Ancón	29,761	204.6	145.5
Panama Oeste	Arraijan	Arraijan Cabecera	41,041	65.5	626.8
		Burunga	39,102	52.4	745.7
		Cerro Silvestre	23,592	19.3	1,225.1
		Juan Demostenes Arosemena	37,044	40.7	909.8
		Veracruz	18,589	49.7	374.0
		Vista Alegre	55,369	30.4	1,818.8
		Total	**244,498**	**435.6**	-

Source: Census 2010

Indigenous people

According to the Census of 2010, 4.0 % of the population of Panama Province, and 4.4 % of Panama Oeste Province is indigenous people (12.0% is the national rate). Those indigenous people are not originally from the provinces of Panama or Panama Oeste, but came from other parts of the country for better education, better work conditions, and better health care. The indigenous people who live in the urban area mainly work in the tertiary industry, such as tourist sector, restaurant, and hotels, and they do not maintain their traditional life style anymore. They do not maintain their traditional lifestyle anymore in the urban area.

Poverty

The Human Development Index (HDI) of Panama in 2012 is 0.780, ranked at 59th worldwide (ranked at 4th among Latin American countries). The life expectancy at birth is 76.3 years, the mean year of schooling is 9.4 years, the expected year of schooling is 13.2 years, and GNI per capita is USD13,519.

Table 19.11 shows the HDI of the project influence area in 2002[9]. According to the table, there is a huge gap between *corregimientos*, especially for average annual income per capita. In general, Arraijan and Veracruz have lower points for most of the indexes.

Table 19.11 HDI of Corregimiento in the Project Area

Human development index	***Corregimiento****				
	Arraijan	**Juan Demóstenes Arosemena**	**Veracruz**	**Vista Alegre**	**Ancon**
Average annual income per capita (USD)	2,128	3,034	1,773	2,973	6,980
Economically active population minimum wage and more (%)	80.7	85.9	77.1	87.2	82.5
Housings with acceptable materials (%)	89.1	96.9	90.1	98.1	83.3
Housings with acceptable services (%)	32.1	75.2	35.7	81.8	84.3
Schooling Achievement (%)	61.7	71.4	57.5	72.8	79.2
Literacy (%)	96.1	97.7	94.3	98.0	97.1
Average schooling (years)	8.9	10.4	8.3	10.6	11.5

Source: Prepared by URS Holdings, Inc. based on UNDP. INDH Panama 2002.
* There is no available information for Corregimientos of Burunga and Cerro Silvestre

Housing

The typical housing in the project area is individual housing constructed by permanent material. Only in Ancon corregimiento, apartment type is the typical housing type.

[9] This is the latest available data of the HDI of each *corregimiento* in Panama.

Table 19.12 Types of Housing in the Project Area

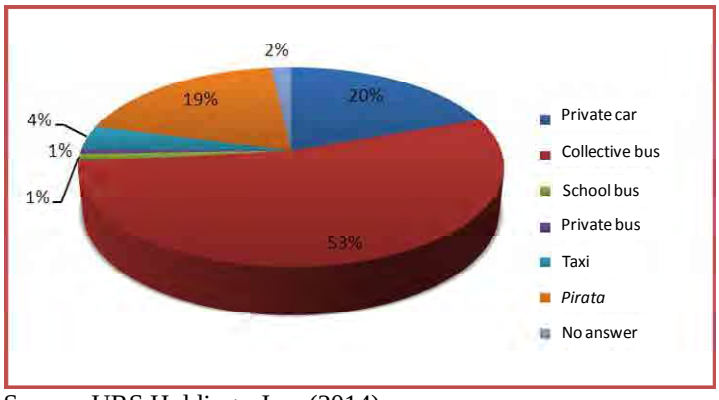
Province	District	*Corregimientos*	Populated area	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panama Oeste	Arraijan	Arraijan Cabecera	Arraijan	86.60	3.21	4.92	1.68	3.37	0.01	0.21
		Juan Demóstenes Arosemena	Ciudad del Futuro	99.60	0.20	0.00	0.00	0.07	0.00	0.14
			Hato Montaña	99.75	0.00	0.25	0.00	0.00	0.00	0.00
			Nuevo Arraiján	96.05	0.51	0.36	0.87	2.12	0.02	0.07
			Resident of Nuevo Arraijan	99.34	0.00	0.07	0.22	0.15	0.00	0.22
			San Bernardino	100.0	0.00	0.00	0.00	0.00	0.00	0.00
			Urbanization of Hato Montaña	99.56	0.33	0.00	0.00	0.00	0.00	0.11
		Veracruz	Howard	88.83	1.14	0.00	8.90	0.00	0.19	0.94
		Vista Alegre	Resident of Vista Alegre	99.28	0.07	0.00	0.36	0.29	0.00	0.00
			Vista Alegre	83.60	0.68	1.88	2.37	10.76	0.19	0.52
		Burunga	Barriada 2000	88.81	3.01	3.38	0.96	3.70	0.00	0.15
			Barriada Omar Torrijos	87.67	2.20	4.39	1.20	4.04	0.05	0.45
			Burunga	89.12	1.24	0.48	2.55	6.27	0.03	0.31
		Cerro Silvestre	Cerro Silvestre	90.19	1.16	1.55	0.60	6.28	0.04	0.18
			La Estancia	89.52	2.86	5.71	0.95	0.95	0.00	0.00
			San Vicente de Bique	92.60	1.76	3.17	0.59	1.29	0.00	0.59
			Urbanization of Nuevo Chorrillo	95.99	0.44	2.31	0.44	0.49	0.00	0.32
Panamá	Panamá	Ancón	Ancón	61.46	0.47	0.00	33.24	0.04	0.16	4.63

Source: Prepared by URS Holdings, Inc. based on Contraloría General de la República. Censo, 2010.
(1) Individual house (permanent), (2) Individual house (semi-permanent), (3) Provisional, (4) Apartment, (5) Room in house or neighborhood, (6) On the street, hut, port or airport, (7) Place not for habitation

Transportation

In the Project area, the main transportation methods are collective bus, taxi, *piratas*, and private cars. Most people take at least two modes of transportation to get to work or study.

According to the questionnaire survey in the project area, only 20 % use private cars, and the rest depend on some transportation provide services (See **Figure 19.13**). For example, 53 % of the respondents use collective bus, and 19 % use *piratas* although they recognize the higher fee and security problem.



Source: URS Holdings, Inc. (2014)

Figure 19.13 Transportation System in the Project Area

Economic Activities

The main economic activities in the project influence area is the tertiary industry (commercial and services). There is no industrial area in the project area.

Table 19.13 Economic Activities in the Project Influence Area

Province	District	*Corregimientos*	Populated places	Economic Activities (%)		
				Primary industry	Secondary Industry	Tertiary Industry
Panama Oeste	Arraijan	Arraijan Cabecera	Arraijan	0.93	20.22	78.85
		Juan Demóstenes Arosemena	Ciudad del Futuro	0.78	14.36	84.86
			Hato Montaña	2.06	10.28	87.66
			Nuevo Arraiján	0.99	16.66	82.34
			Residencial of Nuevo Arraijan	0.99	13.91	85.10
			San Bernardino	8.11	21.62	70.27
			Development of Hato Montaña	0.60	12.08	87.32
		Veracruz	Howard	0.85	19.32	79.83
		Vista Alegre	Resident of Vista Alegre	0.67	12.03	87.30
			Vista Alegre	2.02	22.9	75.08
		Burunga	Barriada 2000	1.09	26.63	72.28
			Barriada Omar Torrijos	0.99	24.21	74.80
			Burunga	1.05	24.9	74.05
		Cerro Silvestre	Cerro Silvestre	0.74	20.18	79.08
			La Estancia	0.00	31.40	68.60
			San Vicente de Bique	3.19	26.77	70.04
			Development of Nuevo Chorrillo	0.48	17.01	82.51
Panamá	Panamá	Ancón	Ancón	1.00	9.92	88.98
			Average	**1.48**	**19.13**	**79.39**

Source: URS Holdings, Inc. (2014)

Cultural and archeological aspects

During the EIA, archaeological studies were carried out in the direct influence area of the projects. The studies were carried out via a review of the existing documents and a field visit along the project alignment and the area where the stations will be constructed.

No archaeological findings were identified along the alignment of Metro Line 3 project/ 4th Panama Canal Bridge projects. At the same time, there is not any national historical buildings or sites of cultural significance in the direct influence are of both projects.

19.7.2 Impact Assessment

Following the preparation of the EIA study, the scoping review tables were updated to show the revised impact levels for each of the 29 areas of impact. The results of the impact assessment are therefore summarised in **Tables 19.14 and 19.15** overleaf.

Tables 19.14 and 19.15 show that the scoping review was fairly accurate in predicting what the key impacts associated with the two projects would be, resulting in few surprises in terms of expected impacts during the main EIA study.

Overall, it can be said that the majority of negative impacts for both projects are associated with the construction process, and relate to public disturbance type impacts (which tend to be reversible and short term) such as noise generation and traffic problems; there are not many significant negative operational impacts.

Despite the baseline surveys identifying 13 endangered species in the project area (including three mangrove species), the EIA studies both concluded that expected negative impacts on habitats for endangered species are insignificant. This is mainly because most of the species, whilst rare on an international scale, are actually fairly prolific at a local level. Other reasons for the lack of concern over rare species are that animal species in the project area will already be accustomed to the degraded nature of the environment, and to the presence of large transport infrastructure and are therefore unlikely to be affected by the presence and operation of the proposed projects. During the scoping phase of the studies, the area of mangroves on the western bank of the Canal was of concern due to the expected loss of the area during construction of the 4th Panama Canal Bridge. The EIA for that project revealed that, whilst the mangrove swamp was indeed of ecological significance, the area to be lost during construction would be comparatively small, and the majority of the area to be cleared would regenerate rapidly (the area will not be permanently buried or paved and is only required for construction purposes).

The construction of the scheme, and to some extent the operation, is expected to cause negative impacts on the physical environment (including water quality, air quality, noise, and hydrology) but the EIA studies generally assessed these potential impacts as “moderate” during construction and “low” during operation. As is described in **Section 19.7.3** below, standard mitigation measures are very effective in managing impacts associated with the physical environment, so, providing a robust EMP is prepared by the eventual contractor, the forecast impacts are not of significant concern to the study team.

None of the negative operational impacts identified were classified as “high” or “very high” significance; most were “moderate” or “low”. Conversely, a number of “high” or “very high” significance positive impacts were identified during the impact assessment exercise for both projects. The key positive operational impacts are as follows:

- Improvement in air quality/climate change (high significance);
- Improvement in urban mobility and accessibility (high significance);
- Improvement in the lifestyles of the populations around the project (high significance);
- Stimulus to national economy (high significance);
- Improvement to the dynamics of the road network (very high significance);
- Changes in the patterns of demand and efficiency of public transportation (very high significance); and
- Transformation of the urban transportation system (very high significance).

Table 19.14 Draft Scoping and Study Results Chart for Metro Line 3 Project

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
1	Land Acquisition & Resettlement	B-	D	B-	D	[Construction stage] - About 130,000 m^2 land acquisition and resettlement of five families will be required. About 41 economic units (businesses) will also be required to relocate. [Operation stage] - No negative impact is foreseen in the operation phase.
2	Local Economy	B+	B+ B-	B-	B+	[Construction stage] - Access to the shops/businesses along the alignment will be interrupted by the construction, which will cause negative impacts on the existing businesses. For the Line 1 project, most of the business along the alignment needed to close during the construction phase because the amount of customers declined totally. [Operation stage] - The existing businesses will be blessed with new influx of peoples. Also new business will be created around the Metro Line 3 stations, which will activate the local economy in the project area.
3	Employment	B+	B+ B-	A+	B+	[Construction stage] - Construction activities will generate a need for skilled and non-skilled labour in the project area; such as supervisors, masons, excavators, electricians, heavy equipment drivers, and general workers. At the same time, indirect employment will be generated such as service providers for workers. [Operation stage] - The number of direct employment jobs for Metro operation will be reduced compared with construction phase. However, indirect employment related to Metro operation will be newly generated, and also the local economy will require more employment as a result of activation of the local economy.
4	Livelihoods	B+	B+ B-	B-	A+	[Construction stage] - The livelihoods of local people in the immediate project area and the people who use the roads will be affected by traffic jams, detours, movement of heavy equipment and other machinery. Noise and deterioration of air quality will also affect the livelihoods of the local people who live very close to the alignment. [Operation stage] - Expected benefits from Metro Line 3 are: saving in travel time, mobilization in a safe and comfortable space, easy access to different urban areas, which will improve the quality of life for Metro Users. Development of new business activities as an additional benefits to the population will change the livelihoods in positive way, too.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
5	Land Use and Local Resources Usage	B-	C	B-	B+	[Construction stage] - Some temporary land use change will occur as a result of construction – for example contractors' camps and storage areas, and also of land acquisition for depot and stations. - Impact on local resources usage will not be foreseen. [Operation stage] - Some areas will be converted from existing land use to stations, car parks, depots, etc. - Operation of the project is expected to stimulate growth in the local economy, including creating of new businesses and increased housing development. This will lead to an improved land use and development pattern on a local basis.
6	Social Capital and Local Organizations	D	D	D	D	[Construction stage] [Operation stage] - According to the questionnaire surveys and community participation activities, no impact is foreseen.
7	Existing Infrastructure and Public Services	B-	A+	B-	A+	[Construction stage] - Interruptions to existing utilities and services are likely during construction, however standard mitigation measures will be highly effective. - Construction will cause noise disturbance, dust (in the dry season), and will potentially interfere with local drainage systems. Again, standard mitigation measures are highly effective in managing these types of impact. [Operation stage] - Journey times for those using Metro Line 3 to commute to Panama City from the West bank of the Canal will be greatly reduced. - Likewise, it is expected that congestion on the road and Bridge of the Americas (plus the 4th Panama Canal Bridge) will be alleviated due to the displacement of travellers to the metro system. - Access to existing public services will be improved. - Presence of the metro system is eventually expected to generate positive secondary impacts for local infrastructure.
8	Ethnic Minorities and Indigenous Community	D	D	D	D	[Construction stage] [Operation stage] - Negative impact on ethnic minorities and indigenous community is not foreseen.
9	Unbalanced Distribution of Benefits and Damages by the Project	D	D	D	D	[Construction stage] [Operation stage] - Unbalanced distribution of benefits and damages by the Project is not foreseen.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
10	Local Conflicts Caused by Common Interests	C	D	D	D	[Construction stage] - According to the questionnaire survey and community participation activities, no impact is foreseen. The existing transportation sector also agrees with this project and aims to integrate their system to Metro system. [Operation stage] - According to the questionnaire survey and community participation activities, no impact is foreseen.
11	Cultural Heritage	C	D	D	D	[Construction stage] - The consultations and archaeological studies uncovered no significant evidence of archaeological sites in the immediate project area. No cultural sites are in the project direct influence area - Any chance archaeological finds will be managed via the EMP. [Operation stage] - Operation will have no deleterious effects on cultural heritage.
12	Right of Water Use	C	D	D	D	[Construction stage] - No water use issues are expected to be encountered during the Line 3 construction process. [Operation stage] - Operation will have no deleterious effects right to water usage.
13	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	[Construction stage] - Large numbers of construction workers will be present, which could increase the prevalence of infectious diseases without sufficient mitigation measures such as HIV-AIDS Prevention Programs for workers and local communities (assuming that not all workers will be recruited locally). [Operation stage] - Operation is very unlikely to have deleterious effects on prevalence of infectious disease.
14	Safety	B-	D	B-	B-	[Construction stage] - The construction phase presents danger to both workers and the public. Drilling of piles and installation of raised piers is dangerous for workers. Large beams will be raised on to the piers, and this presents a danger for the public. Traffic diversions also present a risk. [Operation stage] - As the system will be raised, scope for accidents – principally falls – will be present, however it should be noted that the worldwide safety record for operation is extremely impressive. It should also be noted that the monorail system will indirectly offset road traffic journeys, and so will theoretically be responsible for a reduction in road traffic accidents

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
15	Topography and Geography	B-	D	B-	D	[Construction stage] - Relatively little cut and fill will be required for the raised line, as changes in elevation will be compensated for largely via alteration of pier height. - The main cut and fill activities will be for ground level infrastructure such as station entrances, and parking areas. [Operation stage] - Negative impacts are not foreseen as slope protection will be carried out.
16	Soil Erosion	B-	D	B-	D	[Construction stage] - Although much of the alignment is already paved, those areas that are not will be liable to erosion due to the combination of the hilly nature of the terrain in some areas, the frequent and heavy rain that occurs in the project area, and the clearance of vegetation. [Operation stage] - Once constructed and under operation, the scheme is not expected to cause soil erosion.
17	Hydrology	C	D	B-	B-	[Construction stage] - Due to the nature of the terrain and the frequent and heavy rain that occurs in the project area, runoff from civil works areas as well as dewatering water could potentially cause minor effects on the hydrology of the project area if not properly mitigated. [Operation stage] - A minor increase in surface runoff is expected to result from operation of the scheme.
18	Flora and Fauna and Biodiversity	B-	B-	B-	D	[Construction stage] - Approximately 43 hectares of vegetation will be lost due to the construction of the project. More than half of this area is mature secondary forest; the remainder is a mix of various forest types and grassland. - 13 rare or endangered species were identified in the flora and fauna surveys, however these species are thought to be locally abundant. Due to presence of road etc already, the monorail is not expected to have significant further impacts on fauna. [Operation stage] - Operation of the system is unlikely to have significant direct negative impacts on flora, fauna and biodiversity
19	Landscape	B-	B- B+	B-	B- B+	[Construction stage] - Temporary landscape impacts during construction are unavoidable, yet minor. [Operation stage] - The presence of the scheme will significantly alter the landscape of the project area. Whether that change is for the better or worse is entirely subjective.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
20	Protected Areas (PAs)	C	C	D	D	[Construction stage] - No Protected Areas are in the vicinity of the project, and construction procedures and materials are not expected to encourage secondary negative impacts on protected areas further afield. [Operation stage] - No Protected Areas are in the vicinity of the project.
21	Global Warming	D	B+	D	A+	[Construction stage] - No significant impacts on global warming are expected to occur during construction of the scheme. [Operation stage] - Operation of the system will have a significant positive impact in terms of emission reduction, and potentially, global warming. This is principally due to the expectation that the rail system will attract existing car and bus users and therefore avoid the emissions associated with the vehicles. The fact that roughly 50 % of Panama's electric energy comes from hydropower further emphasises this positive impact. A second cause of emission reduction will be via alleviation of traffic congestion in Panama City. The estimate of annual CO_2 reduction due to the project is between 16,000-25,000 tonnes per year.
22	Air Pollution	B-	A+	B-	A+	[Construction stage] - Air pollution due to emissions from machinery and civil works are expected, however this will be localised, short term and easily mitigated via the EMP. [Operation stage] - Operation of the system will generate no local air pollution issues, and indeed will help to reduce or at least slow the increase of air pollution in the project area due to the offset of attracting travellers that would have otherwise used polluting vehicles such as cars. High positive impact. - In addition to the reduction in emissions in the immediate project area, the scheme should also help to reduce emissions in Panama City.
23	Water Pollution	B-	D	B-	B-	[Construction stage] - Although the EIA survey results showed that surface waters in the project area are already contaminated, runoff from construction sites and from dewatering is a source of potential negative impact, though standard mitigation measures should allow for some control. [Operation stage] - Water pollution may arise during operation of the system, especially as a result of maintenance activities.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
24	Soil Pollution	B-	D	B-	B-	[Construction stage] - Although the EIA survey results showed that soils in the project area, in particular in the urban areas, are already contaminated due to the traffic and light industry/commerce, spillages of fuel and lubricants from machinery, paints and other hazardous waste, as well as incorrectly disposed sold waste, presents a risk of soil pollution during the construction process. - Marine sediments may also be at risk from pollution during the construction process. [Operation stage] - The risk of soil pollution during operation is much lower than during construction, but will remain present.
25	Solid Waste	B-	D	B-	B-	[Construction stage] - Potential for solid waste-related impacts is covered by water and soil pollution aspects of the EIA studies and therefore the impact levels assigned are similar. A comprehensive waste management plan will be required during construction. [Operation stage] - Potential for solid waste-related impacts will be present during operation; however this potential will be much lower than during the construction process.
26	Noise and Vibration	B-	A+	B-	B-	[Construction stage] - Noise and vibration will be generated due to the operation of construction equipment and the traffic caused by heavy vehicles. [Operation stage] - Noise and vibration will be generated by the scheme (due to wheel contact, horns, etc), in particular in the immediate area around the alignment, stations and associated infrastructure. - To some extent the increase in noise during operation in the immediate project area of influence will be offset by a lowering in road traffic noise in the wider area.
27	Subsidence	C	D	D	D	[Construction stage] - The metro system will be entirely above ground, and there will therefore be no significant tunnelling or underground excavations. Dewatering will be required during construction at certain locations (e.g. bridge and rail support piling) but, considering the fairly low volumes and considering the ground conditions, subsidence is very unlikely, and was not considered a significant impact by the EIA studies. [Operation stage] - The operation of the project is not expected to have an effect on subsidence.
28	Offensive Odours	D	D	B-	D	[Construction stage] - The offensive odours can be occurred if the solid/liquid waste management will not be carried out adequately, however the impact will be minor. [Operation stage] - No impact is foreseen.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
29	Traffic	A-	A+	A-	A+	[Construction stage] - Significant negative impacts would occur without careful consideration and planning of the works, particularly in the wooded area west of the Americas Bridge. This impact can be reduced by employing detailed temporary works planning. [Operation stage] - Operation of the scheme is expected to bring about significant positive impacts on traffic due to the expected alleviation of the current congestion levels.

C.: Construction phase, O.: Operation phase
+: Positive impact, -: Negative impact
A: Very significant, B: Significant, C: Unknown, D: No impact
Source: JICA Study Team

Table 19.15 Draft Scoping and Study Results Chart for 4th Panama Canal Bridge Project

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
1	Land Acquisition & Resettlement	B-	D	B-	D	[Construction stage] - Land acquisition and resettlement are not foreseen. Relocation of ACP buildings and six economic unit displacements will be required. [Operation stage] - Operation of the bridge is not expected to have any impacts in this area.
2	Local Economy	B+ B-	B+	A+	A+	[Construction stage] - During the construction phase, demand for goods and services and for workers will be generated, which could activate the local economy. [Operation stage] - The connectivity of Panama City and Panama West will be improved with revitalization of roads and efficient public transportation system. In addition, the Special Economic Zone, Panama-Pacifico will receive benefit from the project.
3	Employment	B+ B-	B+	A+	B+	[Construction stage] - Construction activities will generate skilled and non-skilled labour in the project area, such as supervisors, masons, excavators, electricians, heavy equipment drivers, and general workers. At the same time, indirect employment will be generated such as service provider for workers. [Operation stage] - New employment will be generated for maintenance of the bridge and the access roads.
4	Livelihoods	B+ B-	B+	B-	B+	[Construction stage] - There is no residence in the immediate project area. However, the movement of heavy equipment and other machinery will affect the livelihoods of people who live in the project influence area. [Operation stage] - The reduction of traffic jams will improve the quality of life of the people in the project area and wider area, too.
5	Land Use and Local Resources Usage	A-	D	B-	D	[Construction stage] - Construction will cause the loss of some areas of secondary forest and mangrove, however some re-growth is expected to occur after construction is finished. - Most required land is government owned. - On a wider scale, the overall character of the project area will not change [Operation stage] - Operation of the bridge is not expected to have any impacts in this area.
6	Social Capital and Local Organizations	C	C	D	D	[Construction stage] - According to the questionnaire surveys and community participation activities, no impact is foreseen. [Operation stage] - According to the questionnaire surveys and community participation activities, no impact is foreseen.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
7	Existing Infrastructure and Public Services	B-	A+	B-	A+	[Construction stage] - Construction of the approach roads will at times adversely affect the already congested transport corridor. Additional delays due to road closures and diversions will be likely. - Interruptions to existing utilities and services are possible during construction, however few residents live near the bridge project area. - Construction will also cause noise disturbance, dust (in the dry season), and will potentially interfere with local drainage systems. Standard mitigation measures are highly effective in managing these types of impact. [Operation stage] - The bridge will partly alleviate the traffic problem currently experienced in the environs of the Bridge of the Americas, and will permit the operation of Metro Line 3. - Access to existing public services will be improved.
8	Ethnic Minorities and Indigenous Community	D	D	D	D	[Construction stage] [Operation stage] - There is no ethnic minorities and indigenous community in the project area.
9	Unbalanced Distribution of Benefits and Damages by the Project	D	D	D	D	[Construction stage] [Operation stage] - Unbalanced distribution of benefits and damages by the Project is not foreseen.
10	Local Conflicts Caused by Common Interests	D	D	D	D	[Construction stage] [Operation stage] - According to the questionnaire survey and community participation activities, no impact is foreseen.
11	Cultural Heritage	C	D	D	D	[Construction stage] - The consultations and archaeological studies uncovered no significant evidence of archaeological sites in the immediate project area. No cultural sites are in the immediate project area - Any chance archaeological finds will be managed via the ESMP. [Operation stage] - Operation will have no deleterious effects on cultural heritage.
12	Right of Water Use	C	D	D	D	[Construction stage] - No water use issues are expected to be encountered during the bridge construction process. [Operation stage] - Operation will have no deleterious effects right to water usage.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
13	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	[Construction stage] - Large numbers of construction workers will be present, which could increase the prevalence of infectious diseases without sufficient mitigation measures such as HIV-AIDS Prevention Programs for workers and local communities. (Assuming that not all workers will be recruited locally). [Operation stage] - Operation is very unlikely to have deleterious effects on prevalence of infectious disease.
14	Safety	D	D	B-	B-	[Construction stage] - The construction phase presents danger mainly to workers rather than the public. The main concerns for public safety will be at the road connection points. No impact is foreseen for the canal shipping because the operation will be suspended during the construction of the bridge (maximum for 24 hours). [Operation stage] - The bridge will include numerous safety measures so should be very safe. Despite this, risks cannot be entirely eliminated.
15	Topography and Geography	D	D	B-	D	[Construction stage] - Relatively little cut and fill will be required for the bridge, however Sosa Hill will be affected during construction of the approach road/line. [Operation stage] - Negative impacts are not foreseen as slope protection will be carried out.
16	Soil Erosion	B-	D	B-	D	[Construction stage] - Areas that have been stripped of vegetation will be at risk of erosion due to the combination of the hilly nature of the terrain and the frequent and heavy rain that occurs in the project area, as will stockpiles of borrow material for the approach road embankment material. [Operation stage] - Once constructed and under operation, the scheme is not expected to cause soil erosion.
17	Hydrology	C	D	B-	D	[Construction stage] - The construction process is expected to have a minor the hydrology of the project area. [Operation stage] - No effects on hydrology or groundwater are expected to result from operation of the scheme.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
18	Flora and Fauna and Biodiversity	A-	D	B-	D	[Construction stage] - Approximately 4.5 hectares of vegetation will be lost due to the construction of the project, of which 0.363 is mangrove. Reforestation plan will be carried out for the loss of vegetation. Compensation tariff for cutting mangrove area will be paid by SMP prior to clearance. - Although the mangrove is a rare habitat, the amount to be lost is very small, and is expected to regenerate very rapidly. [Operation stage] - Operation of the system is unlikely to have significant direct negative impacts on flora, fauna and biodiversity
19	Landscape	A-	C	B-	B- B+	[Construction stage] - Temporary landscape impacts during construction are unavoidable, yet minor. [Operation stage] - Although the visual impact of the bridge will be to some extent diluted due to the presence of the existing Bridge of the Americas, the design of the new bridge will still be a significant change to the landscape. Whether that change is for the better or worse is entirely subjective. The type of the new bridge will be arch type as same as the Bridge of the Americas.
20	Protected Areas (PAs)	C	C	D	D	[Construction stage] - No Protected Areas are in the vicinity of the project, and construction procedures and materials are not expected to encourage secondary negative impacts on protected areas further afield. [Operation stage] - No Protected Areas are in the vicinity of the project.
21	Global Warming	D	B+	D	B+	[Construction stage] - No significant impacts on global warming are expected to occur during construction of the scheme. [Operation stage] - Operation of the system will have a minor positive impact in terms of emission reduction, and potentially, global warming.
22	Air Pollution	B-	A+	B-	B+	[Construction stage] - Air pollution due to emissions from machinery and civil works are expected, however this will be localised, short term and easily mitigated via the EMP. The EIA classified construction impact as a moderate negative. [Operation stage] - Operation of the system will generate no local air pollution issues. Moderate positive impact is foreseen because of alleviation of current traffic jam in the project area.

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
23	Water Pollution	B-	D	B-	B-	[Construction stage] - Although the EIA survey results showed that surface waters in the project area are already contaminated, runoff from construction sites and from dewatering is a source of potential negative impact, though standard mitigation measures should allow for some control. - Marine water pollution is also a risk during construction of the bridge. [Operation stage] - Operation of the system may cause some minor water pollution impacts if the bridge is not properly drained and if oil & sediment traps are not maintained.
24	Soil Pollution	B-	D	B-	B-	[Construction stage] - Soils in the areas of the approach roads could be impacted by spillages of fuel and lubricants from machinery, paints and other hazardous waste, as well as incorrectly disposed sold waste, presents a risk of soil pollution during the construction process. - Marine sediments may also be at risk from pollution during the construction process. [Operation stage] - The risk of soil pollution during operation is much lower than during construction, but will remain present.
25	Solid Waste	B-	D	B-	B-	[Construction stage] - Potential for solid waste-related impacts is covered by water and soil pollution aspects of the EIA studies and therefore the impact levels assigned are similar. A comprehensive waste management plan will be required during construction. [Operation stage] - Potential for solid waste-related impacts will be present during operation; however this potential will be much lower than during the construction process.
26	Noise and Vibration	B-	B-	B-	B-	[Construction stage] - Noise and vibration will be generated due to the operation of construction equipment and the traffic caused by heavy vehicles, however there are few sensitive receptors in the project area. [Operation stage] - Noise and vibration will be generated by the scheme, however it is not expected to be particularly significant. - The project will not induce additional traffic noise, but will move some of the traffic noise currently carried by the Americas Bridge.
27	Subsidence	C	D			[Construction stage] - *To be described in FR.* [Operation stage] - *To be described in FR.*

Ref	Issue	Scoping		Results of EIA		Reason for Evaluation
		C.	O.	C.	O.	
28	Offensive Odours	D	D	B-	D	[Construction stage] - The offensive odours can be occurred if the solid/liquid waste management will not be carried out adequately, however the impact will be minor. [Operation stage] - No impact is foreseen.
29	Traffic	B-	A+	A-	A+	[Construction stage] - Construction of the approach roads will at times adversely affect the already congested transport corridor. Additional delays due to road closures and diversions will be likely. [Operation stage] - Operation of the scheme is expected to bring about significant positive impacts on traffic due to the expected alleviation of the current congestion levels.

C.: Construction phase, O.: Operation phase
+: Positive impact, -: Negative impact
A: Very significant, B: Significant, C: Unknown, D: No impact
Source: JICA Study Team

19.7.3 Mitigation Measures

As described above, the EIA studies determined that the majority of expected negative impacts were minor to moderate, and would in general be occurring temporarily during the construction period. The majority were also likely to impact the physical and social environments rather than the biological environment.

As a result of the above impact characteristics, the mitigation measures developed to manage negative impacts were generally standard mitigation measures that are commonly accepted to be a part of "best practice" construction. Examples of these standard mitigation measures include such measures as:

- Dust prevention via tarpaulins on haul trucks and sprinkling access roads with bowser trucks;
- Noise prevention via use of modern, well maintained machinery, use of sound enclosures for generators, limiting working times, and installation of noise barriers;
- Water pollution prevention via use of modern, well maintained machinery, implementation of an effective waste management plan, proper storage of hazardous materials and wastes in impervious bunded areas, and proper collection and treatment of sewage, dewatering water and other liquid wastes prior to discharge;
- Worker health and safety measures such as obligatory use of PPE, clear warning signage, strict enforcement of site rules, regular health checks and provision of adequate meals and accommodation arrangements;
- Public health and safety measures such as construction of sturdy fencing around work areas, netting below work areas at height, and adequate and safe diversions for both road users and pedestrians;
- Community liaison activities, to include holding regular public meetings, distribution of information pamphlets, regular updates on construction schedule, and provision of a grievance redress mechanism.

As has been discussed, few unusual or special mitigation measures were deemed necessary for the present projects, however some particular mitigation measures are noteworthy:

- Transplanting of any rare flora species encountered during the early stages of construction work;
- Implementing a wildlife rescue and relocation plan throughout the construction period;
- Implementing an offset plan for lost areas of mangrove and forest[10];
- Implementing a reforestation plan that employs fast-growing native species, with at least 10% of species being useful as food sources for wildlife;
- Provision of cut timber to Project Affected Persons, charity, artisanal workshops or some other similar worthy recipient;
- Implementing a Resettlement Action Plan;
- Implementing a community education to establish "Culture of Metro";
- Establishment of inter-institutional coordination committee for intervention to the Canal of Panama operation by the construction of the 4th Panama Canal Bridge.

A full list of the mitigation measures is provided in the EMP section below.

[10] All mangrove trees cut will form part of a mangrove reforestation plan, the procedures for which are already set out via ANAM's Resolution 20 of 23 May 2012. The mangrove area will be surveyed by ANAM and a tariff set for compensation payment prior to clearance. Reforestation at a ratio of 3 for 1 will also be required, at a location of ANAM's choosing.

19.7.4 Environmental Management Plan

Comprehensive outline Environmental Management Plans (EMPs) were prepared as part of the EIA studies. The EMPs included information on implementation of mitigation measures, along with specific mitigation plans for construction and operation such as waste management plans, water and soils protection plans, traffic management plans and public consultation plans.

A summary table showing impacts and corresponding planning of mitigation measures is provided below (**Table 19.16**). The owner of the projects is responsible for implementation of all EMPs.

Table 19.16 Main EMP for Metro Line 3 and the 4th Panama Canal Bridge Projects

Environmental Impact/Aspect	Main Mitigation Measurement	Implementation Period
Microclimatic Change	· Cut down only those trees that are strictly necessary · Tree Planting Plan	Construction
Air pollution	· Adequate maintenance of the construction equipment · Maintenance of the work areas that have barren land being moist · Use adequate vehicle filters and diesel-based equipment · Establish adequate locations for storage, mixing and loading of construction materials · Cover and confine stored materials and products of earthmoving · Regulate the maximum speed to the established limits on access roads to the project area	Construction
Loss of carbon-capturing potential	· Flora and Fauna Protection program · Cut only those trees strictly necessary	Construction
Increase of unpleasant odors	· Maintenance of all engines to maximize the efficiency of combustion and minimize the emission of pollutant gases · Provision of adequate portable sanitation services and supply of portable toilet for workers · Adequate waste management	Construction
Noise	· Establish adequate work time · Education for workers to avoid generation of unnecessary noise · Make population informed about the activities · Supply the workers with adequate protective equipment against noise	Construction
	· Periodic Maintenance Program of the Metro car wheels · Install physical or plant-tissue screens in the depot · Visual inspection and periodic monitoring	Operation
Vibrations	· “Smooth blasting” in open area · Make public informed about the activities	Construction
	· Periodic Maintenance Program of all the Metro car wheels, as well as with road maintenance · Visual inspection and periodic monitoring	Operation
Erosion, sedimentation and land compaction	· Movement of large amount of earthwork be carried out in dry season · Adequate pluvial water management in rainy season · Slope protection with high density grass · Maintenance of slope	Construction
Soil pollution	· Adequate waste management · Creation of Zones for the temporary storages of residue, wastes, dirty water and used lubricants · Adequate place for maintenance of equipment · Contaminated Land Management Plan · Excavated Material Management Plan · Adequate management of disposal of fats and oils · Contingency Plan in case of spillage	Construction

Environmental Impact/Aspect	Main Mitigation Measurement	Implementation Period
Surface and underground water flow	· Fill in and level depressions, holes or ditches · Remove vegetation in the areas only strictly necessary	Construction
	· Maintenance of forest area	Operation
Water quality deterioration	· Comply with the DGNTI-COPANIT 35-2000 and DGNTI-COPANIT 39-2000 · Contingency Plan in case of spillage	Construction
	· Visual inspections and monitoring of the quality of surface waters · Adequate waste water management of the Depot	Operation
Surface runoff	· Detailed design studies of the drainage system in the depot · Installation of infiltration trenches in the depot	Construction
	· Visual inspections of drainages and monitoring	Operation
Loss of vegetation coverage	· Remove vegetation in the areas only strictly necessary · Request the permits or authorization from the ANAM, the Municipality of Panama and Panamá Oeste for the necessary cutting and obtain them · Payment of the ecological according to the Resolution AG-0235-2003/ANAM · Payment of the indemnification tariff for Mangrove Cuts (Res. J.D. No 20 of 23 May 2012) · Provision of timbers to PAPs, charity, and to the artisanal workshop · Reforestation Plan · Plan for the Rescue and Relocation of Flora	Construction
	· Periodic maintenance of green areas · Maintenance of reforested areas	Operation
Lost terrestrial habitat and wildlife	· Tree and Grass Planting Plan · Prevention of existing forest area · Reforestation Plan as compensation for cutting trees · Minimum illumination of work site · Avoid unnecessary noise from whistles, horns, sirens, turned-on engines, etc. · Environmental Education Plan for workers · Plan for Rescue and Relocation of Fauna according to Resolution AG-0292-2008	Construction
Aquatic wildlife	· Adequate management of plant material, removed soil, wastes and wreckage · Comply with DGNTI-COPANIT 35-2000 and DGNTI-COPANIT 39-2000	Construction
	· Visual inspections and periodic monitoring of water quality	Operation
Changes in urban mobility and accessibility in localities near the area of influence	· Mark the work areas and pedestrian walkways · Installation of alternative stops for buses and taxis · Coordination with public transportation servers · Maintain the community informed on closing streets, temporary detours and any other affectation · Establishment of routes for machinery, equipment, vehicles and supplies	Construction
Changes in land-use	· Maintain permanent dialogue with temporarily or permanently PAPs	Construction

Environmental Impact/Aspect	Main Mitigation Measurement	Implementation Period
Risk of effects on health and safety to residents and workers	· Education for workers on labor security measures · Health education for workers · Provision of personal protection equipment to all workers · Provision to workers a safe and healthy work environment · Open health centre for workers · Installation of traffic signs · Establish traffic routes for heavy equipment, machinery and other vehicles · Installation of warning signs and safety cones in sites with potential risks · Maintain fluid communication with public and private institutions close to the project · Establish barriers that impede access to work areas for unauthorized personnel · Periodic health and security inspections · Risk Prevention and Contingency Program.	Construction
	· Periodic campaigns in the population regarding health and security in the Metro's area of operation · Contingency Plan in case of leaks, spillage, fires or other contingency crises	Operation
Intervention of public and private property	· Clearly and timely inform the population on the characteristics, purposes, benefits and effects of the project · Community participation activities · Establishment and implementation of Grievance Redress Mechanism · Implementation of RAP	Construction
Impact on lifestyle of local people	· Clearly and timely inform the population about the characteristics, purposes, benefits and effects of the project · Community participation activities · Establishment and implementation of Grievance Redress Mechanism · Establish adequate work time · Traffic management plan	Construction
Transformation of the landscape structure	· Conserves as much land as possible in its natural state · Execute an Environmental Recovery and Close/Post-close Plan once construction ends	Construction
	· Maintain the areas surrounding the stations clean · Use colors consistent with nature to decorate the station zones	Operation
Modification of the road network dynamic and Changes in road safety	· Extensive coordination with the Transit and Road Transport Authority, collective and selective public transportation providers · Informative campaign · Maintenance of alternative route · Traffic management plan	Construction
	· Strictly apply the Traffic Laws of the Republic of Panama · Installation of traffic sign · Avoid moving machinery, equipment and trains through congested routes during peaks hours (between 6 and 9 of the morning and between 4 and 7 at night) or during the night · Installation of pedestrian crosswalks and sidewalks, pedestrian bridges · Maintenance of roads affected by the project	
	· Establish speed limits consistent with the new road structure of the zone · Installation of sufficient number of clear traffic sign	Operation

Source: Prepared by JICA Study Team based on URS Holdings, Inc. (2014)

19.7.5 Cost Estimate for EMP

The EIA studies included preparation of cost estimates for implementation of the environmental and social mitigation and management measures proposed in the outline EMPs. The estimated costs of environmental management during the construction phase are as follows:

- Metro Line 3 Project: **3,616,016.50 USD**
- 4th Panama Canal Bridge Project: **2,033,762.65 USD**

Breakdowns of the cost estimates for mitigation are provided in **Appendix 11-7** (Metro Line 3 Project) and **Appendix 11-8** (4th Panama Canal Bridge Project).

19.7.6 Monitoring Plan

The monitoring plans for both projects were prepared during the EIA studies for construction and operation phases, for Air Quality, Occupational health & safety, Ambient Noise, Structural Vibrations, Occupational Vibrations, Surface Water Quality, Waste Water, and Soil Quality. **Appendix 11-9** shows the plan. In Panama, the project owner is responsible for carrying out monitoring for the first three years of operation. The monitoring results will be reported to ANAM quarterly during the construction phase and annually during operation. The draft of monitoring form is attached as **Appendix 11-10**.

19.8 Strategic Resettlement Action Plan (SRAP)

In Panama, a Resettlement Action Plan (RAP) is not normally prepared during the feasibility study but during the detailed design stage. However, it was required to prepare a Strategic RAP (SRAP) during this FS due to the requirement to adhere to JICA Guidelines. A detailed RAP, or MINI RAP as called in the Metro Line 1 project, will be prepared based on the SRAP by SMP after determining the final design of the project. The SRAP was generally prepared to cover all contents required for RAP.

19.8.1 Necessity of Resettlemnet and Land Acquisition

(1) Project component which requires resettlement and land acquisition

Metro Line 3 Project

For the Metro Line 3 project, land acquisition is required mainly for construction of access escalators to the monorail stations, intermodal facilities (bus stop and taxi stop), park & ride, and depot.

Fourteen stations are planned along the Metro Line 3 Project. All stations have a raised platform system and will be placed within the existing RoW. The escalators and taxi/bus stops will be allocated together with stations, which will require minimum land acquisition, resettlement, and economic displacement.

A depot will be constructed at the end of the Metro Line 3 alignment, at Hato Montaña along the Panamericana Highway. About 12 ha land acquisition will be required. Two Park & Ride facilities in Nuevo Chorillo and Vista Alegre will require land acquisition. However, no resettlement or economic displacement is required for either case.

4th Panama Canal Bridge Project

No resettlement or land acquisition is required for the 4th Panama Canal Bridge project.

The access road of the 4th Panama Canal Bridge will run within governmental land (existing RoW, land of ACP, and Panama Port Company).

(2) Alternative analysis

Metro Line 3 Project

SMP and the JICA Study Team carried out various alternative analyses for route selection and system selection for the Metro Line 3 Project (See **Chapter 5**). The main five aspects taken into consideration during the analysis were demand of services, physical issues, land availability and resettlement, and negative impacts on environment and social setting (See **Appendix 11-2**).

With respect to route selection, two main options were analysed; the Panamerican Highway Route; and the Autopista Route. Both of them are existing roads with four lanes. The possibility of resettlement and land acquisition is higher for the Panamerican Highway Route than the Autopista Route, because the former highway is older and the urban activities have been developing along the route for many years. However, taking into considerations the demand for the Metro, the Panamerican Highway was selected. If the Autopista Route were selected, land acquisition and resettlement would be required to open new roads to bring customers from the Panamerican Highway area to the Autopista Route.

Regarding the system selection, there is no significant difference of possibility of resettlement and land acquisition among the systems.

4th Panama Canal Bridge Project

SMP and ACP had carried out the alternative analysis for the location of the 4th Panama Canal Bridge before starting this feasibility study (2012 to 2013). Three locations of the bridge, and tunnel option were analyzed. The location was selected on the north side of the existing bridge, Bridge of Americas, where there is no residential area in the immediate project area to avoid resettlement and land acquisition (See section **19.5**).

(3) Mechanism to avoid and minimize resettlement

The main activity which requires resettlement and economic displacement is installation of stations and associated infrastructure (escalators, bus and taxi stops) for the Metro Line 3 Project. The station locations were fixed during a field visit with SMP considering the current land use of RoW and the land availability to avoid and minimize resettlement, economic displacement, and land acquisition. SMP will give more effort to define the location of stations and alignment to minimize resettlement, economic displacement, and land acquisition in the further stage of the project.

19.8.2 Legal Framework related to Resettlement and Land Acquisition

(1) Panamanian Legal framework for Resettlement and Land Acquisition

Table 19.17 shows the main legal framework for land acquisition and resettlement in Panama.

Table 19.17 Main Legal Framework for Land Acquisition and Resettlement

Name of legal instrument	Main functions
Law 21 of 2nd July 1997	Approves regional development plan in the inter ocean region and general plan for use, conservation, and development of the Canal area.
Article 48 of Panamanian Constitution	Establishes that expropriation can be carried out in cases of wider public benefit, providing it is carried out legally and with prior payment of compensation.
Panamanian Political Constitution Art. 117	The State assures that all the population, especially in the low income sector, has the right to live in housing where they can enjoy certain rights.
Law 22 of 2006	Regulates the valuation process and criteria for acquisition or transfer of affected land (procedures are implemented by the Ministry of Economics and Finance and Land National Authority).
Civil Code (Chapter 5)	Regulates use of right of way.
Legal Code Book 16	Articles 1913 to 1926 provide the process of ordinary expropriation by the State.
Law No.6 of January 1 of 2002	Provide the citizen's right of free access to information. The State has obligation to promote public participations for public works.
Law No.57 of 1946 Art.5	The State cannot compensate for the structure or activities within the right of way.

Source: JICA Study Team

(2) Key Principles of JICA Policies on Involuntary Resettlement

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.
II. When population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.
III. People who must be involuntarily resettled and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.
IV. Compensation must be based on the full replacement cost[11] as much as possible.
V. Compensation and other kinds of assistance must be provided prior to displacement.
VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

[11] "Replacement cost" is as follows.

Land	Agricultural Land	The pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.
	Land in Urban Areas	The pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes.
Structure	Houses and Other Structures	The market cost of the materials to build a replacement structure with an area and quality similar or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.
VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.
IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.
X. The above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guidelines that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principles based on World Bank OP 4.12 are as follows.
XI. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.
XII. Eligibility of benefits include the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don´t have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.
XIII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihood is land-based.
XIV. Provide support for the transition period (between displacement and livelihood restoration).
XV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.
XVI. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, an abbreviated resettlement plan is to be prepared.

In addition to the above core principles from the JICA policy, it also puts emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

(3) Comparison of JICA Guidelines and the Panamanian Legal Framework

The following table shows a comparison of JICA Guidelines and the Panamanian legal framework on resettlement, and the policy of resettlement and land acquisition to be implemented in the current Line 3 and the 4th Panama Canal Bridge projects.

Table 19.18 Comparison of JICA Guidelines and the Panamanian Legal Framework

	JICA Guidelines	Panamanian legal framework	Gap between JICA Guidelines and Panamanian legal framework	Policy of resettlement for current project
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.	There is no regulation. However, recent practices have proved to comply with IFCs standards (mainly WB and IDB). Panama has signed international conventions on human rights and others.	There is no regulation which determines "Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives".	Panamanian public works always tries to avoid or minimize involuntary resettlement and loss of means of livelihood. The alignment of Metro Line 3 project and the 4th Panama Canal Bridge project was defined according to JICA guidelines and Panamanian practice.
2	When population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.	**Law 114 of 1943**: Regulates compensation when affected by public works. **Law No.57 of 1946 Art.3**: The State can expropriate private property for public and social benefit. If the State and the owner of property don't get agreement about compensation, the juridical process. **American Convention of Human Rights** ("Pact of San Jose of Costa Rica"): Art. 21 establishes "No person shall be deprived of his/her property, except through just compensation, due to public utility or of social interest in the cases and according to the procedures established by the law".	There is no gap between JICA Guidelines and the Panamanian legal framework.	Involuntary resettlement and loss of means of livelihood has been minimized, and the compensation will be taken according to the Panamanian legal framework and OP4.12 of WB.
3	People who must be resettled involuntary and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.	**Panamanian Political Constitution Article 62**: The State has obligation for social and economic improvement of all families. **Panamanian Political Constitution Art. 117**: The State assures that all population, especially low income sector, can live housing where they can enjoy social right. **Presidential Ministry. Resolution 154-Dec, 2010:** Delegates functions regarding compensation related to Line 1 to SMP.	There is no big gap between JICA Guidelines and the Panamanian legal framework.	The compensation measure will be taken according to the Panamanian legal framework and OP4.12 of WB.
4	Compensation must be based on the full replacement cost as much as possible.	**Tax Code. Law 8-Jan 1956 updated Law 33, 2010 and Law 31, 2011):** Regulates procedures for valuating properties. **Law 22 of 2006** (Public Procurement): regulates valuation process and criteria for acquisition or transfer of affected land at market price (procedures are	Several methods for compensation are accepted and in use in Panama. Specific regulation was established for Line 1 to guarantee full replacement cost for compensation.	The compensation will be based on the full replacement cost according to OP4.12 of WB.

	JICA Guidelines	Panamanian legal framework	Gap between JICA Guidelines and Panamanian legal framework	Policy of resettlement for current project
		implemented by Ministry of Economics and Finance and Land National Authority).		
5	Compensation and other kinds of assistance must be provided prior to displacement.	**Panamanian Political Constitution Art. 48**: The State can expropriate private property for public benefit. The expropriation should be carried out with legal process. The compensation for such expropriation should be paid before starting construction.	There is no big gap between JICA Guidelines and the Panamanian legal framework.	Compensation and assistance will be provided prior to displacement according to the Panamanian regulation and OP 4.12 of WB.
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	**Law No.6 of January 1 of 2002**: Provide the citizen's right of free access to information. The State has obligation to promote public participations for public works.	There is no big gap between JICA Guidelines and the Panamanian legal framework.	There is not foreseen large-scale involuntary resettlement for Metro Line 3 project and the 4th Panama Canal Bridge project.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	**Law No.6 of January 1 of 2002**: Provide the citizen's right of free access to information. The State has obligation to promote public participations for public works. **Law 41 of July 1, 1998 and Decree 123, 2009.** Regulates citizen participation during EIA process.	There is no big gap between JICA Guidelines and the Panamanian legal framework.	Various methodologies of public participation activities have been carried out during EIA studies and SRAP preparation according to the Panamanian legal framework and OP 4.12 of WB.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	**Law No.6 of January 1 of 2002**: Provide the citizen's right of free access to information. The State has obligation to promote public participations for public works.	There is no big gap between JICA Guidelines and the Panamanian legal framework.	The consultation has been carried out according to the Panamanian legal framework and OP 4.12 of WB.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.	**Law No.6 of January 1 of 2002**: Provide the citizen's right of free access to information. The State has obligation to promote public participations for public works. **Executive Decree No.150 of July 02 of 2009**: SMP promotes support and cooperation of community for Metro project.	There is no big gap between JICA Guidelines and the Panamanian legal framework.	Various methodologies of public participation activities have been carried out during EIA studies and SRAP preparation according to the Panamanian legal framework and OP 4.12 of WB. The mechanism of public participation activities will be planned in the SRAP for implementation and monitoring stages according to the Panamanian legal framework and OP 4.12 of WB.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	**Agreement 5, from June 2003:** Establishes the application of Conflict Resolution Methods (MASC's) during the execution of the National Program for Land Administration (PRONAT). Metro Line 1 project established its own grievance	There is no big gap between JICA Guidelines and the Panamanian legal framework.	Grievance mechanisms will be planned in the SRAP according to OP 4.12 of WB.

	JICA Guidelines	Panamanian legal framework	Gap between JICA Guidelines and Panamanian legal framework	Policy of resettlement for current project
		mechanisms.		
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.	There is no specific regulation for this. However, preceding procedures made for several development projects including Metro Line 1 project has accomplish with JICA guideline.	There is a gap.	During the preparation of SRAP, possible affectations have been identified. Socioeconomic survey and asset inventory have been carried out for all possible affected persons during the FS. The cut-off date will be established after determining the final alignment of the project.
12	Eligibility of benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don´t have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.	**Law No.57 of 1946 Art.5**: The State cannot compensate for the structure or activities within the right of way. However, procedures established for Metro Line 1 project accomplished with JICA guideline.	There is a gap.	Eligibility of benefits includes all PAPs along the project alignment according to OP 4.12 of WB and as same as Metro Line 1 project did.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihood is land-based.	There is no specific regulation.	There is a gap.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihood is land-based according to OP4.12. (However there is no case in the current project.)
14	Provide support for the transition period (between displacement and livelihood restoration).	There is no regulation. However, SMP provided support for Metro Line 1 Project.	There is a gap in terms of legal framework, but there are some project of recent year in Panama that project proponent provided support for the transition	SMP will provide support for transition period according to OP4.12.

	JICA Guidelines	Panamanian legal framework	Gap between JICA Guidelines and Panamanian legal framework	Policy of resettlement for current project
			period.	
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.	**Law No.04 of January 29 of 1999**: Establishes equal opportunity for men and women. **Panamanian Political Constitution Art. 86, Executive Decree No.1 of January 11 of 2000:** Establish special considerations and attention for indigenous people. **Executive Decree 103 of September 1, 2004:** Creates the National Secretary for the Social Integration of population with special needs.	There is no gap between JICA Guidelines and the Panamanian legal framework.	Particular attention has been taken in consideration for vulnerable people in the preparation of SRAP.
16	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.	**Panamanian Political Constitution Art. 48**: The State can expropriate private property for public benefit. The expropriation should be carried out with legal process. The compensation for such expropriation should be paid before starting construction. **Law No.57 of 1946 Art.3**: The State can expropriate private property for public and social benefit. If the State and the owner of property don't get agreement about compensation, the juridical process.	There is no gap between JICA Guidelines and the Panamanian legal framework. The RAP was prepared based on OP 4.12 for the Line 1 project, and has been prepared for Meto Line 2 project, too.	Abbreviated resettlement plan will be prepared according to JICA Guidelines and OP4.12.

Source: JICA Study Team

(4) Policy of resettlement and land acquisition for Line 3 project and the 4th Panama Canal Bridge Project

I. The Government of the Republic of Panama will use the Project Resettlement Policy (the Project Policy) for the Metro Line 3 and the 4th Panama Canal Bridge specifically because existing national laws and regulations have some gaps compared to international practice, including JICA's policy. The Project Policy is aimed at filling-in any gaps in what local laws and regulations cannot provide in order to help ensure that PAPs are able to restore their situation to at least their pre-project condition. This section discusses the principles of the Project Policy and the entitlements of the PAPs based on the type and degree of their losses. Where there are gaps between the legal framework for resettlement and JICA's Policy on Involuntary Resettlement, JICA will support the Government of Panama to carry out an adequate environmental and social considerations.

II. Land acquisition and involuntary resettlement will be avoided where feasible, or minimized, by identifying possible alternative project designs that have the least adverse impact on the communities in the project area.

III. Where displacement of households is unavoidable, all PAPs losing assets, livelihoods or resources will be fully compensated and assisted so that they can improve, or at least restore, their former economic and social conditions.

IV. Compensation and rehabilitation support will be provided to any PAPs, that is, any person or household or business which on account of project implementation would have his, her or their:

- Standard of living adversely affected;
- Right, title or interest in any house, interest in, or right to use, any land (including premises, agricultural and grazing land, commercial properties, tenancy, or right in annual or perennial crops and trees or any other fixed or moveable assets, acquired or possessed, temporarily or permanently;
- Income earning opportunities, business, occupation, work or place of residence or habitat adversely affected temporarily or permanently; or
- Social and cultural activities and relationships affected or any other losses that may be identified during the process of resettlement planning.

V. All affected people will be eligible for compensation and rehabilitation assistance, irrespective of tenure status, social or economic standing and any such factors that may discriminate against achievement of the objectives outlined above. Lack of legal rights to the assets lost or adversely affected tenure status and social or economic status will not bar the PAPs from entitlements to such compensation and rehabilitation measures or resettlement objectives. All PAPs residing, working, doing business and/or cultivating land within the project impacted areas as of the date of the latest census and inventory of lost assets (IOL), are entitled to compensation for their lost assets (land and/or non-land assets), at replacement cost, if available and restoration of incomes and businesses, and will be provided with rehabilitation measures sufficient to assist them to improve or at least maintain their pre-project living standards, income-earning capacity and production levels.

VI. PAPs that lose only part of their physical assets will not be left with a portion that will be inadequate to sustain their current standard of living. The minimum size of remaining land and structures will be agreed during the resettlement planning process.

VII. People temporarily affected are to be considered PAPs and resettlement plans address the issue of temporary acquisition.

VIII. The resettlement plans will be designed in accordance with the Panamanian legal framework and JICA's Policy on Involuntary Resettlement.

IX. The Resettlement Plan will be prepared in Spanish and disclosed for the reference of PAPs as well as other interested groups.

X. Payment for land and/or non-land assets will be based on the principle of replacement cost.

XI. Replacement lands, if the preferred option of PAPs, should be within the immediate vicinity of the affected lands wherever possible and be of comparable productive capacity and potential. As a second option, sites should be identified that minimize the social disruption of those affected; such lands should also have access to services and facilities similar to those available in the lands affected.

XIII. Resettlement assistance will be provided not only for immediate loss, but also for a transition period needed to restore livelihood and standards of living of PAPs. Such support could take the form of short-term jobs, subsistence support, salary maintenance, or similar arrangements.

XIV. The resettlement plan must consider the needs of those most vulnerable to the adverse impacts of resettlement (including the poor, those without legal title to land, ethnic minorities, women, children, elderly and disabled) and ensure they are considered in resettlement planning and mitigation measures identified. Assistance should be provided to help them improve their socio-economic status.

XV. PAPs will be involved in the process of developing and implementing resettlement plans.

XVI. PAPs and their communities will be consulted about the project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to the extent possible be involved in the decisions that are made concerning their resettlement.

XVII. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition (including compensation and income restoration measures) within the agreed implementation period. The funds for all resettlement activities will come from the Government.

XVIII. Displacement does not occur before provision of compensation and of other assistance required for relocation. Sufficient civic infrastructure must be provided in resettlement site prior to relocation. Acquisition of assets, payment of compensation, and the resettlement and star of the livelihood rehabilitation activities of PAPs, will be completed prior to any construction activities, except when a court of law orders so in expropriation cases. (Livelihood restoration measures must also be in place but not necessarily completed prior to construction activities, as these may be ongoing activities.)

XIX. Organization and administrative arrangements for the effective preparation and implementation of the resettlement plan will be identified and in place prior to the commencement of the process; this will include the provision of adequate human resources for supervision, consultation, and monitoring of land acquisition and rehabilitation activities.

XX. Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, will be identified and set in place as part of the resettlement management system. An external monitoring group will be hired by the project and will evaluate the resettlement process and final outcome. Such groups may include qualified NGOs, research institutions or universities.

Cut-off-date of Eligibility

The cut-off-date of eligibility refers to the date prior to which the occupation or use of the project area makes residents/users of the same eligible to be categorized as PAPs and be eligible to Project entitlements.

According to the SMP's experience with Metro Lines 1 Project, and other projects which required resettlement and land acquisition in Panama, it is not common to establish a cut-off date during the feasibility study so as to not give perspective to the local community. The cut-off-date will be established after determining of the final alignment, and all PAPs to be identified at that moment will be eligible for compensation.

Under this circumstance, the JICA Study Team had a discussion with JICA Headquarters about this issue and decided that a cut-off date was not established during this F/S.

19.8.3 Scope of Resettlement and Land Acquisition

(1) Results of census for PAPs

The field visits were carried out at various times; January 22 to 25, February 12 to 15, and March 14 of 2014 to identify possible PAPs along the Metro Line 3 project alignment and the 4th Panama Canal Bridge Project. SMP also participated in one field visit to minimize the number of PAPs by adjusting the location of stations, columns, and escalators.

The census was applied to all PAPs in February and March 2014. The results are following:

- Three types of impact are foreseen; resettlement, economic displacement, and land acquisition.
- Impacts can be categorized as permanent or temporary (only during construction).

Six types of PAPs were identified in the project area.

- **Owner** is a structure owner on private land, or owner of private land.
- **Owner-Occupant** is a structure owner on private land but still under process of transfer, inheritance, trail for inheritance, mortgage, etc. and the status is illegal.
- **Lessee** is a person who pays for rent of private land or institutional land.
- **Occupant** is a person/family who lives or has economic activities within the RoW or in the bank of Canal of Panama.
- **Collective occupant** is a group of people who work in the same activity area in the RoW or at the bank of the Canal.
- **Lessee-Occupant** is a person/family who lives or has economic activities within the RoW paying for rent of structure.

Metro Line 3 Project

Table 19.19 shows the number of project affected units (PAUs) and project affected persons (PAPs) for the Metro Line 3 project.

Five families will be required to be displaced; with a total number of PAPs is 17. 35 economic units (shops, offices, and etc.) will be required to be displaced.

Table 19.19 Number of project affected units and PAPs (Metro Line 3 Project)

Type of Impact	Type of loss	Number of PAUs	Number of PAPs
Resettlement			
Owner	Structure on private land	1	3
Owner-occupant	Structure on private land	2	5
Occupant	Structure on RoW	2	9
	Sub total	**5**	**17**
Economic Displacement			
Owner	Structures on private land	3	-
Lessee	Structures on private land	3	-
	Structure on government land	1	-
Occupant	Structures on RoW	28	-
	Sub total	**35**	-
	Total	**40**	**17**

Source: JICA Study Team

4th Panama Canal Bridge Project

Table 19.20 shows the number of PAUs and PAPs for the 4th Panama Canal Bridge component.

No resettlement is foreseen, because the project area is mainly used for institutional buildings and port activities.

Four shops within the RoW, one taxi station, and one fishermen base are subjects to be displaced. The number of PAPs is more than 128 persons according to the result of census.

Table 19.20 Number of project affected units and PAPs (4th Panama canal Bridge Component)

Type of Impact	Type of loss	Number of PAUs	Number of PAPs
Economic Displacement			
Occupant	Structures on RoW	4	19
Collective Occupant	No structures (Taxi station)	1	30
	Structures on the bank of Canal Fishermen Base)	1	79
	Total	**6**	**128**

Source: JICA Study Team

(2) Results of Property Inventory

The inventory on possible affected land and structures was carried out in March and April 2014. During the census of PAPs, the legal documents of property and land also were collected as much as possible. It is important to mention that some people denied to present the legal document and to take photos of structure.

Land

Six types of land were identified within the area, which are institutional (governmental) land used for institutional buildings, institutional (governmental) land used for private sector, private land with commercial building, private land with housing, private land (vacant lot) and RoW (governmental land) with private structures. **Figure 19.14** shows the typical type of affected land for both projects.

Private Land with Housing (Nuevo Chorrillo)

Private Land with commercial building (Vista Alegre)

Vacant lot (Private land) (Hato Montaña)

RoW with Private Structure

Institutional Land (ACP Pump Station)

Institutional Land (Used by private sector)

Source: JICA Study Team

Figure 19.14 Typical Type of Land to be Affected

Metro Line 3 Project

Table 19.21 shows the type of land and areas to be acquired by Metro Line 3 Project. 2,650.94 m^2 of housing land, 2,244.40 m^2 of commercial land, and 127,920.00 m^2 of vacant land will be required to be acquired.

Table 19.21 Area and type of land to be acquired

Land use	Affected Area (m^2)
Housing	2,650.94
Commercial	2,244.40
Vacant lot (private land)	127,992.00
Total	132,887.34

Source: JICA Study Team

4th Panama Canal Bridge Project

No land acquisition of private land will be acquired for the 4th Panama Canal Bridge Project. All the alignment will pass within the existing road RoW and the government land. An inter-institutional coordination has been carried out between SMP, ACP, and the Panama Port Company (Government concessional company).

Structures

In Panama, the type of structure is categorized by *Contraloria General de la Republica*. In this project area, four types of structure were identified. **Figure 19.15** shows the typical type of possibly affected structures.

- **Permanent structure**: A structure constructed with material of long life, such as concrete, blocks, bricks, stones, wood, adobe, etc.
- **Semi-permanent** structure: A structure with mixture of long life material and medium or short life time, such as cane, straw, stick, bamboo, etc.
- **Provisional structure**: A structure with provisional character, and constructed by old wood, pieces of iron, cans, cardboard, clothes, plastics, etc.
- **Stand**: A structure with tires.

Permanent structure (Mini super and housing) (*1)

Semi-permanent structure (Shop) (*1)

Provisional structure (Shop) (*1)

Stand (Shop) (*2)

Permanent structure (ACP) (*1)

Permanent structure (ACP) (*1)

Source: (*1) JICA Study Team, (*2) URS Holdings, Inc. (2014)

Figure 19.15 Typical Type of Structures to be Affected

Metro Line 3 Project

32 structures in total will be affected by the project. Six structures of them are used for residential[12], and 26 for commercial use. **Table 19.22** shows the number of affected structures for each type.

Table 19.22 Type and number of structures to be affected (Metro Line 3 Project)

Type of structures	Number
Residential structures	
Permanent	6
Commercial structures	
Permanent	16
Semi-permanent	8
Provisional	2
Total	**32**

Source: JICA Study Team

4th Panama Canal Bridge Project

Nine structures will be affected permanently by the project. Three ACP structures (two buildings and one high-voltage tower), four commercial structures, and three structures of artisanal fishermen activity base will be displaced.

Table 19.23 Number and Type of Affected Structures (4th Panama Canal Bridge Project)

Type of structures	Number
Institutional structures	
Permanent	6
Semi-permanent	1
Commercial structures	
Permanent	2
Semi-permanent	1
Provisional	3
Stand	1
Total	**14**

Source: JICA Study Team

(3) Socioeconomic Characteristics of the PAPs

PAPs by Resettlement

Five of the houses belonging to families to be resettled are built on private land, one in RoW. All six families live in the permanent structure housing type, and have access to electricity, sanitation service, potable water, and garbage collection. Two families have access to sewerage and the rest do not. One house is abandoned.

Among 17 PAPs, 7 are male and 10 are female. There are two families with infant, and there are three families with elder people (up to 60 years old). There are two families of women-headed households. There are two families with psychological disabilities.

The main transportation system used by PAPs is bus and taxi. Only one family has a car.

The average monthly income of 5 affected families is US$2,150. The highest income is US$6,500 and the lowest is US$300. The average monthly expense is US$1,310. The highest is US$4,000 and the lowest is US$250.

[12] One of these six residence is abounded.

PAPs by Economic Displacement

Economic Units along the alignments

Six economic units are located in private land, one in governmental land, and 28 in RoW. 16 economic units have permission for business, and the rest of them refused to provide the relevant information.

The types of economic activities are: fast food restaurant, sale of fruits /snacks /foods /seafood /plants /sundry goods/electrical goods/ car spare parts, mini super market, car wash, barbershop, lawyer office, rent of equipment, and so on. The main customers of these businesses are local people. The average of number of workers is three per economic unit.

The average income of economic units is US$4,075.94 per month. However, the range of income is quite big: the lowest monthly income is US$100.00, and the highest monthly income is US$10,700. There are five economic units which have another better economic income (income from the affected economic unit is lower than the other economic income). 14 economic units have no other income source rather than the possible affected economic activities.

Artisanal Fishermen Activity Base

There is a comprehensive artisanal fishing activity on the east bank of the Panama Canal close to the proposed bridge launch point around 400 m. According to the questionnaire survey that took place in April 2014, there are 79 economic units (owner of boats) who directly work in this area. Their main activities are: artisanal fishing, tourist activities (visiting islands and providing tours around the coast), and sale of seafood, fish, and bait.

The fishing activities have been carried out in this area since 1964. All boat owners apparently have permission for operation from ARAP. They have not formed a formal association for now, but they have been initiating the process on this.

	
All fishes and seafood are sent from here to the market in Panama City.	The boats used for artisanal fish in this area.

Source: JICA Study Team

Figure 19.16 Artisanal Fishermen Activities

Taxi Station

There is a taxi station close to the Panama Port Company entrance. There is no structure. However, a group of 30 drivers base their activity at that point. They started to use this area since 1964, with the permissions from ATTT. The main customers are the workers and officers who work in the port area, and the fishermen in the bank of the Canal.

Source: JICA Study Team

19.8.4 Measures for Compensation and Social Assistance

(1) Compensation and Social Assistance for Loss

In Panama, economic compensation is the most common compensation method for losses due to public works. All loss of land, structures, and source of income will be compensated based on the criteria established in OP 4.12 of World Bank.

- All PAPs are entitled to be fully compensated, and to receive support to improve or at least restore their current socio-economic conditions.
- Any PAP directly affected by the project requiring resettlement and economic displacement receive support during the process of compensation and rehabilitation, regardless of their social or economic status or any factor that could be considered discriminatory including no legal tenure to the land, structures, and other property they occupy without legal rights.
- Temporarily affected families/economic units, whether or not subject to resettlement/displacement, will be considered for temporary compensation.
- A MINI RAP will be designed consistent with this SRAP and, in general, JICA Guidelines.
- Compensation cost for loss of properties will be calculated on the replacement cost.
- Support will be provided for resettlement during the transition period necessary to restore living standards of PAPs. This support may include, where necessary, assistance in the form of livelihood support, temporary jobs, or any other governmental action deemed practicable and agreed between the parties.
- Particular attention will be paid to vulnerable people, according to the results of socio-economic census, including women, children, elderly and disabled people.
- The process of resettlement, compensation and start of implementation of rehabilitation measures will be developed in the period before the start of construction of the project.

(2) Entitlement Matrix

Table 19.24 shows the entitlement matrix of the Metro Line 3/4th Panama Canal Bridge Projects. SMP will elaborate detailed compensation and social assistance plans in the process of elaboration of MINI RAP based on this entitlement matrix.

Table 19.24 Entitlement Matrix

Type of loss	Entitled persons	Options for compensation and social assistance plan	Responsible Organization
Land	・Owner	・Economic compensation at replacement cost ・If the owner rent any part of the affected land, additional economic compensation for the lost of rent	SMP, CGR/MEF
	・Occupant	・Cost coverage for legal resister of entitlement of new land	SMP, ANATI
Structures	・Owner	・Economic compensation for buildings, improvements, and other structures within	SMP, CGR/MEF

Type of loss	Entitled persons	Options for compensation and social assistance plan	Responsible Organization
		the affected area at replacement cost.	
		・Construction of new building at better or at least same level of the original condition.	SMP
		・Prepare options for displacement.	SMP, ANATI, MIDES
		・Cost coverage of move, or provider of moving services	SMP
		・Preparation of public services for new place, and cost coverage for reconnection of public services	Municipalities
		・Additional assistance if PAPs require	PAN (National Help Program), MIDES, SENADIS, MOP, ANATI)
	・Lessee	・Prepare options of new place for installation of shop	AMPYME, MITRADEL
		・Cost coverage of move, or provider of moving services	SMP
	・Occupant	・Construction of new commercial structure at better or at least same level of conditions	SMP, MIDES, AMPYME, MITRADEL
		・Service provision for moving	
		・Cost coverage for legal process for new place	
Sources of income	・Owner ・Lessee ・Occupant ・Workers	・*Payment for lost profits* (*1) during closure of business	SMP
		・Economic compensation for salaries during closure of shop	SMP
		・Orientation for alternative sources of income, or capacity building of economic activities	AMPYME
		・Economic compensation for basic food basket for three months (*2)	SMP
		・Assistance of PAPs to participate capacity building program if PAPs ask to	AMPYME, MITRADEL
Place for activities	・Occupant with stand	・Assistance to find new location ・Cost coverage for legal process for new place	SMP
	・Fishermen	・Assistance to find new location with the same or better conditions compared with the current conditions	SMP, ARAP
	・Taxi station	・Assistance to find new location within the area where drivers have permission for operation issued by ATTT. ・Cost coverage for legal process for new place, if any.	SMP
Vulnerable persons	Women, children, elderly and disabled people	・Offer of programs according to the necessity of PAPs, such as health, education, assistance for handicapped persons, psychological assistance, and etc.	SMP, SENADIS
Loss of access to housing/shops	・Owner ・Lessee ・Occupant	・Insert temporally access to housing and shops	SMP

(*1) Payment of lost profits will require a detailed investigation. SMP will carry out the analysis in

elaboration of MINI RAP.
(*2) "Three months" was estimated by the longest duration of closure of shops in the Metro Line 1 Project. The time is expanded according to the actual situation.
Source: JICA Study Team

19.8.5 Grievance Redress Mechanism

The objective of establishing a grievance redress mechanism is to manage any complaints from PAPs and local communities with rapid and satisfactory measures.

During the implementation of the both projects, the contractor will open field offices at key points along the Project alignments in order to implement RAP and also to receive any complaints from PAPs and other local communities. These offices will open before the construction stage to update the current SRAP to prepare MINI RAP, and will be closed by 15 calendar days after the date of termination of construction stage.

The complaint resolution process will have two stages: the first one will be initiated by the contractor's field office (Social Management Office), and the second stage by SMP.

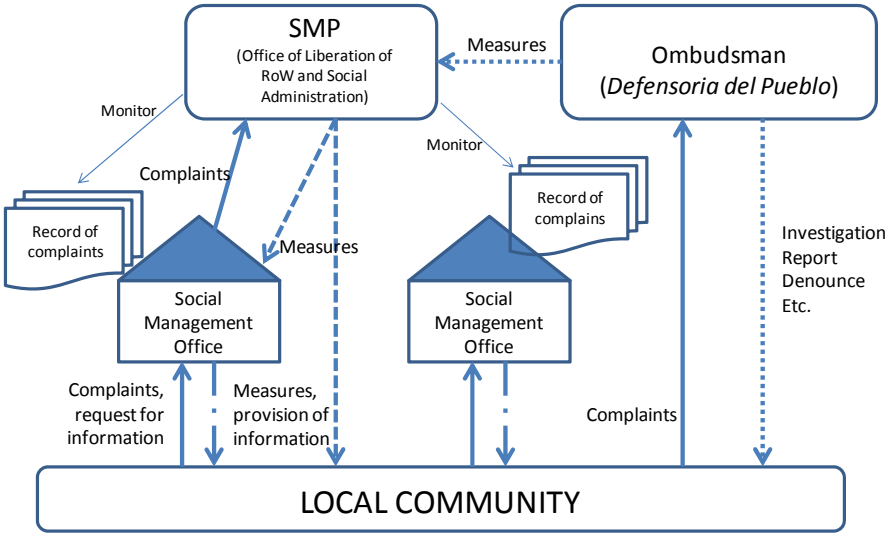
The main functions of the Social Management Office are:

- Guide and give advice to people who visit the office asking for information about the objectives, scopes and benefits of the project
- Guide people in registering their complaints, concerns or requests, and explain the procedures and stages at their disposal
- Attend rapidly to complaints from local people
- Conduct field inspections in order to verify the registered complaints, through third party interviews and a survey of damages
- Monitor the process of complaint resolution, from the date of its registration to its closing, which is verified for the corresponding record in the complaint registry
- Develop individual files for recorded and addressed cases, which shall contain the type of complaint, field verification visits, and its resolution
- Inform the complainant on the progress of the case resolution
- Ensure that complaints are resolved rapidly; otherwise, if the complaint is not resolved within 30 days after being lodged at the Social Management Office, complaint needs to be passed to the Legal Office of SMP.

For lodging of complaints, SMP will establish a format for register sheet. The format will contain the followings items:

- Name, identification number, contact details, type of PAPs
- Description of complaint, photos if any
- Date of receiving complaint and of resolving the problem
- Measures taken.

Apart from the Social Management Office or SMP, Panama has an Ombudsman (*Defensoría del Pueblo*) whose objectives are to execute non jurisdictional control and protect human rights from government abuse.



Source: JICA Study Team

Figure 19.17 Grievance Redress Mechanism

19.8.6 Implementation System

SMP has an "Office of Liberation of RoW and Social Administration" to implement resettlement, economic displacement, and land acquisition. This office worked for the Metro Line 1 project successfully according to OP 4.12 of World Bank.

SMP has/will establish the agreement with the related institutions to implement the RAP. **Table 19.25** shows the organization identified for implementation of RAP.

Table 19.25 Organization for Implementation of RAP

Organization	Function
SMP	Implements RAP with other institutional support. Office of Liberation of RoW and Social Administration is the main unit to work on implementation of RAP.
Ministry of Public Works (MOP)	Provides support for liberation of RoW and transfer
National Authority for Land (ANATI)	Provide support for legalization of properties
ACP	Coordinate with SMP to manage affected buildings of ACP.
Municipality of Arraijan	Provides support for community participations, liberation of RoW, transfer, follow-up of PAPs.
Ministry of Social Development (MIDES)	Provide scholarships for a young person who works and studies. Provide economic support for the elderly person who does not receive retirement pensions.
Ministry of Works and Labor Development (MITRADEL)	*Mi Primer Empleo (My first job) program* provides training for young people. *SRPE* (Public Service of Employment) provides facilitation new jobs through a database of job opportunities.
Authority of micro small and medium enterprises (AMPYME)	Promotes and support new initiative for business.
National Secretaries for Disability (SENADIS)	Provides support for handicapped persons and his/her family.
National Institute for Professional Formation and Train (INADEH)	Provides training for job.
Institute for Training and Development of Human Resources (IFHARU)	Provide scholarships for low income families.
Aquatic Resources Authority of Panama (ARAP)	Issue permission for marine activities including fishing.
Transit and Land Transportation Authority of Panama (ATTT)	Issue permission for operation of taxi.

Source: JICA Study Team

19.8.7 Implementation Schedule

The implementation schedule of RAP for both projects was prepared in accordance with Metro Line 1 project.

The implementation of RAP for Metro Line 3 project is estimated for 12 months. **Table 19.26** shows the draft of implementation of schedule.

Table 19.26 Implementation Schedule of RAP for the Metro Line 3 Project

Activities / Months	1	2	3	4	5	6	7	8	9	10	11	12
Design and adjustment												
Implementation of Program of Information and Consultation												
Notification and Divulgation of process for acquisition, reconstruction, replacement of property and/or economic activities												
Implementation of Program of land acquisition and/or liberation of RoW												
Communication of offer for owner and Occupant												
Process of negotiation and definition of compensation												
Legal procedure, transfer and payment of Compensation												
Up-date of cadastral data												
Legal and technical advice for process of acquisition, replacement, and rehabilitation of previous conditions												
Adaption of partially affected properties												
Programa de restablecimiento de condiciones económicas y sociales												
Monitoring												
Closing audit												

Source: JICA Study Team

The implementation of RAP for the 4th Panama Canal Bridge Project is estimated for 10 months. **Table 19.27** shows the draft of implementation of schedule.

Table 19.27 Implementation Schedule of RAP for the 4th Panama Canal Bridge Project

Activities / Months	1	2	3	4	5	6	7	8	9	10
Design and adjustment										
Implementation of Program of Information and Consultation										
Notification and Divulgation of process for acquisition, reconstruction, replacement of property and/or economic activities										
Liberation of RoW										
Communication of offer for Occupant										
Process of negotiation and definition of compensation										
Legal procedure, transfer and payment of Compensation										
Legal and technical advice for reinstallation of economic activities										
Reestablishment of economic and social conditions										
Monitoring										
Closing audit										

Source: JICA Study Team

These schedules will be adjusted, and the details will be defined by SMP in the preparation of MINI RAP.

19.8.8 Cost

The cost for implementation of RAP for both projects was estimated during this feasibility study based on the available information from January to June 2014. The estimated costs of implementation of RAP are as follows:

- Metro Line 3 Project: **25,973,069.90 USD**
- 4th Panama Canal Bridge Project: **5,301,055.50 USD**

Table 19.28 and **Table 19.29** show the detail of the estimated costs.

Table 19.28 Estimated Cost of RAP for Metro Line 3 Project (*1)

USD

Item	Unit Cost	Unit	Quantity	Sub Total
Land acquisition	23,327,577.40	LS	1	23,327,577.40
Compensation for resettlement families	402,596.50	LS	1	402,596.50
Compensation for economic displacement (*2)	2,086,516.00	LS	1	2,086,516.00
Compensation for temporary impact	156,380.00	LS	1	156,380.00
Total				**25,973,069.90**

(*1) The cost was estimated with the available information on June 2014.
(*2) The estimated cost for compensation for economic displacement includes the payment of "lost profits". However, as mentioned above, more detail investigation is required for payment of "lost profits" as measures of compensation.
Source: JICA Study Team based on URS Holdings, Inc. (2014)

Table 19.29 Estimated Cost of RAP for 4th Panama Canal Bridge (*1)

USD

Item	Unit Cost	Unit	Quantity	Sub Total
Compensation for economic displacement (*2)	301,055.50	LS	1	301,055.50
Relocation of ACP structures (*3)	5,000,000.00	LS	1	5,000,000.00
			Total	**5,301,055.50**

(*1) The cost was estimated with the available information on June 2014.
(*2) The estimated cost for compensation for economic displacement includes the payment of "lost profits". However, as mentioned above, more detail investigation is required for payment of "lost profits" as measures of compensation.
(*3) The reference cost was given by SMP for replacement of ACP Buildings 66-A, 66-B and the high-voltage transmission tower.
Source: JICA Study Team based on URS Holdings, Inc. (2014)

In the further stage of the projects, SMP will update the information on PAPs then the cost for implementation of RAP will be adjusted, too.

19.8.9 Monitoring Plan

Two monitoring systems will be established for the both Projects. One is an internal monitoring system for completion of planned activities, and another is an external monitoring system to evaluate the impact generated by implementation of RAP and audit of internal monitoring. The monitoring activities will be closed six months after closing all RAP activities.

The internal monitoring will be carried out monthly by the Office of Liberation of RoW and Social Administration of SMP, based on the site visit, interview with PAPs, check the register of complains and solutions. The monitoring report will be submitted to the top of SMP and other relevant agencies.

The external monitoring will be carried out monthly by a third party, for example NGOs, University, or others who have experience of monitoring RAP activities. The external monitoring group will review the internal monitoring report, carrying out site visits, hold interviews with PAPs when necessary, and review the complaints resister. They will prepare a monthly monitoring report and submit it to SMP and other relevant agencies.

19.9 Conclusion and Recommendation

Comprehensive EIA and SRAP studies have been carried out for the two projects, exceeding the requirements of both Panamanian law and JICA Guidelines. The studies included significant effort to gather and analyse both existing available data, and new baseline data obtained via field surveys and interviews. Forest inventories were also carried out as part of the baseline studies, in accordance with Panamanian legislation.

The approach to the EIA and SRAP studies was fully participatory, and local communities, civil society, and academia were consulted throughout the project process. Designs and approaches were modified were necessary in accordance with the opinions provided in these public meetings and focus group discussions. The draft of monitoring form is attached as **Appendix 11-11**.

The impact assessments were conducted using a systematic and quantitative methodology, allowing for an accurate prediction of potential positive and negative environmental and social impacts. Following the identification of impacts, a comprehensive outline Environmental Management Plan (EMP) was prepared. The EMP lists the mitigation measures developed by the study team to reduce potential negative impacts to acceptable levels, and to maximise the benefits of positive impacts. The expected costs of implementing the EMP were provided so that sufficient funds will be made available for environmental and social mitigation during preparation of overall cost estimates and tender documents.

The key findings and conclusions of the EIA studies were as follows:

- The alignment of both projects pass through an area which is largely urban, commercial or industrial, and which is highly trafficked and generally disturbed by anthropogenic activities.
- As a result, background noise levels are high, and water and air quality results obtained in the project area reflect the human presence. Likewise, the estuarine environment in the Panama Canal at the location where the 4th Panama Canal Bridge is proposed also shows signs of existing biological and chemical pollution resulting from the very high levels of shipping activity in the Canal, and its proximity to Panama City.

- The project alignments do pass through some natural forested areas, and one area of mangrove, however the baseline studies determined that the habitats to be lost were generally already disturbed, did not host significant diversity or density of flora and fauna species, and were not critical habitat for the threatened species identified.
- The presence and operation of the project will have sustained, highly significant positive impacts on various aspects of the social environment, including alleviation of traffic congestion, increased economic development, and reduction in journey times.
- The presence and operation of the project will also produce localised positive impacts in some areas due to reduction / offset in emissions and noise from buses and other road traffic. At a wider scale, the operation of the project is expected to offset between 16,000-25,000 tonnes of CO_2 per year.
- The majority of expected negative impacts are associated with the construction process, and relate to public disturbance type impacts (which tend to be reversible and short term);
- The construction and operation of both the 4th Panama Canal Bridge Project and the Metro Line 3 Project are not expected to have significant negative impacts on terrestrial or marine flora and fauna. Whilst a number of internationally rare species were identified during the field surveys, no primary forest exists and none of the areas to be lost were considered as critical habitat for the rare species identified. Rapid regeneration of the small mangrove area to be lost during construction is also predicted.
- Land acquisition (totalling around 13ha), resettlement (five families), and displacement of economic units (around 41 units) will be required. Throughout the study various alternative analyses and design changes were carried out to minimize such negative impacts, but a certain number is unavoidable. In fact, it is considered that the above numbers are relatively low for projects of this nature and scale.
- A Strategic Resettlement Action Plan was prepared according to World Bank OP 4.12 and JICA Guidelines. SMP will update the SRAP and prepare MINI RAP during the tender document preparation stage.
- All PAPs have been be well informed about the project and will be compensated adequately. Public support for the projects is overwhelmingly positive.
- The classification of most negative impacts during construction were moderate or low and these can be easily mitigated for via the Environmental Management Plan (EMP) using standard mitigation measures that form of part of construction best practice.
- The classification of most negative impacts during operation were “low”. Only four operational negative impacts were classified as “moderate”; noise, vibration, and effect on the local microclimate. It should be highlighted that these moderate impacts will only occur in very restricted localised areas, and will not be widely experienced.
- None of the potential impacts classified as “high” or “very high” were negative; all were positive.
- Reaction to the projects within the community and civil society was generally very positive.

These conclusions and results of studies are summarized in the JICA Environmental Checklist in **Appendix 11-12**.

The following recommendations to JICA and the project proponents are provided by the JICA Study Team:

1. Article 49 of Decree 123 states that EIA studies have a validity of two years from approval to the "initiation of project execution". The wording of this article is somewhat vague, and it is not stated what activities constitute "initiation". The study team has learned that a condition of EIA approval is likely to be an annual report to ANAM, and that, providing the 1st annual report to ANAM demonstrates some progression with the project (for example design activities or preparation of bidding documents) this is classified as "initiation of project execution". It is therefore recommended that SMP / JICA ensure that follow-on studies on the projects begin within one year of EIA approval, to avoid the need to repeat the EIA study in the future.
2. Although the projects are generally very well supported by the Panamanian public, it is nevertheless recommended that consultation with PAPs, the local population and civil society is maintained throughout planning, design and construction.
3. Likewise, it will be important to ensure that environmental and social specialists are included in the design and construction supervision teams.
4. To ensure that the eventual Contractor fulfils his contractual obligations with regards to mitigation of potential environmental and social impacts, it is strongly recommended that the mitigation measures be included in the Bill of Quantities where feasible, and should also be linked to payment items in the contract.
5. During this feasibility study, the JICA Study Team supported SMP in carrying out the EIA studies and preparing the draft EIA report, according to the Panamanian legal framework and JICA Guidelines. In the months ahead, ANAM will review the EIA report. It should be noted by all parties that if ANAM requires any additional work, report revisions, or other conditions for approval of the EIA report, the Panamanian Government will be responsible for complying with ANAM and carrying out any additional work.

Chapter 20 Introduction of Applicable Japanese Technology

20.1 General

In this Chapter, the JICA Study Team introduces the Japanese technologies that are applicable to the Project. The technology covers following two cases:

- Technology that is planned for in this study.
- Technology not planned for, but which needs to be studied or planned for in the detailed design stage.

The following Japanese technology is introduced for Metro Line-3 and the 4th Panama Canal Bridge Projects:

Metro Line-3 Project (See Chapter 20.2)

- Battery Power System (BPS)

4th Panama Canal Bridge Project (See Chapter 20.3)

- Steels for Bridge High Performance Structure (SBHS)
- Advanced Weathering Steel (Nickel Type)
- Steel Pipe Sheet Pile (SPSP)
- Low-position Lighting

20.2 Metro Line-3 Project

20.2.1 Battery Power System (BPS) for Railway

The monorail system proposed in this study is itself a technology developed in Japan. As a part of the power supply system, the Battery Power System (BPS) using high-capacity nickel hydrogen battery called the "GIGACELL™" is another applicable Japanese technology.

When trains stop for an extended period due to power failure of an outside source, the BPS is able to move all the trains on the main line to the nearest stations.

The BPS has the following functions, which are applicable not only for emergency situations;

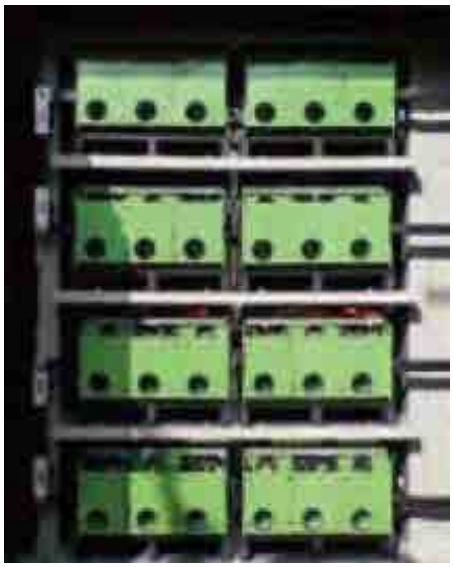
- BPS is able to store the excessive electricity generated by the operating trains by charging the GIGACELL. In this way, the regenerated electricity can be fully utilized.
- BPS is able to reduce power demand during the peak hour by discharging its electricity.
- BPS is able to assist optimum train operation by stabilizing line voltage, by feeding power to the accelerating trains and by preventing voltage drop.
- BPS is able to support substation functions by discharging power, which enables the downsizing of the substation facilities.

The application of BPS is also closely related to passenger evacuation methods. During discussions with SMP, the necessity of providing an evacuation walkway (catwalk) for emergency evacuation purposes was considered. However, in the case of monorails, many monorail lines have no evacuation walkway because of the difficulty of passengers transferring from a train to a walkway, and also because the walkway structure spoils the scenery. As a result of the discussions, it was concluded that no evacuation walkway would be required if the BPS is installed. (In case of an emergency, the train would not stop, but would be powered by the BPS to run to the nearest station.)

BPS has been successfully introduced in the Tokyo Monorail, Osaka Subway and Den-en-toshi Line in Japan. In addition, operation tests are currently underway on the Washington D.C. Metro operated by the Washington Metropolitan Area Transit Authority.

Source: Kawasaki Heavy Industries, Ltd.

Figure 20.1 BPS Cabinet



Source: Kawasaki Heavy Industries, Ltd.

Figure 20.2 Inside of a BPS Cabinet

Source: Kawasaki Heavy Industries, Ltd.

Figure 20.3 High-capacity nickel-metal hydride battery GIGACELL™, used for the BPS

20.3 4th Panama Canal Bridge Construction Project

20.3.1 Steels for Bridge High Performance Structure (SBHS)

(1) Objective

SBHS will be used in the main bridge of the 4th Panama Canal Bridge for the following reasons.

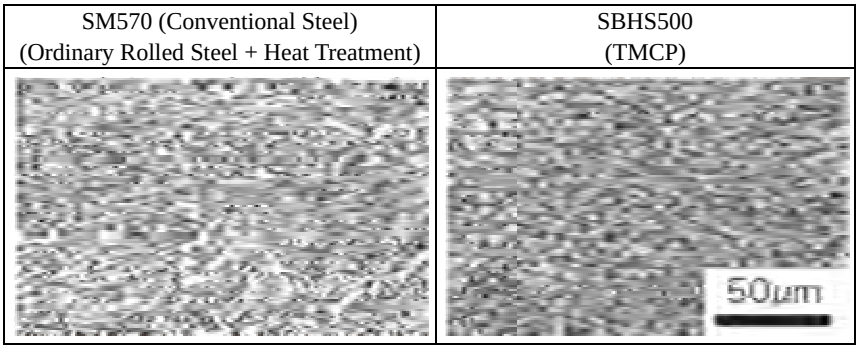
- The main bridge of the 4th Panama Canal Bridge was planned as a long-span bridge (center span: 540m) and its steel weight greatly affects the construction cost; therefore, SBHS was applied to reduce the thickness (weight).
- The joints of the external components will use site welding (boltless) to improve their maintainability; therefore, SBHS was applied to ensure weldability.

(2) Technical Features

1) Production

The Thermo-mechanical Control Process (TMCP) is applied to the production of SBHS to properly control the heating, rolling and cooling processes. The crystal grains are refined into fine grains to achieve superior strength, toughness and weldability.

The crystal composition of conventional steel and SBHS is shown in Figure 20.4.



Source: The Japan Iron and Steel Federation

Figure 20.4 Cristal Composition of Conventional Steel and SBHS

2) Yield Strength

SBHS has 3 classes of yield strength. The yield strength of SBHS is higher than that of equivalent conventional steel in each class and its thickness can therefore be reduced. However, the thickness of SBHS700 can be reduced by only 2-5% compared to conventional steel; thus, its effects are limited.

Yield strengths of conventional steel and SBHS are shown in Table 20.1.

Table 20.1 Yield Strengths of Conventional Steel and SBHS

Thickness: 50mm

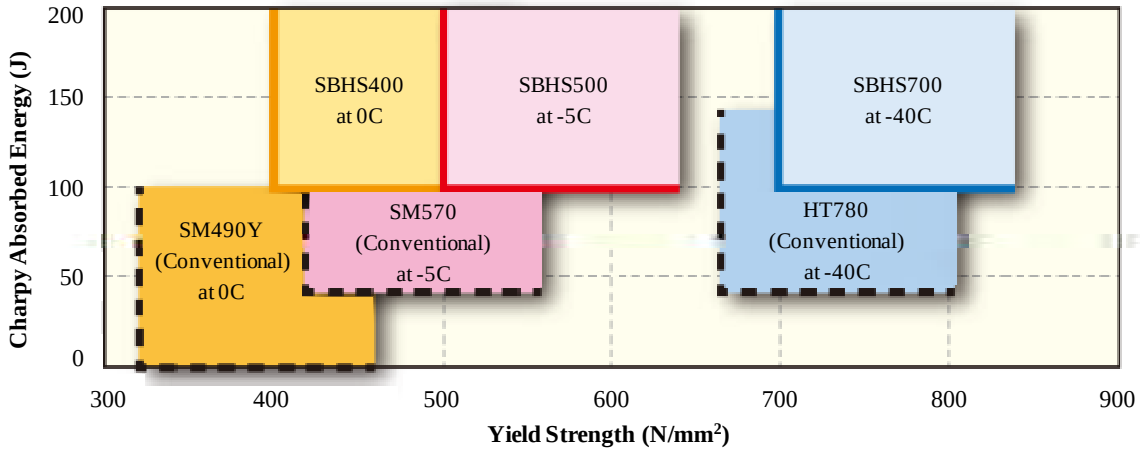
Property	490N/mm^2 Class		570N/mm^2 Class		780N/mm^2 Class	
	SBHS	Conventional	SBHS	Conventional	SBHS	Conventional
	SBHS400, SBHS400W	SM490Y, SMA490W	SBHS500, SBHS500W	SM570Y, SMA570W	SBHS700, SBHS700W	HT780
Yield Strength (N/mm^2)	≥400	≥335	≥500	≥430	≥700	≥685

Source: The Japan Iron and Steel Federation

3) Toughness

The toughness of SBHS is higher than that of conventional steel and its structural stability in plastic range is superior.

Charpy absorbed energy of conventional steel and SBHS is shown in Figure 20.5.



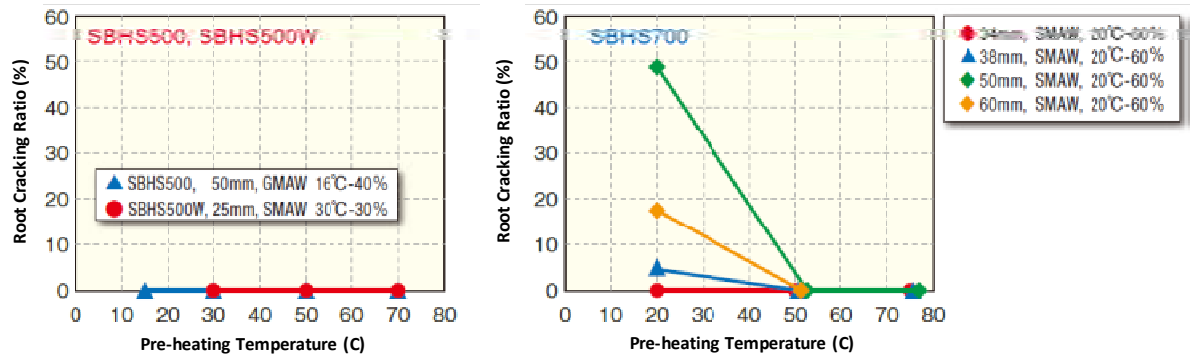
Source: The Japan Iron and Steel Federation

Figure 20.5 Charpy Absorbed Energy of Conventional Steel and SBHS

4) Weldability

The conventional steels need pre-heating control. On the other hand, SBHS can be welded at lower pre-heating temperature and its weldability is superior. Particularly, SBHS400 and 500 do not need pre-heating control resulting in greater workability and quality.

Root cracking ratio of SBHS500 and 700 is shown in Figure 20.6.



Source: The Japan Iron and Steel Federation

Figure 20.6 Root Cracking Ratio of SBHS500 and 700 (Y-groove Weld Cracking Test)

5) Experience

SBHS700 has still not been introduced in bridge construction works for the following reasons:

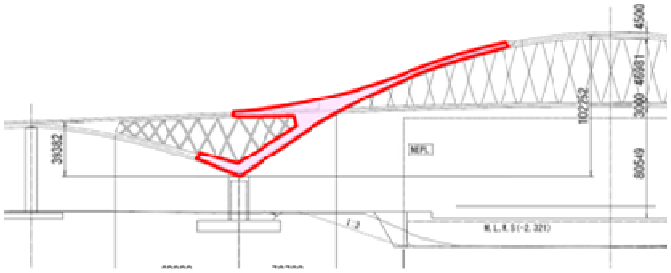
- Pre-heating temperature is lower than that of conventional steel; however, pre-heating control is still required.
- Fatigue strength is equivalent to that of conventional steel; thus there is no advantage in thickness reduction.

(3) Plan for the Project

Conventional steel (SM490Y class) was mainly applied to the main structural components of the main bridge of the 4th Panama Canal Bridge; however, where the thickness would exceed 40mm, SBHS500 was applied to reduce thickness and ensure weldability.

SBHS500 was applied at the conjunction and bottom of the arch rib, where there are large internal forces, in order to reduce the thickness and ensure weldability.

The planned SBHS components in the Project are shown in Figure 20.7.



Source: JICA Study Team

Figure 20.7 Components using SBHS in the Project (Main Bridge of the 4th Panama Canal Bridge)

20.3.2 Advanced Weathering Steel (Nickel Type)

(1) Objective

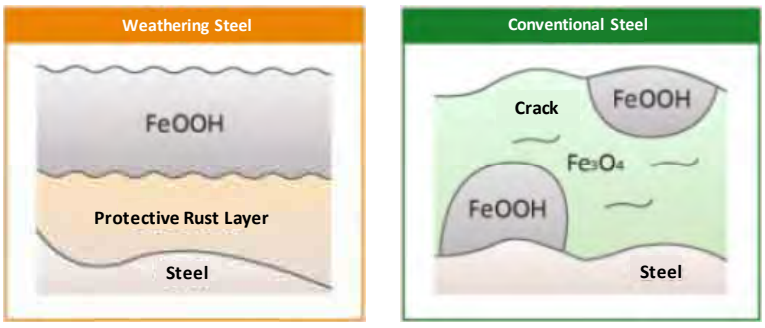
The main bridge of the 4th Panama Canal Bridge and part of the approach bridges are to be steel bridges. The box-shaped arch rib was employed to reduce the area that needs to be painted; however, the necessity of repainting work still remains. Therefore, the application of weathering steel was studied to reduce the repainting work.

(2) Technical Features

1) Mechanism of Weathering Steel

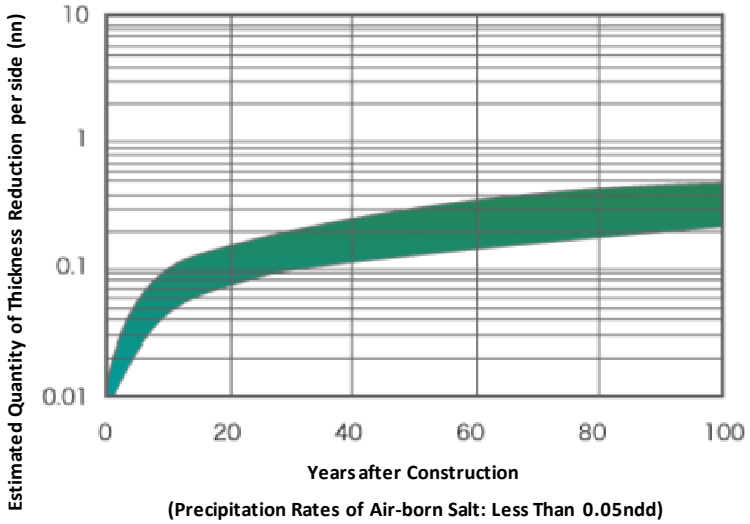
Weathering steel contains a suitable amount of alloying elements including Copper, Chromium and Nickel allowing it to form a dense protective layer of rust on the surface through repeated moderately dry and wet conditions in the atmosphere. The protective rust layer protects the steel surface from further corrosion by reducing the continuous formation of rust over time.

Illustrations of the rust layer of weathering steel and conventional steel, and an example of the estimated curve of thickness reduction (SBHS) are shown in Figures 20.8 and 20.9, respectively.



Source: The Japan Iron and Steel Federation

Figure 20.8 Illustrations of Rust Layer of Weathering Steel and Conventional Steel



Source: The Japan Iron and Steel Federation

Figure 20.9 Example of Estimated Curve of Thickness Reduction

2) Advanced Weathering Steel (Nickel Type)

Advanced weathering steel (Nickel type) has more Nickel (1-3%) added to it in comparison to the other weathering steels to improve its corrosion resistance in areas with a high precipitation rate of air-born salt. In actual use, its applicability needs to be confirmed by conducting an exposure test and measuring the precipitation rate of air-born salt at the planned site.

(3) Plan for the Project

The Project road was planned as part of an urban road; therefore, the steel bridges will be painted to ensure corrosion protection and improved bridge aesthetics. The type of paint to be applied is the Fluorine resin paint in consideration of its high durability near the Pacific Ocean and a repainting frequency that is expected to be 40 years.

On the other hand, the steel components will be made of weathering steel. In case there is partial peeling of the paint before the time for repainting, maintenance work can be reduced because the steel will be protected by the rust layer.

The weathering steel to be used is the Nickel type in the JICA Study and its exposure test and measurement of precipitation rate of air-born salt is being conducted on the Bridge of the Americas. The suitability of its use will be confirmed in the D/D stage in accordance with the analysis of the test results.

20.3.3 Steel Pipe Sheet Pile (SPSP)

(1) Objective

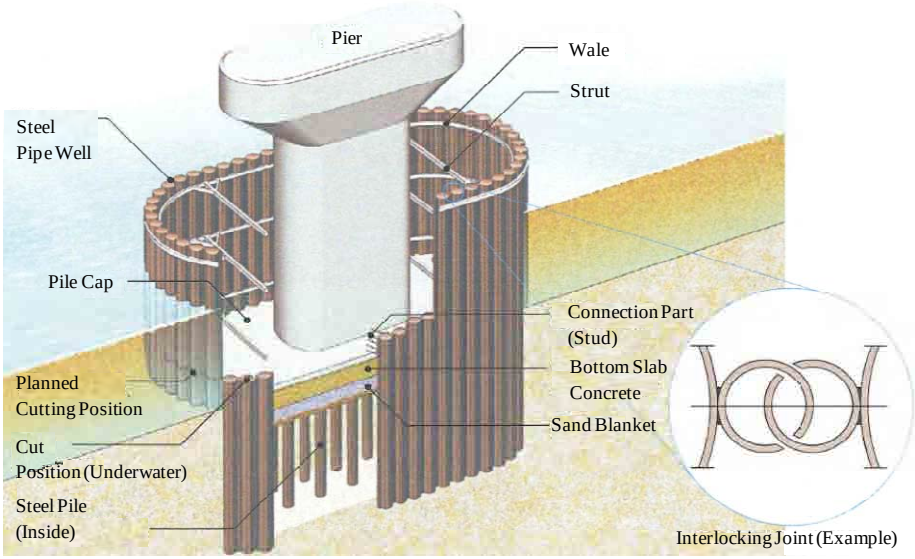
The main bridge of the 4th Panama Canal Bridge is a long-span bridge (center span: 540m) over the Panama Canal; therefore, a large-scale, temporary cofferdam and foundation are required.

SPSP can combine the foundation with the temporary cofferdam, furthermore its bending rigidity is high; therefore, SPSP was selected in the JICA Study.

(2) Technical Features

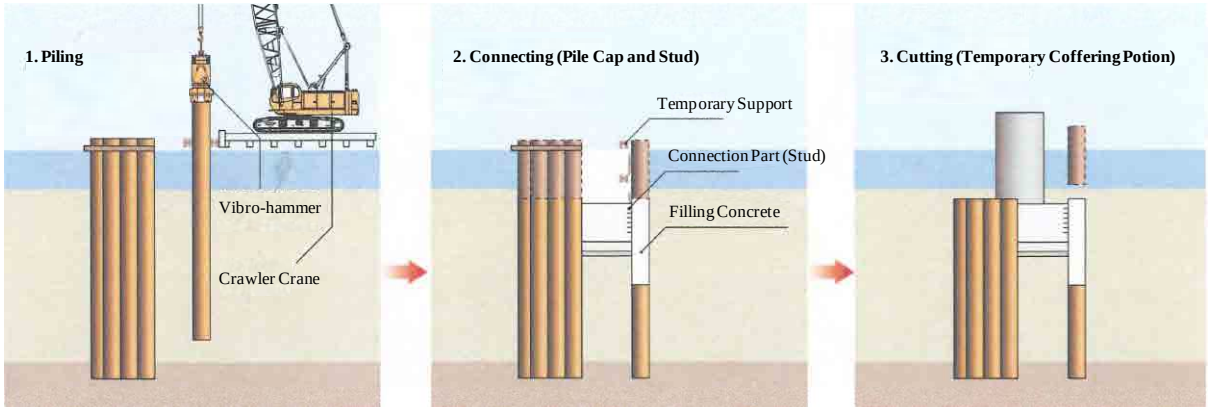
SPSP consists of steel sheet piles that are joined to each other by studs forming a closed shape. It behaves as a unitary structure and ensures a high resistance to horizontal and vertical forces. Furthermore, it is economical because it combines the foundation with the temporary cofferdam.

Images of SPSP, the main construction sequence of SPSP, and the field welding of studs at the connecting part (photo) are shown in Figures 20.10 to 20.12.



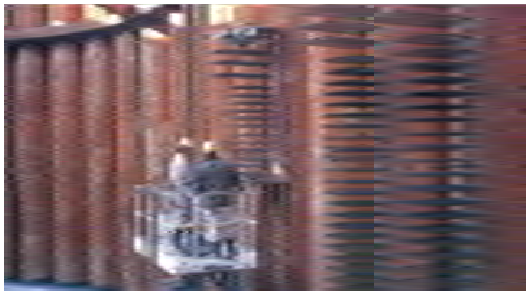
Source: Japanese Technical Association for Steel Pipe Piles and Sheet Piles

Figure 20.10 Image of SPSP



Source: Japanese Technical Association for Steel Pipe Piles and Sheet Piles

Figure 20.11 Main Construction Sequence of SPSP



Source: Japanese Technical Association for Steel Pipe Piles and Sheet Piles

Figure 20.12 Field Welding of Stud at Connecting Part (photo)

(3) Plan for the Project

SPSP will be employed for the west side pier of the main bridge of the 4th Panama Canal Bridge (P32 Pier) in consideration of the large horizontal force and its location in the Panama Canal. On the other hand, SPSP was not employed for the piers of the west approach bridge of the 4th Panama Canal Bridge by reason of the small horizontal force and the possibility of using embanked construction roads.

20.3.4 Low-position Lighting

(1) Objective

The application of low-position lighting on the 4th Panama Canal Bridge is considered for the following reasons:

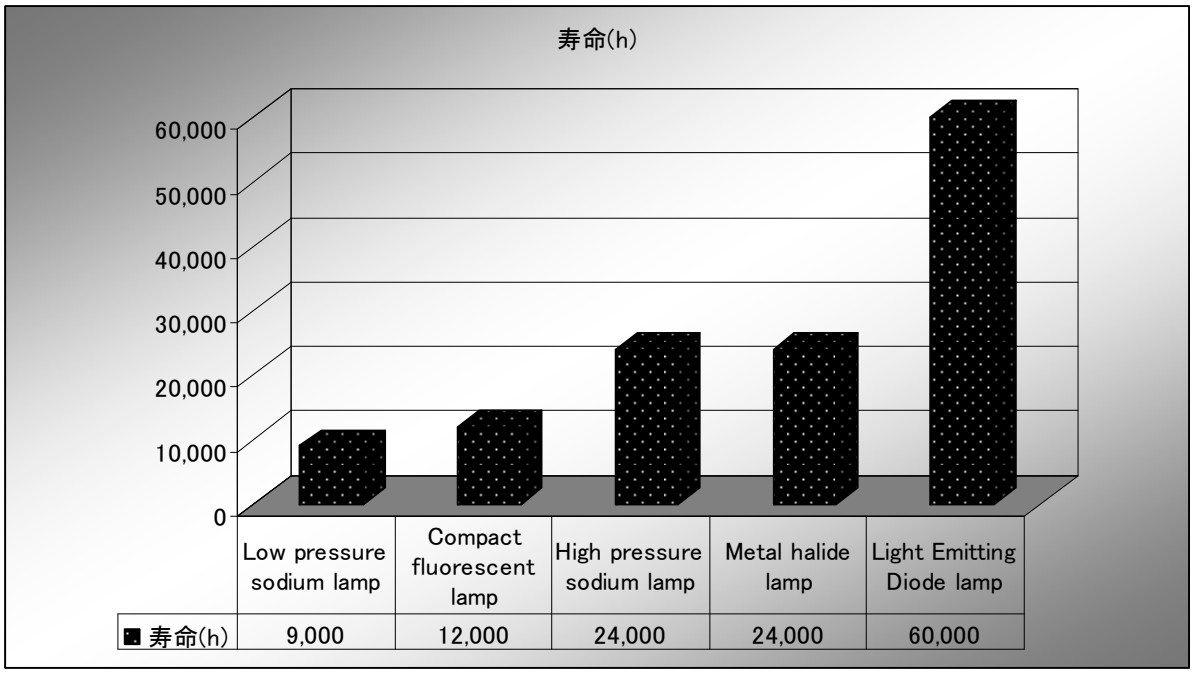
- The foundations of light poles are problematic on the arch rib.
- From the view of aesthetics, different lighting systems are used for the arch rib and for the other areas.
- Maintenance and inspection of low-position lighting can be performed without lane closure because there is no need to use vehicles for working at heights.

(2) Technical Features

1) Characteristics of the LED light source

For LED light source, the initial cost of construction is a little higher, but maintenance costs will be lower.

There are significant advantages over conventional lamps in terms of maintenance, power, and the environment.



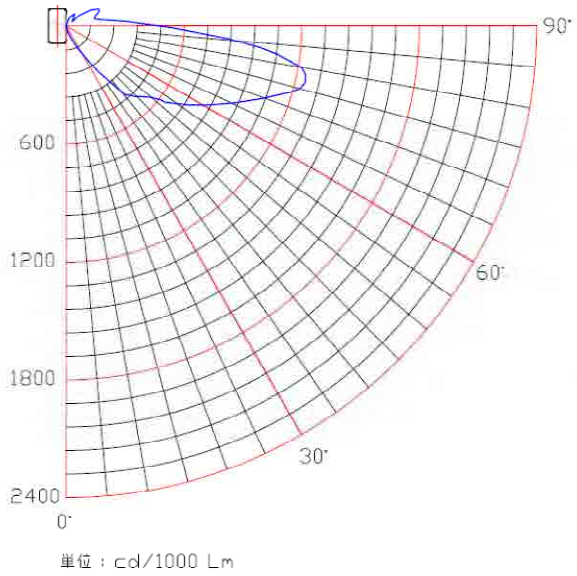
Source: JICA Study Team

Figure 20.13 Life of Various Light Sources

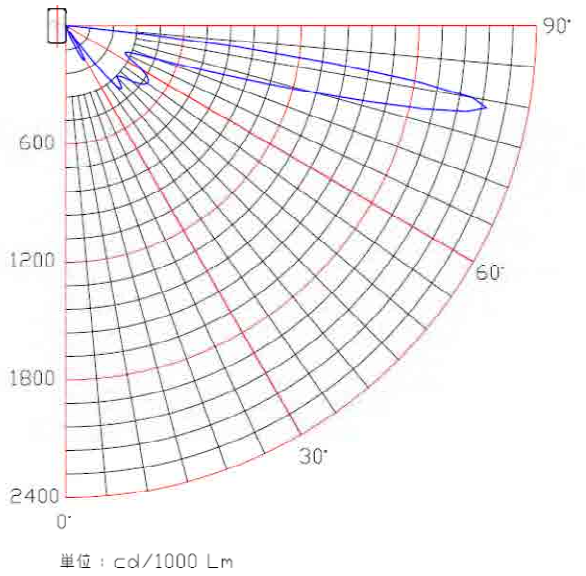
2) Light distribution of LED lighting

The LED light source makes the control of light distribution possible; it is possible to realize efficient illumination.

Light distribution curve

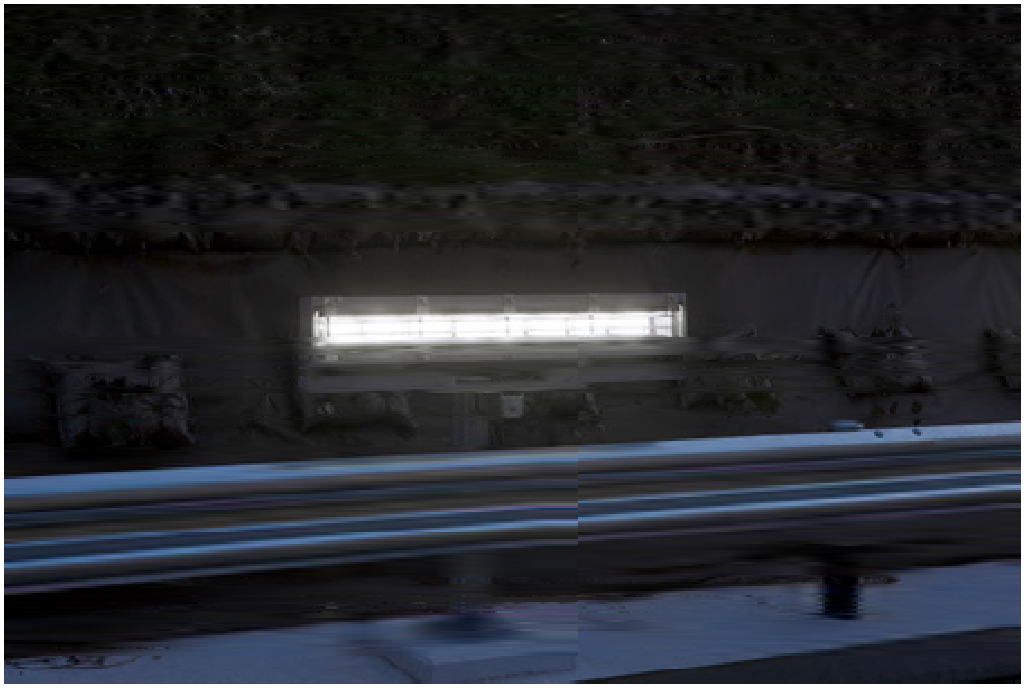


Light distribution curve (LED)



Source: JICA Study Team

Figure 20.14 Light Distribution Curve of LED Lamp

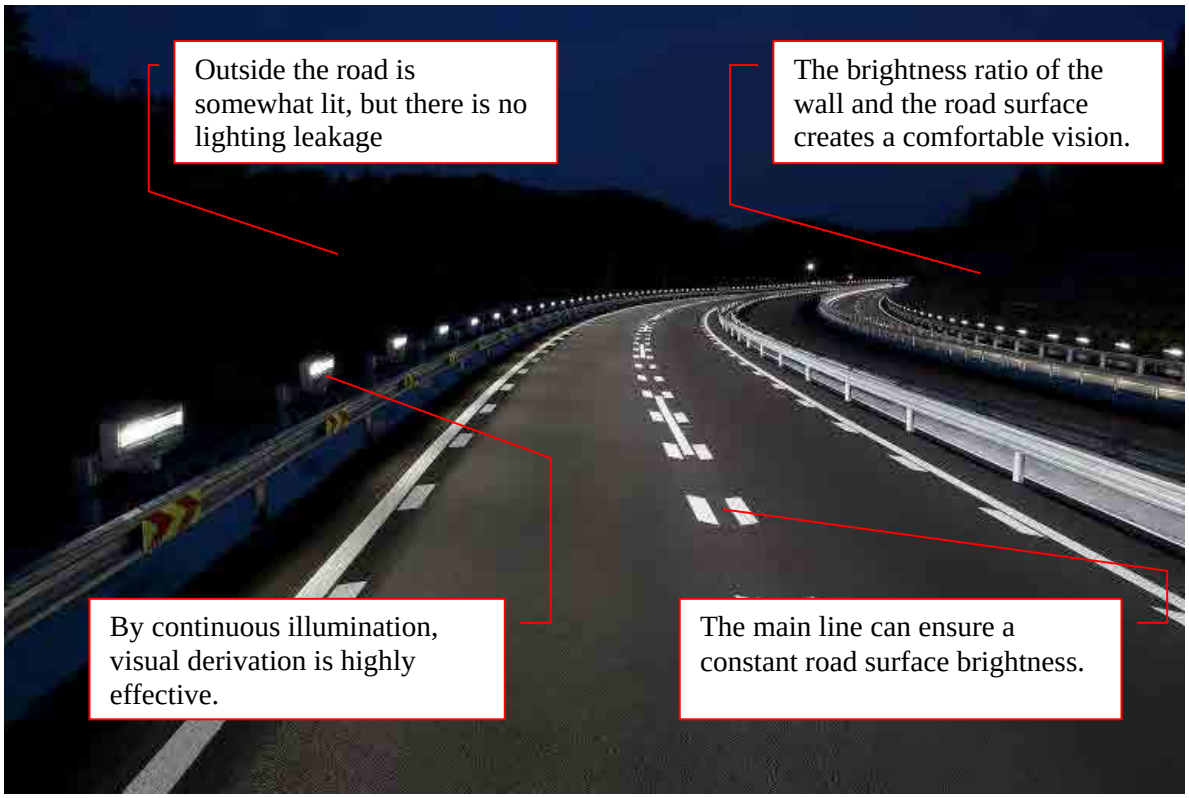


Source: East Nippon Expressway Company Limited

Figure 20.15 Light Distribution Photo of LED Lamp

3) Road surface uniformity of LED low-position lighting

The low-position LED lighting is able to control light distribution, the uniformity of the road surface illumination is excellent and the visibility of obstacles is also excellent.



Source: Central Nippon Expressway Company Limited

Figure 20.16 The Vision of LED Low-position Lighting of the Road Surface

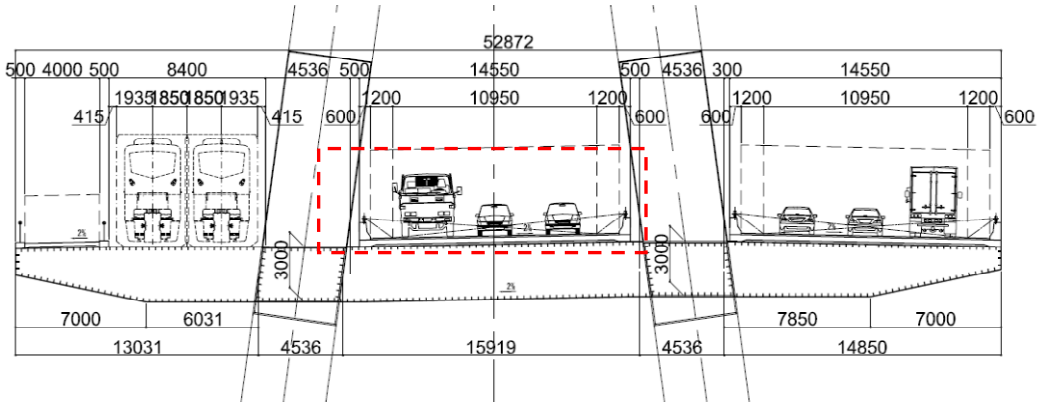
(3) Plan for the Project

Normally a light pole is 12m or 10m high. The mounting position of low-position lighting, at about 1m height, is excellent for construction and maintenance.

The uniformity of low-position lighting and visibility by continuous placement is also very excellent and is superior to induction lighting.

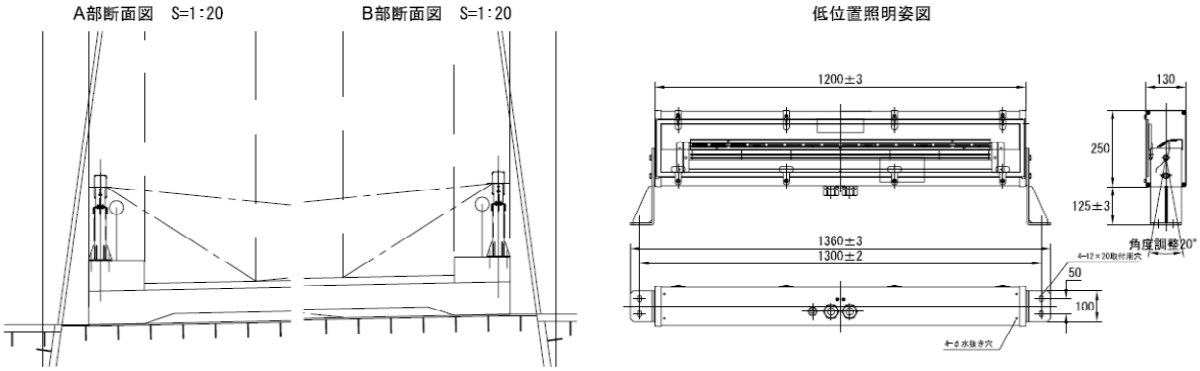
Figures 20.17 and 20.18 show the proposed application of the low-position lighting. However, there is no precedence for its use in Panama. Luminance of the road surface shall be confirmed by simulation at the detailed design stage to decide on whether to adopt it or not.

Therefore, in this study the pole-type lighting is tentatively planned for.



Source: JICA Study Team

Figure 20.17 Area for Low-position Lighting Installation (4th Panama Canal Bridge)



Source: JICA Study Team

Figure 20.18 Locations of Low-position Lighting Installation (4th Panama Canal Bridge)

Chapter 21 Conclusions and Recommendations

21.1 Conclusions

1) The Project (Urban Transportation Line-3 and the 4th Panama Canal Bridge) is to construct a new bridge over the Panama Canal and introduce an urban transport system, aiming at alleviating traffic congestion on the Bridge of Americas and contributing the development of the area to the west of the canal. From the analysis of the benefits and costs of the Project, it was concluded that the Project would be economically feasible. In addition, it was estimated that the Project would reduce 17,000 tons of CO_2 per year in 2035.
2) After the comparison analysis among railway, monorail, AGT, LRT, BRT and other urban transport systems for the urban transportation Line-3, the straddle type monorail, which can perform flexibility for steep slopes and curves, was selected as the best system.
3) In the beginning of the Study, the route was assumed to be along Autopista, although after the comparison analysis with along Pan-American Road, it was concluded that the route should go through Pan-American Road, where the adjoining area had been already urbanized.
4) A monorail train is composed of 6-cars, and the monorail system will carry 20,000 passengers per direction in peak hours in 2035. A total of 156 cars will be introduced at the beginning of the operation and added cars according to the demand increase. The traction power is direct current of 1500 volt, and 4 intermediate cars are motor cars in which induced motors are controlled by VVVF and equipped with electricity regeneration function.
5) The line is constructed as elevated structure except for the section on the 4th Panama Canal Bridge, and runs along the median of roads in principle.
6) The road link of the 4th Panama Canal Bridge along with Approaches is an inner city road of 3 lane dual carriageway (6 lanes) with median strip in Panama City starting at the conjunction with the Corridor Norte at Albrook, then crossing the Panama Canal from Balboa Port on the eastern bank side to Arraijan on the western bank side about 6.72 km in length. The road/monorail combined section of 2.183 km consisting of the 4th Panama Canal Bridge and adjacent viaducts is multi-purpose bridge structures to carry the 6 lane road and the double track Metro Line 3.
7) On the western bank side, there exist Gelabert International Airport which require civil aviation limits for road longitudinal alignment, Omar Torrijos Intersection which is large and complex roundabout, and important buildings and underground utilities along the Av. Roosevelt. The 4th Panama Canal Bridge crosses the Panama Canal in approximately 6.72 km between Balboa Port on the eastern bank side and Arraijan on the western bank side. At the Arraijan ending point, an access road to the First Bridge "Puente de las Américas" is scheduled.
8) As for the bridge type of the 4th Panama Canal Bridge, a preliminary design of the 840m long steel arch bridge was conducted by the Study Team as alternative bridge type of the 1,118m long cable stayed bridge which was examined in the Pre Feasibility Study by ACP. In case of the steel arch bridge, lift-up method of arch rib segment from the barges using the Panama Canal was examined by the Study Team and risk analysis on the lift-up method was conducted by ACP and SMP. The Study Team implicated the results of the risk analysis into the construction cost of the steel arch bridge.
9) Multi-criteria analysis was conducted by the Study Team to evaluate the 1,118m long cable stayed bridge and the 840m long steel arch bridge. As a result, the 840m long bridge was regarded as advantageous from the view points of high rigidity of arch structure, good landscaping of arch bridge with the existing First Bridge "Puente de las

Américas" and life cycle cost including initial investment and 100 year maintenance costs.

10) The Study Team has conducted a concept design on the Improvement of the Omar Torrijos Intersection including new construction of an underpass to augment the traffic capacity for the north-south traffic flows in Panama City. The concept design of the Omar Torrijos Intersection Improvement was followed by micro-simulation analysis to assess the traffic movements in the morning peak hours. The micro simulation revealed that traffics from the 4th Panama Canal Bridge mainly flow toward the Av. Omar Torrijos Herrera in the intersection but volume of traffics toward the Corridor Norte proposed by Pre Feasibility Study as the possible connectivity is extremely low. Accordingly, it is confirmed through the micro-simulation analysis that the Improvement of Omar Torrijos Intersection is very obvious to provide better connectivity of the 4th Panama Canal Bridge Project.
11) During this F/S, an EIA was carried out and Strategic RAP was prepared through various type of community participation activities. Any very significant negative impacts were not foreseen, and an Environmental Management Plan was prepared to manage adequately all negative impact. No resettlement will be required. The compensation will be implemented to the economic displacement and relocation of ACP buildings.
12) Before the construction of the Fourth Bridge Project, the Client, SMP, would have to conduct the detailed design on the Fourth Bridge and Approaches. The detailed design requires 18 months. The Study Team recommends that wind-tunnel test be conducted in order to examine the stability of the structure and optimize the shapes, lines and sizes of the stiffening girders of the arch bridge. Since the lift of the arch rib segment has no precedence, the Study Team recommends that a mathematical model test (3D image) be conducted during the detailed design in order to examine a safe construction plan.
13) Implementation of the project for the Omar Torrijos Intersection Improvement is essential in order to obtain better connectivity of the Fourth Bridge. It is desired that the completion of the Omar Torrijos Intersection Improvement should be in the same time as the Fourth Bridge.
14) The construction of the Fourth Bridge and Approaches requires 48 months, of which last 6 months are regarded as overlapped working period for the bridge finishing works and installation works of Metro Line 3 infrastructures such as rails, electrical and mechanical facilities.
15) The Project cost is as shown in Table 21.1.

Table 21.1 Project Cost

To ensure fairness of procurement process as well as project implementation, information should not be disclosed for a fixed period.

1 USD = 99.7 JPY
Source: JICA Study Team

21.2 Recommendations on Project Implementation Stage

21.2.1 Urban Transport Line-3

In the project implementation stage, it is necessary to consider the following issues.

- Coordination of design and construction between Line-3 and 4th Panama Canal Bridge
- Land acquisition for the depot area
- Selection of the contractor having technology and experiences
- Confirmation of the new organization of SMP

(1) Coordination of design and construction between Line-3 and 4th Panama Canal Bridge

Since the monorails run on the 4th Panama Canal Bridge, accurate adjustments will be required for the design and construction for sections around the merging points of Line-3 and the approach roads of the 4th Panama Canal Bridge. In addition, it is necessary to match deflections and displacements between Line-3 and the 4th Panama Canal Bridge, and the displacements of monorail's girder in case of earthquakes needs to conform to that of the 4th Panama Canal Bridge. Furthermore, since Line-3 cannot start its operation before the completion of the 4th Panama Canal Bridge construction, a close coordination of the construction schedule is required.

Therefore, the coordination of design and construction between Line-3 and the 4th Panama Canal Bridge is an important issue, and it is recommended that utilizing a project management consultant that coordinates the engineering services of Line-3 and the 4th Panama Canal Bridge, or integration of the engineering services.

(2) Land acquisition for the depot area

Since urban development by private sector is taking place actively around the depot area, the possibility of urban development at the depot area cannot be denied in case that the project delays.

Therefore, SMP should start the process of land acquisition for the depot area before undertaking the project.

(3) Selecting contractor having technology and experiences

As described in the section 8.5, it is recommended that Line-3 will be implemented by applying a Design-Build contract in FIDIC Yellow Book. In this case, proper technology and rich experiences for monorail system should be required for the international competitive bidding because the contractor will be responsible for the detailed design. The following points shall be confirmed through pre-qualification process;

- Experiences of monorail system construction in his home country and overseas, at least 3 lines in total. The system quoted shall be under operation having operating length of 10km or more. Considering the basic requirements of public transportation system, the system shall have at least 20 years operation experience.
- The system quoted, at least one line, shall have a hilly terrain section similar to Panama Metro Line 3.
- Considering future renewal of rolling stock and turnouts, the Contractor/manufacturer shall have, at least, 30 years experience on the similar products.
- A proof or evidence of transportation capacity required in the performance specification.

- Technical standards applied in his home and overseas countries.
- Experiences and periods involved, directly or indirectly, in the monorail operation and maintenance services.
- Experiences of accidents and mechanical failures in the system quoted.
- Construction period of the quoted lines.

It is recommended to include the abovementioned items in the pre-qualification questionnaire.

(4) Confirmation of the new organization of SMP

It is necessary to coordinate with ACP for the implementation of the Project, and SMP has the capacity to play the role. On the other hand, as described in 8.6.2, SMP will be reorganized to Metro de Panamá, S.A., a 100% state- owned company. It is desirable that Metro de Panamá, S.A. will have established before the start of the Project, although there has been no particular activity as of July 2014. Since SMP or its successor will be the implementation body of the Project, its transformation should be monitored.

To start the Project in the early stage, the structure of the new organization should be confirmed and the new organization should be established as soon as possible.

21.2.2 4th Panama Canal Bridge

The Study Team recommends the following points to consider for the execution of the Project by SMP and for the operation and maintenance of facilities after completion of the Project.

- Approval of using navigation channel in erection works
- Detailed design on the 4th Panama Canal Bridge and Approaches by SMP as Owner's Design Contract
- Detailed Study on Arch Bridge Erection Method
- Coordination with Metro Line 3 during detailed design and construction
- Improvement of Omar Torrijos Intersection for better connectivity of the 4th Panama Canal Bridge
- Approval of EIA Report
- Consideration of contract packaging
- Qualified firms through Pre-qualification process taking into consideration the high technologies and sufficient experiences

(1) Approval of Using Navigation Channel in Erection Works

The using of navigation channel in erection works is not approved yet by ACP at the time and it is necessary to obtain the approval based on this Draft Final Report.

(2) Detailed Design on the 4th Panama Canal Bridge and Approaches by SMP as a Design-Bid-Build Contract

The Client, SMP, would have to conduct the detailed design on the 4th Panama Canal Bridge and Approaches prior to the construction of the Project. The detailed design requires 18 months. The Study Team recommends that a wind-tunnel test be conducted in order to examine the stability of the structure and optimize the shapes, lines and sizes of the stiffening girders of the arch bridge. Since the lifting of the arch rib segment has no structures.

(3) Detailed Study on Arch Bridge Erection

Without precedence, the Study Team recommends that a mathematical model test (3D image) be conducted during the detailed design and if any weakness be found to strengthen the process to ensure stability in lifting and fixing the arch. Prior to the actual erection of the arch rib rifting works, a Full Size Test should be carried out in the vicinity of the erection site to confirm the function and capacity of the equipment to be used for the arch rib rifting method. Furthermore, the Study Team recommends that an alternative, simpler method be studied for the floating and swinging out of the fallen arch in the approach channel of the Panama Canal.

(4) Coordination with Metro Line 3 during Detailed Design and Construction

The road link of the 4th Panama Canal Bridge along with Approaches is an inner city road of 3 lane dual carriageway (6 lanes) with median strip in Panama City starting at the conjunction with the Corridor Norte at Albrook, then crossing the Panama Canal from Balboa Port on the eastern bank side to Arraijan on the western bank side about 6.72 km in length. The road/monorail combined section of 2.183 km consisting of the 4th Panama Canal Bridge and adjacent viaducts is multi-purpose bridge structures to carry the 6 lane road and the double track Metro Line 3.

The construction of the 4th Panama Canal Bridge and Approaches requires 48 months, of which last 6 months are regarded as overlapped working period for the bridge finishing works and installation works of Metro Line 3 infrastructures such as rails, electrical and mechanical facilities. Accordingly, well coordination between the 4th Panama Canal Bridge and Metro Line 3 Project is very essential.

(5) Improvement of Omar Torrijos Intersection for Better Connectivity of the 4th Panama Canal Bridge

The Study Team has conducted a concept design on the Improvement of the Omar Torrijos Intersection including new construction of an underpass to augment the traffic capacity for the north-south traffic flows in Panama City. The concept design of the Omar Torrijos Intersection Improvement was followed by micro-simulation analysis to assess the traffic movements in the morning peak hours. The micro simulation revealed that traffics from the 4th Panama Canal Bridge mainly flow toward the Av. Omar Torrijos Herrera in the intersection but volume of traffics toward the Corridor Norte is extremely low. Accordingly, it is confirmed through the micro-simulation analysis that the Improvement of Omar Torrijos Intersection is very obvious to provide better connectivity of the 4th Panama Canal Bridge Project. Implementation of the project for the Omar Torrijos Intersection Improvement is essential in order to obtain better connectivity of the 4th Panama Canal Bridge. It is desired that the completion of the Omar Torrijos Intersection Improvement should be in the same time as the 4th Panama Canal Bridge.

(6) Approval of EIA Report

During this feasibility study, the JICA Study Team supported SMP in carrying out the EIA studies and preparing the draft EIA report, according to the Panamanian legal framework and JICA's Guidelines for Environmental and Social Considerations (2010).

In the months ahead, ANAM will review the EIA report. It should be noted by all parties that if ANAM requires any additional work, report revisions, or other conditions for approval of the EIA report, the Panamanian Government will be responsible for complying with ANAM and carrying out any additional work.

(7) Consideration of Contract Packaging

The geographical conditions are divided into east and west sides of the Panama Canal, and the eastern side is located in an urban area including intersections and existing roads. Since the only existing transportation network that connects the eastern and western sides in the vicinity of the Project is the Bridge of the Americas, a separate transportation route is needed for construction on the eastern and western sides.

Furthermore, the main construction works are road and bridge works, and various types of structures are included in the construction items and the construction of these structures needs to be implemented in parallel in a limited work space. Therefore, the construction yards and work schedule shall be adjusted each other to avoid the interference. By these reasons, one construction contract package was assumed for this Study, since this would allow a joint schedule management for the control and implementation of a unified project.

However, it is necessary to decide it by further hearing from construction companies in consideration of construction volume to ensure enough nos. of applicable bidders.

(8) Qualified firms through Pre-qualification Process taking into consideration the high technologies and sufficient experiences

International Competitive Bidding (ICB) will be adopted for the 4th Panama Canal Bridge and Approaches on the basis of the detailed design under the Owner's Design Contract (Conventional Contract). Qualified firms through Pre-qualification Process, which have passed the evaluation criteria including the sufficient technologies and experiences, can participate in the ICB process. The following items might be considered in the evaluation criteria:

- Sufficient experience either in domestic or international projects in the similar bridge building projects
- Sufficient experiences to fabricate and construct solid-rib arch bridges
- Sufficient experiences in off-shore construction of bridges by using barge, including at least 3 projects experienced in the arch rib lift method
- Sufficient size and capacity of factories to fabricate the arch bridge elements within the designated time schedule by the Owner SMP, and sufficient staffing and equipment to be mobilized to the site

21.3 Recommendations on Project Operation Stage

21.3.1 Urban Transportation Line-3

The operating body of Line3 will be SMP (or its successor), which is currently operating Line-1. Maintenance work of rolling stock of Line 1 is outsourced to the manufacturer of the rolling stock of Line 1. Since the system of Metro Line 3 is different from Line 1, another maintenance system shall be formed. Considering the availability of the monorail technology, it is recommended to include the maintenance work and technology transfer for a certain period in the construction contract.

If it is difficult to include the maintenance work in the Contract, the maintenance work shall be outsourced in a similar way to Line 1. However, monorail operators in Japan are reluctant to participate in the overseas projects considering various risks. In order to encourage those experienced monorail operators, it will be effective to apply support from "Agency for Business Support for Overseas Transportation and Urban Development" which

will be formed in near future. Anticipated risks can be decreased by the involvement of the agency.

There are very limited spaces available for railway related business in Line 1 premises because route length is relatively short (13.7km) and the route runs at busy urban area. On the contrary, route length of Line 3 is 25.8km at the beginning and exceeds 30km in the future. Since Line 3 runs mainly suburban and undeveloped areas, the potential for railway related business is very high. Therefore, it is recommended to have a division for property development in the new company for Metro operation. The followings are the example of railway related business;

- Advertisement within railway station and inside of cars
- Kiosks within stations
- Park & Ride facilities
- Station building development

In Japan, the average income from non-railway business is 10.5% of the total income of major 16 private railway companies.

21.3.2 4th Panama Canal Bridge

As with the First Bridge “Puente de las Américas” and the Second Bridge “El Puente Centenario”, the maintenance and management entity for the civil engineering facilities in the Project is the MOP (Ministry of Public Works of Panama) while Land Transit and Transportation Authority (Autoridad del Tránsito y Transporte Terrestre, ATTT) is responsibility for traffic management and equipment maintenance.

Appendices

Appendix 1 : Traffic Survey Forms

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#1

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus 	Metro 
Tiempo total de viaje	15 min	15 min
Tiempo en el vehículo	15 min	15 min
Tiempo en el alimentador (bus)	-	-
Tarifa (B./)	1.0	1.5
Asientos	Sentado	De pie

Caso-2:

Modo	Bus 	Metro 
Tiempo total de viaje	30 min	25 min
Tiempo en el vehículo	30 min	15 min
Tiempo en el alimentador bus)	-	10 min
Tarifa (B./)	1.5	2.0
Asientos	De pie	Sentado

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#2

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus 	Metro 
Tiempo total de viaje	55 min	25 min
Tiempo en el vehículo	45 min	15 min
Tiempo en el alimentador (bus)	10 min	10 min
Tarifa (B./)	1.5	2.0
Asientos	De pie	De pie

Caso-2:

Modo	Bus 	Metro 
Tiempo total de viaje	60 min	25 min
Tiempo en el vehículo	60 min	15 min
Tiempo en el alimentador bus)	-	10 min
Tarifa (B./)	1.0	1.5
Asientos	Sentado	Sentado

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#3

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus 	Metro 
Tiempo total de viaje	15 min	25 min
Tiempo en el vehículo	15 min	15 min
Tiempo en el alimentador (bus)	-	10 min
Tarifa (B./)	1.0	2.0
Asientos	De pie	De pie

Caso-2:

Modo	Bus 	Metro 
Tiempo total de viaje	30 min	15 min
Tiempo en el vehículo	30 min	15 min
Tiempo en el alimentador bus)	-	-
Tarifa (B./)	1.5	2.5
Asientos	Sentado	Sentado

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#4

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus 	Metro 
Tiempo total de viaje	45 min	25 min
Tiempo en el vehículo	45 min	15 min
Tiempo en el alimentador (bus)	-	10 min
Tarifa (B./)	1.5	2.5
Asientos	Sentado	De pie

Caso-2:

Modo	Bus 	Metro 
Tiempo total de viaje	70 min	25 min
Tiempo en el vehículo	60 min	15 min
Tiempo en el alimentador bus)	10 min	10 min
Tarifa (B./)	1.0	2.0
Asientos	De pie	Sentado

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#5

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus	Metro
		
Tiempo total de viaje	25 min	25 min
Tiempo en el vehículo	15 min	15 min
Tiempo en el alimentador (bus)	10 min	10 min
Tarifa (B./)	1.5	3.0
Asientos	Sentado	Sentado

Caso-2:

Modo	Bus	Metro
		
Tiempo total de viaje	30 min	25 min
Tiempo en el vehículo	30 min	15 min
Tiempo en el alimentador bus)	-	10 min
Tarifa (B./)	1.0	2.5
Asientos	De pie	De pie

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#6

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus 	Metro 
Tiempo total de viaje	45 min	15 min
Tiempo en el vehículo	45 min	15 min
Tiempo en el alimentador (bus)	-	-
Tarifa (B./)	1.0	2.5
Asientos	De pie	Sentado

Caso-2:

Modo	Bus 	Metro 
Tiempo total de viaje	60 min	25 min
Tiempo en el vehículo	60 min	15 min
Tiempo en el alimentador bus)	-	10 min
Tarifa (B./)	1.5	3.0
Asientos	Sentado	De pie

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#7

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus 	Metro 
Tiempo total de viaje	15 min	25 min
Tiempo en el vehículo	15 min	15 min
Tiempo en el alimentador (bus)	-	10 min
Tarifa (B./)	1.5	3.5
Asientos	De pie	Sentado

Caso-2:

Modo	Bus 	Metro 
Tiempo total de viaje	40 min	25 min
Tiempo en el vehículo	30 min	15 min
Tiempo en el alimentador bus)	10 min	10 min
Tarifa (B./)	1.0	3.0
Asientos	Sentado	De pie

FORMULARIO DE PREFERENCIA DECLARADA (BUS)……FORM#8

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Parte 2: Elección de modo de viaje

8: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Bus 	Metro 
Tiempo total de viaje	45 min	25 min
Tiempo en el vehículo	45 min	15 min
Tiempo en el alimentador (bus)	-	10 min
Tarifa (B./)	1.0	3.0
Asientos	Sentado	Sentado

Caso-2:

Modo	Bus 	Metro 
Tiempo total de viaje	60 min	15 min
Tiempo en el vehículo	60 min	15 min
Tiempo en el alimentador bus)	-	-
Tarifa (B./)	1.5	3.5
Asientos	De pie	De pie

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#1

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	40	20
En caso de tiempo caminando (min)	-	-
Tarifa (B./)	-	1.00
Asientos	-	Bus: Sentado / Metro: Sentado

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	40	10 + 10
Tarifa (B./)	-	1.00
No. de trasbordos	-	-

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#2

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	40	20
En caso de tiempo caminando (min)	-	5
Tarifa (B./)	-	2.00
Asientos	-	Bus: Pie / Metro: Pie

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	40	10 + 10
Tarifa (B./)	-	2.00
No. de trasbordos	-	1

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#3

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	40	20
En caso de tiempo caminando (min)	-	10
Tarifa (B./)	-	3.00
Asientos	-	Bus: Pie / Metro: Sentado

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	40	10 + 10
Tarifa (B./)	-	3.00
No. de trasbordos	-	2

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#4

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	50	20
En caso de tiempo caminando (min)	-	5
Tarifa (B./)	-	1.00
Asientos	-	Bus: Pie / Metro: Sentado

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	50	10 + 10
Tarifa (B./)		1.00
No. de trasbordos		1

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#5

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	50	20
En caso de tiempo caminando (min)	-	10
Tarifa (B./)	-	2.00
Asientos	-	Bus: Sentado / Metro: Sentado

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	50	10 + 10
Tarifa (B./)		2.00
No. de trasbordos		2

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#6

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	50	20
En caso de tiempo caminando (min)	-	-
Tarifa (B./)	-	3.00
Asientos	-	Bus: Pie / Metro: Pie

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	50	10 + 10
Tarifa (B./)	-	3.00
No. de trasbordos	-	-

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#7

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	70	30
En caso de tiempo caminando (min)	-	10
Tarifa (B./)	-	1.00
Asientos	-	Bus: Pie / Metro: Pie

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	60	10 + 10
Tarifa (B./)	-	1.00
No. de trasbordos	-	2

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#8

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	70	30
En caso de tiempo caminando (min)	-	-
Tarifa (B./)	-	2.00
Asientos	-	Bus: Pie / Metro: Sentado

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	60	10 + 10
Tarifa (B./)	-	2.00
No. de trasbordos	-	-

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM. DE PREFERENCIA DECLARADA DE VIAJE (CARRO)……FORM#9

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: (Carro)

Parte 1: Elección de modo de viaje

1: Cual modo de transporte le gustaría utilizar bajo varias condiciones

Caso-1:

Modo	Carro	Bus + Metro
Tiempo de viaje (min)	70	30
En caso de tiempo caminando (min)		5
Tarifa (B./)		3.00
Asientos		Bus: Sentado / Metro: Sentado

Caso-2:

Modo	Carro	Carro + Metro
Tiempo de viaje (min)	60	10 + 10
Tarifa (B./)		3.00
No. de trasbordos		1

Parte 2: Sobre usted

2: Donde vive?

_____

_____

3: Género……. Hombre 1 Mujer 2

4: Edad _____

5: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#1

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	45
Tiempo en el alimentador (min)	-	-
Tarifa (B./)	3.00	2.00
Asientos	-	Bus: sentado / Metro: de pie

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	3.00	2.00
Asientos	-	Bus: de pie / Metro: sentado

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#2

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	45	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	3.00	2.00
Asientos	-	Bus y Metro: de pie

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	60	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	3.00	2.00
Asientos	-	Bus y Metro: sentado

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#3

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	45
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	3.00	3.00
Asientos	-	Bus y Metro: de pie

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	30
Tiempo en el alimentador (min)	-	-
Tarifa (B./)	3.00	3.00
Asientos	-	Bus y Metro: sentado

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#4

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	45	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	3.00	3.00
Asientos	-	Bus: sentado / Metro: de pie

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	60	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	3.0	3.00
Asientos	-	Bus: de pie / Metro: sentado

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#5

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	45
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	2.00	3.00
Asientos	-	Bus y Metro: sentado

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	2.00	3.00
Asientos	-	Bus y Metro: de pie

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#6

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	45	30
Tiempo en el alimentador (min)	-	-
Tarifa (B./)	2.00	3.00
Asientos	-	Bus: de pie / Metro: sentado

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	60	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	2.00	3.00
Asientos	-	Bus: sentado / Metro: de pie

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#7

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	45
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	1.50	3.50
Asientos	-	Bus: de pie / Metro: sentado

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	30	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	1.50	3.50
Asientos	-	Bus: sentado / Metro: de pie

FORM DE ENCUESTA DE PREFERENCIA DECLARADA (TAXI) ……FORM#8

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Taxi / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar
Desde		
Hacia		

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3. Cuánto paga en total por el viaje? _____

Parte 3: Sobre usted

4: Género…….. Hombre 1 Mujer 2

5: Edad _____

6: En su casa tienen auto particular?..... Si 1 No 2

7: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

8: Cual modo de transporte preferiría utilizar bajo diferentes condiciones.

Caso-1:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	45	30
Tiempo en el alimentador (min)	-	20
Tarifa (B./)	1.50	3.50
Asientos	-	Bus y Metro: sentado

Caso-2:

Modo	Taxi	Bus + Metro
Tiempo de viaje (min)	60	30
Tiempo en el alimentador (min)	-	-
Tarifa (B./)	1.50	3.50
Asientos	-	Bus y Metro: de pie

FORMULARIO DE ENCUESTA DE ORIGEN DESTINO

Nombre del encuestador:		Fecha:
Ubicación:	Hora:	Modo: Piratas / Bus

Parte 1: Información de Viaje

1: Desde donde viene y hacia dónde se dirige?

	Corregimiento	Nombre del Lugar	Casa Sí No
Desde			
Hacia			

2: Cual es el propósito de su viaje?

1. Voy al Trabajo	2. Voy a la universidad	3. De negocios
4. Privado	5. A casa desde: 51. Lugar de trabajo (viaje de regreso) 52. Universidad (Viaje de regreso) 53. Otros lugares	

3: Como se traslada en este viaje? Si utiliza varias formas de traslado por favor menciónelas e indique los puntos de trasbordo

No.		Punto de Trasbordo
1	1. Caminado 2. Bicicleta 3. Carro 4. Taxi 5. Pirata 6. Bus 7. Otros	
2	1. Caminado 2. Bicicleta 3. Carro 4. Taxi 5. Pirata 6. Bus 7. Otros	
3	1. Caminado 2. Bicicleta 3. Carro 4. Taxi 5. Pirata 6. Bus 7. Otros	
4	1. Caminado 2. Bicicleta 3. Carro 4. Taxi 5. Pirata 6. Bus 7. Otros	
5	1. Caminado 2. Bicicleta 3. Carro 4. Taxi 5. Pirata 6. Bus 7. Otros	
6	1. Caminado 2. Bicicleta 3. Carro 4. Taxi 5. Pirata 6. Bus 7. Otros	
7	1. Caminado 2. Bicicleta 3. Carro 4. Taxi 5. Pirata 6. Bus 7. Otros	

4: Cuanto tiempo demora en el viaje ?

Salida: ____:____ Llegada: ____:____

5: Cuanto paga por su viaje completo? B./ _____

Parte 2: Sobre usted

6: Género……. Hombre 1 Mujer 2

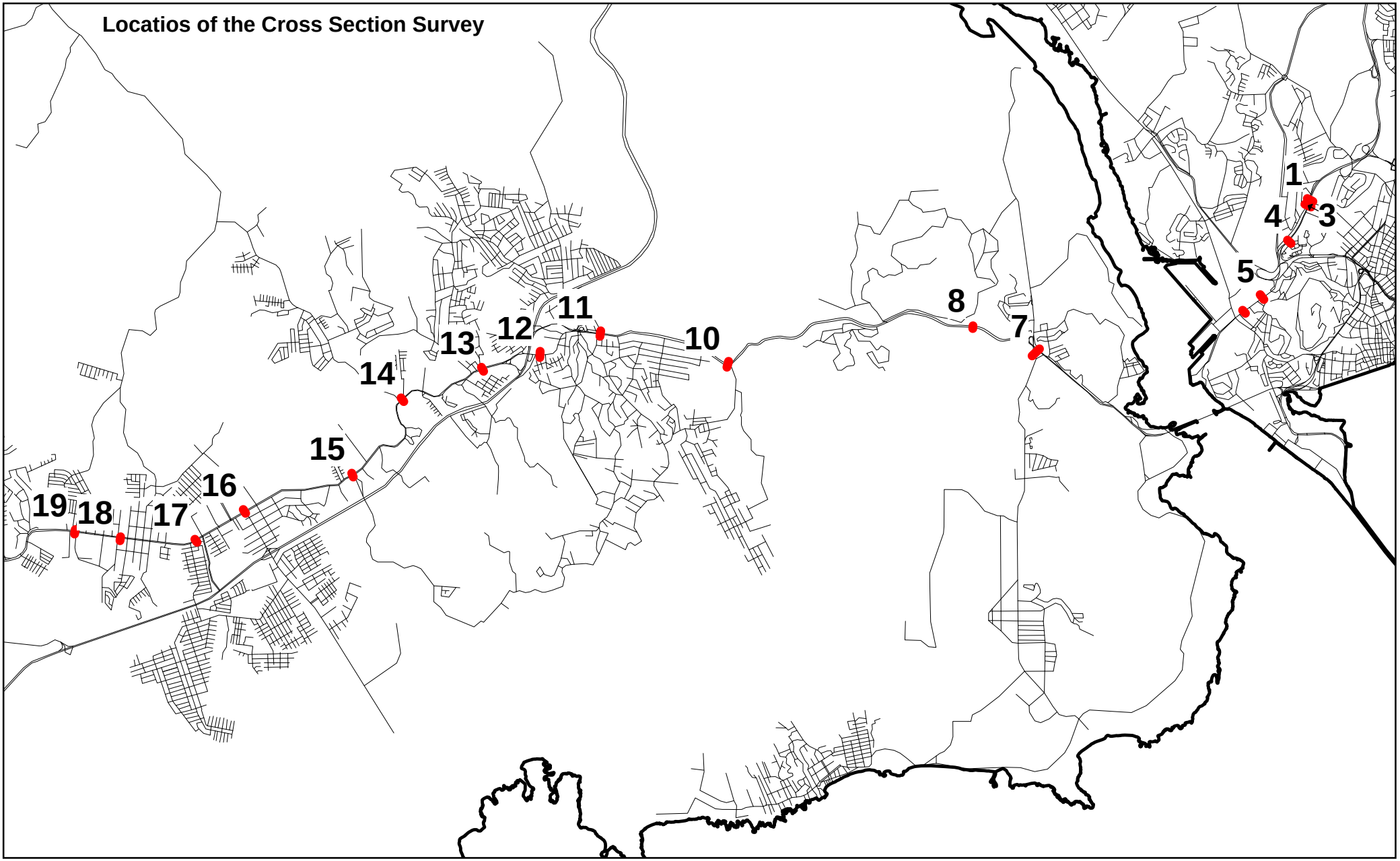
7: Edad _____

8: En su casa tienen auto particular?..... Si 1 No 2

9: Cuál es su status laboral?

Empleado tiempo completo 1	Empleado tiempo parcial 2	Independiente 3
Desempleado 4	Estudiante universitario 5	Ama de Casa 6
Retirado 7		

Appendix 2：Topographic Survey (Cross Section)


Locatios of the Cross Section Survey
1
2
3
4
5
7
8
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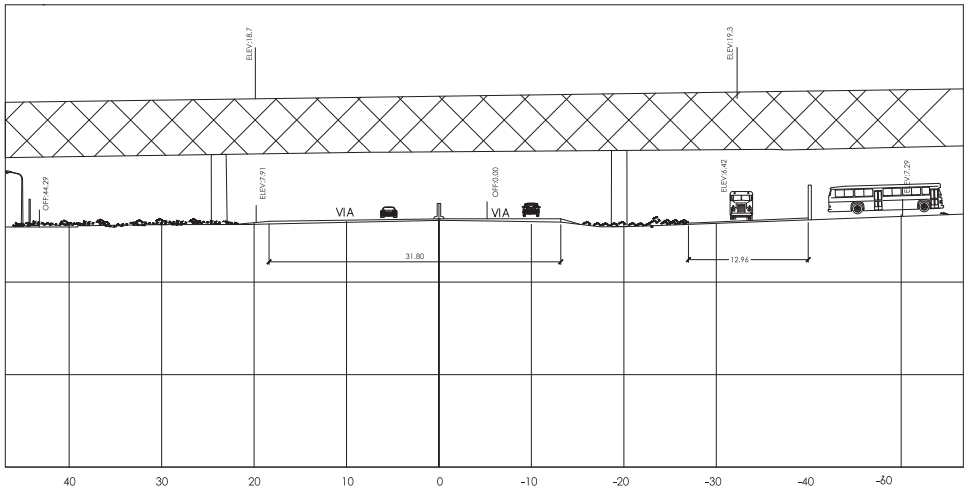
18
19



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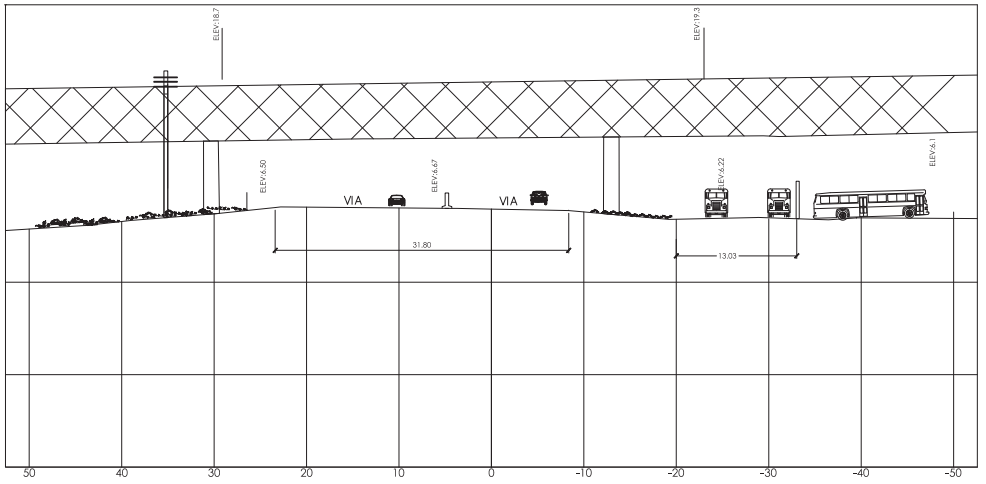

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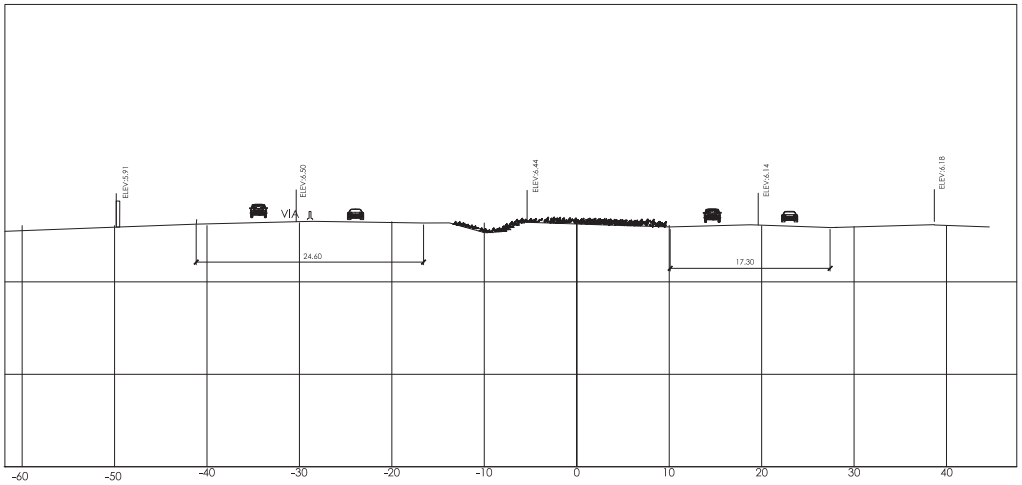

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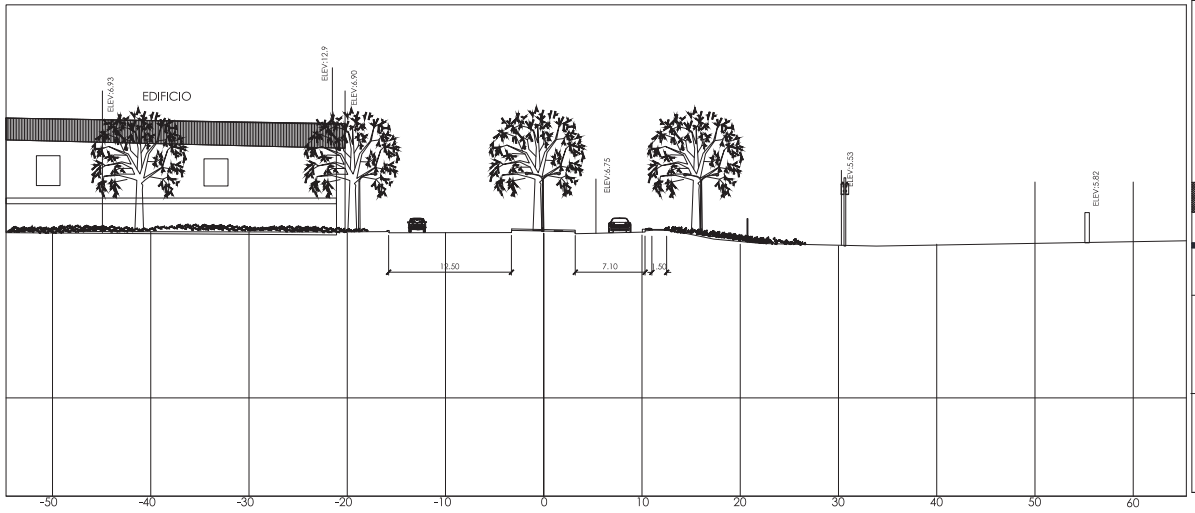
METRO DE PANAMA	REPUBLIC OF PANAMA	CONSULTANT: JICA STUDY TEAM	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT				REMARKS:
	SECRETARIA DEL METRO DE PANAMÁ	NIPPON KOEI CO., LTD. TONICHI ENGNEERING CONSULTANTS, INC. TOSTEM, INC. NIPPON KOEI LAC CO., LTD	DRAWN: GEOTOPO S.A	DATE:	REVIEWED BY:		PAGE: 1/6
			DESIGNED: GEOTOPO S.A	SCALE:	TEAM LEADER/URBAN RAILWAY PLANNING		



SECCION N° 5
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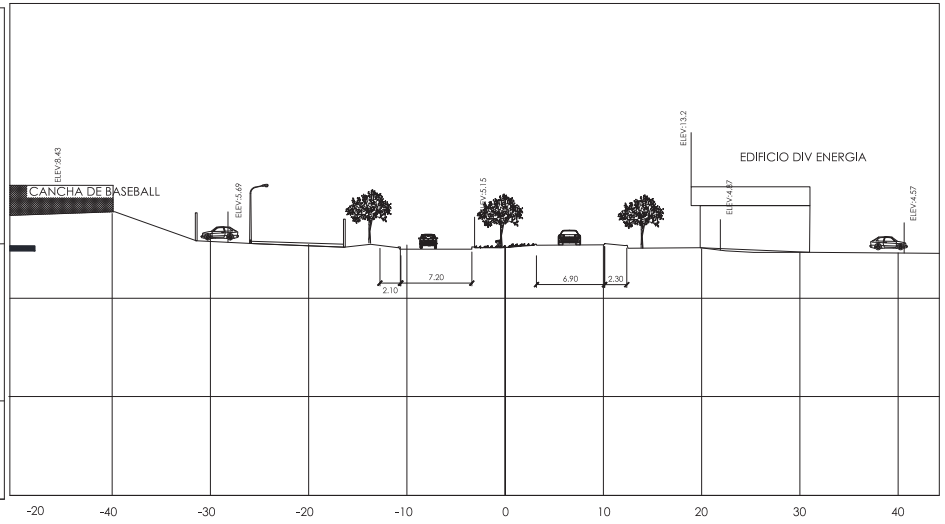

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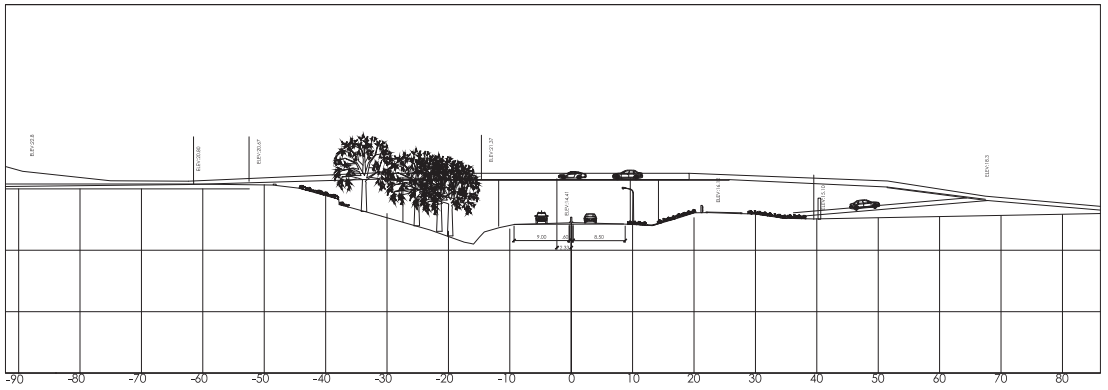
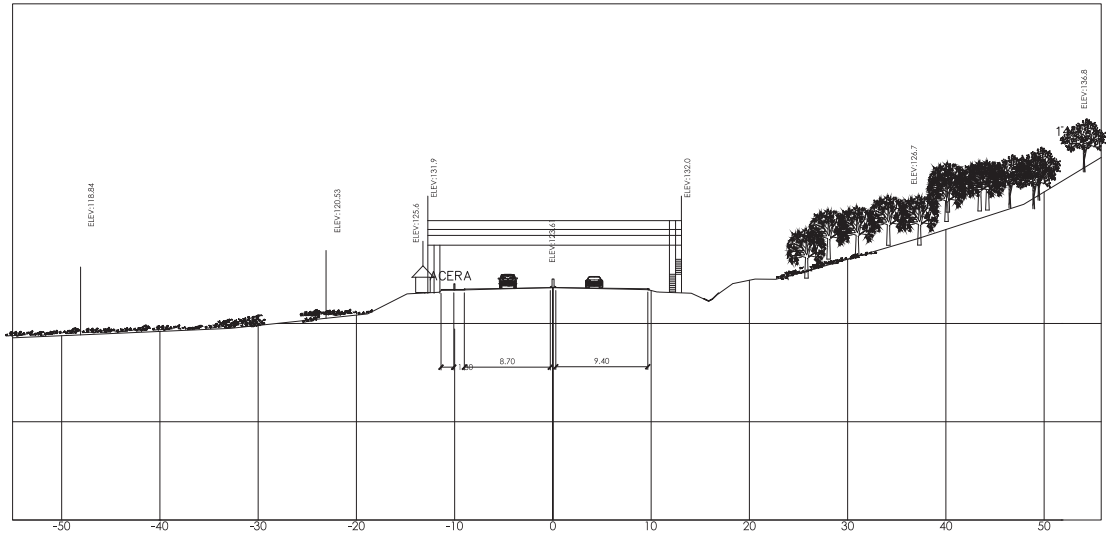
1:250



SECCION N° 7
1:400

METRO DE PANAMA	REPUBLIC OF PANAMA	CONSULTANT: JICA STUDY TEAM	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT			REMARKS:
	SECRETARIA DEL METRO DE PANAMÁ	NIPPON KOEI CO., LTD. TONICHI ENGNEERING CONSULTANTS, INC. TOSTEM, INC. NIPPON KOEI LAC CO., LTD	DRAWN: GEOTOPO S.A	DATE:	REVIEWED BY: TEAM LEADER/URBAN RAILWAY PLANNING	PAGE: 2/6
			DESIGNED: GEOTOPO S.A	SCALE:		

SECCION N° 8
1:250



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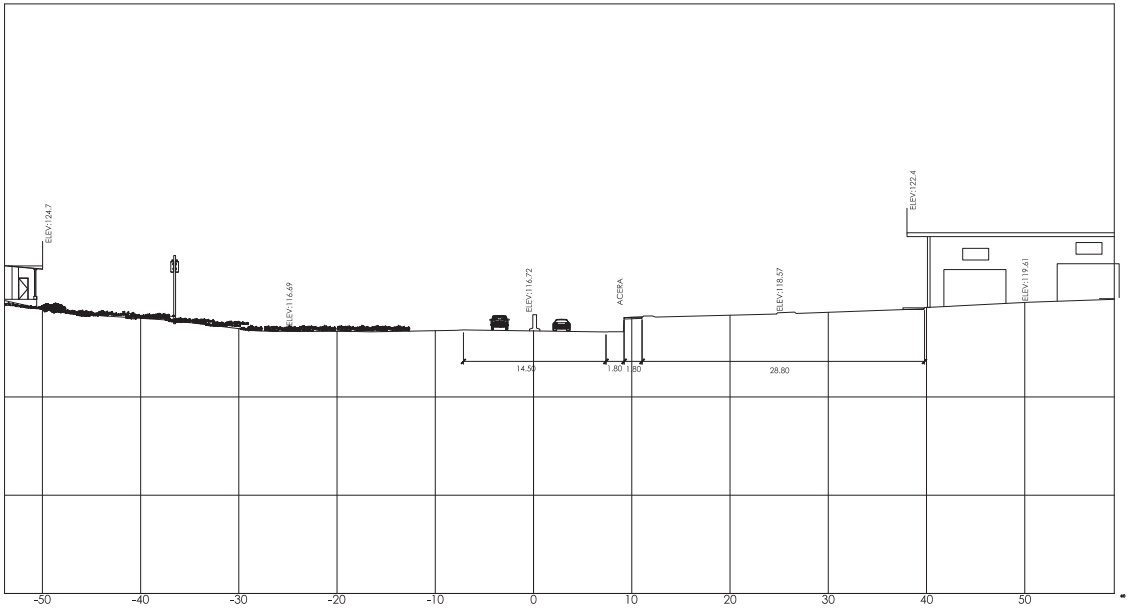
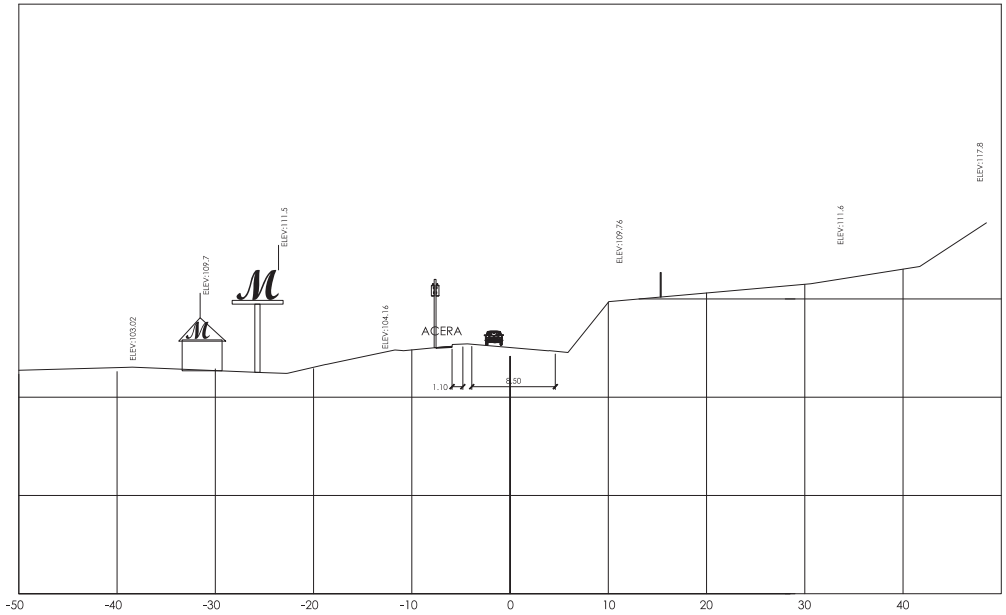
1:250

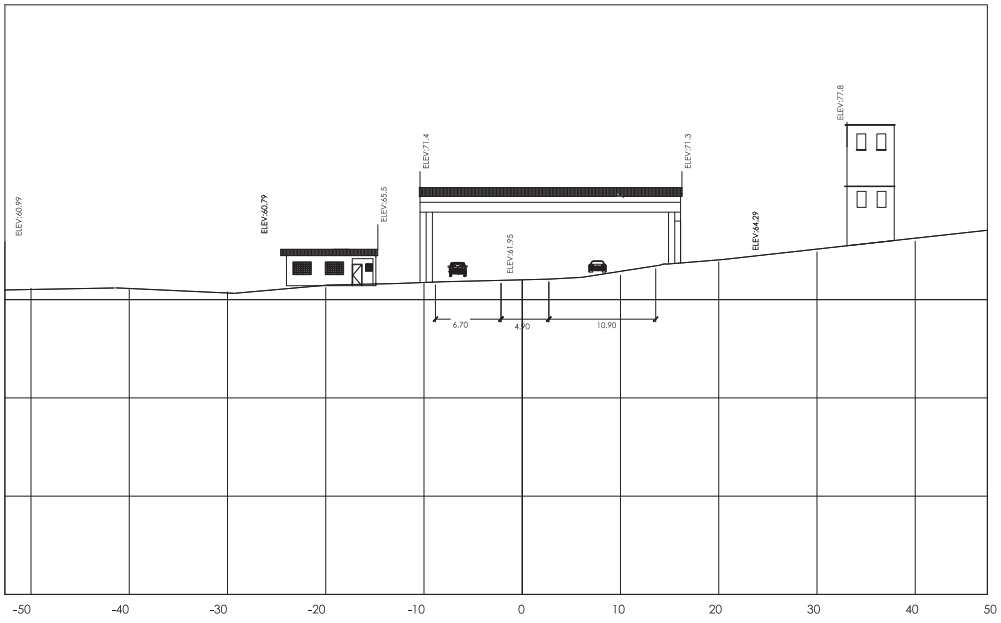


SECCION N° 11
1:250

METRO DE PANAMA	REPUBLIC OF PANAMA	CONSULTANT: JICA STUDY TEAM	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT			REMARKS:
	SECRETARIA DEL METRO DE PANAMÁ	NIPPON KOEI CO., LTD. TONICHI ENGNEERING CONSULTANTS, INC. TOSTEM, INC. NIPPON KOEI LAC CO., LTD	DRAWN: GEOTOPO S,A	DATE:	REVIEWED BY: TEAM LEADER/URBAN RAILWAY PLANNING	PAGE: 3 / 6
			DESIGNED: GEOTOPO S.A	SCALE:		



SECCION N° 12
1:250



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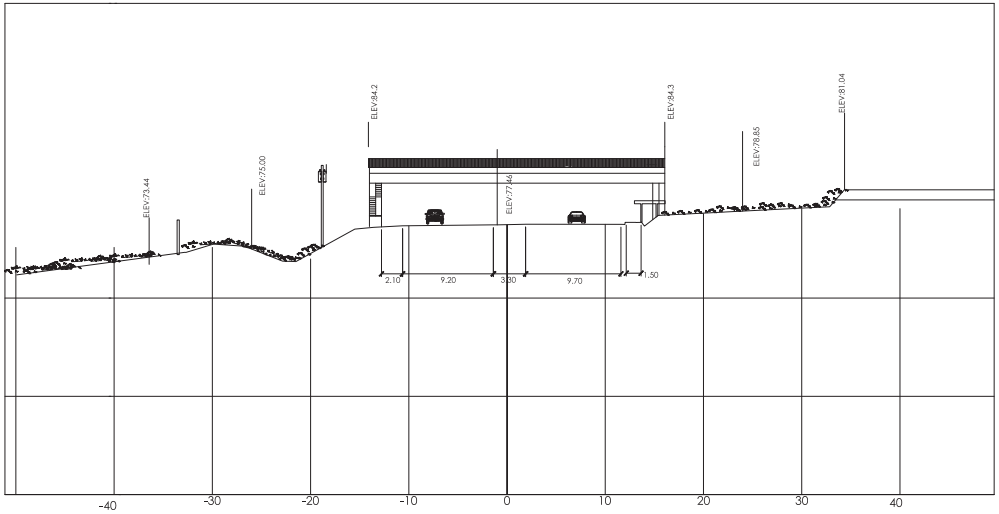
1:250



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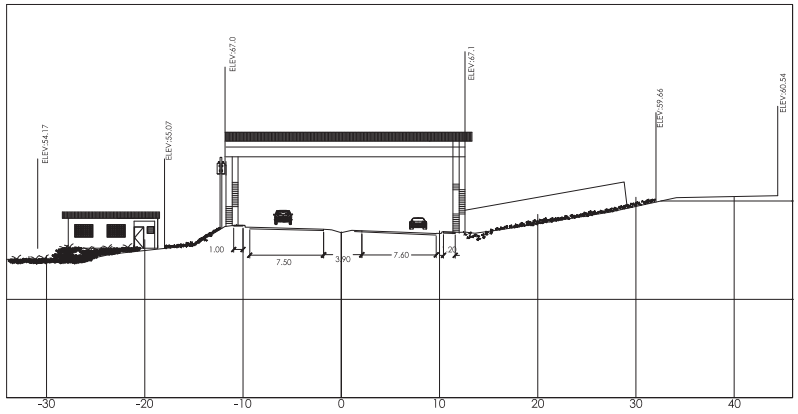
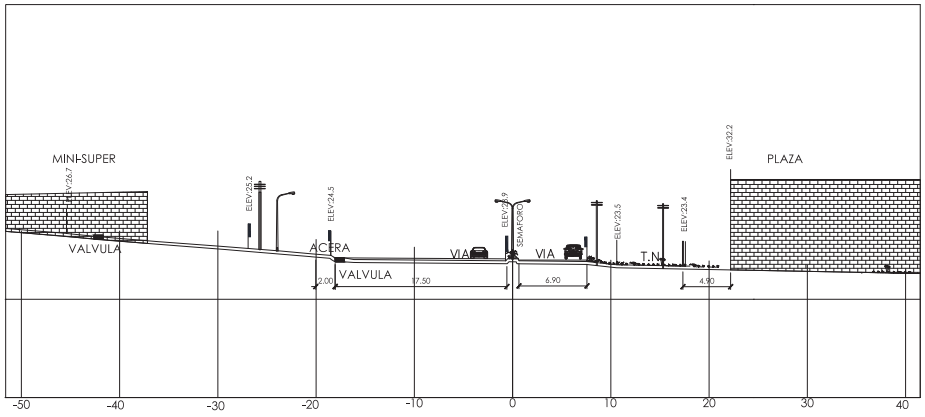
1:250



SECCION N° 15
1:250

METRO DE PANAMA	REPUBLIC OF PANAMA	CONSULTANT: JICA STUDY TEAM	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT			REMARKS:
	SECRETARIA DEL METRO DE PANAMÁ	NIPPON KOEI CO., LTD. TONICHI ENGNEERING CONSULTANTS, INC. TOSTEM, INC. NIPPON KOEI LAC CO., LTD	DRAWN: GEOTOPO S.A	DATE:	REVIEWED BY:	PAGE: 4/6
			DESIGNED: GEOTOPO S.A	SCALE:	TEAM LEADER/URBAN RAILWAY PLANNING	



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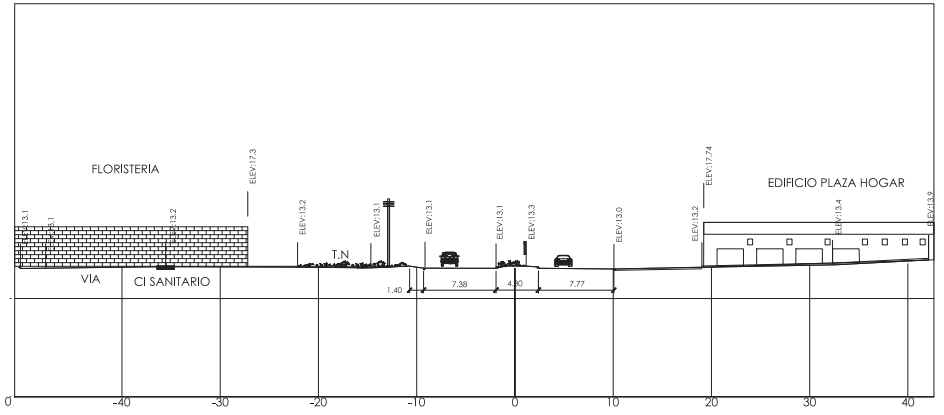
1:250



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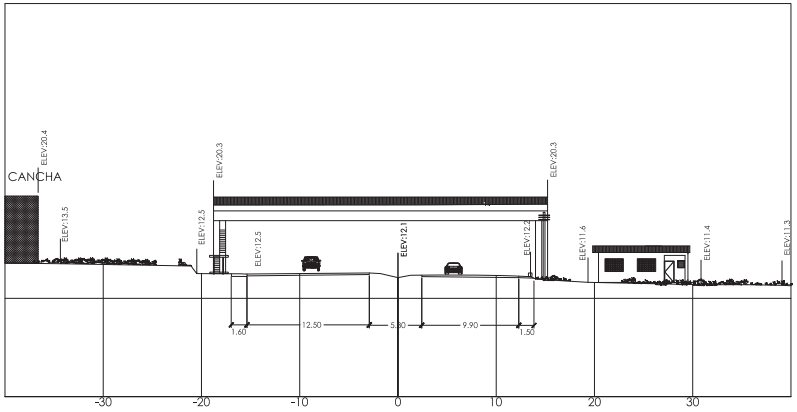
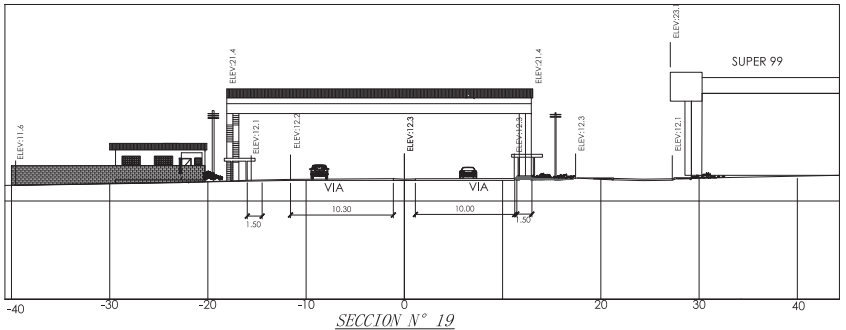
1:250

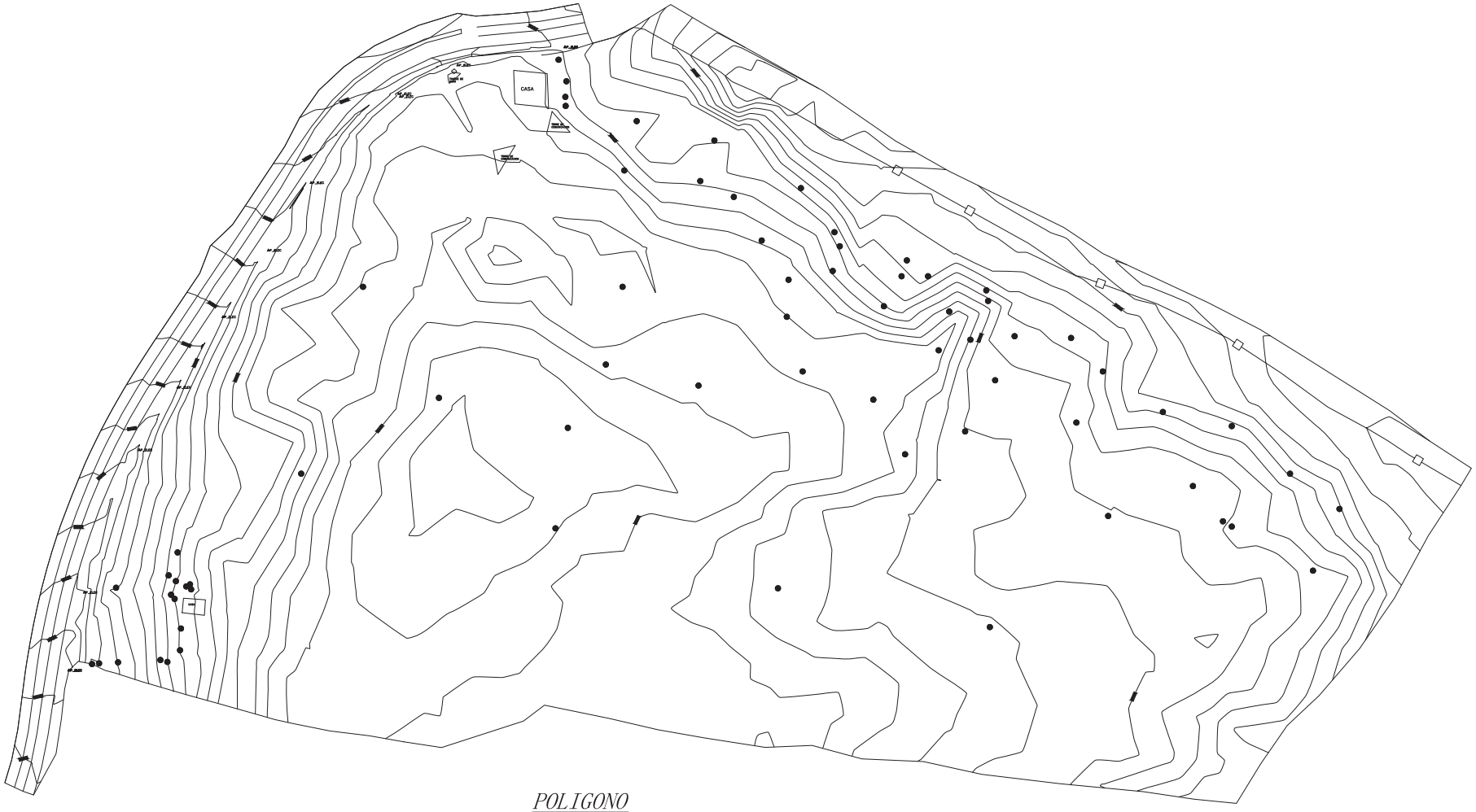


SECCION N° 18
1:250



SECCION N° 19
1:250

METRO DE PANAMA	REPUBLIC OF PANAMA	CONSULTANT: JICA STUDY TEAM	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT			REMARKS:
	SECRETARIA DEL METRO DE PANAMÁ	NIPPON KOEI CO., LTD. TONICHI ENGNEERING CONSULTANTS, INC. TOSTEM, INC. NIPPON KOEI LAC CO., LTD	DRAWN: GEOTOPO S,A	DATE:	REVIEWED BY: TEAM LEADER/URBAN RAILWAY PLANNING	PAGE: 5/6
			DESIGNED: GEOTOPO S.A	SCALE:		

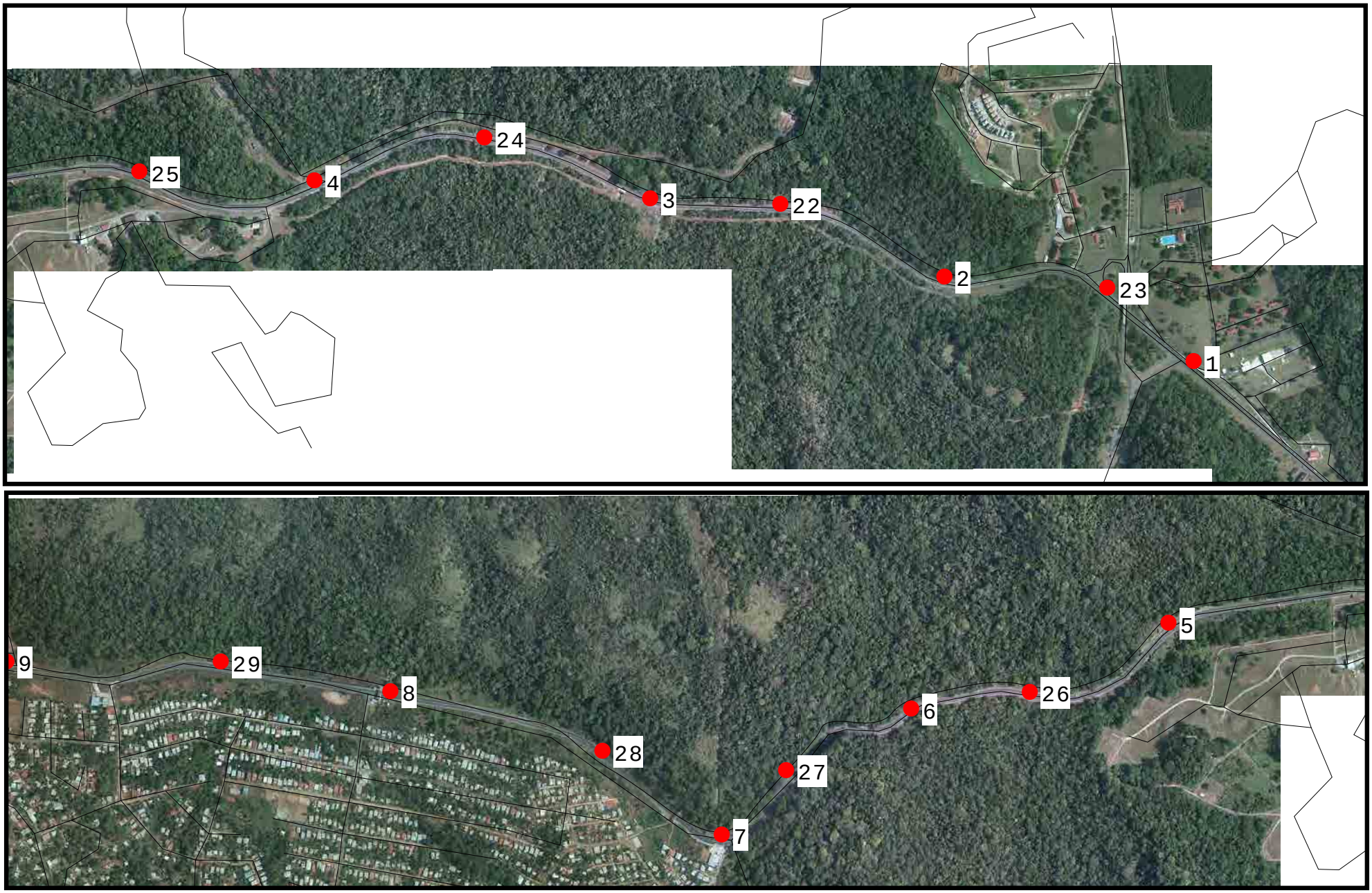


POLIGONO
ESCALA 1: 1250

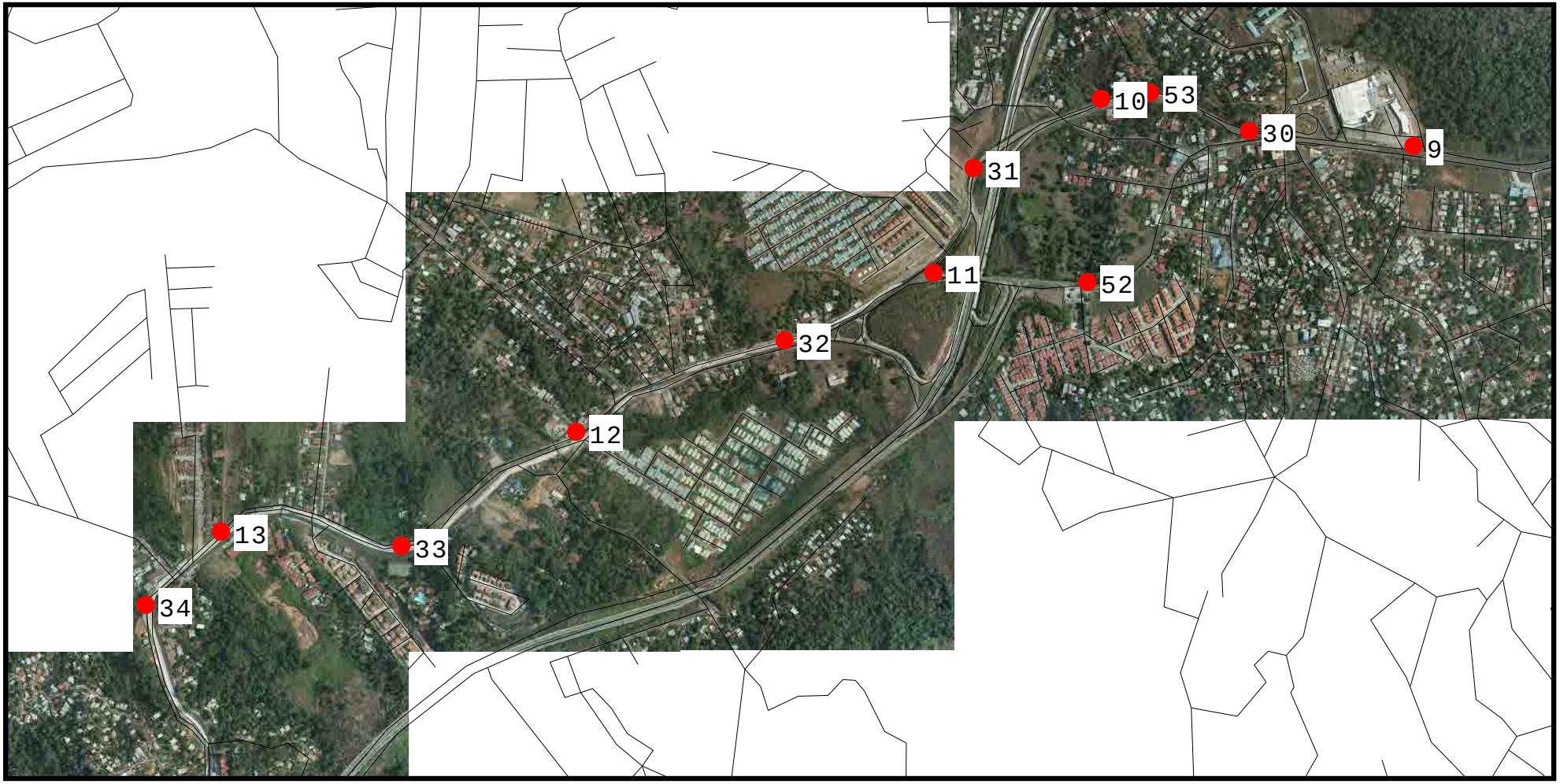
METRO DE PANAMA	REPUBLIC OF PANAMA	CONSULTANT: JICA STUDY TEAM	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT				REMARKS:
	SECRETARIA DEL METRO DE PANAMÁ	NIPPON KOEI CO., LTD. TONICHI ENGNEERING CONSULTANTS, INC. TOSTEM, INC. NIPPON KOEI LAC CO., LTD	DRAWN: GEOTOPO S.A	DATE:	REVIEWED BY:		PAGE: 6/6
			DESIGNED: GEOTOPO S.A	SCALE:	TEAM LEADER/URBAN RAILWAY PLANNING		

Appendix 3：Geographic Survey (Boring Log)

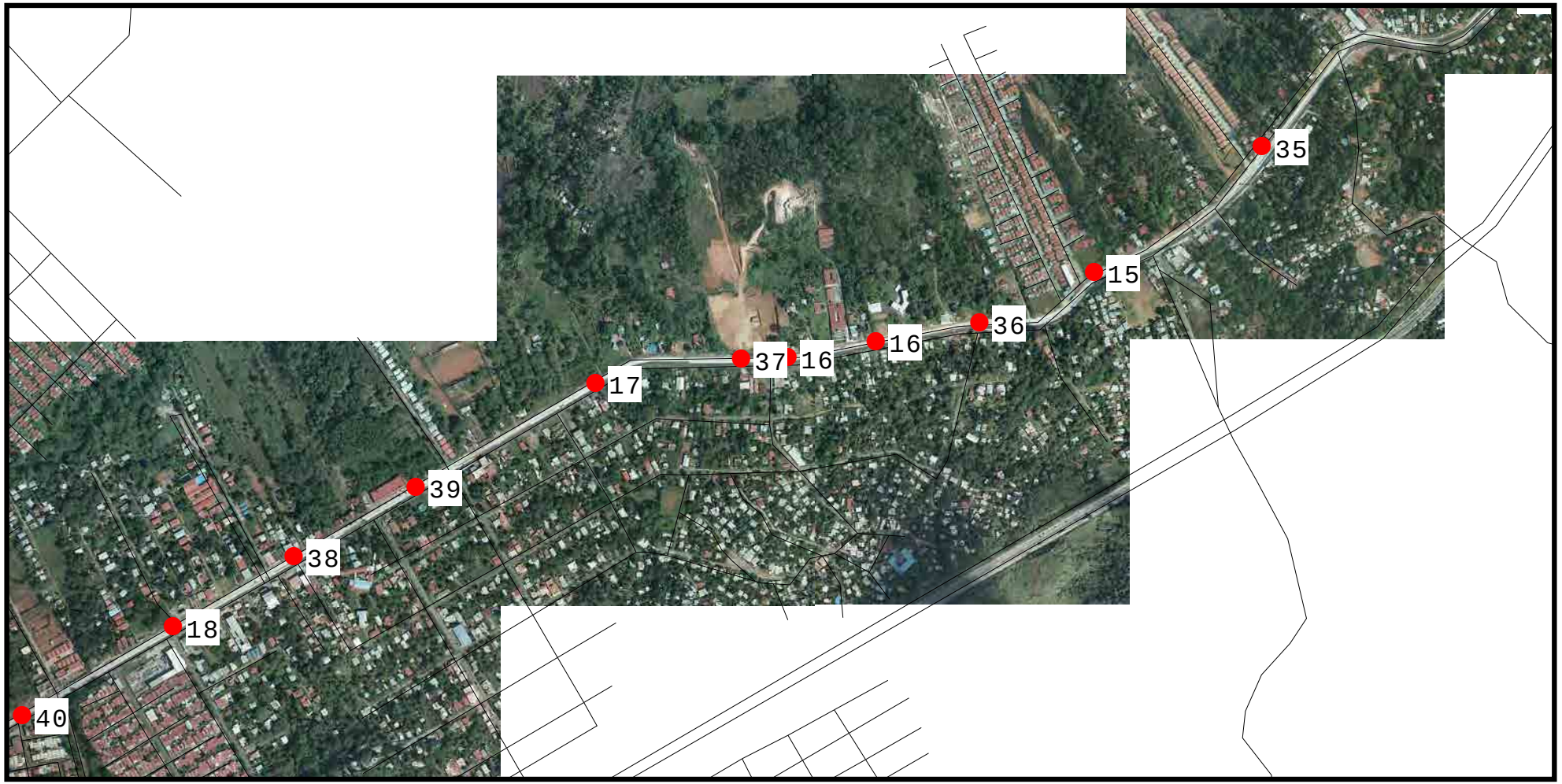
Boring Location Map (1)



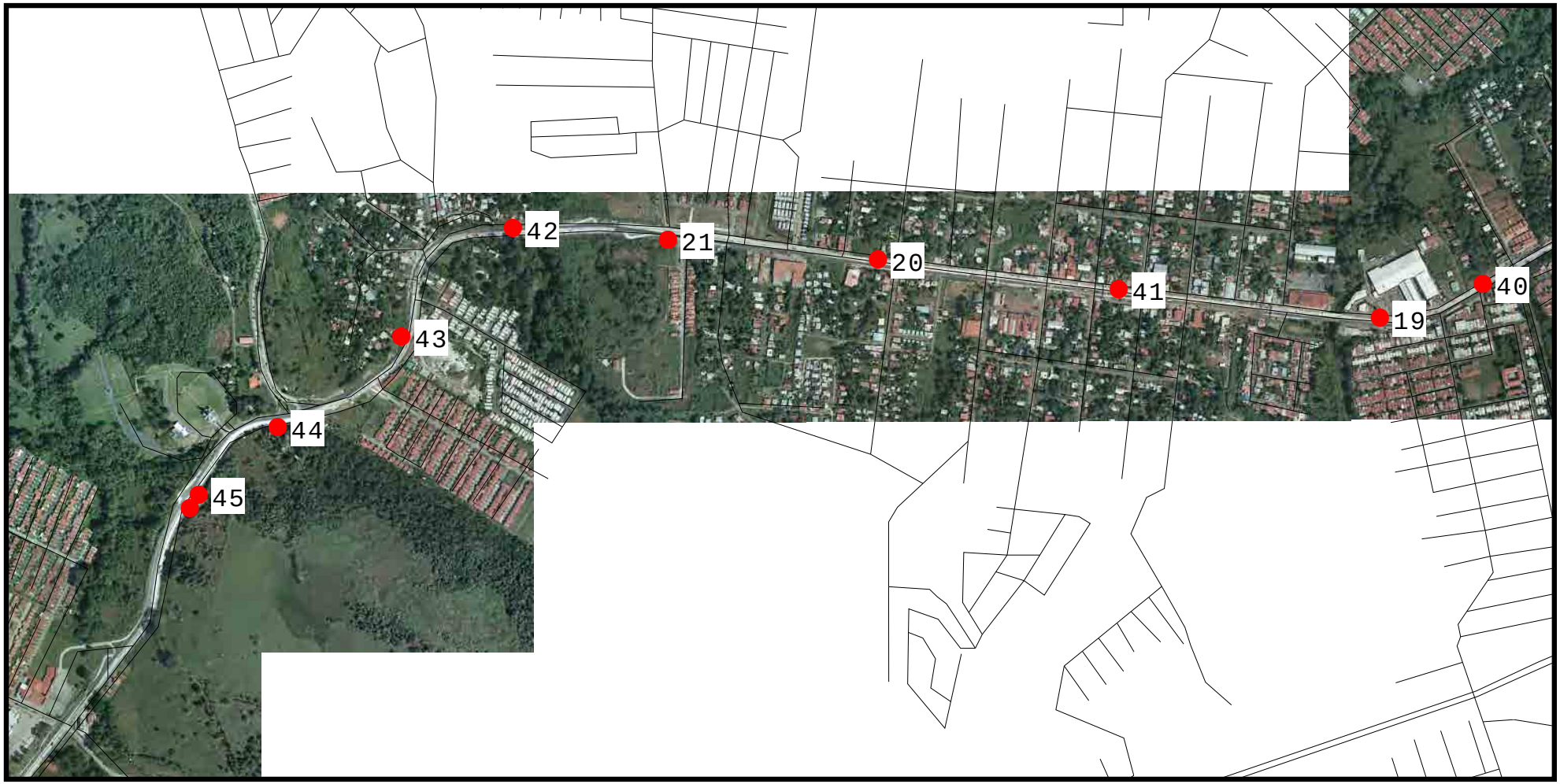
Boring Location Map (2)



Boring Location Map (3)



Boring Location Map (4)



LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/049 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 343
Equipment: ROLATEC 48

Analyst: Ismael Arroyo

BORING : SR 47
DATE: 14/12/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm (W. type B)			0.60	Asphalt and soil																	
1.0				1.80	Marl clayey brown																	
2.0					Marl green sandy silty																	
3.0				3.60			3.00	1 0 1	15 15 15	1												
4.0					Clayey sludges																	
5.0																						
6.0							6.60	0 0 0	15 15 15	0	83	18	65	100	90.10	83.63	1.41	1.29	30.90			
7.0																						
8.0																						
9.0							9.60	1 0 1	15 15 15	1												
10.0																						
11.0																						
12.0							12.00	0 1 0	15 15 15	1												
13.0																						
14.0				14.20																		
15.0				15.45	Silty Sand yellow		15.00	19 28 50	15 15 15	79												
16.0					Very consolidated sands and silts																	
17.0																						
18.0				18.00			18.00	50	R	R	ROCK			ROCK			2.36	2.15	9.80			
19.0																						
20.0	86 mm (D. type T)																					
21.0					Conglomerate Rock		21.60	50	R	R												
22.0																						
23.0																						
24.0				24.63			24.60	50	R	R												

BORING END 24.63 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/039 LINE 3 RAILWAY | Sample N°: 308 | Analyst: Ismael Arroyo | **BORING : SR 50**
CUSTOMER: NIPPON KOEI | Equipment: ROLATEC 400 | **DATE: 04/12/2013**

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm (W. type B)				Filling with gravel and rounded edges																	
1.0																						
2.0																						
3.00																						
3.0					Clay silty		3.00	2 2 2	15 15 15	4												
3.60																						
4.0					Marl with rounded edges																	
5.0																						
6.0							6.40	10 15 20	15 15 15	35	15	6	9	92.96	79.18	73.6	1.29	1.09	23.13			
6.40					Gravel mixed with stones																	
7.0																						
8.0																						
9.0							9.40	1 0 1	15 15 15	1												
9.40					Clay black with sediment																	
10.0																						
11.0																						
12.0							12.00	0 0 0	15 15 15	0												
13.0																						
14.0																						
15.0																						
16.0																						
17.00																						
17.0							17.00	5 5 5	15 15 15	10												
18.0					Marl clayey brown																	
19.0											26	15	11	100	93.04	89.25	1.07	0.78	31.98			
20.00																						
20.0							20.00	55	R	R												
21.0					Loam Rocky brown																	
21.20																						
22.0	86 mm (D. type T)				Rock		22.00	50	1	R												
23.0																						
24.0																						
25.0																						
25.40																						

BORING END 25.40 m

LCC INGENIERIA

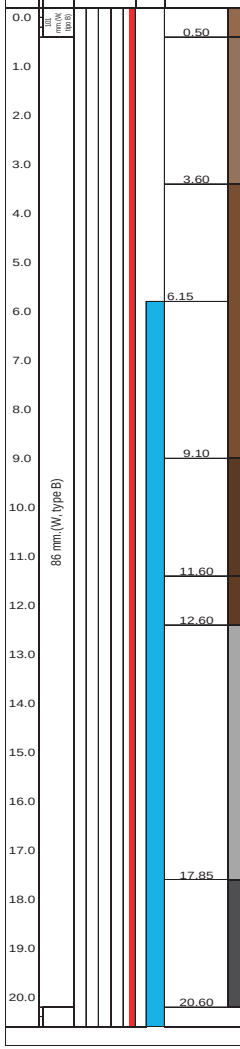
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/001 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 135
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 1
SAMPLE DATE: 5/10/2013



Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.50	Vegetable Soil																	
	Reddish Clay Marly		3.00	5 4 4	15 15 15	8												
3.60							63	34	29	64.16	34.10	31.23	1.87	1.20	91.99			
6.15	Marl and Soft Rock		6.00	4 8 11	15 15 15	19												
9.10	Marl Consolidated		9.00	50	10 R	R												
11.60	Marl more consolidated		11.60	20 50	15 15 R	R												
12.60	Soft Rock Marly		14.70	50	15 R	R	48	28	20	12.94	4.48	3.97	GRAVEL					
17.85	Hard rock, Meteorized		18.00	50	7 R	R												
20.60			20.30	50	10 R	R												

BORING END A 20.60 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/42 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 314
Equipment: ROLATEC 400

Analyst: Ismael Arroyo

BORING : SR 23
DATE: 5/12/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0																						
1.0																						
2.0					Gravel fill																	
3.0							3.00	50 / R	17	R												
4.0																						
5.0											NON PLASTIC MATERIAL			94.98	65.73	58.12	1.92	1.80	6.43			
6.0				6.00	Marl Consolidated brown with boulders																	
7.0				7.30			7.00	50 / R	29	R												
8.0																						
9.0	86 mm.(W. type B)						9.10	32 38 40	15 15 15	78												
10.0					Marl clayey with boulders dark brown																	
11.0																						
12.0							12.10	17 40 50	15 15 15	90												
13.0																						
14.0																						
15.0							15.10	23 27 50	15 15 15	77	51	16	35	94.56	84.48	82.71	1.45	1.01	27.81			
16.0																						
16.90																						
17.0					Rock fractured																	
18.0				18.10			18.10	50 / R	1	R												
19.0	86 mm.(D. type T)				Rock																	
20.0																						
				21.00			18.10	50 / R	1	R												

BORING END 21.02 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/009 LINE 3 RAILWAY Sample N°: 144 Analyst: Ismael Arroyo **BORING : SR 2**

CUSTOMER: NIPPON KOEI Equipment: Rolatec 400 **SAMPLE DATE: 12/10/2013**

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	101 mm.(W, type B)			0.60	Vegetable ground																
1.0				1.50	Brown Clayey loam with yellow inside																
2.0	86 mm.(W, type B)				Brown Clayey loam with yellow inside, with rocky sections					52	28	24	100	64.4	62.58	1.71	1.09	36.3			
3.0				3.10			3.00	50	10	50											
4.0	86 mm.(D, type T)				Fractured Rock																
5.0				5.40						Sample No Plastic			68.49	64.64	64.26	ROCK		7.15			
6.0					Fractured Rock		6.00	50	5	50											
7.0				7.00																	

BORING END A 7.00 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/013 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 177
Equipment: Rolatec 400

Analyst Ismael Arroyo

BORING : SR 22
DATE: 18/10/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0					Vegetable ground																	
0.90																						
1.0					Loam clayey with boulders																	
2.0																						
3.0							3.30	3 5 7	15 15 15	12												
3.30																						
4.0					Clay loamy Brown																	
4.37											61	29	32	99.12	96.46	92.29	1.83	1.33	27.63			
5.0																						
5.10																						
6.0					Clay soft		6.30	2 2 3	15 15 15	5												
7.0																						
8.0																						
8.70																						
9.0					Loam consolidated with rocky levels		9.00	12 15 36	15 15 15	51												
10.0																						
11.0																						
12.0							12.60	50 R	5	R												
13.0																						
14.0											50	30	20	67.44	28.84	23.01	1.77	1.45	18.06			
14.90																						
15.0					Highly fractured rock		15.00	50 R	3	R												
16.0																						
17.00																						
17.0					Hard rock, with blacks tones																	
18.00							18.00	50 R	3	R												

86 mm.(W. type B)
86 mm.(D. type T)

BORING END 18.00 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/050 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 344
Equipment: RL-48

Analyst: Juan Francisco Fernandez

BORING : SR 3
DATE: 16/12/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0				0.60	Soil																	
1.0				1.50	Clay																	
2.0	86 mm.(W. type B)				Silts altered																	
3.0							3.10	8 29 50	15 15 10	R												
4.0				4.50							55	21	34	96.24	85.23	77.81	1.35	1.17	29.56			
5.0					Rock fractured																	
6.0							6.00	50	5	R												
7.0																						
8.0																						
9.0							9.00	50	5	R												
10.0																						
11.0	86 mm.(D. type T)																					
12.0				12.00			12.00	50	1	R	ROCK			ROCK			2.14	2.11	1.10			
13.0					Rock																	
14.0																						
15.0							15.00	50	1	R												
16.0				16.70																		

BORING END 16.70 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/040 LINE 3 RAILWAY Sample N°: 309 Analyst: Juan Franciso Fernandez **BORING : SR 24**

CUSTOMER: NIPPON KOEI Equipment: RL-48 **DATE: 04/12/2013**

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W, type B)				Gravel fill																	
1.0				1.10																		
2.0					Clay with silts alterated						30	19	11	100	95.01	91.37	1.14	0.98	26.71			
3.0				3.00			3.00	7 8 10	15 15 15	18												
4.0					Silts alterated																	
5.0				4.00	Rock																	
6.0	86 mm.(D, type T)			5.20																		
7.0				6.00	Silty clay with rocky sections		6.00	50 R	1	R												
8.0					Rock						ROCK			ROCK			1.97	1.94	3.59			
9.0							9.00	50 R	1	R												
10.0				10.70																		

BORING END 10.70 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/003 LINE 3 RAILWAY Sample N°: 137 Analyst: Ismael Arroyo **BORING : SR 4**
CUSTOMER: NIPPON KOEI Equipment: Rolatec 400 **SAMPLE DATE: 6/10/2013**

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	101 mm.(W, type B)			0.40	Asphalt with gravel																	
1.0				1.20	Vegetable layer																	
2.0				2.20	Brown clay loam with two color veins																	
3.0							3.20	4 5 5	15 15 15	10										0	2.48	
3.60					Light brown clay loam with veins bicolor						71	37	34	100	99.67	98.17	1.59	0.85	46.85			
4.0				4.20																		
5.0	86 mm.(D, type T)																					
6.0					Dark brown clay loam with veins bicolor		6.20	31 50	15 15 R	R												
7.0																						
8.0																						
9.0				9.25			9.20	50	5 R	R												
10.0																						
11.0					Consolidated loam, dark color and varies						Rock			Rock			Rock		4.01			
12.0	86 mm.(W, type B)			12.20			12.20	50	4 R	R												
13.0					Fractured rock black color, with white veins																	
14.0																						
15.0				15.03			15.00	50	3 R	R												

BORING END A 15.03 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/041 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 310
Equipment: ROLATEC 400

Analyst: Juan Francisco Fernandez

BORING : SR 51
DATE :5/12/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W, type B)																					
1.0				1.60	Gravel fill																	
2.0					Clays compacted brown			3 6 3	15 15 15	9												
3.0				3.70			3.10															
4.0					Sandy silt with small boulders						53	39	14	97.44	81.70	78.73	1.18	0.92	31.31			
5.0																						
6.0				6.40			5.80	7 10 13	15 15 15	23												
7.0					Sandy silt																	
8.0																						
9.0				9.90			9.30	13 15 29	15 15 15	44												
10.0					Silts and silts clayey																	
11.0																						
12.0				12.10			12.00	50 R	10	R	83	50	33	97.44	81.70	78.73	1.02	0.61	36.99			
13.0	86 mm.(D, type T)			13.30	Rock fracturated																	
14.0					Rock																	
15.0				15.90																		

BORING END 15.90 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

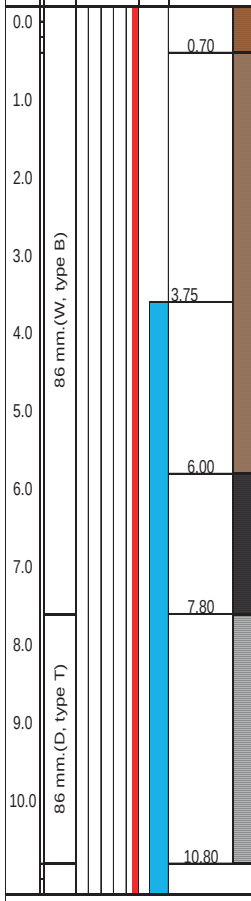
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/011 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 171
Equipment: RL-48

Analyst: Juan Antonio

BORING : SR 25
SAMPLE DATE: 16/10/2013



Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W, type B)			0.70	Filling Material																	
3.0				3.75	Silts clayey brown soft		3.00	3 4 4	15 15 15	8	63	30	33	100	99.34	95.07	1.5	0.83	44.61			
6.0				6.00	Silts soft grayish arcillos		6.00	4 5 5	15 15 15	10												
9.0	86 mm.(D, type T)			7.80	Grayish Rock		9.00	50 R	2	R										256.4	2.44	
10.0				10.80																		

BORING END A 10.80 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/002 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 136
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 5
SAMPLE DATE: 10/10/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 .mm.(W. tipo B)	20 40 60 80 100			Gravel Fill																	
1.0				1.40																		
2.0					Brown loam with internal yellow tones																	
3.0				3.60			3.00	3 4 4	15 15 15	8												
4.0				4.60							51	32	19	100	96.03	89.98	1.57	0.78	50.26			
5.0					Marga tricolor light brown with oxides																	
6.0							6.40	5 5 6	15 15 15	11												
7.0				7.00																		
8.0					Brown sandy loam softer																	
9.0				9.00			9.00	9 18 21	15 15 15	39												
10.0					More consolidated greenish Marga																	
11.0				12.00																		
12.0					Greenish Marga more consolidated, with rocky sections		12.00	9 21 36	15 15 15	57	41	29	12	99.9	82.88	54.2	1.80	1.26	29.73			
13.0				13.80																		
14.0					Roca soft grayish with white veins																	
15.0							15.00	50 R	4	R												
16.0				16.50																		

BORING END A 16.50 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/012 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 172
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 26
SAMPLE DATE: 16/10/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)			0.50	Vegetable ground																	
0.70																						
1.0					Loam clayey Light brown																	
2.0																						
3.0							3.00	5 5 10	15 15 15	16												
3.60					Loam clayey light brown, consolidated						83	35	48	100	96.19	94.69	1.72	1.08	37.43			
4.0				4.20																		
5.0					Loam soft brown, average consolidated																	
6.0							6.00	3 4 5	15 15 15	9												
7.0				7.60																		
8.0					Loam soft brown with green veins and oxides																	
9.0							9.00	5 20 50	15 15 15	70												
9.45																						
10.0					Loam consolidated (Semi rock)																	
10.80																						
11.0	86 mm.(D. type T)				Rock with blacks tones																	
12.0				12.13			12.10	50 R	3	R												
13.0					Rock																	
14.0				14.72			14.70	50 R	2	R												

BORING END A 14.70 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/051 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 345
Equipment: RL-48

Analyst: Juan Francisco Fernandez

BORING : SR 6
DATE: 20/12/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)			0.80	Asphalt																	
1.0					Base layer																	
2.0																						
3.0				3.60			3.00	5 7 7	15 15 10	14	58	11	47	100	96.02	91.26	1.32	1.14	26.71			
4.0					Clayey silt and sandy loams																	
5.0																						
6.0	86 mm.(D. type T)			6.60			6.00	5 7 7	15 15 10	14												
7.0					Silts altered																	
8.0																						
9.0							9.20	8 9 9	15 15 10	18												
10.0																						
11.0				11.00	Rock																	
12.0							12.20	50	1	R	ROCK			ROCK			1.98	1.95	3.56			
13.0																						
14.0				14.82																		

BORING END 14.82 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/014 LINE 3 RAILWAY Sample N°: 178 Analyst: Juan Antonio Cortez **BORING : SR 27**

CUSTOMER: NIPPON KOEI Equipment: RL-48 **DATE: 18/10/2013**

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	101 mm.(W, type B)				Silty clay brown with gravel																
1.0				1.32						41	27	14	95.04	86.75	80.28	1.86	1.28	31.09			
2.0				2.10																	
3.0	86 mm.(D, type T)				Grayish Rock		3.00	50 R	2 R												
4.0																			134.9	2.9	
5.0				5.42			5.40	50 R	2 R												
					BORING END A 5.42 m																

LCC INGENIERIA

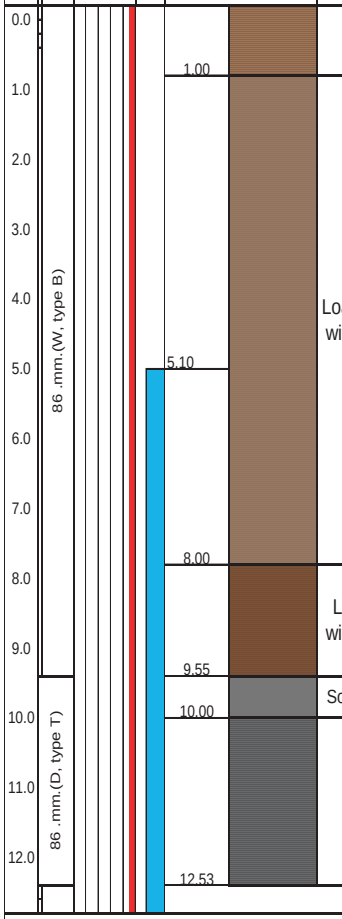
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/004 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 139
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 7
SAMPLE DATE: 8/10/2013



SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
Vegetable layer																	
Loam tricolor, medium consolidated with brown tones, yellow and white		3.20	4 5 6	15 15 15	11	56	32	24	100	92.96	82	1.57	0.88	44.04			
		6.20	12 15 15 22	15 15 15 15	37												
Loam tricolor, More consolidated with brown tones, yellow and white		9.50	50 R	5 R	R	46	18	28	95.4	50.1	38.52	2.07	1.81	12.14			
Soft Rock with brown and yellow tones																	
Rock Black with white veins		12.50	50 R	3 R	R												
BORING END A 12.53 m																	

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/010 LINE 3 RAILWAY Sample N°: 156 Analyst: Juan Antonio Cortez **BORING : SR 28**

CUSTOMER: NIPPON KOEI Equipment: RL-48 **SAMPLE DATE: 12/10/2013**

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W, type B)				Marly clays with many gravel and boulders																	
2.40																						
	86 mm.(W, type T)				Marl with many boulders																	
3.03																						
3.0							3.00	50	3	R	Sample No Plastic			3.73	2.2	2.1	ROCK		1.2			
					Clayey silt with gravel and boulders																	
4.50																						
5.0																						
6.0							6.00	28	15	76												
								34	15													
								42	15													
7.0	86 mm.(W, type B)				Lithified brown loams																	
8.0																						
9.0							9.00	31	15	R	79	24	55	98.42	86.38	78.91	1.95	1.59	18.37			
								9	15													
9.60								R														
10.0					Meteorized Rock																	
11.0																						
12.0	86 mm.(D, type T)						11.60	50	2	R												
12.60								R														

BORING END A 12.60 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/044 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 316
Equipment: RL-48

Analyst: Juan Francisco Fernandez

BORING : SR 46
DATE: 06/12/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm (W. type B)				Filled Material																	
1.0																						
2.0																						
3.0																						
4.0				4.20			4.20	9 9 9	15 15 15	18	67	34	33	26.40	7.77	6.65	1.88	1.23	33.21			
5.0					Clay mixed with gravel and rocks																	
6.0				6.60																		
7.0					Rock fractured		7.20	50	5	R												
8.0																						
9.0																						
10.0							10.20	50	3	R												
11.0																						
12.0	86 mm (D. type T)																					
13.0							13.20	50	2	R	ROCK			ROCK			ROCK					
14.0				14.50																		
15.0					Rock																	
16.0																						
				17.02			13.20	50	1	R												

BORING END A 17.02 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/005 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 140
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 8
SAMPLE DATE: 9/10/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0																						
1.0					Filler gravel																	
1.40																						
2.0					Consolidated Clayey loam																	
3.0							3.20	6 9 11	15 15 15	20												
3.80																						
4.0											83	39	44	92.94	92.11	89.78	1.72	0.92	46.58			
5.0																						
6.0	86 .mm.(W, type B)				Consolidated Clayey loam, softer, with gray, black and reddish veins		6.40	4 4 4	15 15 15	8												
6.47																						
7.0																						
8.0																						
8.50																						
9.0					Silty loam with very soft water and oxides		9.40	5 6 6	15 15 15	12												
8.50																						
10.0																						
11.0					Silty loam with grayish black color and white and yellow tones inside																	
12.0							12.40	11 37 50 R	15 15 15	R												
12.85											43	27	16	99.78	78.14	67.15	1.28	25.89	46.58			
13.0																						
14.0	86 .mm.(D, type T)				Fractured rock, black rock oxides																	
15.0							15.10	50 R	4	R												
16.00																						

BORING END A 16.50 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

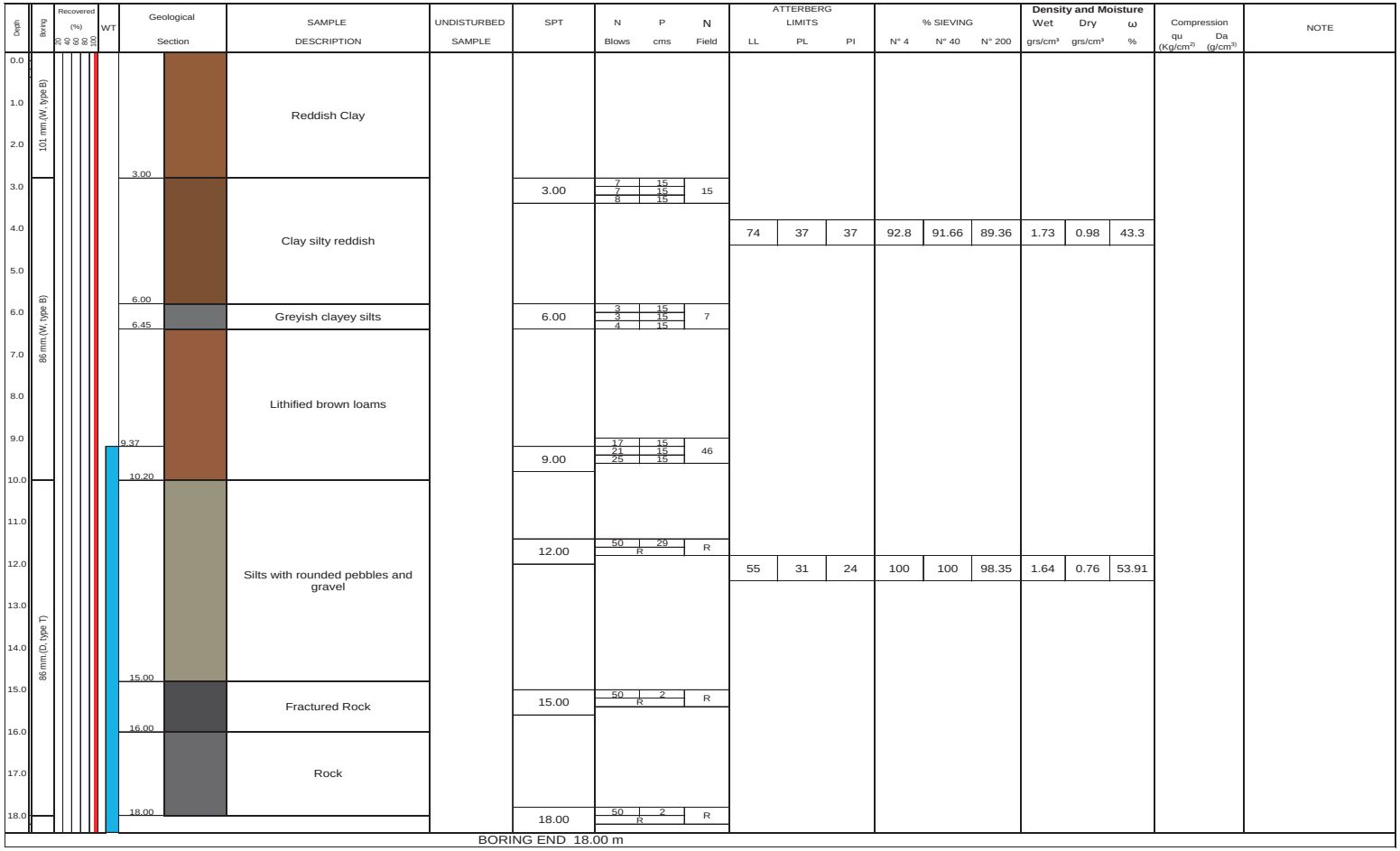
2.

WORK: C/010/001/021 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 212
Equipment: RL-48

Analyst: Juan Antonio

BORING : SR 29
DATE: 23/10/2013



BORING GRAPHIC REPRESENTATION

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/006 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 141
Equipment: RL-48

Analyst: Juan Antonio Cortez

BORING : SR 9
SAMPLE DATE: 09/10/2013

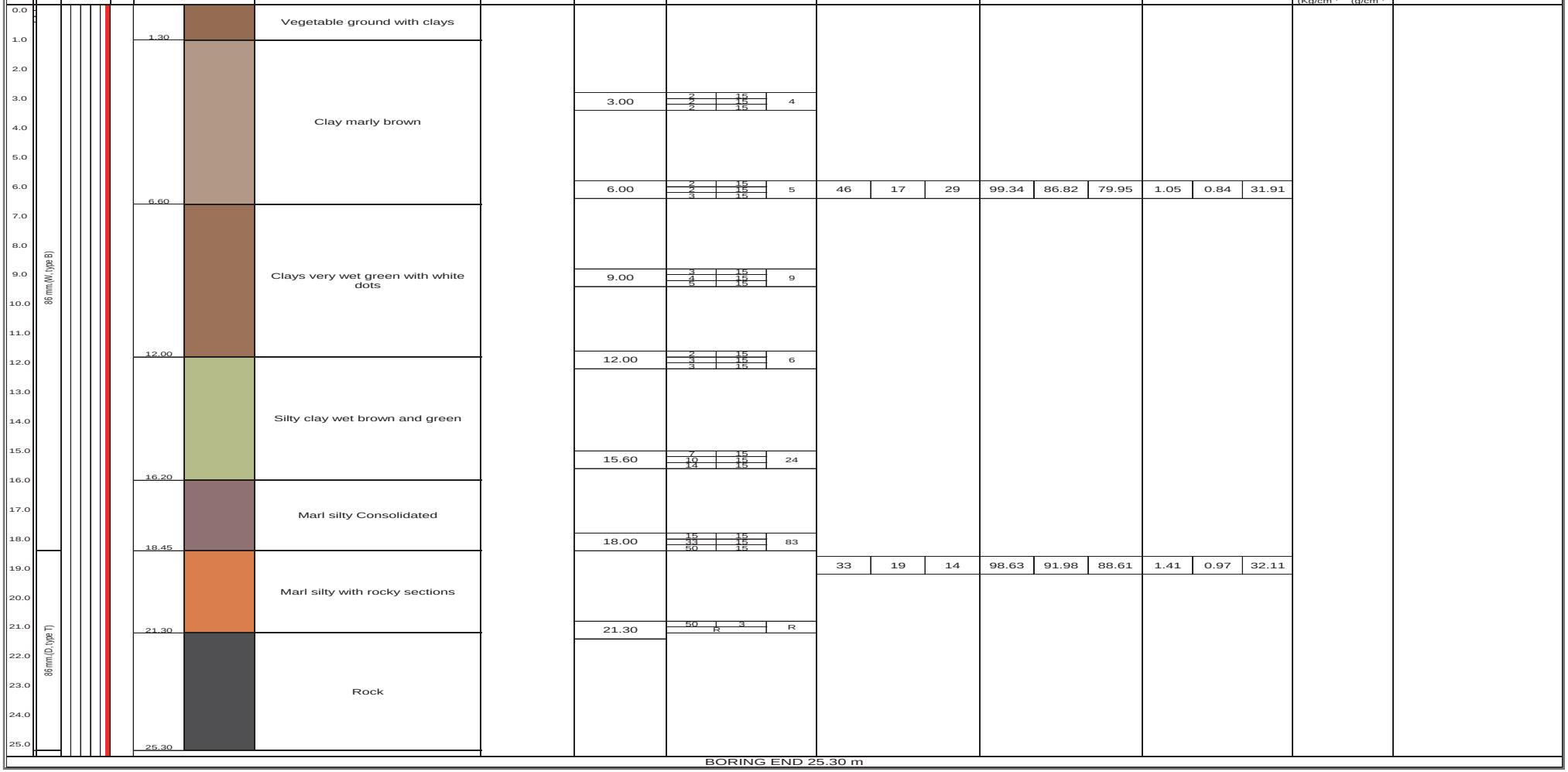
Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)	20 40 60 80 100		0.25	Concrete																	
1.0					Reddish marl																	
2.0																						
3.0							3.00	8 8 9	15 15 15	17												
4.0											61	35	26	100	97.73	92.05	1.71	0.99	42.07			
5.0				5.40																		
				5.80	Clayey silt Color reddish																	
6.0							6.00	6 8 8	15 15 15	14												
7.0				7.80																		
8.0					Grayish clayey silts																	
9.0							9.00	4 5 6	15 15 15	11												
10.0				10.80																		
11.0					Clayey silts, Brown																	
12.0				12.45			11.60	10 18 28	15 15 15	46												
13.0					Sandy loams, Brown						37	30	7	100	91.9	80.71	2.54	1.82	28.18			
13.70							13.80	50	4	50												
14.0					Grayish Fractured Rock																	
15.0	86 mm.(W. type T)																					
16.0																						
17.0				17.10			17.10	50	3	50												

BORING END A 17.10 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/037 LINE 3 RAILWAY | Sample N°: 306 | Analyst: Ismael Arroyo | **BORING : SR 30**
CUSTOMER: NIPPON KOEI | Equipment: ROLATEC 400 | **DATE: 30/11/2013**



LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/048 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 335
Equipment: RL-48

Analyst: Ismael Arroyo

BORING : SR 52
DATE: 12/12/2013

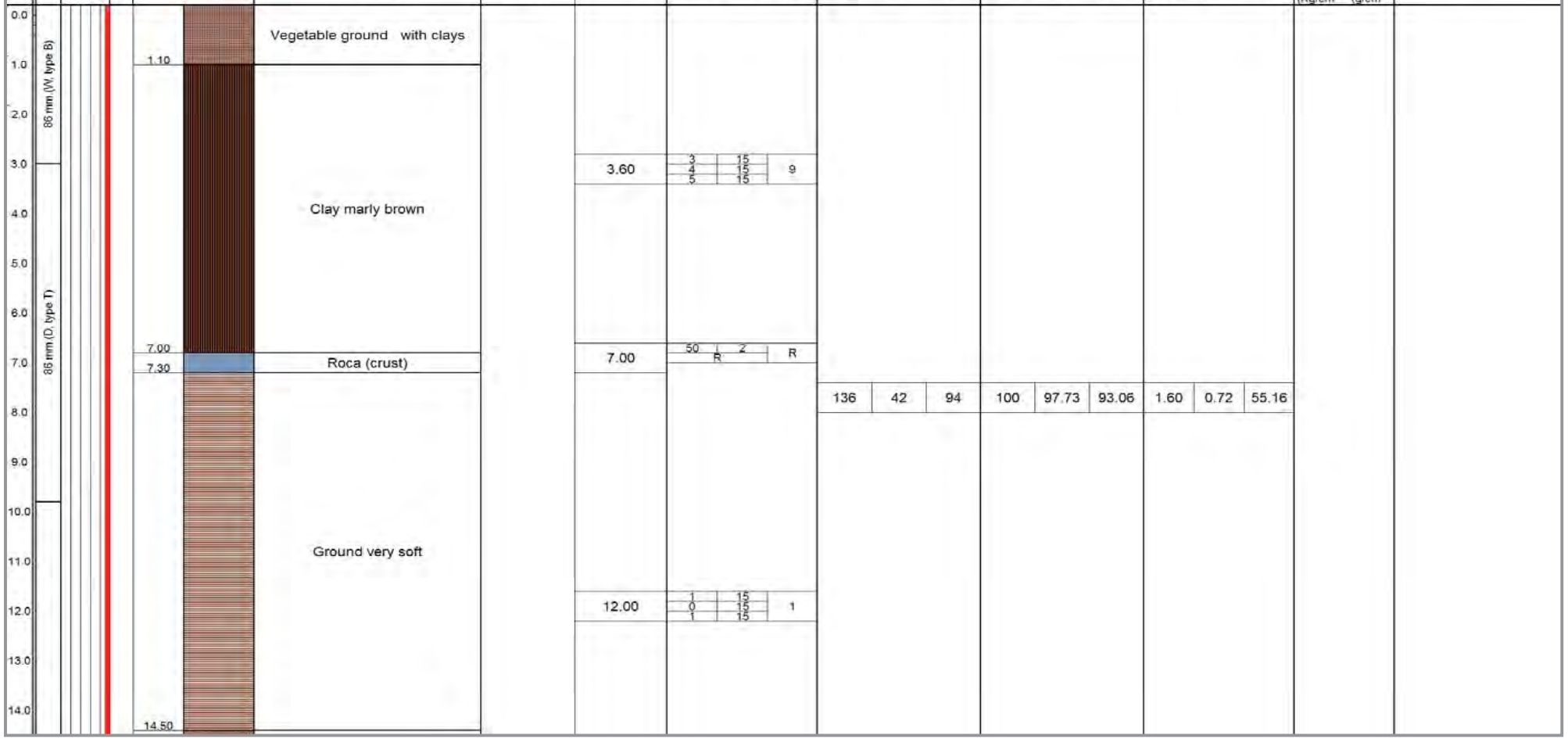
Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)				Vegetable ground with clayey loams																	
1.0				1.80																		
2.0					brown light Marl clayey																	
3.0							3.40	2 4 5	15 15 15	9												
4.0											30	12	18	100	92.62	89.64	1.09	0.71	21.87			
5.0																						
6.0				6.60			6.00	9 10 12	15 15 15	22												
7.0					Very consolidated brown loam																	
8.0																						
9.0				9.45			9.00	22 35 50	15 15 15	85												
10.0					Green silty marl (semi rock)																	
11.0																						
12.0				12.10			12.00	50 R	10	R												
13.0					Green Rock with oxides																	
14.0											NON PLASTIC MATERIAL			34.69	16.83	11.05	1.54	1.31	17.52			
15.0				15.40			15.20	50 R	3	R												
16.0	86 mm.(D. type T)				Rock																	
17.0																						
18.0				18.52			15.20	50	R	R												

BORING END 18.52 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/035 LINE 3 RAILWAY | Sample N°: 296 | Analyst: Isamel Arroyo | **BORING : SR 53**
CUSTOMER: NIPPON KOEI | Equipment: ROLATEC-400 | **DATE: 29/11/2013**



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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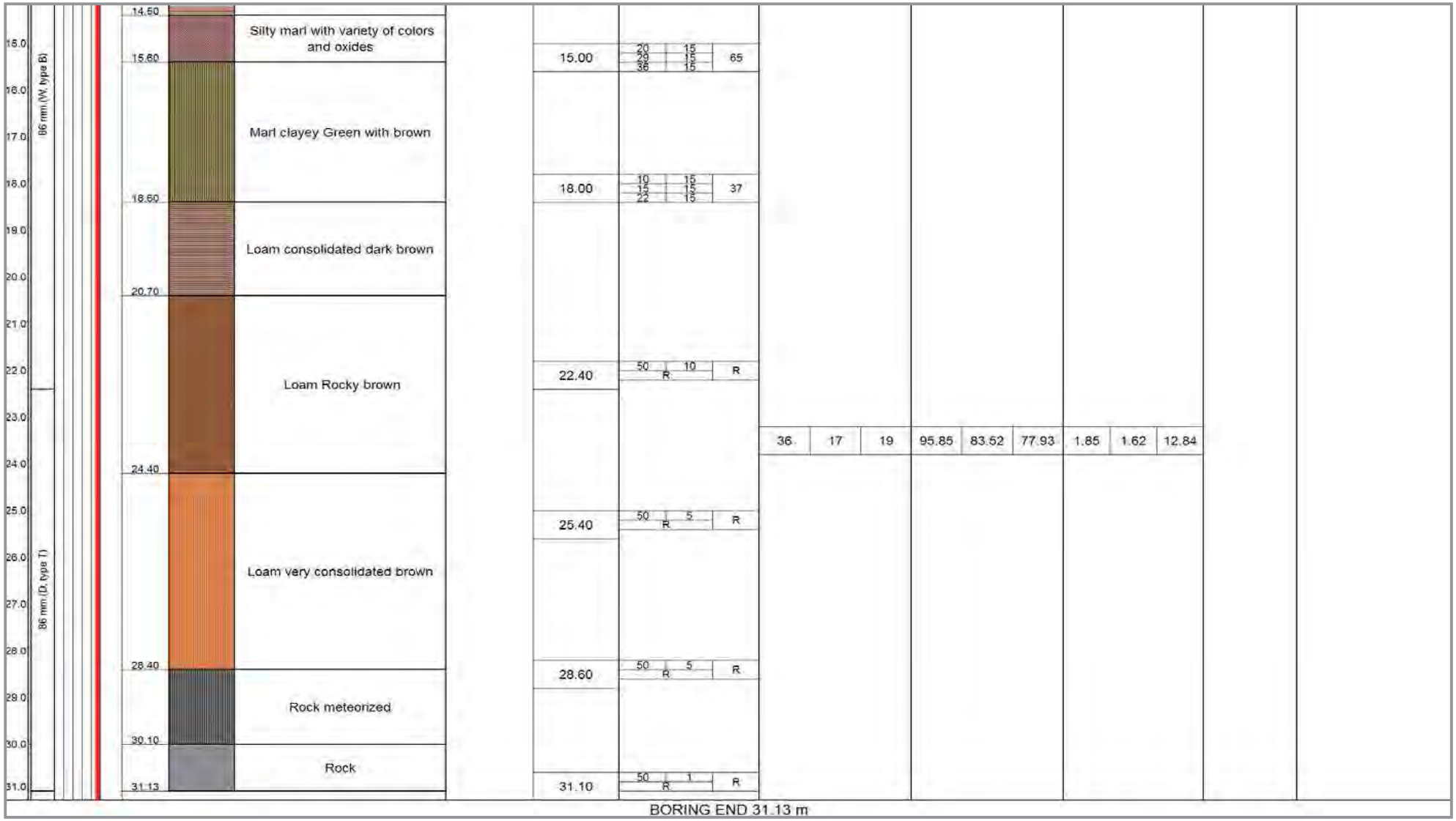

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/007 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 142
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING: SR 10
SAMPLE DATE: 10/10/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0					Loam consolidated reddish tones with black interior																	
1.0																						
2.0																						
3.0							3.20	3 4 6	15 15 15	10												
4.0				4.70							70	32	38	98.77	92.9	89.3	1.79	1.08	39.77			
5.0					Very soft soil high humidity																	
6.0							6.00	1 0 1	15 15 15	1												
7.0																						
8.0																						
9.0							9.00	1 0 0	15 15 15	0												
10.0	86 mm.(W, type B)			9.60	Consolidated Clayey loam																	
11.0				10.50	Very soft soil high humidity																	
12.0							12.60	0 0 2	15 15 15	2	63	29	34	97.09	91.21	72.35	1.75	0.92	47.47			
13.0				13.20	Consolidated Clayey loam																	
14.0				14.00	Fractured rock with color variations																	
15.0	86 mm.(D, type T)						15.60	50	5 R	50												
16.0				16.50																		
17.0				16.80	Rock in black																	

BORING END A 16.80 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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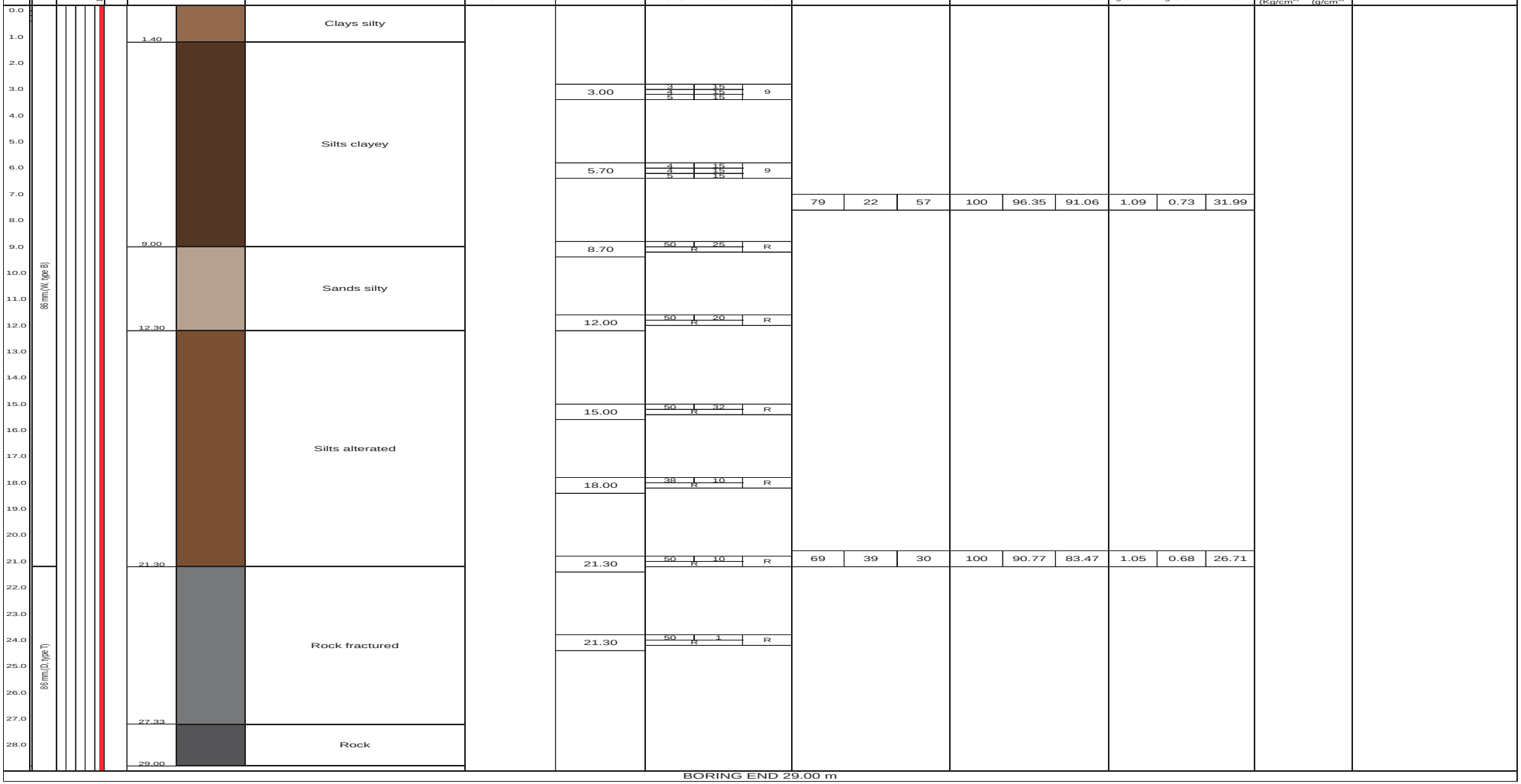
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/045 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 317
Equipment: RL-48

Analyst: Juan Ffrancisco Fernandez

BORING: SR 31
DATE: 10/12/2013



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/008 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 143
Equipment: Rolatec 400

Analyst: Juan Antonio Cortez

BORING : SR 11
SAMPLE DATE: 10/10/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W, type B)			0.60	Loam reddish																	
1.0				1.60	Silt brown color with some gravel and pebbles																	
2.0				2.40	Grayish rock															1040	2.76	
3.0					Loam reddish		3.00	27 34 39	15 15 15	73	Sample No Plastic			88.15	36.76	31.01	ROCK					
4.0																						
5.0				5.10																		
6.0	86 mm.(D, type T)						6.00	50 R	3	R												
7.0				6.70	Grayish meteorized rock						Sample No Plastic			ROCK			ROCK					
8.0																						
9.0				9.00			9.00	50 R	3	R												
17.0																						

BORING END A 9.00 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/0017 LINE 3 RAILWAY Sample N°: 198 Analyst: Ismael Arroyo **BORING : SR 32**

CUSTOMER: NIPPON KOEI Equipment: RL-48 **DATE: 28/10/2013**

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W, type B)			0.60	Vegetable ground																	
1.0				1.25	Dark brown Loam						31	17	14	42.54	14.61	6.18	2.04	1.67	18.19			
2.0	86 mm.(D, type B)			2.00	Rock, with a tone Blue-Black																	
3.0							3.00	50 R	5	R												
4.0											ROCK			ROCK			ROCK			1122	2.66	
5.0				5.42			5.40	50 R	2	R												

BORING END 5.42 m

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/031 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 281
Equipment: RL-48

Analyst: Juan Francisco Fernandez

BORING : SR 12
DATE: 23/11/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0																						
				0.80	Asphalt, concrete and filling																	
1.0																						
2.0					brown clay with soft edges																	
3.0							3.00	2 3 3	15 15 15	6	62	30	32	94.29	90.10	87.92	1.77	1.03	41.58			
				3.60																		
4.0					Marly clay with green veins																	
5.0																						
6.0	86 mm (W, type B)						6.00	8 13 15	15 15 15	28												
				6.60																		
7.0					Silts																	
8.0				8.40																		
				9.15	Rock fractured			50	R	R												
9.0							9.00															
10.0											NON PLASTIC MATERIAL			ROCK			ROCK			116.2	2.39	
11.0	86 mm (D, type T)				Rock																	
12.0							12.00	50	R	R												
13.0				13.80																		

BORING END 13.80 m

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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/015 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 188
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 33
DATE: 23/10/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0					Asphalt with gravel																	
				0.60																		
1.0	86 mm.(W, type B)				Marga greenish consolidated																	
2.0											45	24	21	100	98.51	93.53	1.99	1.43	28.23			
				1.98																		
3.0				3.05			3.00	50 / R	5	R												
4.0					Rock Black Fractured																	
				4.60																		
5.0	86 mm.(D, type T)																					
6.0					Rock Black		6.00	50 / R	2	R	ROCK			ROCK			ROCK			900.7	2.80	
7.0				7.70																		

BORING END 7.70 m

LCC INGENIERIA

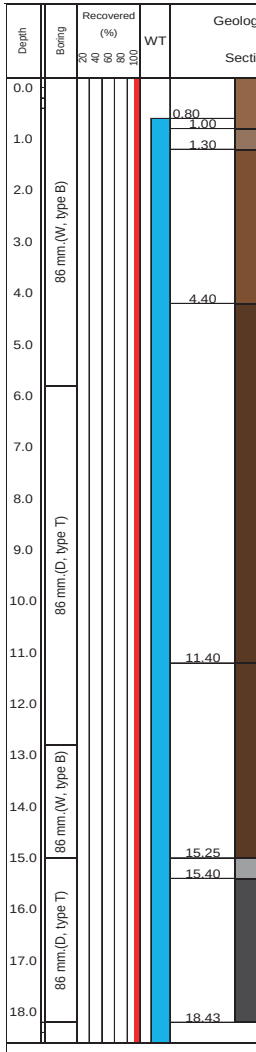
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/0016 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 197
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 13
DATE: 24/10/2013



SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
Gravel fill																	
Level rocky purple shade																	
Loam clayey light brown with black veins		3.00	1 2 2	15 15 15	4	51	26	25	100	98.7	95.3	1.79	0.97	45.85			
Loam with rocks interiors		6.00	50 R	2	R												
		9.00	50 R	10	R												
Loam consolidated brown		12.90	20 50 R	15 15	R												
			50 R	3	R	28	15	13	76.42	35.3	16.55	1.86	1.65	10.93			
Rock Fracturad		15.20	50 R	5	R												
Rock																	

BORING END 18.43 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/027 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 269
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 34
DATE: 18/11/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	101 mm.(W, type B)				Filling Material																	
1.0				1.20																		
2.0					Clay																	
3.0							3.60	6 7 9	15 15 15	16												
4.0				4.20							51	25	26	100	97.72	88.94	1.86	1.36	27.02			
5.0																						
6.0	86 mm.(W, type B)				Marl clayey brown		6.00	5 6 8	15 15 15	14												
7.0																						
8.0																						
9.0				9.45			9.00	21 33 50	15 15 R	83												
10.0					Loam very consolidated																	
11.0																						
12.0				12.45			12.00	15 22 50	15 15 R	72												
13.0					Loams interspersed with edges																	
14.0																						
15.0							15.80	50	7	R												
15.87																						
16.0					Rock bluish black						NON PLASTIC MATERIAL			3.42	3.02	2.94	ROCK	2.4	3.49			
17.0				17.40																		
18.0	86 mm.(D, type T)						18.20	50	2	R												
19.0					Rock																	
20.0																						
21.0				21.37			18.20	50	2	R												

BORING END 21.37 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

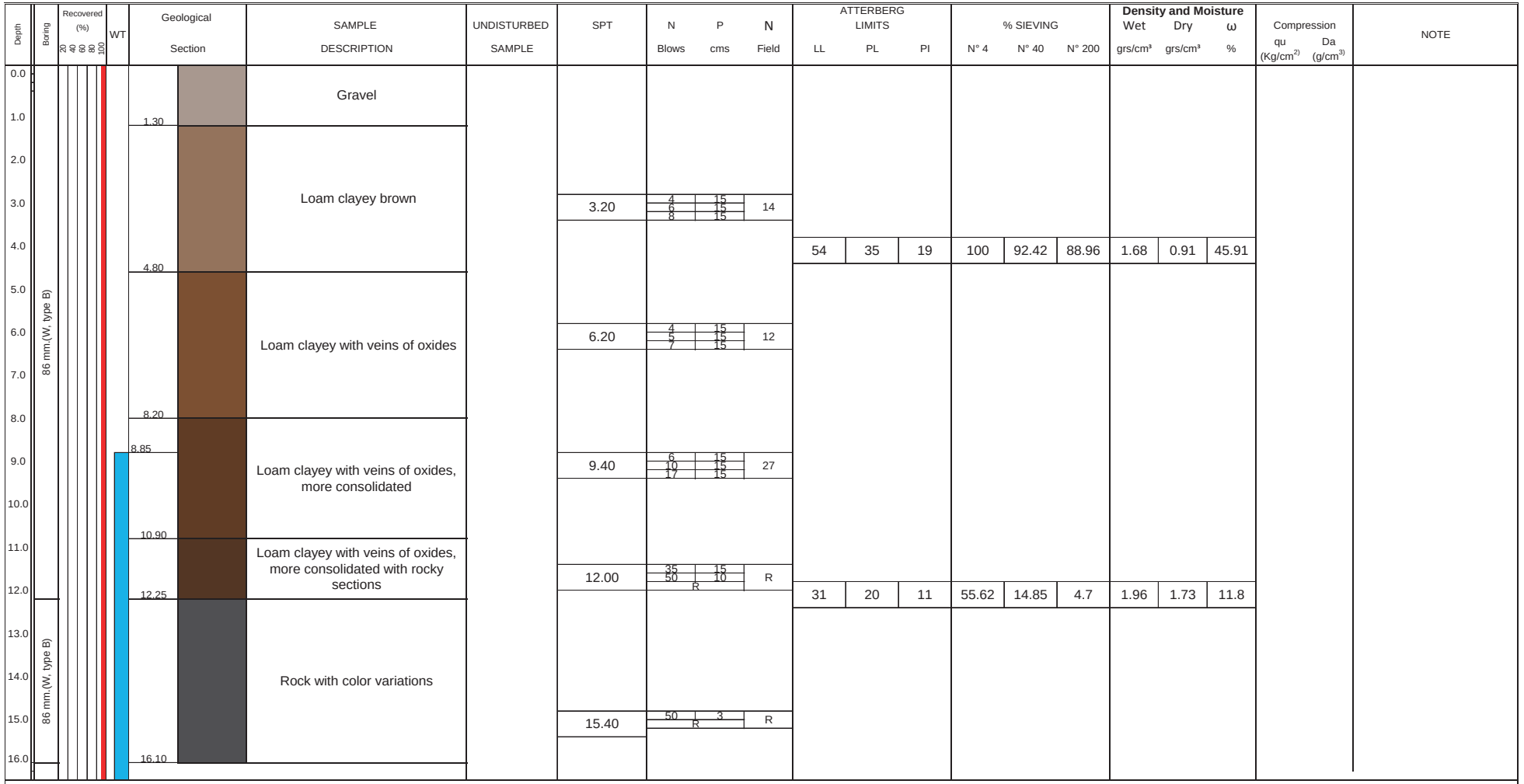
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/0018 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 200
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 14
DATE: 29/10/2013



SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
Gravel																	
Loam clayey brown		3.20	4 6 8	15 15 15	14												
						54	35	19	100	92.42	88.96	1.68	0.91	45.91			
Loam clayey with veins of oxides		6.20	4 5 7	15 15 15	12												
Loam clayey with veins of oxides, more consolidated		9.40	6 10 17	15 15 15	27												
Loam clayey with veins of oxides, more consolidated with rocky sections		12.00	35 50 R	15 10	R												
						31	20	11	55.62	14.85	4.7	1.96	1.73	11.8			
Rock with color variations		15.40	50 R	3	R												

BORING END 16.10 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/029 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 275
Equipment: RL-48

Analyst: Juan Francisco Fernandez

BORING : SR 35
DATE: 20/11/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)				Filling with pebbles and clay																	
1.0				1.40																		
2.0					brown soft Clays																	
3.0				3.20			3.00	5 8 10	15 15 15	18												
4.0					Silts with some clay brown																	
5.0											42	28	14	99.65	96.69	93.89	1.18	1.13	37.12			
6.0				6.00			6.00	6 8 10	15 15 15	18												
7.0					Silts clayey very soft																	
8.0				8.30																		
9.0					Silts with rocky ridges		9.00	5 7 9	15 15 15	16												
10.0				10.90																		
11.0					Rock fractured																	
12.0							12.00	5 6 7	15 15 15	13												
13.0																						
14.0																						
15.0							15.20	4 5 7	15 15 15	12												
16.0																						
17.0																						
18.0							18.00	5 7 9	15 15 15	16	NON PLASTIC MATERIAL			99.75	99.75	99.75	ROCA MET.	2.79	2.56			
19.0																						
20.0				20.80																		
21.0							21.00	16 24 40	15 15 15	64												
22.0					Rock																	
23.0				23.80																		

BORING END 23.80 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/019 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 200
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 15
DATE: 30/10/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	101 mm.(W. type B)			0.25	Concrete																	
				0.60	Gravel																	
1.0				1.50	Rock Fill																	
2.0				1.85	Loam clayey																	
3.0				3.60			3.60	2 3 4	15 15 15	7												
4.0					Loam clayey brown with veins yellow						52	35	17	100	95.39	91.43	1.58	0.73	53.65			
5.0																						
6.0	86 mm.(W. type B)			6.30			6.30	4 6 10	15 15 15	16												
7.0					Loam clayey light brown with veins interiors																	
8.0																						
9.0								7 10 14	15 15 15	24												
10.0							9.60															
11.0																						
12.0				12.16			12.10	50 R	6	R												
				12.60	Fractured rock						ROCK			ROCK			ROCK					
13.0	86 mm.(D. type T)				Rock with oxides of various colors															23.74	2.10	
14.0																						
15.0				15.33			15.30	50 R	3	R												
16.0					Rock with tones of blue																	
17.0				17.02			17.00	50 R	2	R												

BORING END 17.02 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

LCC INGENIERIA

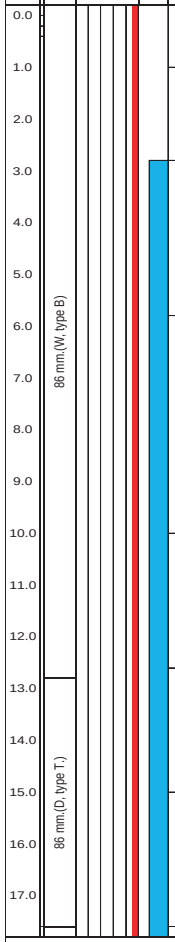
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/032 LINE3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 282
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING: SR 36
DATE: 20/11/2013



Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
1.10	Fill material																	
3.00	Clays																	
6.00	Clays sandy						51	25	26	100	97.35	92.04	1.81	1.15	36.54			
	Clays sandy		6.00	3 3 5	15 15 15	8												
			9.60	5 8 10	15 15 15	18												
10.20	Clay light brown																	
			12.20	12 13 14	15 15 15	27												
12.80	Altered rock with white veins						NON PLASTIC MATERIAL			ROCK METEORIZED			ROCK MET.	2.80	4.30			
15.20	Rock		15.70	50	2	R												
17.62			15.70	50	2	R												

BORING END 17.62 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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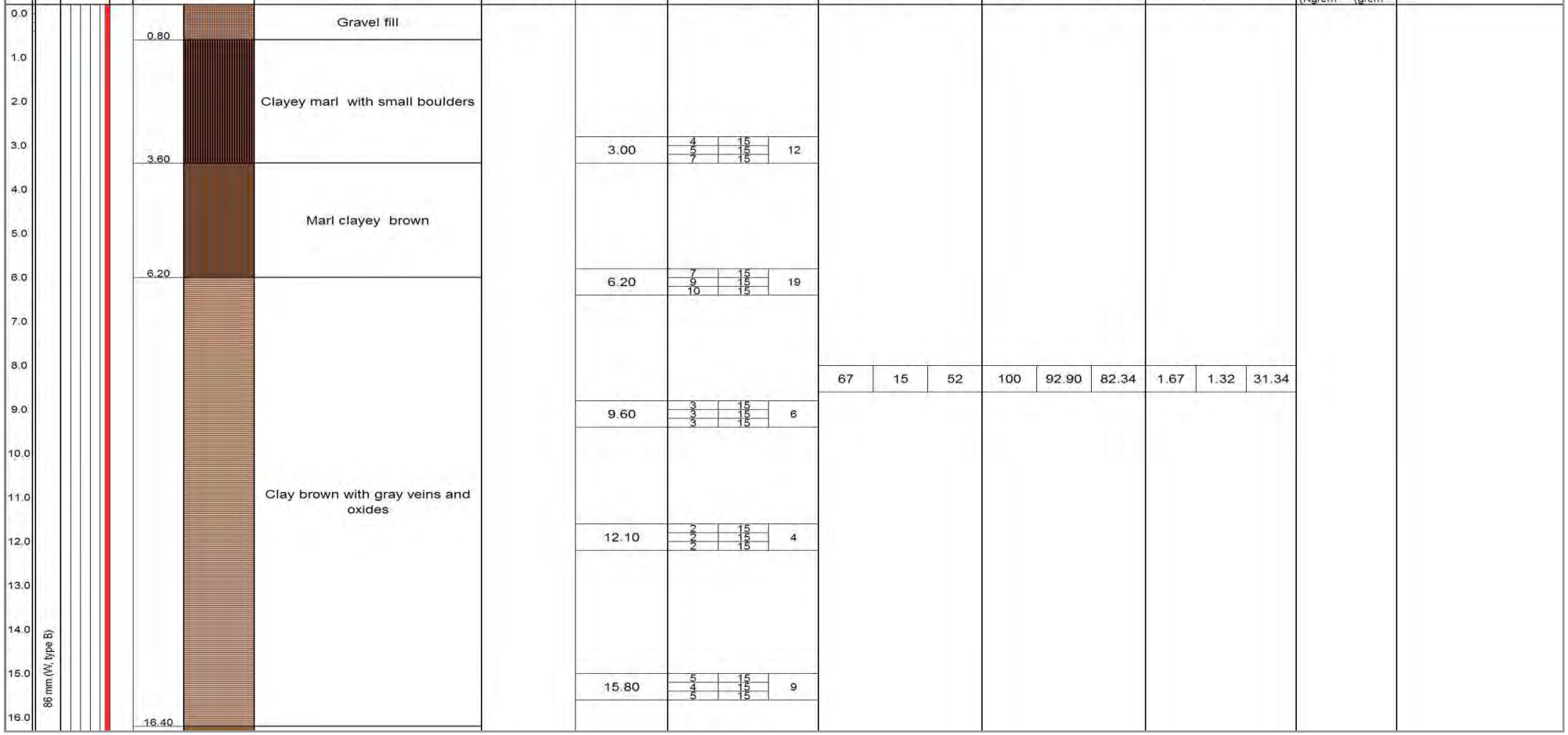
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/043 LINE3 RAILWAY Sample N°: 315 Analyst: Ismael Arroyo **BORING : SR 16**
CUSTOMER: NIPPON KOEI Equipment: ROLATEC 400 **DATE: 7/12/2013**



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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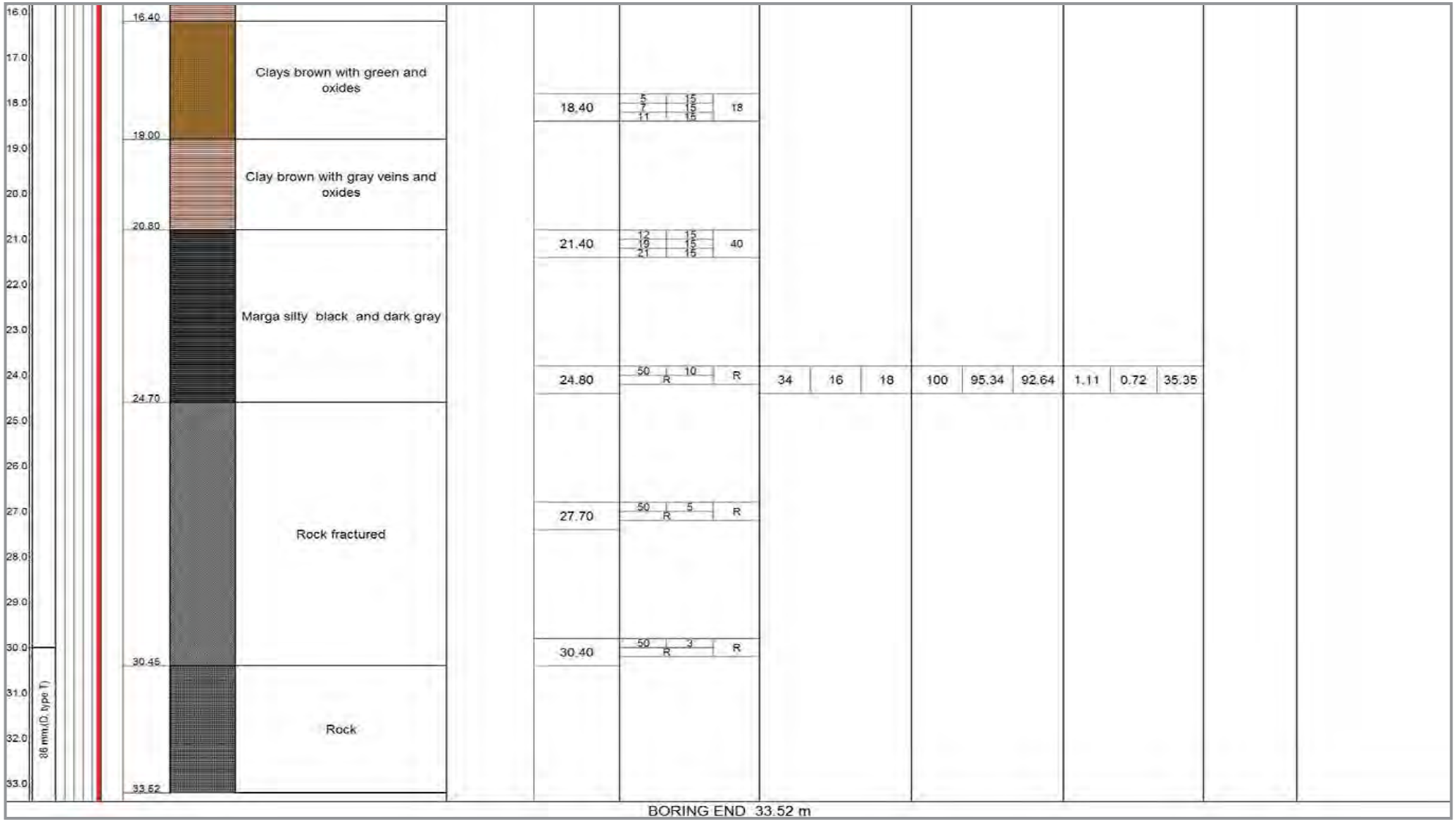

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/047 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 332
Equipment: RL-48

Analyst: Juan Francisco Fernandez

BORING : SR 37
DATE: 12/12/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)				Silts clayey																	
1.0				1.65																		
2.0					Clay brown																	
3.0							3.00	4 7 7	15 15 15	14												
4.0																						
5.0																						
6.0				6.60			6.00	5 8 8	15 15 15	16	83	15	68	100	94.98	91.05	1.54	1.41	36.32			
7.0					Clay brown																	
8.0																						
9.0							9.00	3 4 4	15 15 15	8												
10.0																						
11.0																						
12.0							12.00	1 2 4	15 15 15	6												
13.0																						
14.0																						
15.0				15.40			15.00	50	R	R												
16.0					Fractured and altered rock cemented silts																	
17.0																						
18.0				18.05			18.00	50	R	R	56	42	14	81.85	65.56	61.42	1.72	1.46	28.11			
19.0	86 mm.(D. type T)																					
20.0					Rock fractured																	
21.0							20.90	50	R	R												
22.0				22.20																		
23.0					Rock																	
24.0							24.30	50	R	R												
25.0				25.30																		

BORING END 25.30 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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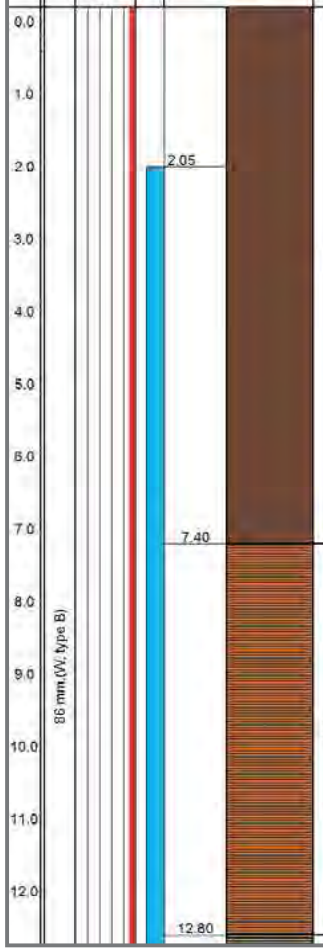
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/020 LINE 3 RAILWAY | Sample N°: 211 | Analyst: Ismael Arroyo | **BORING : SR 17**
CUSTOMER: NIPPON KOEI | Equipment: Rolatec 400 | **DATE: 1/11/2013**



SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
Loam clayey Dark brown with veins of various colors		3.40	4 7 4	15 15 15	11												
		6.20	5 7 10	15 15 15	17	56	29	27	100	99.22	95.42	1.78	1.14	35.89			
Loam sandy with veins of green tone		9.60	5 8 10	15 15 15	18												
		12.20	4 5 6	15 15 15	11												

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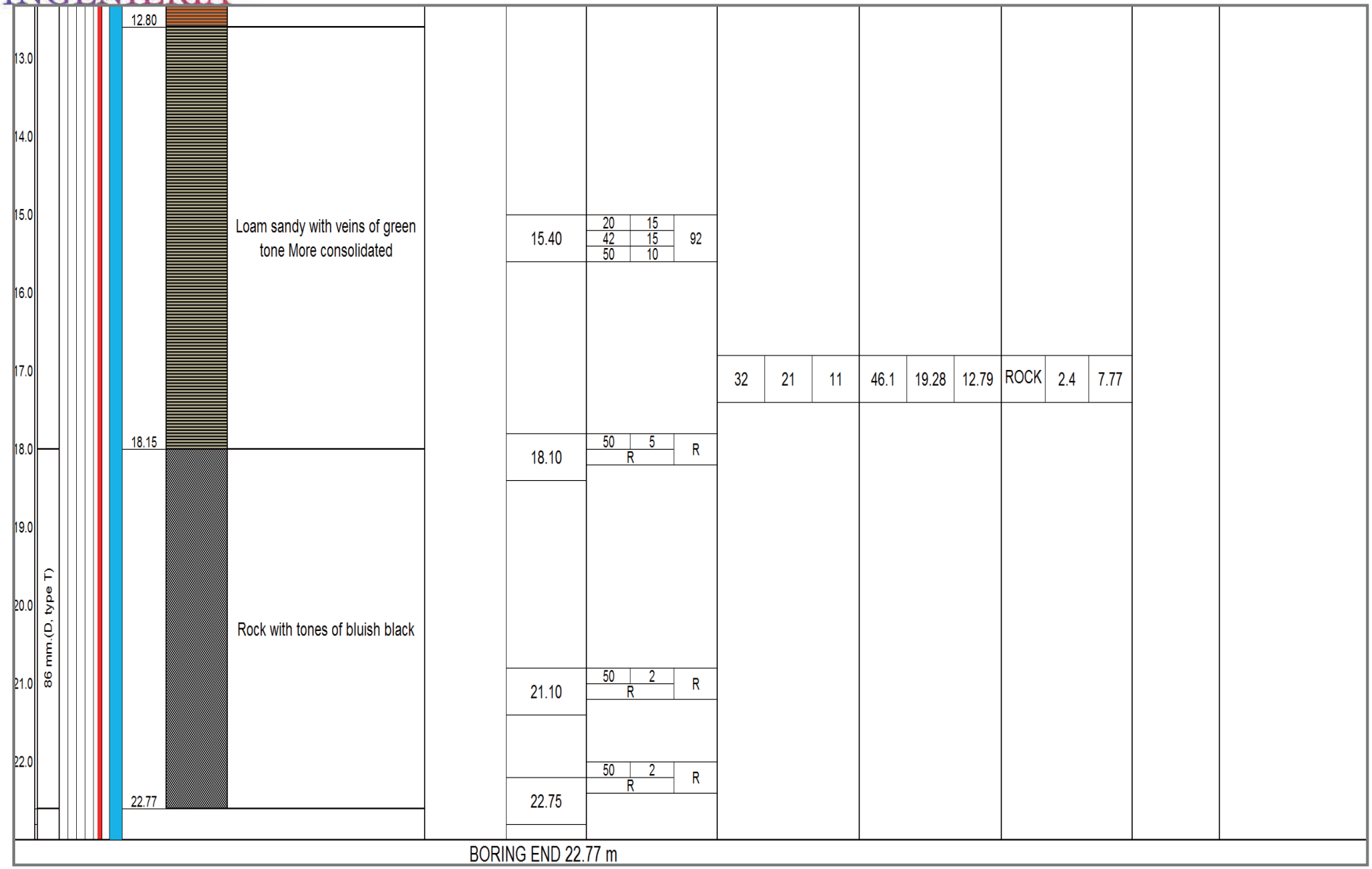

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/028 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 274
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 39
DATE: 20/11/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm (W. type B)			0.60	Concrete (0.20 m) with gravel fill																	
1.0					Clay brown																	
2.0																						
3.0				3.60			3.00	5 8 10	15 15 15	18												
4.0					Marly clay with green veins																	
5.0																						
6.0							6.00	6 8 10	15 15 15	18												
7.0											76	34	42	99.97	98.81	97.48	1.83	1.18	35.34			
8.0																						
9.0				9.60			9.00	5 7 9	15 15 15	16												
10.0					Clay with veins muticolor																	
11.0																						
12.0							12.00	5 6 7	15 15 15	13												
13.0																						
14.0																						
15.0							15.20	4 5 7	15 15 15	12												
16.0																						
17.0																						
18.0							18.00	5 7 9	15 15 15	16												
19.0																						
20.0				21.00																		
21.0					Loam consolidated		21.00	16 24 40	15 15 15	64												
22.0																						
23.0											42	34	8	100	97.33	89.83	1.79	1.16	35.33			
24.0				24.40			24.40	21 37 50	15 15 10	87												
25.0																						
26.0																						
27.0				27.75			27.20	50	R	0												
28.0	86 mm (D. type T)				Rock																	
29.0							27.20	50 R	5	R												
30.0				30.45				50 R	5	R												

BORING END 30.45 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/046 LINE 3 RAILWAY Sample N°: 328 Analyst: Ismael Arroyo **BORING : SR 38**
CUSTOMER: NIPPON KOEI Equipment: Rolatec 400 **DATE: 11/12/2013**

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm (W. type B)				Silts clayey																	
0.90																						
1.0																						
2.0																						
3.0					Clay marly brown		3.00	5 5 6	15 cm/cm	11												
4.0																						
5.0																						
6.00																						
6.0							6.00	4 6 9	15 cm/cm	15												
7.0																						
8.0					Clay brown with water																	
9.00																						
9.0							9.00	7 10 13	15 cm/cm	23												
9.60																						
10.0											76	25	51	100	96.17	92.31	1.14	1.89	21.76			
11.0																						
12.0					Silt clayey gray with yellow		12.20	6 10 11	15 cm/cm	21												
13.0																						
14.0																						
15.0							15.00	9 10 12	15 cm/cm	22												
15.60																						
16.0																						
17.0					Marl silty brown																	
18.0							18.00	10 11 14	15 cm/cm	25												
18.60																						

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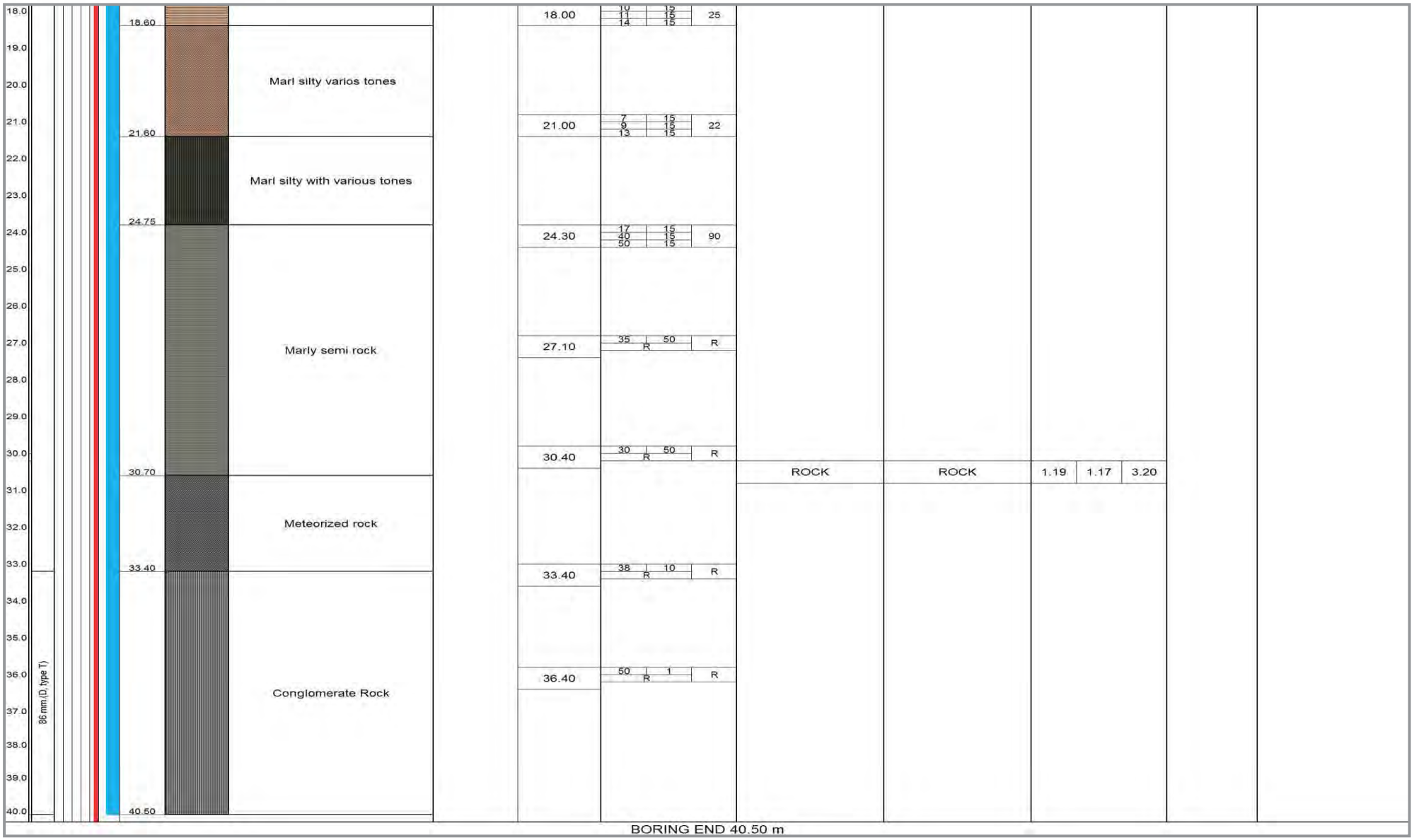

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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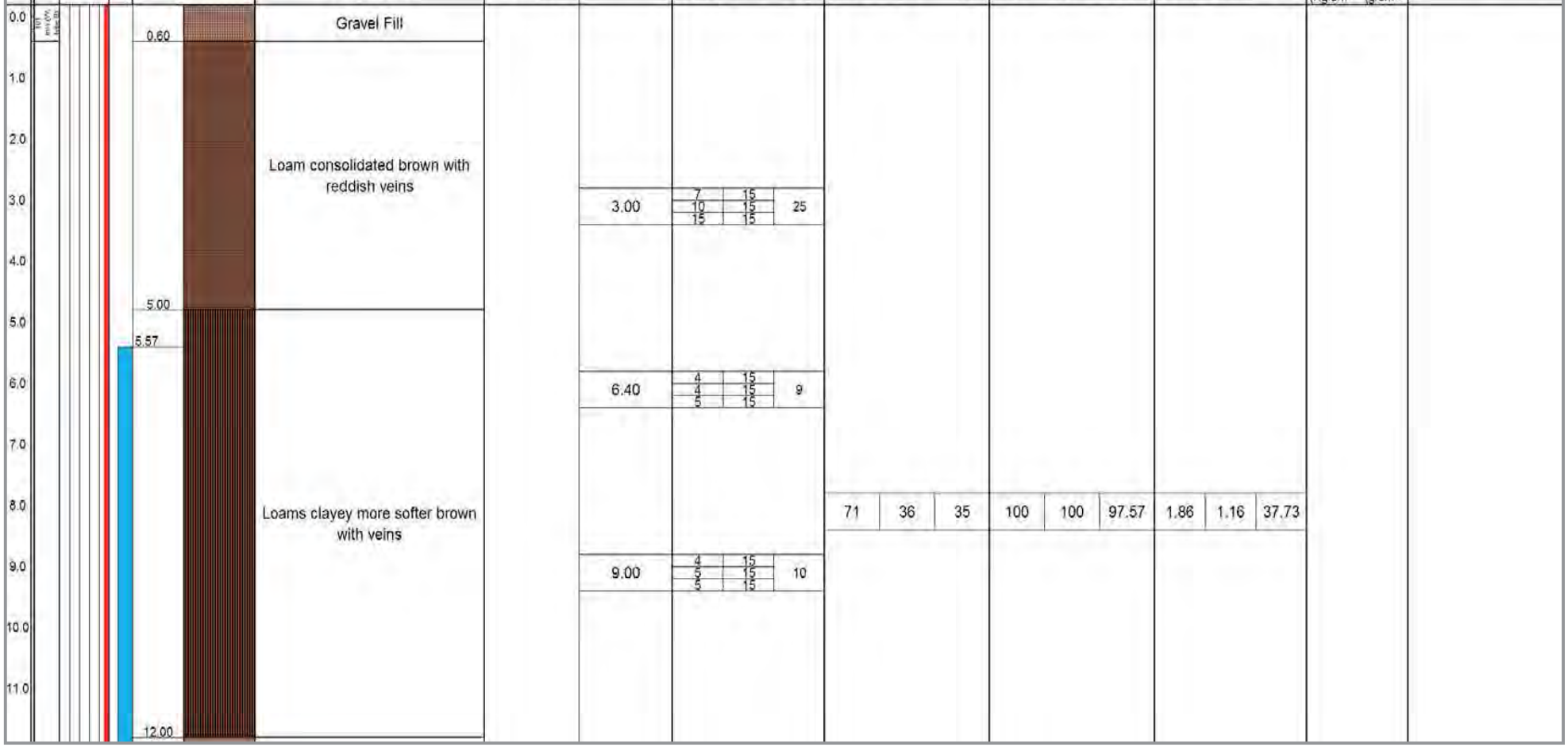
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/023 LINE 3 RAILWAY | Sample N°: 241 | Analyst: Ismael Arroyo | **BORING : SR 18**
CUSTOMER: NIPPON KOEI | Equipment: Rolatec 400 | **DATE: 8/11/2013**



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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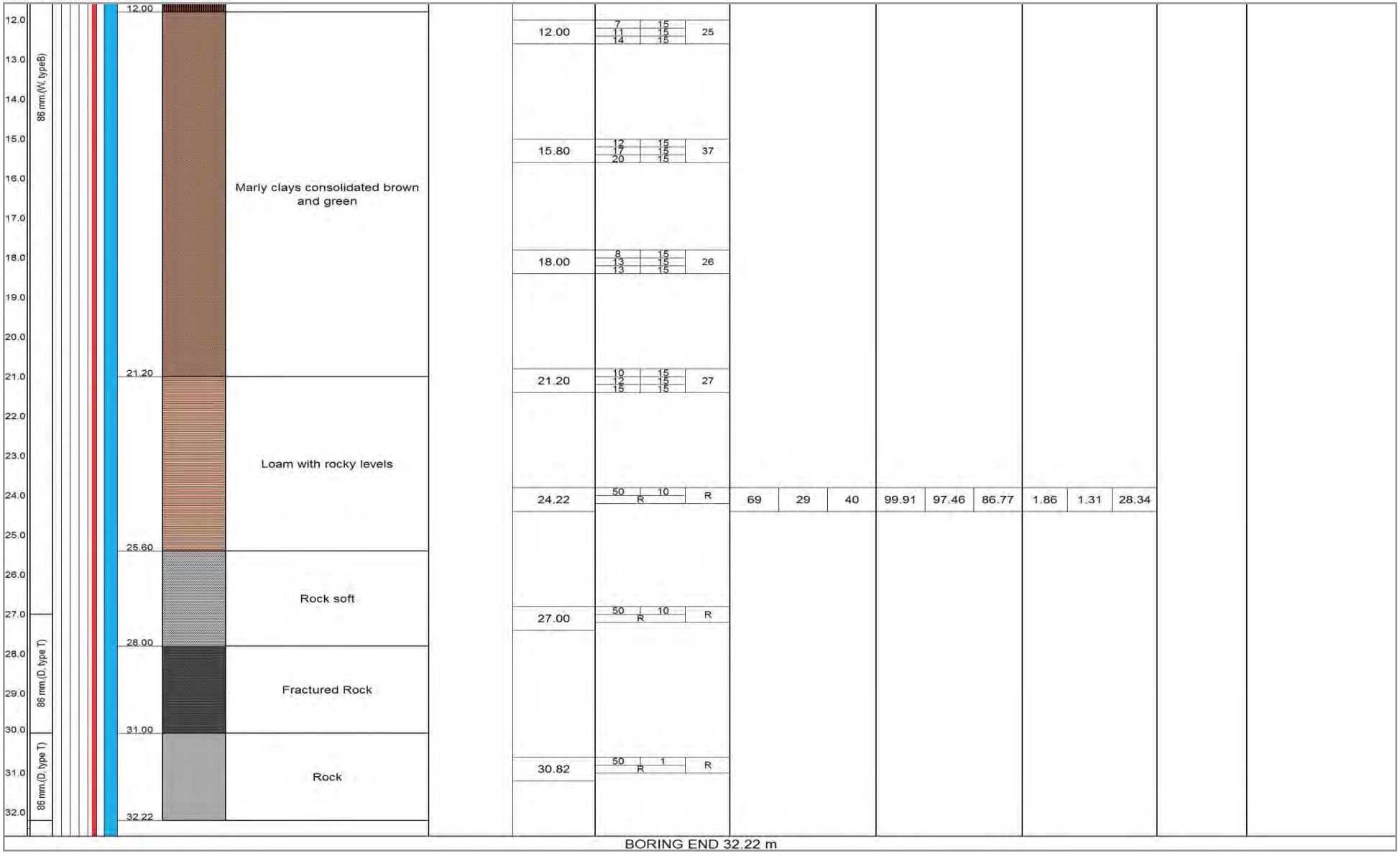

12.00	7 11 14	15 15 15	25								
15.80	12 17 20	15 15 15	37								
18.00	8 13 13	15 15 15	26								
21.20	10 12 15	15 15 15	27								
24.22	50 R	10	R	69	29	40	99.91	97.46	86.77	1.86	1.31	28.34
27.00	50 R	10	R								
30.82	50 R	1	R								

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/030 LINE 3 RAILWAY Sample N°: 280 Analyst: Ismael Arroyo **BORING: SR 40**
CUSTOMER : NIPPON KOEI Equipment: Rolatec 400 **DATE: 23/11/2013**

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)			0.60	Gravel fill																	
1.0				1.40	Clay marly																	
2.0					Gravel																	
3.0				3.60			3.00	1 1 1	15 15 15	2												
4.0					Marly clay with green veins																	
5.0																						
6.0							6.80	4 6 6	15 15 15	11	76	28	48	99.45	94.67	93.52	1.71	0.81	52.8			
7.0				7.40																		
8.0					Clayey Loam																	
9.0				9.80			9.20	12 14 14	15 15 15	28												
10.0					Marl sandy with rounded edges																	
11.0																						
12.0				12.60			12.00	8 11 13	15 15 15	24												

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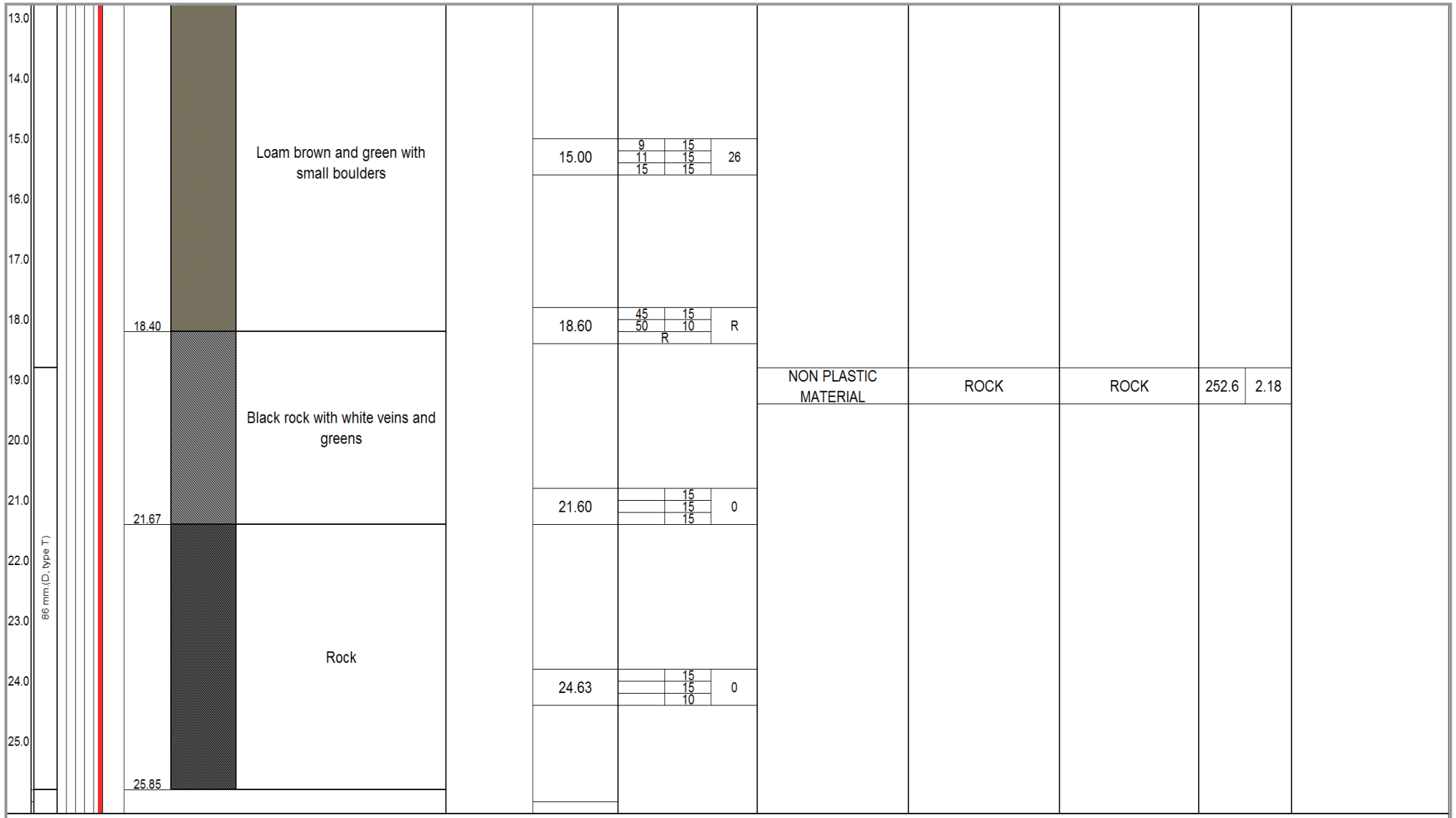

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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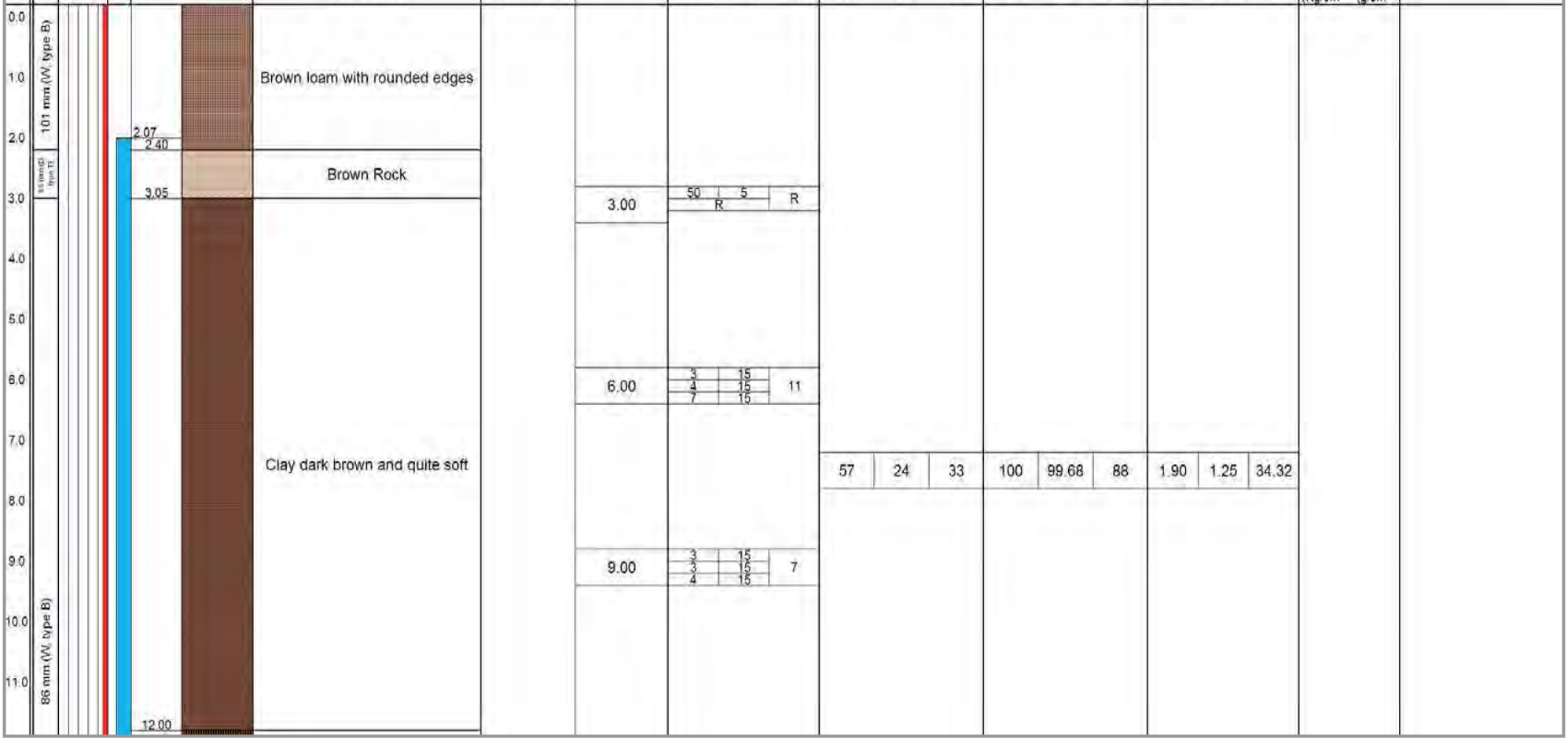
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/022 LINE 3 RAILWAY | Sample N°: 238 | Analyst: Ismael Arroyo | **BORING : SR 19**

CUSTOMER: NIPPON KOEI | Equipment: Rolatec 400 | **DATE: 6/11/2013**



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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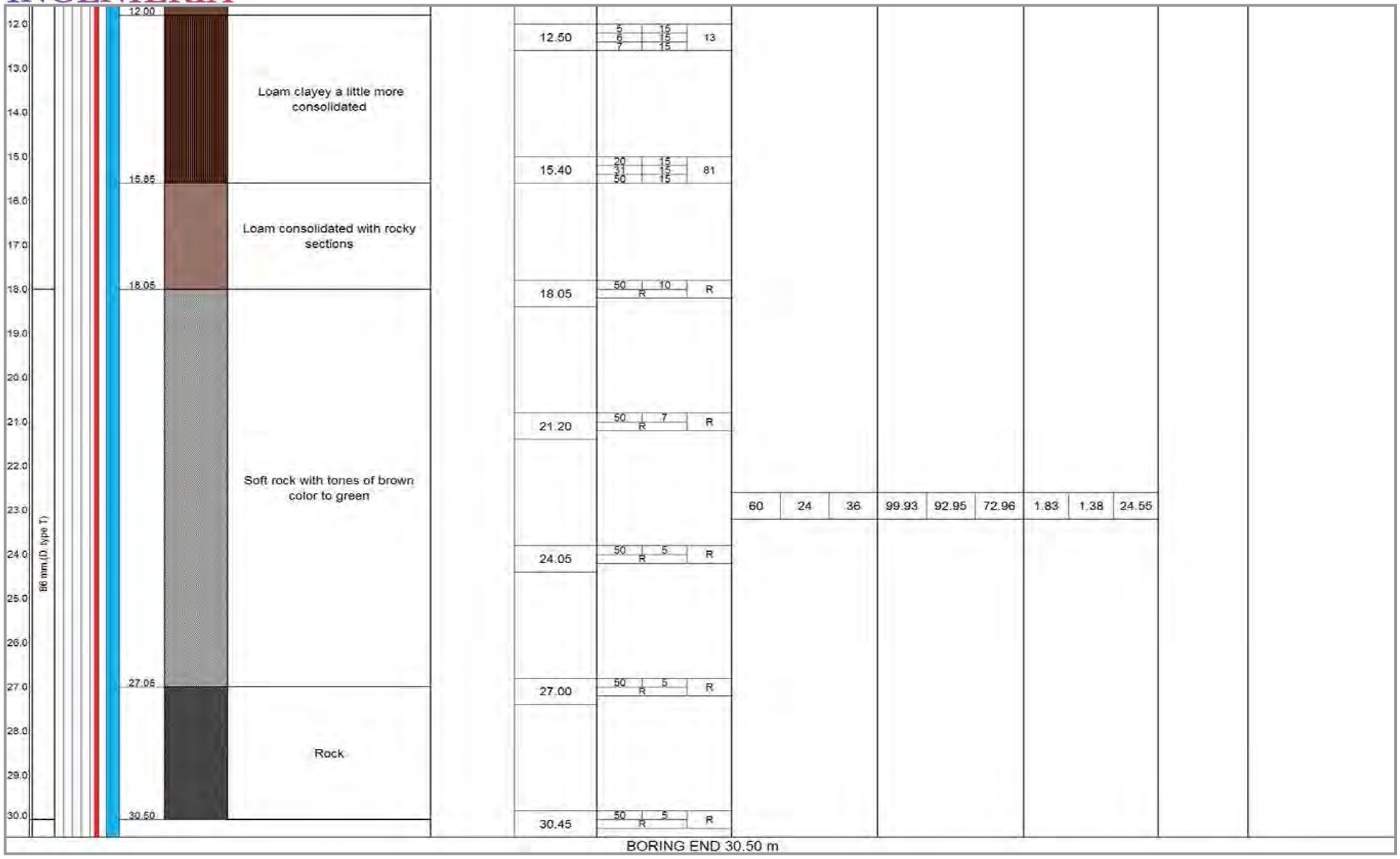

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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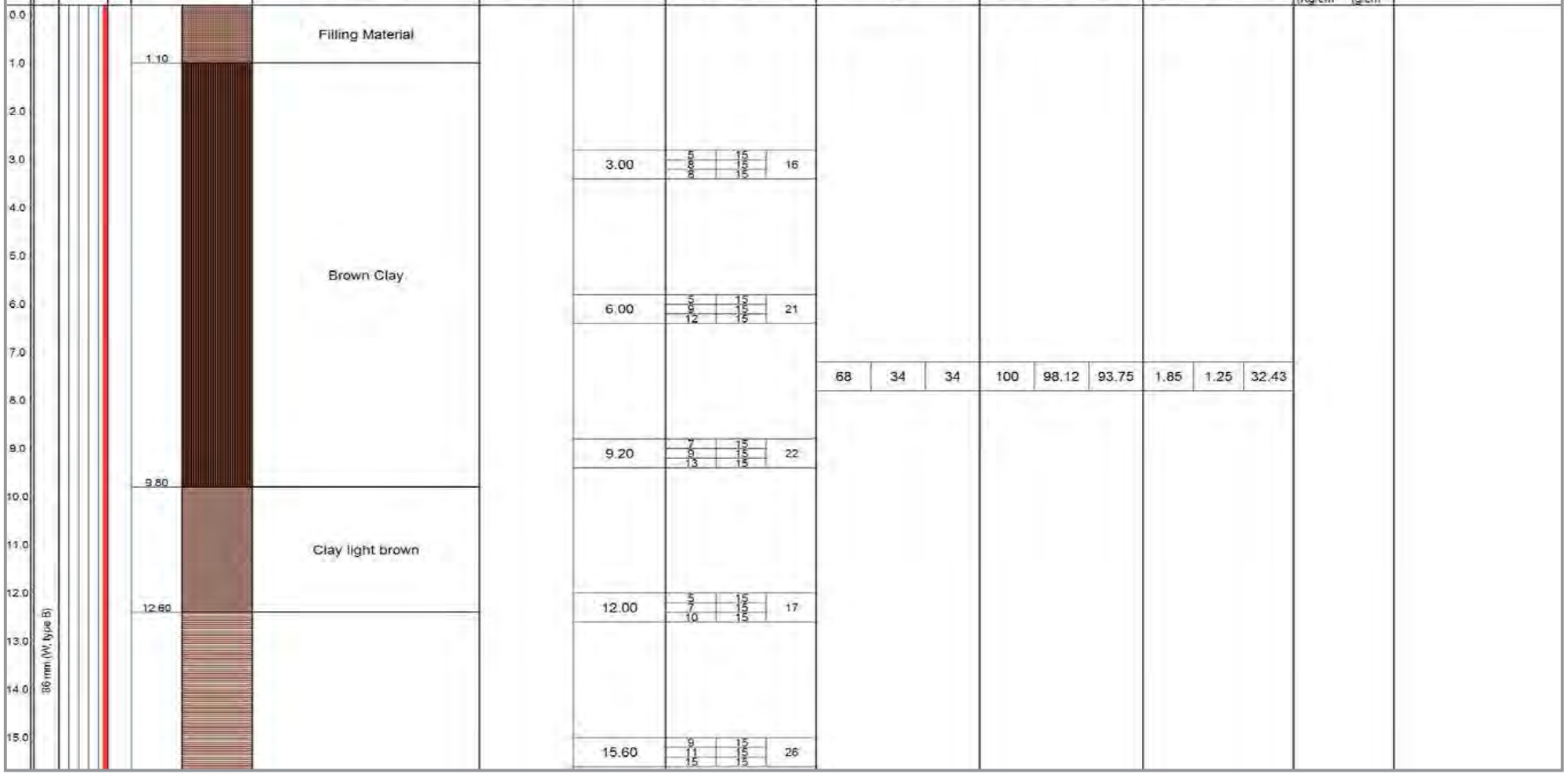
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/026 LINE 3 RAILWAY Sample N°: 260 Analyst: Ismael Arroyo **BORING : SR 41**
CUSTOMER: NIPPON KOEI Equipment: Rolatec 400 **DATE: 15/11/2013**



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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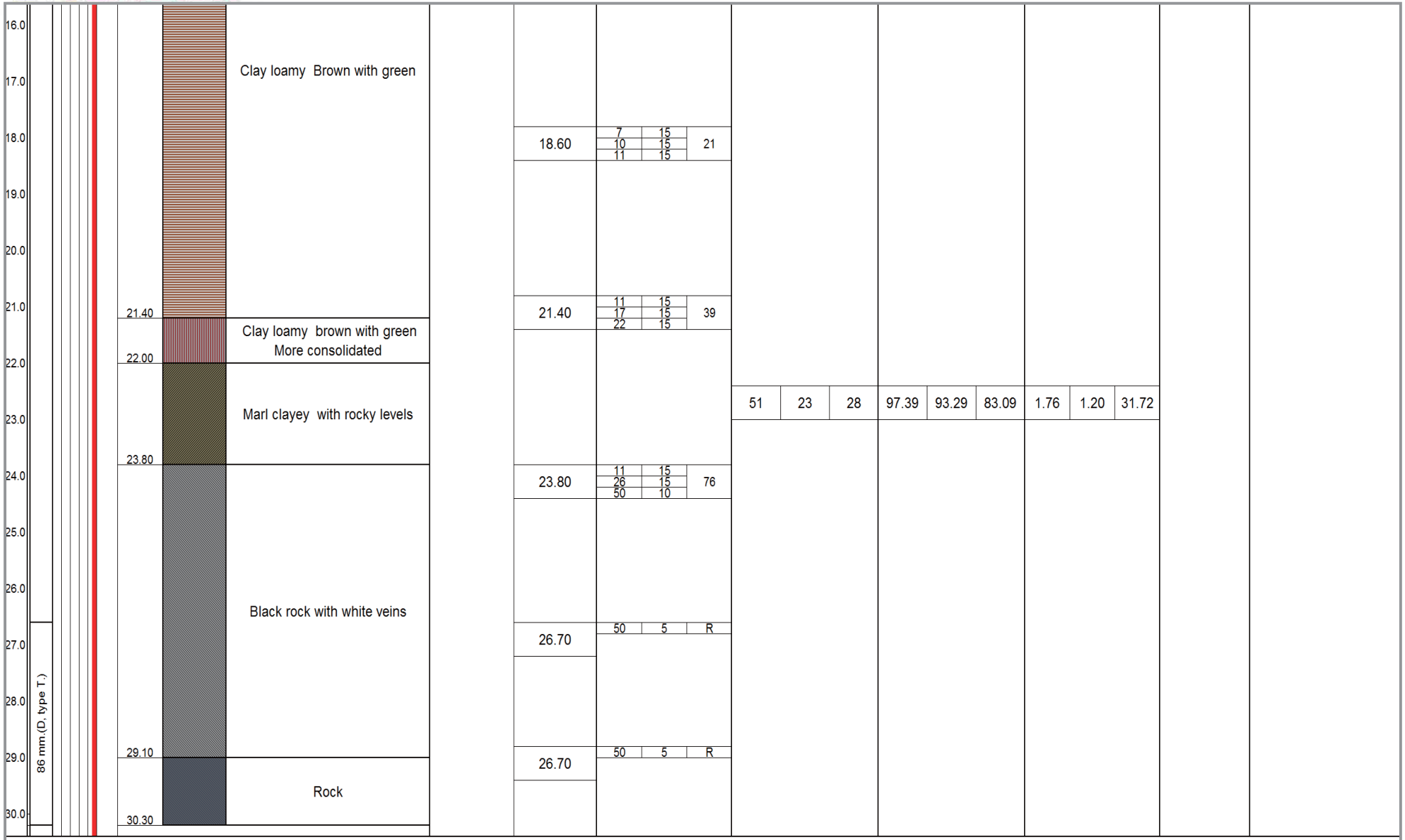

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/024 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 250
Equipment: Rolatec 400

Analyst: Ismael Arroyo

BORING : SR 20
DATE: 13/11/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	101 mm.(W, type B)				Concrete and base layer																	
0.80																						
1.0																						
2.0																						
3.0	86 mm.(W, type B)				Consolidated Loam grayish color with veins		3.40	9 11 17	15 15 15	28												
3.35																						
4.0											44	31	13	100	99.67	92.24	1.81	1.13	37.46			
5.0																						
6.0							6.20	25 50 R	15 15	R												
6.50																						
7.0					Loam very consolidated																	
7.40																						
8.0					Fractured Rock																	
8.32							8.30	50 R	2	R												
9.0																						
10.0																						
11.0	86 mm.(D, type T)				Rock						ROCK			ROCK			ROCK			937.1	2.43	
12.0							8.30	50 R	3	R												
13.0																						
14.0																						
15.0																						
15.22							15.20	50 R	2	R												

BORING END 15.22 m

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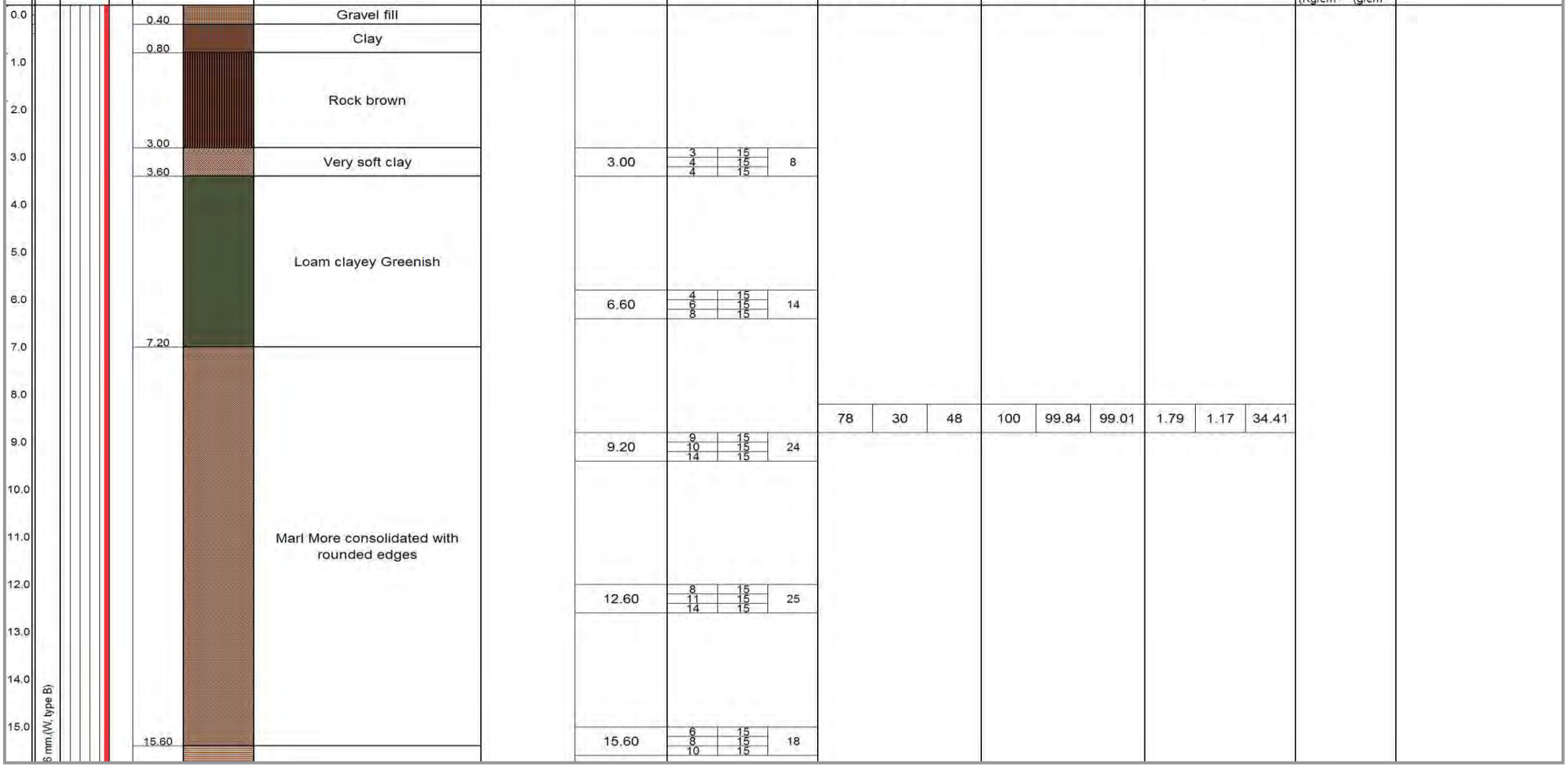
2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/025 LINE 3 RAILWAY | Sample N°: 259 | Analyst: Ismael Arroyo | **BORING : SR 21**
CUSTOMER: NIPPON KOEI | Equipment: Rolatec 400 | **DATE: 13/11/2013**



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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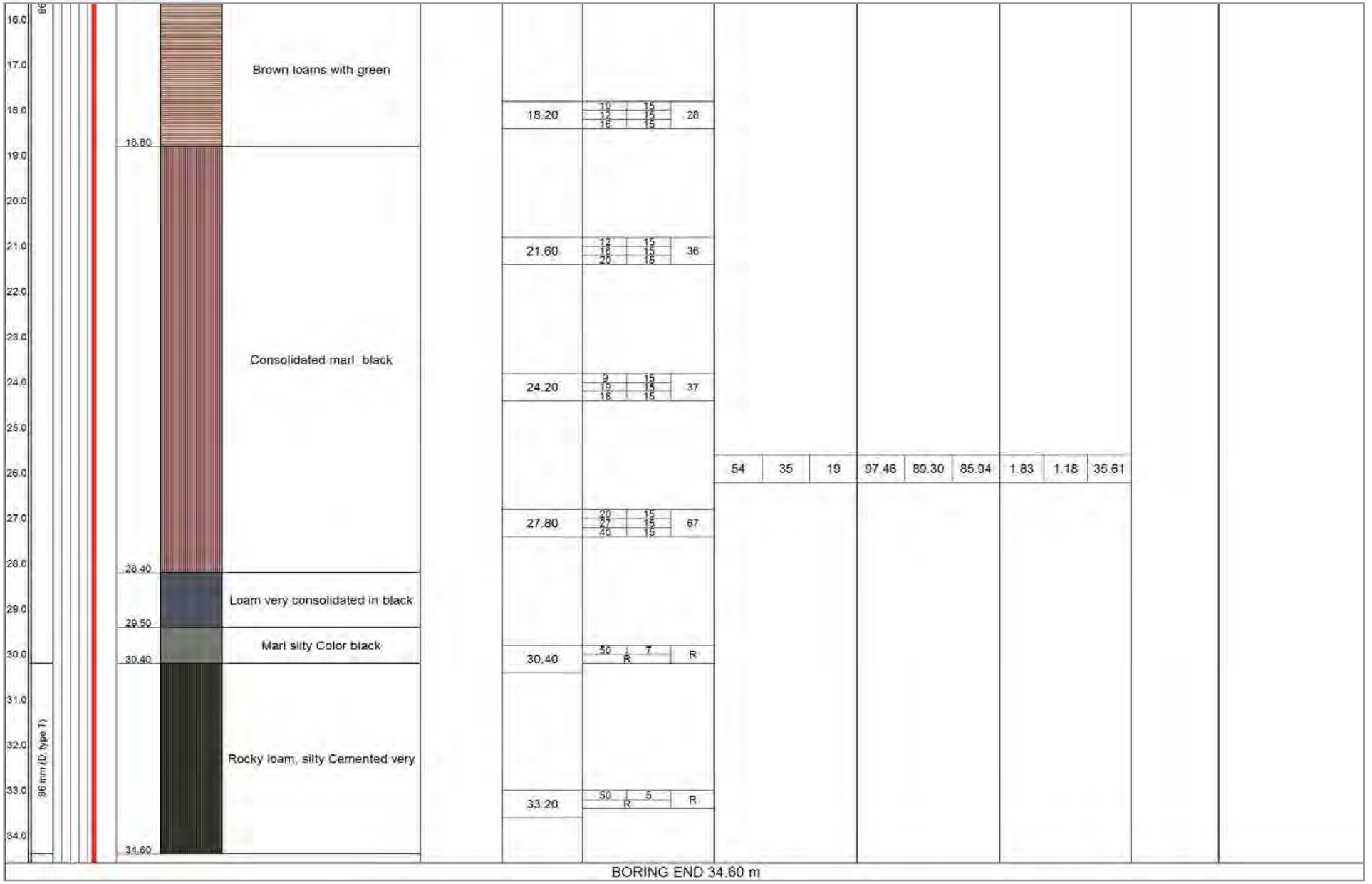

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/036 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 297
Equipment: RL-48

Analyst: Juan Francisco Fernandez

BORING : SR 42
DATE: 29/11/2013

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm (W. type B)				Vegetable ground with clays																	
1.40																						
1.0					Clay brown																	
2.0																						
3.40																						
3.0							2.80	3 4 6	15 15 15	10												
4.0					Silts clayey light brown																	
5.0																						
6.0							6.20	4 3 2	15 15 15	5												
6.80																						
7.0					Silty clayey sand with boulders						33	22	11	98.45	84.21	72.42	1.84	1.43	24.56			
8.0																						
9.0							9.20	5 6 8	15 15 15	14												
9.80																						
10.0					Silts with some clays and altered sections																	
11.0																						
12.0							12.00	13 16 25	15 15 15	41												
13.0																						
14.0																						
15.0							15.00	50	R	R												
16.0																						
17.0																						
18.00																						
18.0					Silts altered with rocky sections		18.00	40 R	10	R												
19.0																						
20.0																						
21.0							21.00	50 R	10	R	52	19	33	100	92	84.96	1.13	0.65	36.75			
21.50																						
22.0					Loam very consolidated brown																	
23.0																						
24.0							24.10	50 R	10	R												
25.0																						
26.0																						
26.70																						
27.0	86 mm (D. type T)				Rock		27.13	50 R	2	R												
28.0																						
28.70																						

BORING END 28.70 m

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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2. BORING GRAPHIC REPRESENTATION

WORK : C/010/001/033 LINE 3 RAILWAY | Sample N°: 292 | Analyst: Ismael Arroyo | **BORING : SR 43**
CUSTOMER: NIPPON KOEI | Equipment: Rolatec 400 | **DATE: 27/11/2013**

Depth	Boring	Recovered (%)	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm (IV, type B)				Silts clayey																	
1.0				1.40																		
2.0					brown loams																	
3.0							3.00	3 4 4	15 15 15	8												
4.0																						
5.0																						
6.0				6.60			6.00	4 6 9	15 15 15	15												
7.0					Loam with oxides greenish																	
8.0																						
9.0							9.00	3 3 4	15 15 15	7												
10.0											47	27	20	100	97.69	88.46	1.49	0.53	64.35			
11.0																						
12.0				12.60			12.00	4 6 6	15 15 15	12												
13.0					Loam with oxides																	
14.0																						
15.0							15.00	6 8 10	15 15 15	18												
16.0																						
17.0																						
18.0				18.00			18.00	18 24 36	15 15 15	60												

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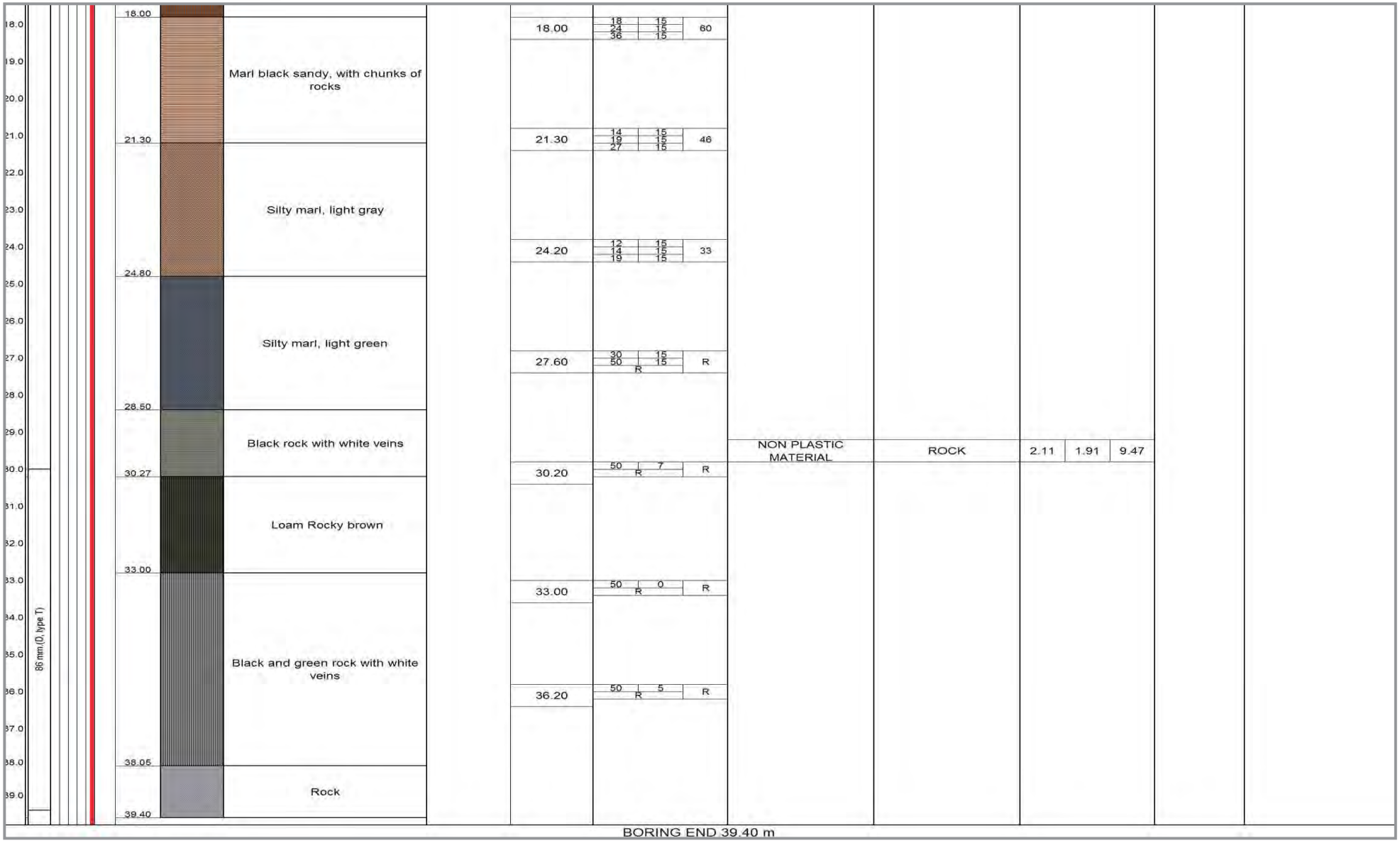

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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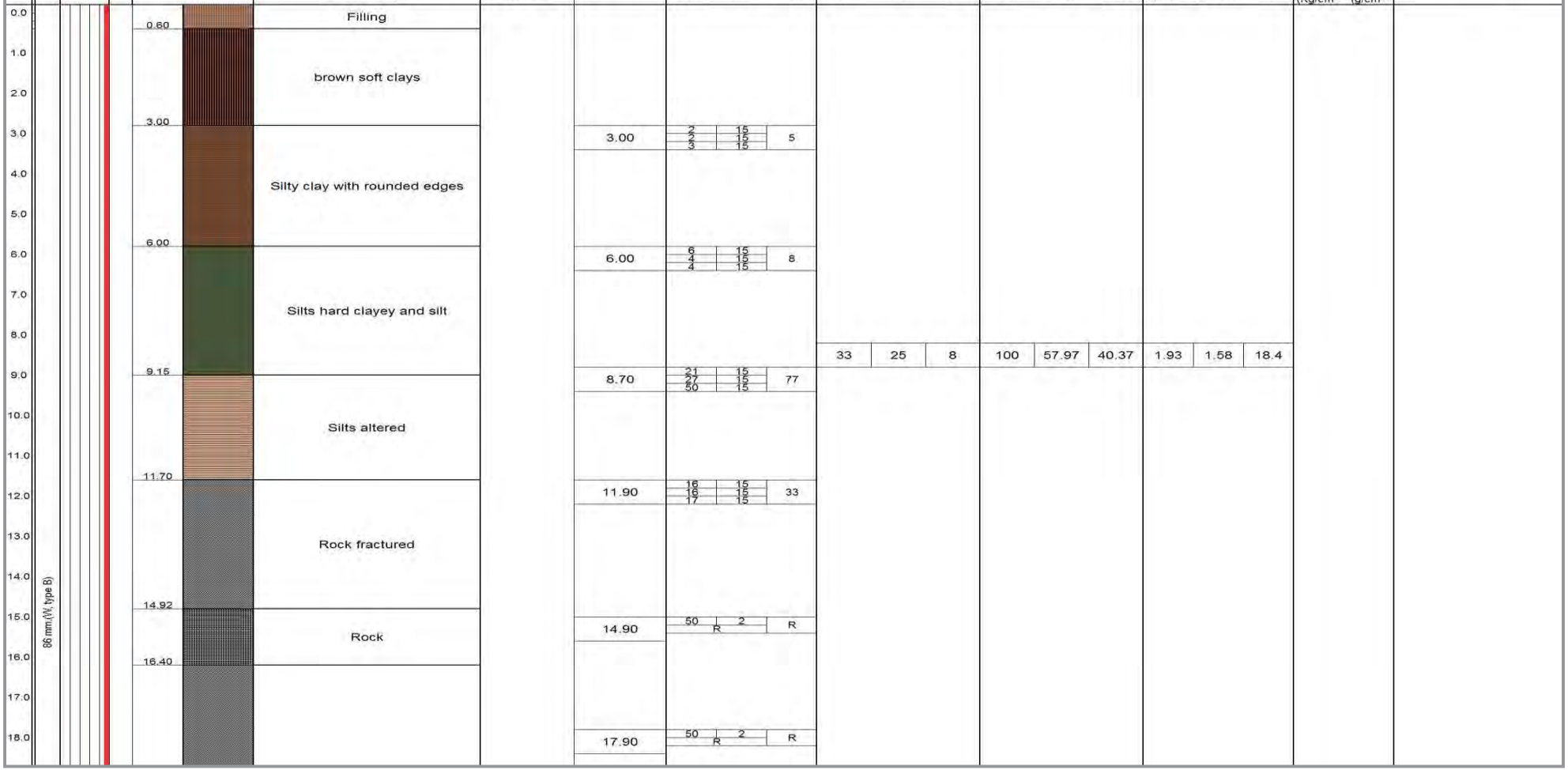
2. BORING GRAPHIC REPRESENTATION

CUSTOMER: C/010/001/034 LINE 3 RAILWAY Sample N°: 293 Analyst: Juan Francisco Fernandez **BORING : SR 44**
CUSTOMER: NIPPON KOEI Equipment: RL-48 **DATE: 25/11/2013**



Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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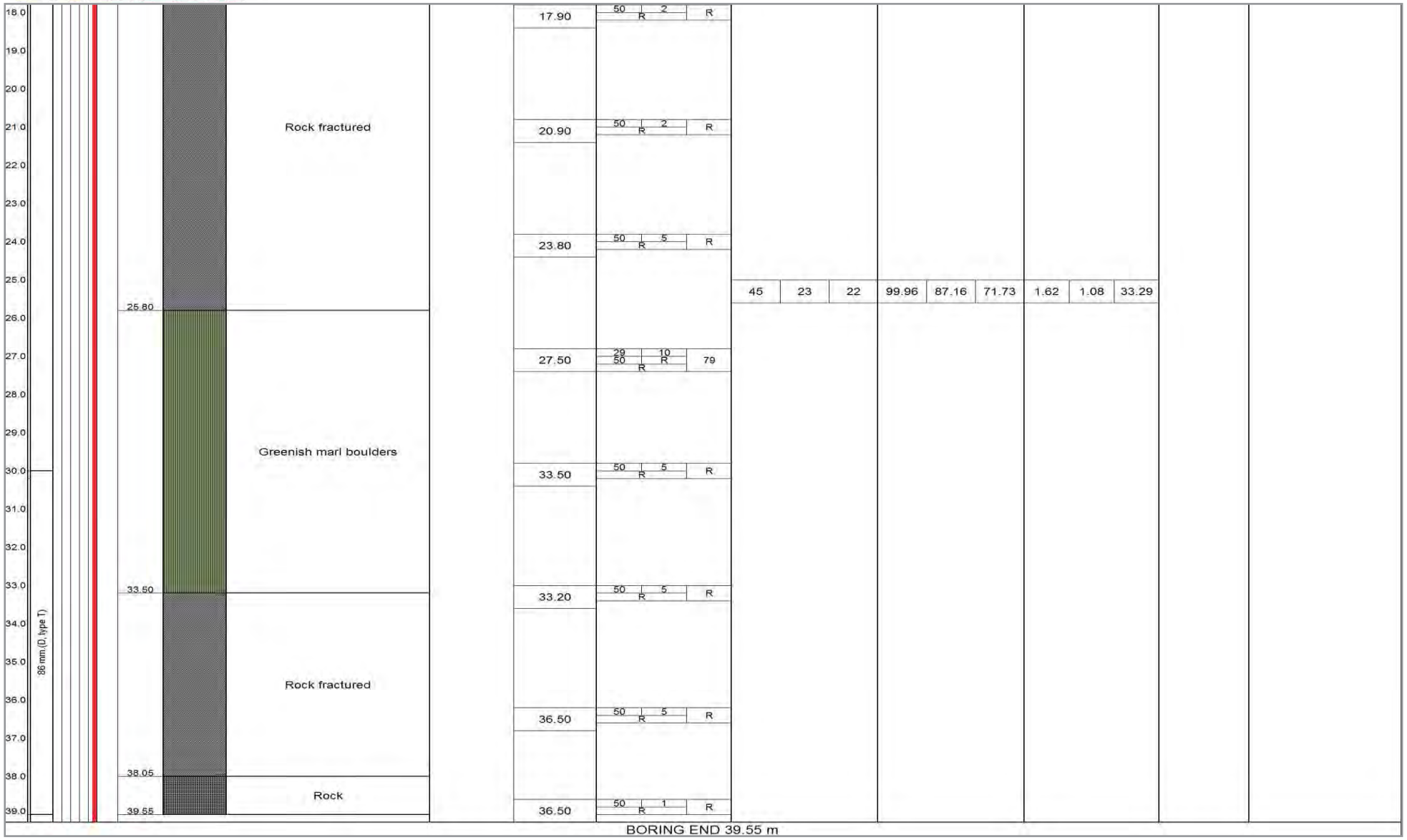

Galera 8B, Ofidepósitos Tocumen II, Calle Nuevo Belén, Tocumen
Teléfono (507) 292-5282; 292-9083

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2. BORING GRAPHIC REPRESENTATION

WORK: C/010/001/038 LINE 3 RAILWAY
CUSTOMER: NIPPON KOEI

Sample N°: 307
Equipment: RL-48

Analyst: Juan Franciso Fernandez

BORING : SR 45
DATE: 03/12/2013

Depth	Boring	Recovered (%) 20 40 60 80 100	WT	Geological Section	SAMPLE DESCRIPTION	UNDISTURBED SAMPLE	SPT	N Blows	P cms	N Field	ATTERBERG LIMITS LL	PL	PI	% SIEVING N° 4	N° 40	N° 200	Density and Moisture Wet grs/cm³	Dry grs/cm³	ω %	Compression qu (Kg/cm²)	Da (g/cm³)	NOTE
0.0	86 mm.(W. type B)				Filling with gravel																	
1.90																						
2.0					Clay silty																	
3.0							3.40	6 7 8	15 15 15	15	52	21	31	100	94.57	89.21	1.11	0.89	33.43			
4.0																						
5.0																						
6.00																						
6.0					Silts altered		6.00	8 14 16	15 15 15	30												
7.0																						
8.0																						
8.60																						
9.0					Rock fractured		9.00	50 R	3	R												
10.0											ROCK			6.73	1.87	1.46	1.98	1.96	3.61			
11.80																						
11.0					Rock																	
12.0							12.00	50 R	1	R												
13.0																						
13.00																						

BORING END 13.00 m