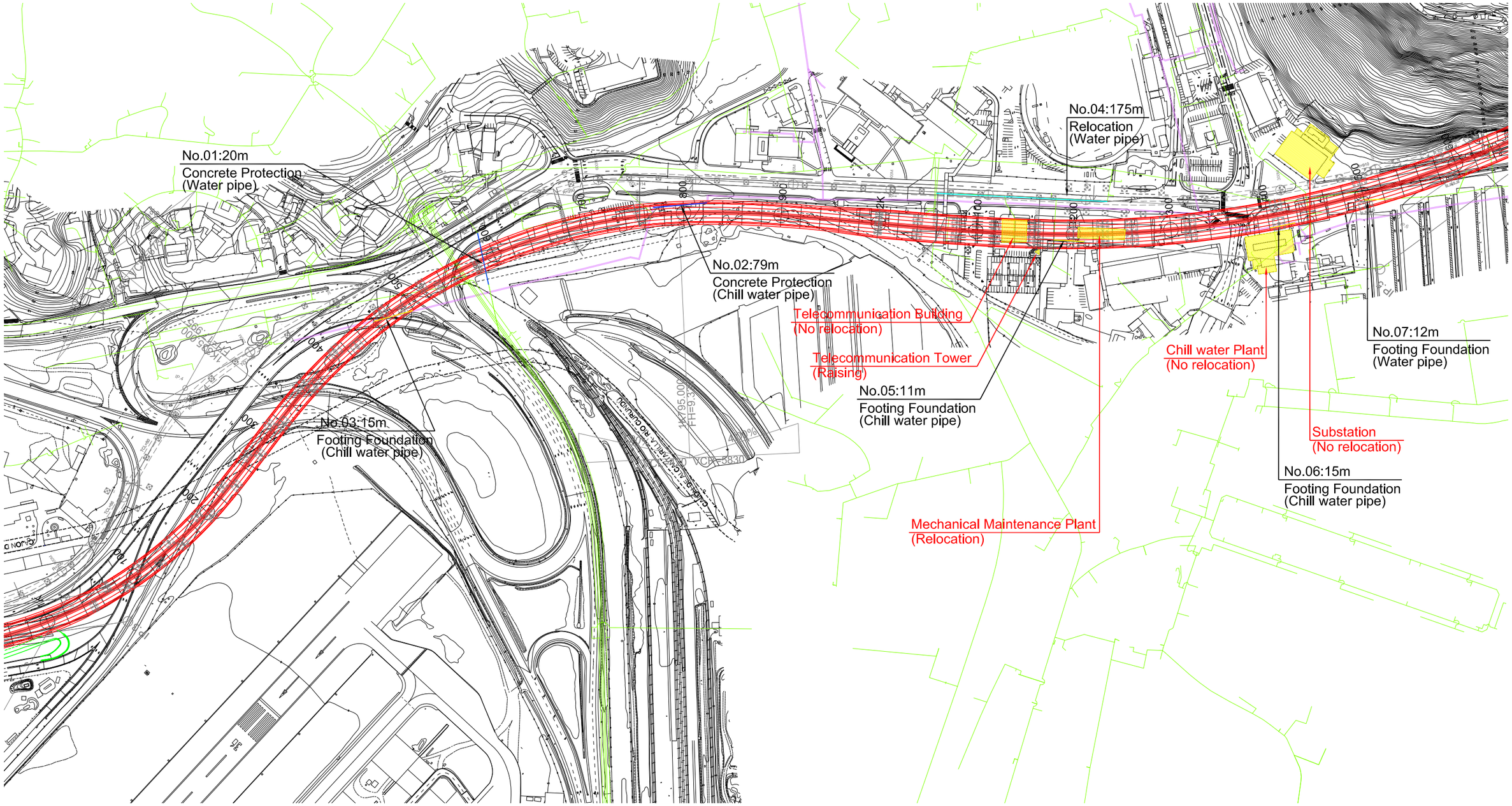
Location of Existing Utilities and Relocation Plan (Water Pipe) (2 of 5)



Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

Legend

- Existing Water Pipe (ACP)
- Existing Chill Water Pipe (ACP)
- Relocation (Water Pipe (ACP))
- On Footing Foundation (Water Pipe/ Chill Water Pipe (ACP))
- Concrete Protection (Water Pipe/ Chill Water Pipe (ACP))

SECRETARIA DEL METRO DE PANAMÁ

JAPAN INTERNATIONAL COOPERATION AGENCY

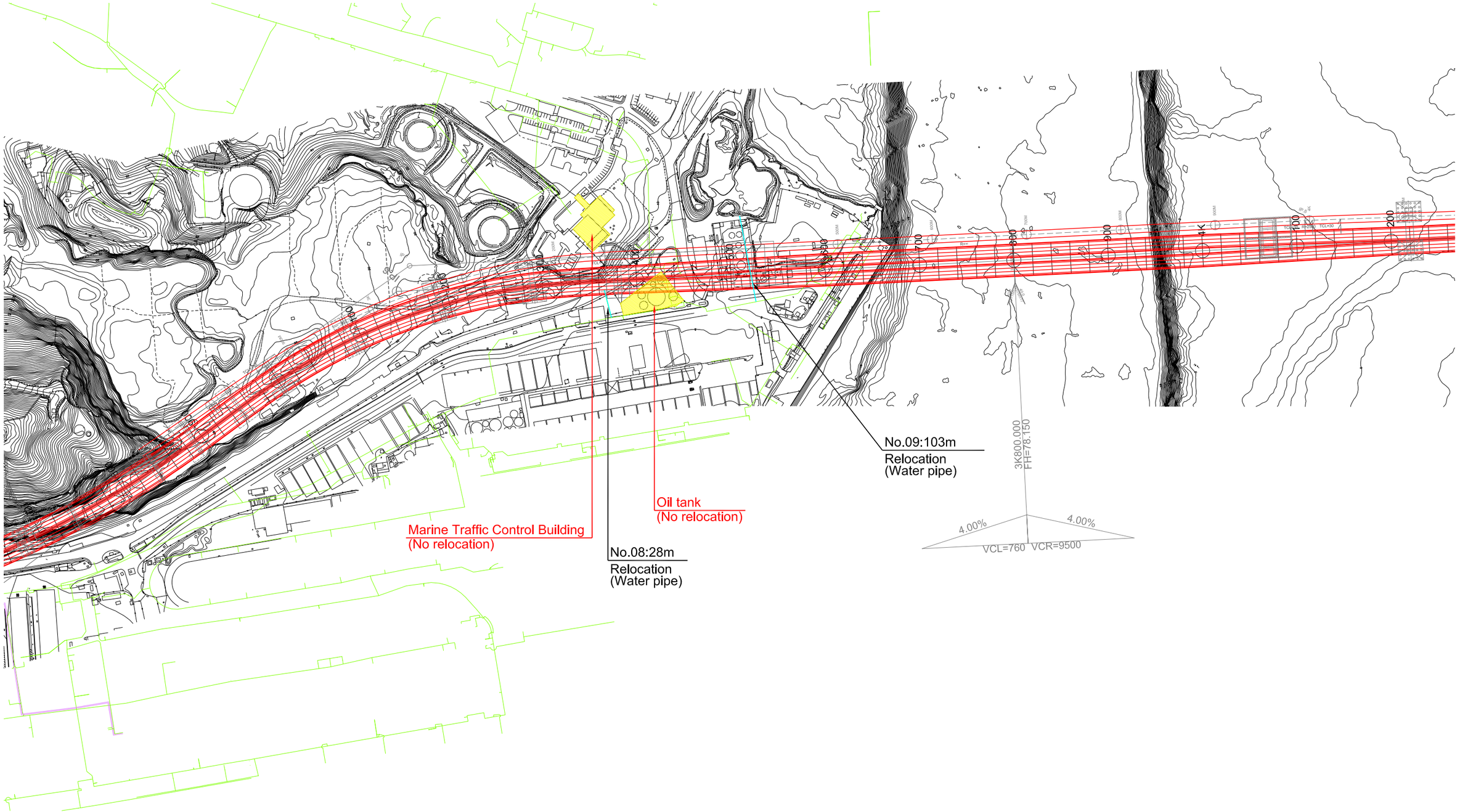
THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT

DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	PAGE:
DESIGNED:	SCALE: S=1:4,000	TEAM LEADER/URBAN RAILWAY PLANNING	CIVIL AND FACILITY PLANNING	APPROVED BY:	2 / 5

REMARKS:

Location of Existing Utilities and Relocation Plan (Water Pipe) (2 of 5)

Location of Existing Utilities and Relocation Plan (Water Pipe) (3 of 5)



Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

Legend

- Existing Utilities (Water pipe)
- Existing Utilities (Chill water pipe)
- Relocation Utilities

SECRETARIA DEL METRO DE PANAMÁ

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT

DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	PAGE:
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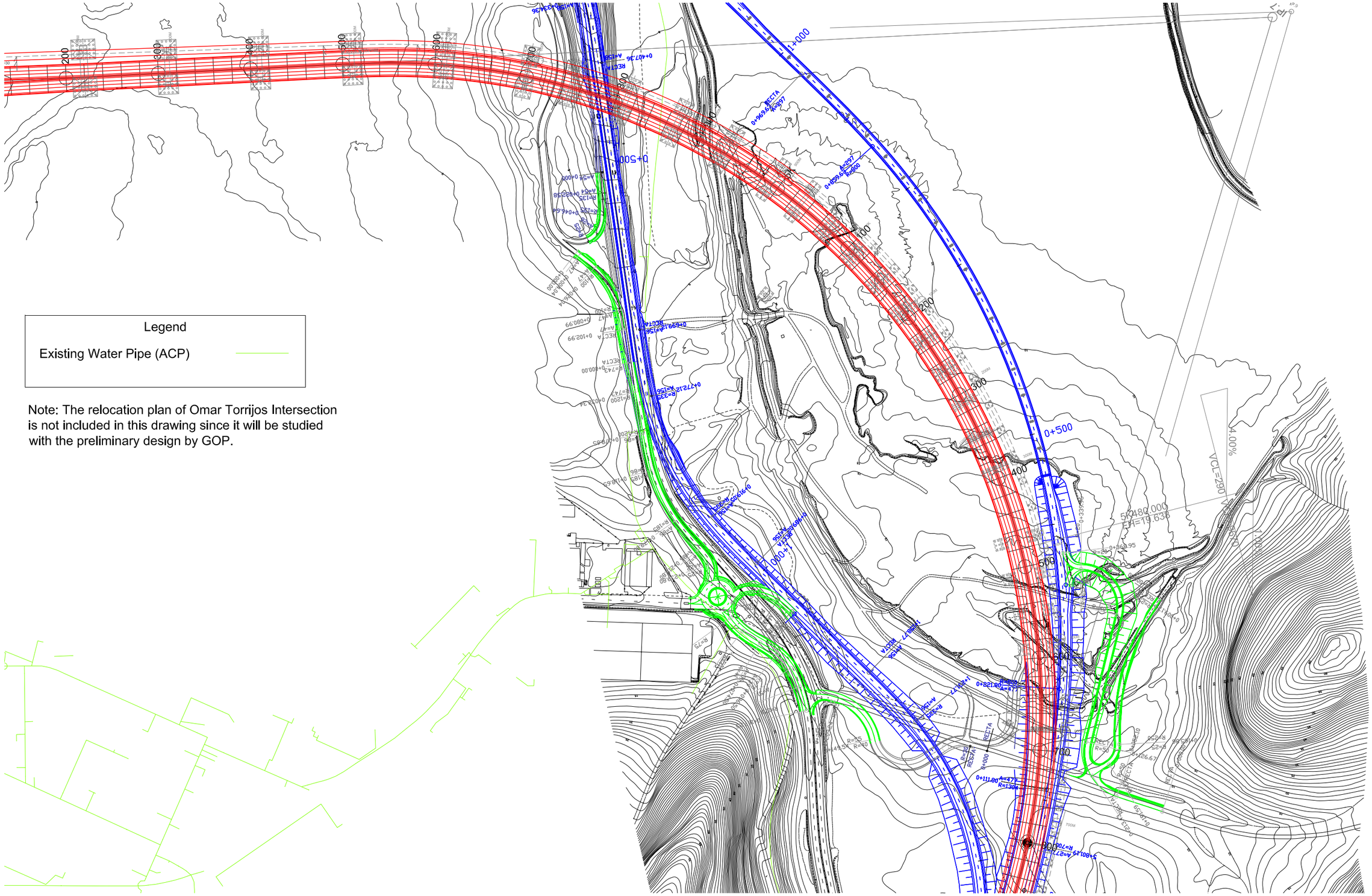
REMARKS:

Location of Existing Utilities and Relocation Plan (Water pipe) (3 of 5)

Location of Existing Utilities and Relocation Plan (Water Pipe) (4 of 5)



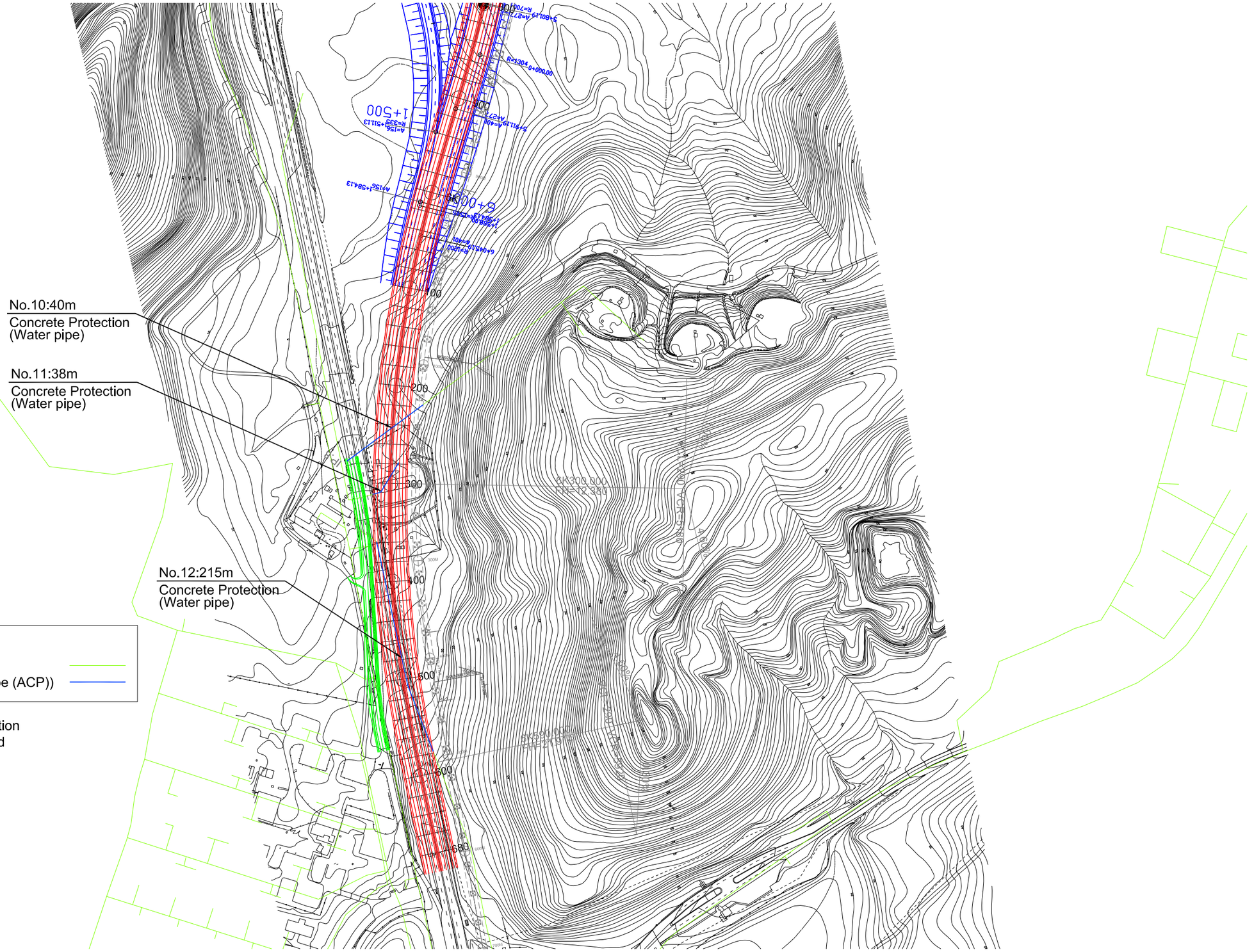
Legend

Existing Water Pipe (ACP)

Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

SECRETARIA DEL METRO DE PANAMÁ / JAPAN INTERNATIONAL COOPERATION AGENCY	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT					REMARKS:
DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	PAGE:	Location of Existing Utilities and Relocation Plan (Water Pipe) (4 of 5)
DESIGNED:	SCALE: S=1:4,000	TEAM LEADER/URBAN RAILWAY PLANNING	CIVIL AND FACILITY PLANNING	APPROVED BY:	4 / 5	

Location of Existing Utilities and Relocation Plan (Water Pipe) (5 of 5)



Legend

Existing Water Pipe (ACP)

Concrete Protection (Water Pipe/ Chill Water Pipe (ACP))

Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

SECRETARIA DEL METRO DE PANAMÁ

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT

DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	PAGE:
DESIGNED:	SCALE: S=1:4,000	TEAM LEADER/URBAN RAILWAY PLANNING	CIVIL AND FACILITY PLANNING	APPROVED BY:	5 / 5

REMARKS:

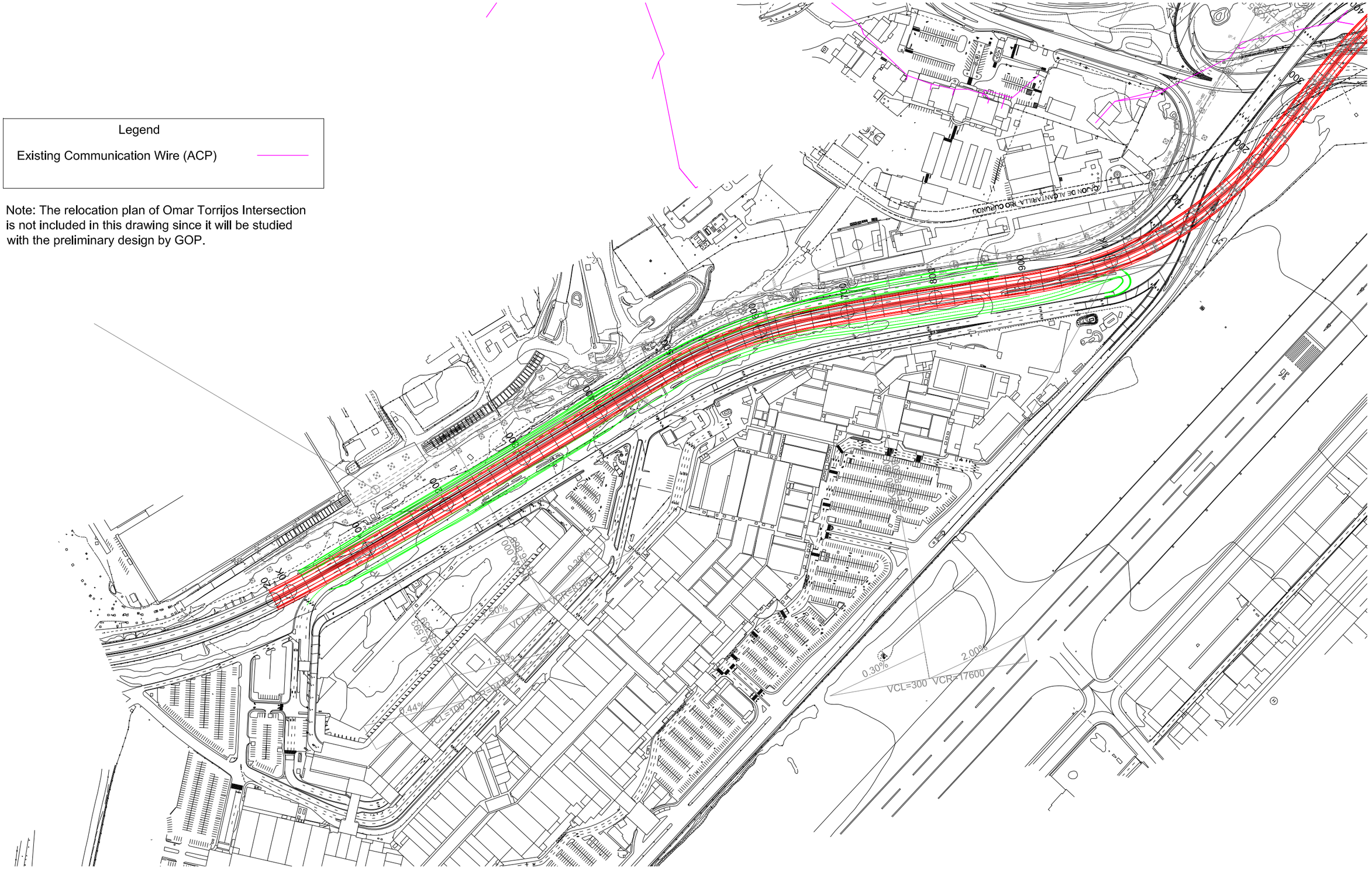
Location of Existing Utilities and Relocation Plan (Water Pipe) (5 of 5)

Location of Existing Utilities and Relocation Plan (Communication wire) (1 of 5)

Legend

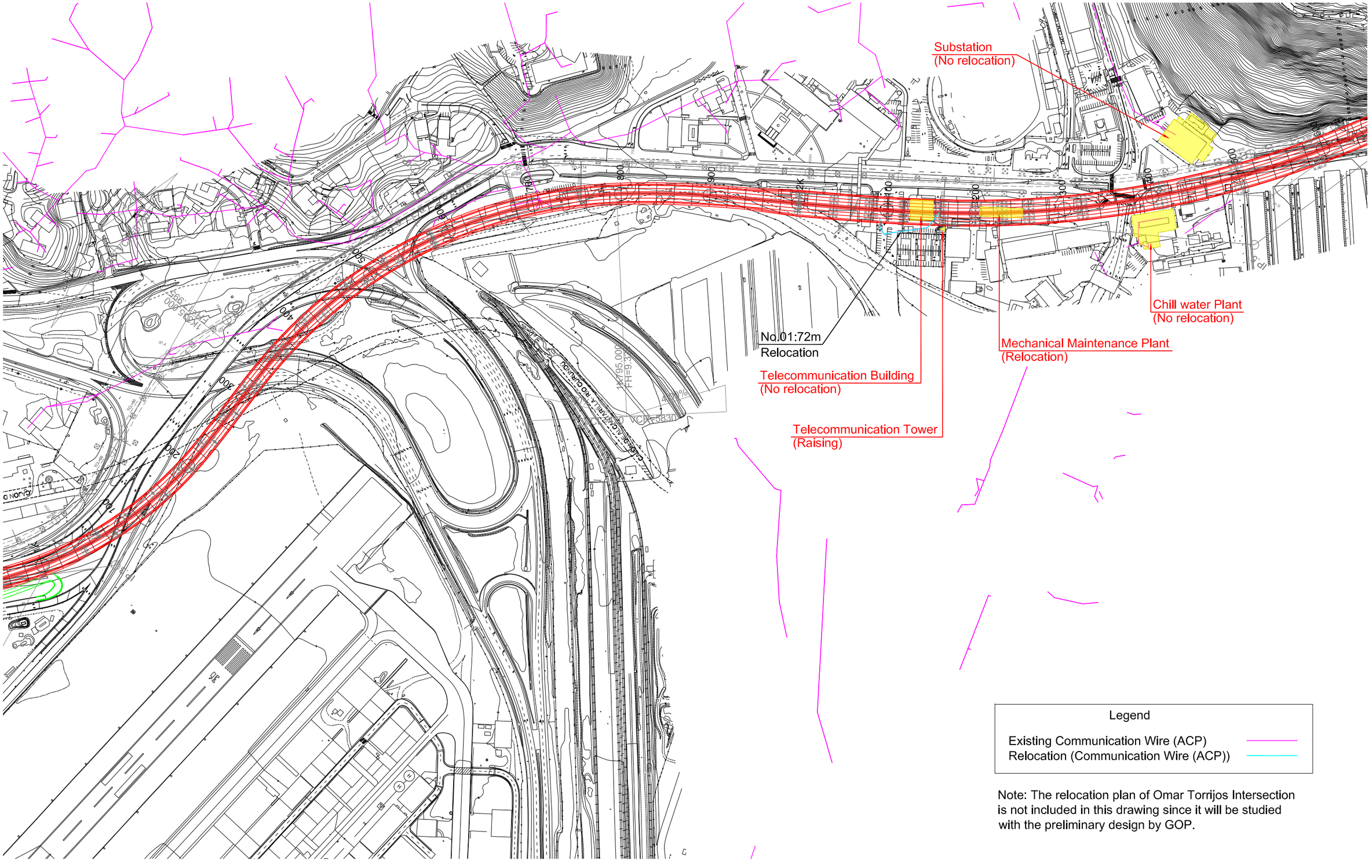
Existing Communication Wire (ACP)

Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.



SECRETARIA DEL METRO DE PANAMÁ	JAPAN INTERNATIONAL COOPERATION AGENCY	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT				REMARKS:
		DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	PAGE: 1/5	Location of Existing Utilities and Relocation Plan (Communication wire) (1 of 5)
		DESIGNED:	SCALE: S=1:4,000	TEAM LEADER/URBAN RAILWAY PLANNING	CIVIL AND FACILITY PLANNING	APPROVED BY:	

Location of Existing Utilities and Relocation Plan (Communication wire) (2 of 5)



Legend

Existing Communication Wire (ACP)

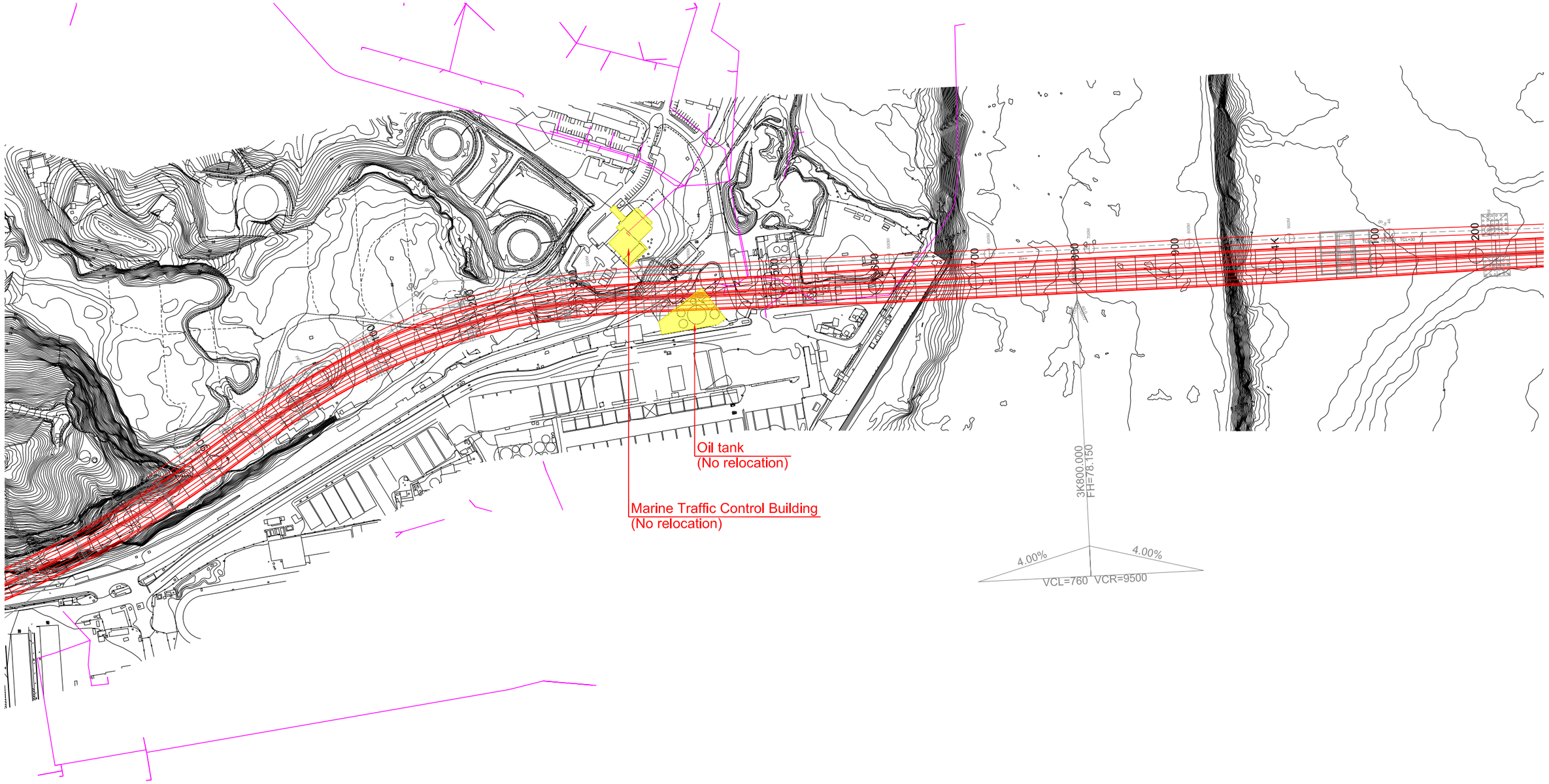
Relocation (Communication Wire (ACP))

Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

SECRETARIA DEL METRO DE PANAMÁ	JAPAN INTERNATIONAL COOPERATION AGENCY	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT				REMARKS:
		DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	PAGE:
		DESIGNED:	SCALE: S=1:4,000	TEAM LEADER/URBAN RAILWAY PLANNING	CIVIL AND FACILITY PLANNING	APPROVED BY:	2/5

Location of Existing Utilities and Relocation Plan (Communication wire) (2 of 5)

Location of Existing Utilities and Relocation Plan (Communication wire) (3 of 5)



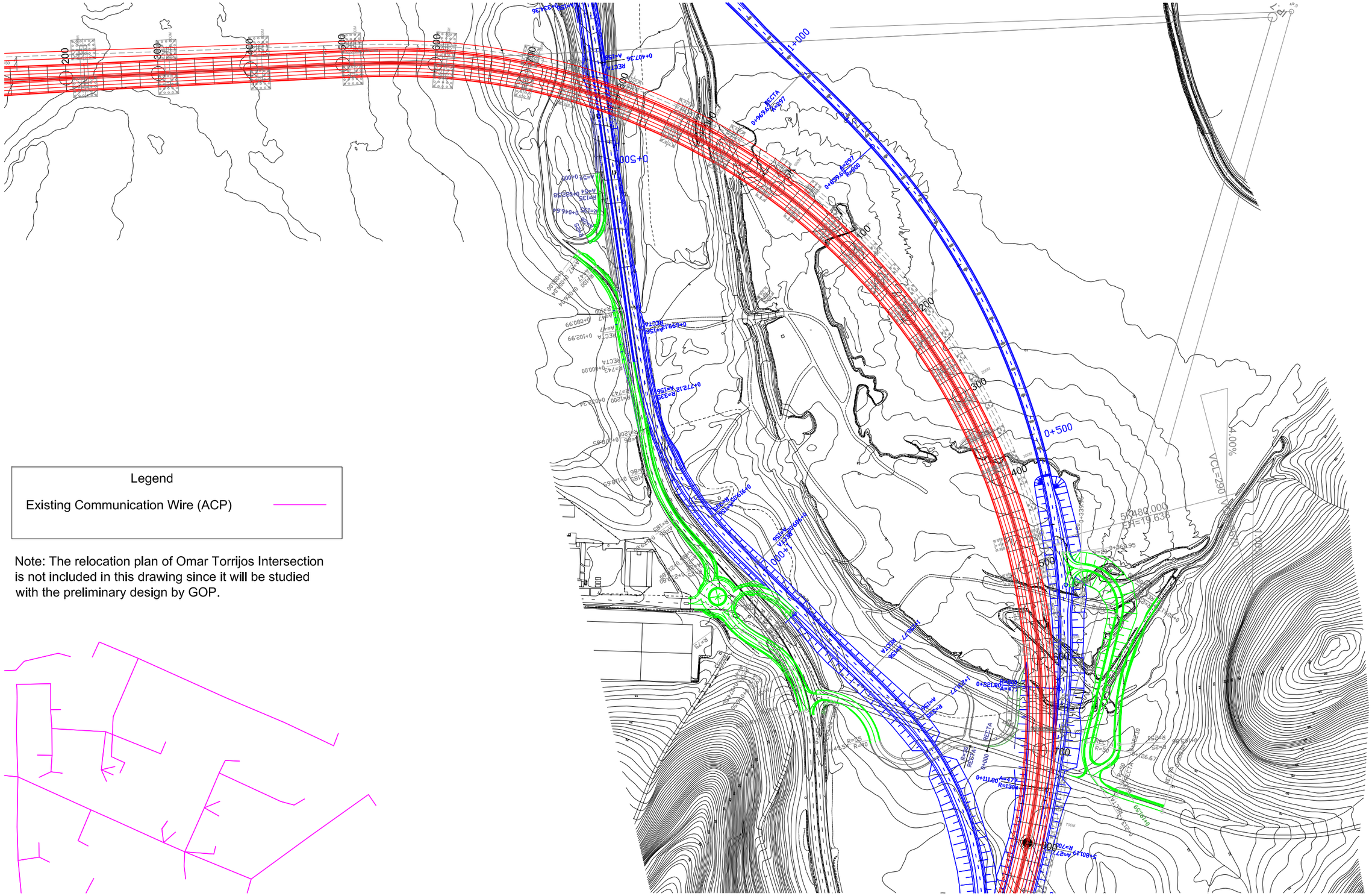
Legend

Existing Communication Wire (ACP)

Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

SECRETARIA DEL METRO DE PANAMÁ / JAPAN INTERNATIONAL COOPERATION AGENCY	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT					REMARKS:
DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	PAGE:	Location of Existing Utilities and Relocation Plan (Communication wire) (3 of 5)
DESIGNED:	SCALE: S=1:4,000	TEAM LEADER/URBAN RAILWAY PLANNING	CIVIL AND FACILITY PLANNING	APPROVED BY:	3 / 5	

Location of Existing Utilities and Relocation Plan (Communication wire) (4 of 5)



Legend

Existing Communication Wire (ACP)

Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

SECRETARIA DEL METRO DE PANAMÁ / JAPAN INTERNATIONAL COOPERATION AGENCY	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT				REMARKS:
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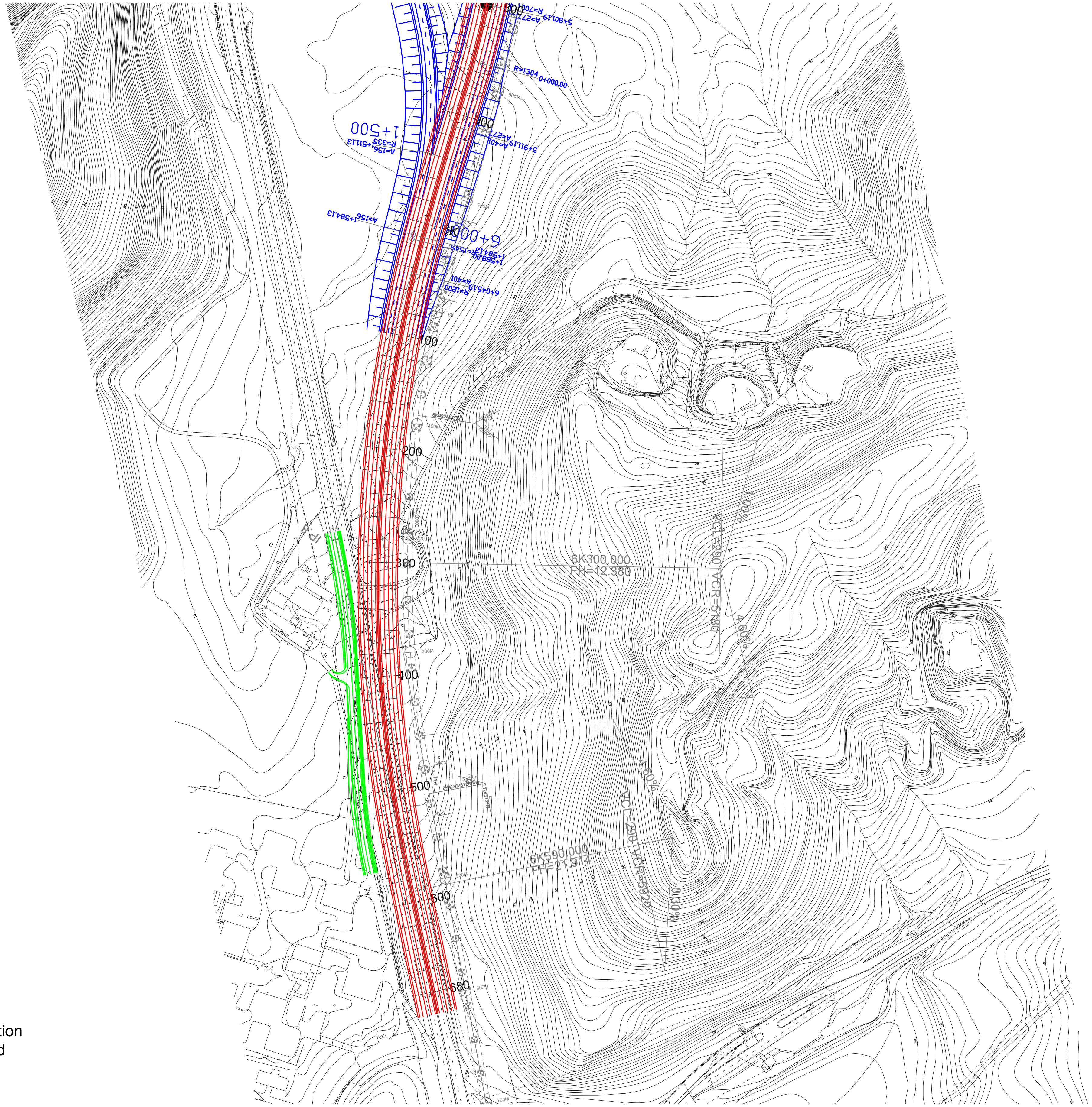
Location of Existing Utilities and Relocation Plan (Communication wire) (4 of 5)

Location of Existing Utilities and Relocation Plan (Communication wire) (5 of 5)



Note: The relocation plan of Omar Torrijos Intersection is not included in this drawing since it will be studied with the preliminary design by GOP.

SECRETARIA DEL METRO DE PANAMÁ	JAPAN INTERNATIONAL COOPERATION AGENCY	THE FEASIBILITY STUDY ON PANAMA CITY URBAN TRANSPORTATION LINE-3 PROJECT					REMARKS:
		DRAWN:	DATE: May 2014	RECEIVED BY:	SUBMITTED BY:	CHECKED BY:	Location of Existing Utilities and Relocation Plan (Communication wire) (5 of 5)
		DESIGNED:	SCALE: S=1:4,000	TEAM LEADER/URBAN RAILWAY PLANNING	CIVIL AND FACILITY PLANNING	APPROVED BY:	PAGE: 5/5

Appendix 7 : Breakdown of Preliminary Construction Cost (4th Panama Canal Bridge)

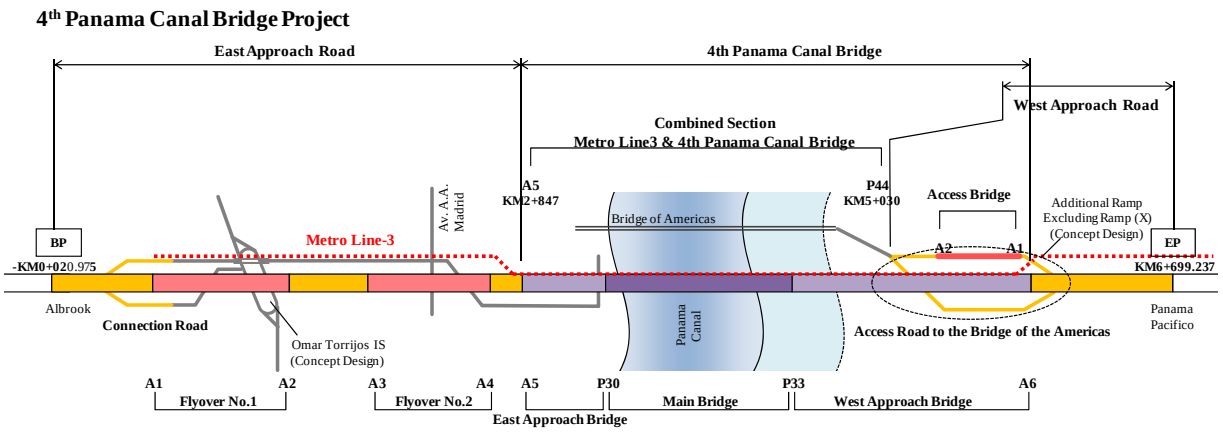
Appendix 7: Breakdown of Preliminary Construction Cost (4th Panama Canal Bridge)

The breakdown of preliminary construction cost is attached in this appendix.
This cost data is tentative and subject to update.

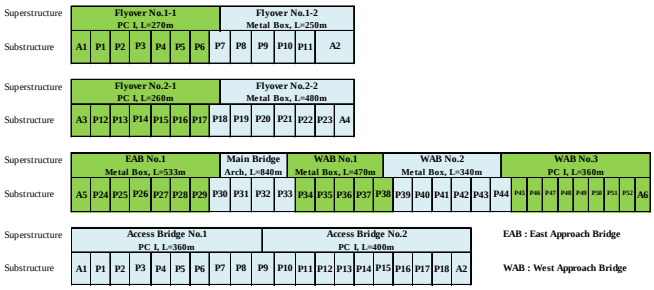
7-1 Using Navigation Channel during Main Bridge Erection

The breakdown of preliminary construction cost in the case of “Using Navigation Channel during Main Bridge Erection” is attached in the next page.

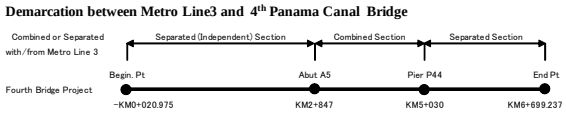
The cost estimate conditions were applied in the followings.



Cost Estimate Condition for Bridge Construction



Demarcation between Metro Line3 and 4th Panama Canal Bridge



Civil Works	Independent	Fourth Panama Canal Crossing Bridge Project	Independent
Civil Works (Rail, cats-walks)	Metro Line 3 Project		
Utilities	Independent		
Land Acquisition/Compensation	Fourth Panama Canal Crossing Bridge Project		
Public Utilities Underground Utilities	Fourth Panama Canal Crossing Bridge Project		

Cost Estimation for 4th Panama Canal Bridge Construction (Arch-rib Lifting Method)

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
1	**Temporary Works (Preliminary Design)**					**93,355,850**	**2,383,144**	**11,690,722**
	Temporary yard	Rental, Preparation & Maintenance for Stock Yard. 270,000m2, including Transportation Material and Equipment from West Yard to East	Ls	1	92,268,000	73,814,400	1,839,824	9,199,120
	Temporary road	Access Road for Work	Ls	1	21,982,000	17,585,600	438,321	2,191,605
	Temporary Jetty	East and West Side Jetty and Embankment for P38 - P44	Ls	1	3,009,000	1,955,850	104,999	299,997
2	**East Approach Road (Preliminary Design)**					**101,913,173**	**7,715,357**	**17,876,100**
	Flyover No.1 (PC-I girder) (A1~P7)					17,425,404	906,322	2,643,635
	Superstructure					8,850,394	538,362	1,420,746
		Concrete (for main girder fck=40N/mm2)	m3	2,228	2,365	3,256,234	200,769	525,415
		Concrete (for situ in place fck=30N/mm2)	m3	1,660	885	1,027,748	44,058	146,524
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	459	1,030	330,583	14,186	47,145
		Concrete (for PC panel fck=40N/mm2)	nos.	1,680	986	1,063,855	59,048	165,114
		Re-bar (SD345)	ton	882	2,243	1,349,968	62,603	197,195
		PC strand (12S15.2B)	ton	154	14,182	1,352,590	83,376	218,229
		Bearing	nos.	112	3,461	99,119	28,768	38,651
		Expansion Joint	m	44	8,411	93,767	27,213	36,561
		Pavement (for Vehicle)	m2	5,382	67	250,600	10,788	35,772
		Waterproofing	m2	5,382	19	25,931	7,554	10,139
	Substructure	A1~P6				8,575,010	367,961	1,222,889
		Concrete (fck=30N/mm2)	m3	4,416	852	2,629,760	112,732	374,919
		Formworks	m2	3,648	194	493,883	21,238	70,478
		Re-bar (SD345)	ton	690	2,563	1,236,225	53,042	176,294
		C.I.P pile (f=1500mm)	m	1,440	4,188	4,215,142	180,949	601,199
	Flyover No.1-2 (Box girder) (P7~A2)					13,108,792	1,265,124	2,572,070
	Superstructure					7,876,214	1,052,040	1,837,299
		Steel (for Vehicle)	kg	2,307,000	4.31	2,643,833	727,350	990,940
		Paint (for Vehicle)	m2	34,600	21	64,007	65,321	71,702
		Concrete (for Deck fck=24N/mm2)	m3	1,699	909	1,274,417	26,952	154,011
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	637	785	412,665	8,727	49,870
		Bearing	nos.	48	10,318	24,764	46,911	49,380
		Expansion Joint	m	44	7,443	16,225	30,736	32,353
		Pavement (for Vehicle)	m2	4,850	71	244,006	9,937	34,264
		Waterproofing	m2	4,850	19	22,728	6,871	9,137
	Substructure	P7~A2				8,406,146	342,320	1,180,412
	For C.I.P pile	Concrete (fck=30N/mm2)	m3	5,249	852	3,173,569	129,236	445,641
		Formworks	m2	3,986	194	548,403	22,332	77,008
		Re-bar (SD345)	ton	692	2,563	1,259,089	51,273	176,805
		C.I.P pile (f=1500mm)	m	1,152	4,188	3,425,085	139,478	480,959
	Flyover No.2 -1 (PC-I girder) (A3~P18)					22,169,418	1,220,718	3,431,009
	Superstructure					11,419,832	758,920	1,897,477
		Concrete (for main girder fck=40N/mm2)	m3	2,786	2,617	4,215,479	306,595	726,878
		Concrete (for situ in place fck=30N/mm2)	m3	2,309	823	1,328,578	57,027	189,486
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	442	1,030	318,339	13,661	45,399
		Concrete (for PC panel fck=40N/mm2)	nos.	2,240	955	1,369,646	76,650	213,204
		Re-bar (SD345)	ton	1,191	2,415	1,943,117	93,106	286,835
		PC strand (12S15.2B)	ton	193	14,824	1,653,765	120,246	285,127
		Bearing	nos.	140	3,461	123,899	35,961	48,313
		Expansion Joint	m	87	5,031	112,302	32,593	43,790
		Pavement (for Vehicle)	m2	6,942	67	323,238	13,914	46,141
		Waterproofing	m2	6,942	18	31,468	9,167	12,304
	Substructure	A3~P17				10,749,587	461,798	1,533,532
		Concrete (fck=30N/mm2)	m3	6,103	865	3,688,557	158,509	526,258
		Formworks	m2	4,838	199	671,896	29,053	96,041
		Re-bar (SD345)	ton	952	2,563	1,705,631	73,183	243,234
		C.I.P pile (f=1500mm)	m	1,600	4,188	4,683,502	201,054	667,999
	Flyover No.2-2 (Box girder) (P18~A4)					27,150,730	3,383,179	6,090,107
	Superstructure					10,798,241	2,470,016	3,546,600
		Steel (for Vehicle)	kg	6,176,000	4.32	6,157,257	2,044,755	2,658,634
		Paint (for Vehicle)	m2	92,645	21	171,386	174,903	191,990
		Concrete (for Deck fck=24N/mm2)	m3	4,225	909	3,169,166	67,023	382,989
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	815	785	528,154	11,170	63,827
		Bearing	nos.	56	14,004	39,210	74,275	78,185
		Expansion Joint	m	59	9,569	28,229	53,475	56,289
		Pavement (for Vehicle)	m2	12,816	71	644,781	26,257	90,542
		Waterproofing	m2	12,816	19	60,058	18,157	24,144
	Substructure	P18~A4				16,352,489	913,164	2,543,507
	For C.I.P pile	Concrete (fck=30N/mm2)	m3	9,382	772	5,064,441	217,609	722,533
		Formworks	m2	7,271	208	1,058,209	45,280	150,783
		Re-bar (SD345)	ton	2,265	2,563	4,058,041	174,116	578,703
		C.I.P pile (f=1500mm)	m	2,016	4,188	5,901,193	253,330	841,679
		Top Beam (Steel)	kg	520,000	4.82	270,606	222,830	249,809

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
	Road work					17,299,064	735,931	2,460,647
	Earth Works					2,872,742	117,154	403,567
		Clearing and Grubbing	m2	20,255	4	51,139	2,261	7,360
		Demolition of Pavement(Drainage Facility)	m2	21,940	10	149,340	6,499	21,388
		Embankment	m3	222,863	12	1,981,841	78,919	276,509
		Cutting	m3	10,328	27	191,578	8,267	27,367
		Slope Protection (Shotcreate)	m2	5,598	127	498,845	21,209	70,943
	Drainage Works	Side Ditch, Batch Basin, Drainage Pipe	Ls	1	722,667	504,951	21,706	72,050
	Pavement Works					6,245,084	267,938	890,573
		Asphalt Pavement (t=0.3)	m2	5,464	67	254,205	10,973	36,317
		Concrete Pavement (t=0.3)	m2	29,247	235	4,799,699	205,741	684,271
		Base Course (t=0.2)	m2	31,968	53	1,191,180	51,224	169,985
	Road Structure Works				-	6,813,742	292,258	971,588
		Retaining Wall (Terre Arme´e)	m2	10,780	904	6,813,742	292,258	971,588
	Road Furniture and Miscellaneous				-	862,544	36,874	122,870
		Guard Rail	m	3,428	128	307,248	13,114	43,747
		Concrete Barrier (Median)	m	1,607	468	525,418	22,527	74,911
		Road Marking	m2	2,213	14	22,349	910	3,138
		Road Sign	nos.	12	898	7,529	323	1,074
	Connection Road (East Side)					4,759,765	204,083	678,631
	Earth Works					147,496	6,364	21,069
		Clearing and Grubbing	m2	9,079	4	22,922	1,014	3,299
		Demolition of Pavement(Drainage Facility)	m2	2,312	10	15,737	685	2,254
		Embankment	m3	2,415	64	108,837	4,666	15,517
	Drainage Works	Concrete Curb, Catch Basin, Drainage Vertical Pipe	Ls	1	360,889	252,476	10,809	35,981
	Pavement Works					1,653,242	70,623	235,452
		Asphalt Pavement (t=0.3)	m2	2,400	67	111,657	4,820	15,952
		Concrete Pavement (t=0.3)	m2	7,200	235	1,181,586	50,649	168,453
		Base Course (t=0.2)	m2	9,600	53	359,999	15,154	51,046
	Structure Works					2,521,625	108,400	359,806
		Retaining Wall (Terre Arme´e)	m2	3,500	1,031	2,521,625	108,400	359,806
	Road Furniture and Miscellaneous					184,927	7,886	26,323
		Guard Rail (Side)	m	2,000	128	179,258	7,651	25,523
		Road Marking	m2	375	14	3,787	154	532
		Road Sign	nos.	3	898	1,882	81	269
3	**4th Panama Canal Bridge (Preliminary Design)**					**317,683,894**	**39,480,200**	**71,153,284**
	East Approach Bridge (Box girder) (A5~P30)					36,871,313	5,239,014	8,915,084
	Superstructure					13,395,007	3,495,893	4,831,375
		Steel (for Vehicle)	kg	6,302,000	4.34	5,791,111	2,147,373	2,724,747
		Steel (for Monorail)	kg	2,336,000	4.23	2,095,182	776,904	985,793
		Paint (for Vehicle)	m2	94,519	21	174,853	178,442	195,874
		Paint (for Monorail)	m2	35,034	21	64,809	66,139	72,601
		Concrete (for Deck fck=24N/mm2)	m3	4,692	909	3,519,461	74,431	425,322
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	1,358	785	879,732	18,605	106,314
		Bearing	nos.	90	11,792	53,066	100,523	105,814
		Expansion Joint	m	118	7,443	43,912	83,183	87,561
		Pavement (for Vehicle)	m2	14,231	71	704,313	30,318	100,538
		Waterproofing	m2	14,231	19	68,567	19,974	26,810
	Substructure	A5~P29			-	23,476,306	1,743,121	4,083,709
	For C.I.P pile	Concrete (fck=30N/mm2)	m3	16,925	821	9,712,910	417,049	1,385,427
		Formworks	m2	17,507	221	2,715,059	115,198	385,889
		Re-bar (SD345)	ton	5,306	2,724	10,104,339	433,541	1,440,943
		Top Beam (Steel)	kg	1,814,000	5	943,998	777,333	871,450
	Main Bridge (Arch) (P30~P33)					122,019,415	24,052,974	36,218,310
	Superstructure					34,491,973	20,810,331	24,249,180
		Steel (for Vehicle)	kg	37,373,000	5.93	25,567,414	19,559,091	22,108,162
		Paint (for Vehicle)	m2	448,476	21	1,074,808	822,229	929,388
		Concrete (for Deck fck=24N/mm2)	m3	7,195	909	5,102,862	143,495	652,250
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	1,945	785.12	1,259,822	26,643	152,248
		Bearing	nos.	4	109,453	21,891	41,467	43,650
		Expansion Joint	m	99	13,760	68,111	129,022	135,813
		Drainage	nos.	129	313	30,256	1,006	4,022
		Pavement (for Vehicle)	m2	22,428	71	1,127,783	46,008	158,448
		Pavement (for Pedestrian)	m2	3,360	50	118,331	4,819	16,616
		Waterproofing	m2	25,788	19	120,696	36,549	48,583
	Substructure	P30~P33			-	87,527,442	3,242,644	11,969,130
	For C.I.P pile	Concrete (fck=30N/mm2)	m3	48,179	684	26,300,117	663,605	3,285,726
		Formworks	m2	34,055	248	6,733,781	169,102	840,460
		Re-bar (SD345)	ton	15,900	2,526	32,032,665	811,261	4,004,917
		C.I.P pile (f=1800mm)	m	1,500	4,709	5,632,781	142,616	704,204
	For S.P.S.P (P32 only)	Steel pipe sheet pile (Exterior, SKY490, f=1500 x t25 mm)	kg	3,172,356	8	16,223,398	958,121	2,575,594
		Top Beam (Steel)	kg	1,162,000	5	604,700	497,939	558,228

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
	West Approach Bridge (Box girder) (P33~P44)					116,882,919	8,815,501	20,468,728
	Superstructure					19,197,966	5,144,442	7,058,479
		Steel (for Vehicle)	kg	9,185,000	4.34	8,157,586	3,157,936	3,971,247
		Steel (for Monorail)	kg	3,395,000	4.30	2,988,966	1,157,078	1,455,078
		Paint (for Vehicle)	m2	137,771	21	254,865	260,096	285,506
		Paint (for Monorail)	m2	50,922	21	94,201	96,135	105,527
		Concrete (for Deck fck=24N/mm2)	m3	7,130	909	5,056,481	142,191	646,322
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	2,064	785	1,336,928	28,274	161,566
		Bearing	nos.	130	10,318	67,070	127,050	133,737
		Expansion Joint	m	118	9,038	53,142	100,666	105,964
		Pavement (for Vehicle)	m2	21,627	71	1,087,505	44,365	152,789
		Waterproofing	m2	21,627	19	101,221	30,652	40,744
	Substructure	P34~P44			-	97,684,953	3,671,059	13,410,249
	For C.I.P pile	Concrete (fck=30N/mm2)	m3	34,944	931	25,951,214	654,801	3,242,137
		Formworks	m2	31,393	331	8,306,104	208,587	1,036,706
		Re-bar (SD345)	ton	11,532	2,487	22,868,129	579,159	2,859,112
		C.I.P pile (f=1800mm)	m	10,400	4,709	39,054,001	988,806	4,882,490
		Top Beam (Steel)	kg	2,893,000	5	1,505,505	1,239,705	1,389,804
	West Approach Bridge (PC-I girder) (P44~A6)					41,910,247	1,372,710	5,551,162
	Superstructure					14,538,696	681,429	2,130,937
		Concrete (for main girder fck=40N/mm2)	m3	3,582	2,006	4,785,053	239,403	716,473
		Concrete (for situ in place fck=30N/mm2)	m3	2,968	736	1,741,346	44,192	217,804
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	612	908	281,944	27,284	55,394
		Concrete (for PC panel fck=40N/mm2)	nos	2,880	822	1,727,817	63,826	236,090
		Re-bar (SD345)	ton	1,457	2,483	2,804,354	81,171	360,765
		PC strand (12S15.2B)	ton	209	17,157	2,392,445	119,766	358,293
		Bearing	nos.	180	2,866	151,639	36,311	51,429
		Expansion Joint	m	87	5,811	149,114	35,708	50,575
		Pavement (for Vehicle)	m2	9,612	67	454,733	18,551	63,888
		Waterproofing	m2	11,412	18	50,251	15,217	20,227
	Substructure	P45~A6				27,345,548	690,129	3,416,480
		Concrete (fck=30N/mm2)	m3	12,524	656	6,555,829	165,452	819,068
		Formworks	m2	8,989	188	1,350,570	34,085	168,737
		Re-bar (SD345)	ton	3,027	2,340	5,651,573	142,631	706,093
		C.I.P pile (f=1800mm)	m	3,900	4,430	13,787,577	347,962	1,722,583
	Road Furniture and Miscellaneous				-	26,003	1,152	3,745
		Road Marking	m2	2,232	15	23,292	1,042	3,364
		Road Sign	nos.	4	954	2,711	110	381
4	**West Approach Road (Preliminary Design)**					**52,120,607**	**1,937,849**	**7,134,273**
	West Approach Road					18,870,853	761,067	2,642,491
	Earth Works					12,011,197	488,671	1,686,187
		Clearing and Grubbing	m2	50,476	4	130,246	5,355	18,341
		Demolition of Pavement(Drainage Facility)	m2	4,708	9	29,671	1,214	4,172
		Embankment	m3	274,890	61	11,851,280	482,102	1,663,675
	Drainage Works	Side Ditch, Catch Basin, Drainage Pipe	less	1	494,557	394,657	9,960	49,307
	Pavement Works			-		5,429,183	220,210	761,499
		Asphalt Pavement (t=0.3)	m2	4,450	67	210,487	8,592	29,578
		Concrete Pavement (t=0.3)	m2	23,824	235	3,966,178	161,965	557,393
		Base Course (t=0.2)	m2	28,274	53	1,075,424	43,122	150,342
		Side Walk	m2	2,995	81	177,094	6,530	24,187
	Road Furniture and Miscellaneous				-	1,035,817	42,226	145,497
		Guard Rail	m	2,618	128	238,036	9,678	33,410
		Fence	m	1,198	412	350,715	14,259	49,225
		Concrete Barrier (Median)	m	1,309	468	434,236	17,726	61,019
		Road Marking	m2	1,047	14	10,279	460	1,485
		Road Sign	nos.	4	898	2,551	104	358

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
	Access Road to the Bridge of the Americas (Inbound and Outbound)					33,249,754	1,176,782	4,491,782
	Road work					4,886,757	196,796	684,006
	Earth Works					1,199,312	48,841	168,413
		Clearing and Grubbing	m2	30,976	4	79,929	3,286	11,255
		Demolition of Pavement(Drainage Facility)	m2	12,756	9	80,390	3,290	11,305
		Embankment	m3	218,000	7	1,038,993	42,266	145,853
	Drainage Works	Concrete Curb, Catch Basin, Drainage Pipe	less	1	164,852	131,552	3,320	16,436
	Pavement Works				-	3,555,893	144,635	499,157
		Asphalt Pavement (t=0.3)	m2	5,088	67	240,664	9,824	33,818
		Concrete Pavement (t=0.3)	m2	15,264	235	2,541,124	103,771	357,121
		Base Course (t=0.2)	m2	20,352	53	774,105	31,040	108,218
	Superstructure				-	12,240,593	566,914	1,787,301
		Concrete (for main girder fck=40N/mm2)	m3	3,025	2,107	4,315,470	205,103	635,355
		Concrete (for situ in place fck=30N/mm2)	m3	2,253	911	1,636,542	41,494	204,658
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	646	727	138,025	33,040	46,801
		Concrete (for PC panel fck=40N/mm2)	nos.	2,280	839	1,398,513	51,312	190,743
		Re-bar (SD345)	ton	1,166	2,462	2,153,662	71,603	286,323
		PC strand (12S15.2B)	ton	209	15,212	2,157,315	102,575	317,659
		Bearing	nos.	152	2,866	128,048	30,663	43,429
		Expansion Joint	m	44	5,031	64,489	15,440	21,870
		Pavement (for Vehicle)	m2	4,806	67	227,366	9,275	31,944
		Waterproofing	m2	4,806	18	21,163	6,408	8,518
	Substructure	A1~A2			-	15,723,347	396,815	1,964,433
		Concrete (fck=30N/mm2)	m3	7,287	720	4,184,967	105,617	522,859
		Formworks	m2	6,193	195	965,635	24,370	120,644
		Re-bar (SD345)	ton	1,131	2,340	2,111,638	53,292	263,822
		C.I.P pile (f=1500mm)	m	2,532	4,188	8,461,107	213,536	1,057,108
	Road Furniture and Miscellaneous				-	399,057	16,256	56,042
		Guard Rail	m	4,240	128	385,512	15,674	54,109
		Road Marking	m2	795	14	7,805	349	1,127
		Road Sign	nos.	9	898	5,739	233	806
5	**Omar Torrijos Intersection (Concept Design incl. Cost No.1,7,8,9,11,12)**		Ls	1	196,900,000.0	**137,830,000**	**5,889,279**	**19,630,930**
6	**Additional Ramp-West Side (Concept Design incl. Cost No. 1,7,8,9,11,12)**		Ls	1	6,100,000.0	**4,270,000**	**182,451**	**608,170**

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
7	**Utilities (Preliminary Design)**					**8,386,980**	**1,013,543**	**1,849,725**
	Electrical and Mechanical facilities					-	-	-
	Road Lighting					-	-	-
	-Include installation cost(20%)	Lamp(LED type)	set	1,102.0	3,600	-	395,530	395,530
		Cubicle for lighting(Outdoor type)	unit	3.0	36,000	-	10,768	10,768
	-Include construction cost(10%)	Pole(H=12.0m Straight type)	set	551.0	1,100	606,100	-	60,428
		Basis of pole	set	422.0	5,500	2,321,000	-	231,404
		Basis of cubicle	set	3.0	8,800	26,400	-	2,632
		Power cable	m	33,488.0	11	368,368	-	36,726
		Electrical Conduit	m	33,488.0	22	736,736	-	73,453
	Bridge Lighting					-	-	-
	-Include installation cost(20%)	Lamp(LED type)	set	352.0	3,600	-	126,340	126,340
	-Include construction cost(10%)	Pole(H=12.0m Straight type)	set	176.0	1,100	193,600	-	19,302
		Power cable	m	10,172.0	11	111,892	-	11,156
		Electrical Conduit	m	10,172.0	22	223,784	-	22,311
	Others Lighting					-	-	-
	-Include installation cost(20%)	Illumination lamp	set	848.0	2,400	-	202,909	202,909
		Cubicle for illumination lamp(Outdoor type)	set	1.0	36,000	-	3,589	3,589
	-Include installation cost(20%) and Spare parts(3.5%)	Floodlight(Light-up)	set	84.0	6,210	-	52,008	52,008
		Airplane Warning Light	set	1.0	24,840	-	2,477	2,477
		Marine Warning Light	set	4.0	24,840	-	9,906	9,906
		Solar cells for power supply control panel	unit	5.0	24,840	-	12,383	12,383
		Solar cells panel	set	5.0	12,420	-	6,191	6,191
		Control panel for airplane Warning Light and Marine Warning Light	unit	2.0	37,260	-	7,430	7,430
	-Include construction cost(10%)	Power cable	m	6,720.0	22	147,840	-	14,740
		Electrical Conduit	m	6,720.0	39	258,720	-	25,794
		Basis of cubicle	set	1.0	8,800	8,800	-	877
	Meteorological observatory facilities					-	-	-
	-Include installation cost(20%) and Spare parts(3.5%)	Variable Massaging Sigh board	set	2.0	149,040	-	29,719	29,719
		Operations panel for VMS	unit	2.0	37,260	-	7,430	7,430
		Meteorological observatory equipment	set	1.0	124,200	-	12,383	12,383
		Temperature meter	set	1.0	5,216	-	520	520
		Rain meter	set	1.0	5,216	-	520	520
		Visibility meter	set	1.0	62,100	-	6,191	6,191
		Anemometer	set	1.0	5,651	-	563	563
		Precipitation meter	set	1.0	10,681	-	1,065	1,065
		Connected to system of ATTT(Include fiber cable)	set	1.0	186,300	186,300	-	18,574
	-Include construction cost(10%)	Steel pole(H=7.2m)	set	2.0	8,800	17,600	-	1,755
		Steel pole(H=3m)	set	1.0	5,500	5,500	-	548
		Communication wire	m	840.0	17	13,860	-	1,382
		Cable rack	m	840.0	77	64,680	-	6,449
		Power cable	m	840.0	22	18,480	-	1,842
	Closed - circuit television(CCTV)					-	-	-
	-Include installation cost(20%)	CCTV camera	set	3.0	18,000	54,000	-	5,384
		CCTV device	unit	3.0	60,000	180,000	-	17,946
		Connected to system of ATTT(Include fiber cable)	set	1.0	180,000	180,000	-	17,946
	-Include construction cost(10%)	Steel pole(H=10m)	set	3.0	11,000	33,000	-	3,290
		Fiber optic	m	2,520.0	11	27,720	-	2,764
	Elevator facilities					-	-	-
	-Include installation cost(20%)	Elevator equipment	unit	2.0	150,000	-	29,910	29,910
		Drive unit	unit	2.0	120,000	-	23,928	23,928
		Shaft(Equipment)	set	2.0	300,000	-	59,820	59,820
		Operations panel	unit	2.0	60,000	-	11,964	11,964
	-Include construction cost(10%)	Cable and Plumbing	m	400.0	66	26,400	-	2,632
		Shaft(Civil)	set	2.0	1,100,000	2,200,000	-	219,340
	Utilities					-	-	-
	Water supply(IDAAN)					-	-	-
	-Include construction cost(10%)	PVC,18 inches	m	840.0	132	110,880	-	11,055
		Connection of bridges and earthwork	set	6.0	3,300	19,800	-	1,974
		Connected to existing pipe	set	2.0	5,500	11,000	-	1,097
		Water supply valve	set	2.0	8,800	17,600	-	1,755
		Flexible pipe	set	19.0	5,500	104,500	-	10,419
	Communication wire（Cable and Wireless,）					-	-	-
	-Include construction cost(10%)	HDPE,4 inches	m	840.0	33	27,720	-	2,764
		Connection of bridges and earthwork	set	6.0	2,200	13,200	-	1,316
		optical closure	set	2.0	2,200	4,400	-	439
	High-voltage line（GasFenosa）					-	-	-
	-Include construction cost(10%)	HDPE,6 inches	m	840.0	55	46,200	-	4,606
		Connection of bridges and earthwork	set	6.0	2,200	13,200	-	1,316
		Sleeve joint	set	2.0	3,850	7,700	-	768

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
8	**Public Utilities Relocation (Preliminary Design)**				**-**	**15,370,640**	**-**	**1,532,453**
	Transmission line					-	-	-
	-Include construction cost and connected to existing(20%)	Transmission line relocation	set	1.0	1,596,000	1,596,000	-	159,121
		Transmission line tower removal	set	2.0	600,000	1,200,000	-	119,640
		Buried construction	m	160.0	6,000	960,000	-	95,712
		Power cable×3	m	480.0	48	23,040	-	2,297
		Electrical Conduit(φ130)× 6	m	960.0	120	115,200	-	11,485
		Joint	set	2.0	120,000	240,000	-	23,928
	Power line					-	-	-
	-Include construction cost and connected to existing(20%)	Power line relocation 01	set	63.0	6,000	378,000	-	37,687
		Power line relocation 02	set	33.0	6,000	198,000	-	19,741
		Power line relocation 03	set	25.0	6,000	150,000	-	14,955
		Power line relocation 04	set	22.0	6,000	132,000	-	13,160
		Power line relocation 05	set	55.0	6,000	330,000	-	32,901
		Power line relocation 06	set	26.0	6,000	156,000	-	15,553
		Power line relocation 07	set	50.0	6,000	300,000	-	29,910
		Power line relocation 08	set	38.0	6,000	228,000	-	22,732
		Power line relocation 09	set	84.0	6,000	504,000	-	50,249
		Power line relocation 10	set	51.0	6,000	306,000	-	30,508
		Power line relocation 11	set	80.0	6,000	480,000	-	47,856
		Power line relocation 12	set	20.0	6,000	120,000	-	11,964
		Power line relocation 13	set	150.0	6,000	900,000	-	89,730
	Water pipe and drainage					-	-	-
	-Include construction cost and connected to existing(20%)	Water pipe (Concrete protection) 01	set	20.0	6,000	120,000	-	11,964
		Water pipe (Concrete protection) 02	set	79.0	6,000	474,000	-	47,258
		Chill water pipe (Footing foundation) 03	set	15.0	9,600	144,000	-	14,357
		Water pipe (Relocation) 04	set	175.0	9,600	1,680,000	-	167,496
		Chill water pipe (Footing foundation) 05	set	11.0	3,600	39,600	-	3,948
		Chill water pipe (Footing foundation) 06	set	15.0	3,600	54,000	-	5,384
		Chill water pipe (Footing foundation) 07	set	12.0	3,600	43,200	-	4,307
		Water pipe (Relocation) 08	set	28.0	9,600	268,800	-	26,799
		Water pipe (Relocation) 09	set	103.0	9,600	988,800	-	98,583
		Water pipe (Concrete protection) 10	set	40.0	6,000	240,000	-	23,928
		Water pipe (Concrete protection) 11	set	38.0	6,000	228,000	-	22,732
		Water pipe (Concrete protection) 12	set	215.0	6,000	1,290,000	-	128,613
		Water supply valve	set	8.0	9,600	76,800	-	7,657
		Flexible pipe	set	8.0	6,000	48,000	-	4,786
	Communication wire					-	-	-
	-Include construction cost and connected to existing(20%)	Communication wire relocation 01	set	72.0	3,600	259,200	-	25,842
	Telecommunication building tower					-	-	-
	-Include construction cost(10%)	Improvement of tower	set	1.0	1,100,000	1,100,000	-	109,670

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
9	**Environmental Mitigation and Monitoring (Preliminary Design)**					**2,021,453**	**0**	**201,539**
	Mitigation Plan					-	-	-
	Noise and Vibrations Control Program	Acoustic barriers barriers	km	6.75	9,500.00	64,125	-	6,393
	Soil Protection	Construction of containment barriers, ditches and sediment traps	km	6.75	16,000.00	108,000	-	10,768
	Surface Water Quality Control	Petroleum absorbers, dispersants, clean-up equipment and floating barriers	km	6.75	56,000.00	378,000	-	37,687
	Flora Protection	Tree and Grass Planting Plan in affected grassy areas (includes maintenance for 5 years)	ha	1.66	8,750.00	14,481	-	1,444
		Flora Rescue and Recovery Plan (forest and mangroves)	ha	2.88	350.00	1,007	0	100
		Reforestation Plan (forest and mangroves)	ha	2.88	7,700.00	22,161	0	2,209
	Fauna Protection	Placing signs in construction areas in stations and forest areas to instruct regarding good behavior toward fauna	sign	8.00	200.00	1,600	-	160
		Fauna Rescue and Relocation Plan (forest and mangrove sectors of the alignment)	ha	2.88	500.00	1,439	-	143
	Environmental Education Plan	Preparation and Execution of the Environmental Education Plan	worker	1,000.00	120.00	120,000	-	11,964
	Socio economic, Historical and Cultural	Disclosure of hiring policies for labor and employment opportunities for the local population	worker	1,000.00	33.00	33,000	-	3,290
		Notification to communities of the development of construction activities	location	3.00	900.00	2,700	-	269
		Placement of speed control signalization	sign	13.00	200.00	2,600	-	259
		Placement of warning and safety signalization in risk areas	area	6.00	3,800.00	22,800	-	2,273
	Environmental Supervisor	Salary	year	4.00	19,500.00	78,000	-	7,777
		Material and work equipment	year	4.00	2,400.00	9,600	-	957
	Social Aspects Manager	Salary	year	4.00	26,000.00	104,000	-	10,369
		Materials and work equipment	year	4.00	2,400.00	9,600	-	957
	Community Liaison Officer	Salary	year	4.00	19,550.00	78,200	-	7,797
		Materials and work equipment	year	4.00	3,000.00	12,000	-	1,196
	Environmental and Social Management Personnel Transportation	Vehicle's (4x4)	year	2.00	36,000.00	72,000	-	7,178
	Mitigation Plan					-	-	-
	Air Quality Monitoring	Quarterly monitoring of vehicular emissions	year	4.00	14,300.00	57,200	-	5,703
		Air quality monitoring before starting construction in Ancon Sector	year	3.00	1,000.00	3,000	-	299
		Quarterly air quality monitoring	year	4.00	29,400.00	117,600	-	11,725
	Noise Emissions Monitoring (Ambient and Occupational)	Quarterly occupational noise monitoring	year	4.00	28,600.00	114,400	-	11,406
		Baseline noise monitoring before construction in Ancon Sector	site	3.00	750.00	2,250	-	224
		Baseline noise monitoring before construction along the alignment.	site	8.00	750.00	6,000	-	598
		Quarterly noise monitoring	year	4.00	21,400.00	85,600	-	8,534
	Vibration Level Monitoring (Ambient and Occupational)	Quarterly full-body vibration monitoring	year	4.00	36,600.00	146,400	-	14,596
		Baseline ambient vibration monitoring before construction in Ancon sector and alignment	site	11.00	930.00	10,230	-	1,020
		Quarterly ambient vibration monitoring	year	4.00	29,400.00	117,600	-	11,725
		Monitoring in case of blasts	site	2.00	930.00	1,860	-	185
	Surface Water Quality Monitoring	Quarterly surface water quality monitoring	year	4.00	29,200.00	116,800	-	11,645
	Soil Quality Monitoring	Quarterly soil quality monitoring	year	4.00	11,800.00	47,200	-	4,706
	Land Subsidence Monitoring	Quarterly land subsidence monitoring	year	4.00	15,000.00	60,000	-	5,982
10	**Risk Cost (Preliminary Design and Concept Design)**		Ls	1	13,877,996.6	-	**1,383,636**	**1,383,636**
Total Construction Amount						**732,952,597**	**59,985,459**	**133,060,832**

Non Eligible Portion

11	**Environmental Compensation (Preliminary Design)**					**12,310**	**-**	**1,227**
	Environmental Compensation	Mangroves	ha	0.36	5,000.00	1,815	-	181
		Mature secondary forest	ha	1.67	5,000.00	8,340	-	831
		Intermediate secondary forest	ha	0.24	3,000.00	720	-	72
		Young secondary forest	ha	0.61	1,000.00	607	-	61
		Grassy plants	ha	1.66	500.00	828	-	83
12	**Land Acquisition & Resettlement (Preliminary Design)**					**5,301,056**	**-**	**528,515**
	Compensation for economic displacement		Ls	1	301,055.5	301,056	-	30,015
	Relocation of ACP structures		Ls	1	5,000,000.0	5,000,000	-	498,500

7-2 Without Using Navigation Channel during Main Bridge Erection

The preliminary construction cost in the case of "Without Using Navigation Channel during Main Bridge Erection" was modified from Section 7-1 in the following items.

Cost Estimation for 4th Panama Canal Bridge Construction (Cable Erection Method)

Item No.	Description		Unit	Qty	Unit Rate (USD)	L/C (USD)	F/C ('1000 JPY)	Total ('000 JPY)
1	**Temporary Works (Preliminary Design)**					**100,872,751**	**2,570,503**	**12,627,516**
	Temporary yard	Rental, Preparation & Maintenance for Stock Yard. 270,000m2, including Transportation Material and Equipment from West Yard to East	Ls	1	101,664,126	81,331,301	2,027,183	10,135,913
	Temporary road	Access Road for Work	Ls	1	21,982,000	17,585,600	438,321	2,191,605
	Temporary Jetty	East and West Side Jetty and Embankment for P38 - P44	Ls	1	3,009,000	1,955,850	104,999	299,997
3	**4th Panama Canal Bridge (Preliminary Design)**					**321,418,407**	**42,337,105**	**74,382,521**
	Main Bridge (Arch) (P30~P33)					125,753,928	26,909,880	39,447,547
	Superstructure					38,226,486	23,667,236	27,478,417
		Steel (for Vehicle)	kg	37,373,000	6.80	29,301,927	22,415,997	25,337,399
		Paint (for Vehicle)	m2	448,476	21	1,074,808	822,229	929,388
		Concrete (for Deck fck=24N/mm2)	m3	7,195	909	5,102,862	143,495	652,250
		Concrete (for Barrier & Curb fck=24N/mm2)	m3	1,945	785.12	1,259,822	26,643	152,248
		Bearing	nos.	4	109,453	21,891	41,467	43,650
		Expansion Joint	m	99	13,760	68,111	129,022	135,813
		Drainage	nos.	129	313	30,256	1,006	4,022
		Pavement (for Vehicle)	m2	22,428	71	1,127,783	46,008	158,448
		Pavement (for Pedestrian)	m2	3,360	50	118,331	4,819	16,616
		Waterproofing	m2	25,788	19	120,696	36,549	48,583
9	**Environmental Mitigation and Monitoring (Preliminary Design)**					**2,310,003**	**0**	**230,307**
	Mitigation Plan					-	-	-
	Noise and Vibrations Control Program	Acoustic barriers barriers	km	6.75	9,500.00	64,125	-	6,393
	Soil Protection	Construction of containment barriers, ditches and sediment traps	km	6.75	16,000.00	108,000	-	10,768
	Surface Water Quality Control	Petroleum absorbers, dispersants, clean-up equipment and floating barriers	km	6.75	56,000.00	378,000	-	37,687
	Flora Protection	Tree and Grass Planting Plan in affected grassy areas (includes maintenance for 5 years)	ha	1.66	8,750.00	14,481	-	1,444
		Flora Rescue and Recovery Plan (forest and mangroves)	ha	2.88	350.00	1,007	0	100
		Reforestation Plan (forest and mangroves)	ha	2.88	7,700.00	22,161	0	2,209
	Fauna Protection	Placing signs in construction areas in stations and forest areas to instruct regarding good behavior toward fauna	sign	8.00	200.00	1,600	-	160
		Fauna Rescue and Relocation Plan (forest and mangrove sectors of the alignment)	ha	2.88	500.00	1,439	-	143
	Environmental Education Plan	Preparation and Execution of the Environmental Education Plan	worker	1,000.00	120.00	120,000	-	11,964
	Socio economic, Historical and Cultural	Disclosure of hiring policies for labor and employment opportunities for the local population	worker	1,000.00	33.00	33,000	-	3,290
		Notification to communities of the development of construction activities	location	3.00	900.00	2,700	-	269
		Placement of speed control signalization	sign	13.00	200.00	2,600	-	259
		Placement of warning and safety signalization in risk areas	area	6.00	3,800.00	22,800	-	2,273
	Environmental Supervisor	Salary	year	5.00	19,500.00	97,500	-	9,721
		Material and work equipment	year	5.00	2,400.00	12,000	-	1,196
	Social Aspects Manager	Salary	year	5.00	26,000.00	130,000	-	12,961
		Materials and work equipment	year	5.00	2,400.00	12,000	-	1,196
	Community Liaison Officer	Salary	year	5.00	19,550.00	97,750	-	9,746
		Materials and work equipment	year	5.00	3,000.00	15,000	-	1,496
	Environmental and Social Management Personnel Transportation	Vehicle's (4x4)	year	2.00	36,000.00	72,000	-	7,178
	Mitigation Plan					-	-	-
	Air Quality Monitoring	Quarterly monitoring of vehicular emissions	year	5.00	14,300.00	71,500	-	7,129
		Air quality monitoring before starting construction in Ancon Sector	year	3.00	1,000.00	3,000	-	299
		Quarterly air quality monitoring	year	5.00	29,400.00	147,000	-	14,656
	Noise Emissions Monitoring (Ambient and Occupational)	Quarterly occupational noise monitoring	year	5.00	28,600.00	143,000	-	14,257
		Baseline noise monitoring before construction in Ancon Sector	site	3.00	750.00	2,250	-	224
		Baseline noise monitoring before construction along the alignment.	site	8.00	750.00	6,000	-	598
		Quarterly noise monitoring	year	5.00	21,400.00	107,000	-	10,668
	Vibration Level Monitoring (Ambient and Occupational)	Quarterly full-body vibration monitoring	year	5.00	36,600.00	183,000	-	18,245
		Baseline ambient vibration monitoring before construction in Ancon sector and alignment	site	11.00	930.00	10,230	-	1,020
		Quarterly ambient vibration monitoring	year	5.00	29,400.00	147,000	-	14,656
		Monitoring in case of blasts	site	2.00	930.00	1,860	-	185
	Surface Water Quality Monitoring	Quarterly surface water quality monitoring	year	5.00	29,200.00	146,000	-	14,556
	Soil Quality Monitoring	Quarterly soil quality monitoring	year	5.00	11,800.00	59,000	-	5,882
	Land Subsidence Monitoring	Quarterly land subsidence monitoring	year	5.00	15,000.00	75,000	-	7,478
10	**Risk Cost (Preliminary Design and Concept Design)**		Ls	1	6,814,041.9	**-**	**679,360**	**679,360**
Total Construction Amount						**744,492,561**	**62,325,447**	**136,551,355**

Appendix 8：Breakdown of O&M Cost
(Preliminary Design Section)
(4th Panama Canal Bridge)

Appendix 8: Breakdown of Preliminary O&M Cost (Preliminary Design Section) (4th Panama Canal Bridge)

The breakdown of preliminary O&M cost is attached in this appendix.

This cost data is tentative and subject to update.

8-1 O&M Cost for Civil Works

Appendix 8 O&M Cost (Preliminary Design Section) (Civil Works)

Road	Category			Item	Specifications	Qty		Time		Unit Rate				Amount	
						Qty	Unit (/1 time)	Frequency (Year)	Times (100 Years)	F/C (JPY)	L/C (USD)	Equiv. in F/C (JPY)	Equiv. in L/C (USD)	Equiv. in F/C (JPY/100 Years)	Equiv. in L/C (USD/100 Years)
4th Panama Canal Bridge	Common			Repair of road marking		6,737	m	10	10	199	8	997	10	67,167,890	673,700
				Repair of road signs		6,737	m	10	10	4,985	200	24,925	250	1,679,197,250	16,842,500
	East Approach Bridge	Road		Pavement	Concrete	29,247	m2	30	3	2,592	104	12,961	130	1,137,211,101	11,406,330
				Pavement	Surface course, dense-grade asphalt	5,464	m2	10	10	1,336	54	6,680	67	364,995,200	3,660,880
				Repair of MSEW	MSEW	11,570	m2	50	2	-	200	19,940	200	461,411,600	4,628,000
				Repair of cutslope	Mortar spraying	5,598	m2	20	5	997	40	4,985	50	139,530,150	1,399,500
				Side ditch, catch pit		3,174	m	15	6	3,390	136	16,949	170	322,776,756	3,237,480
				Repair of guardrails	Flexible guard fence	3,428	m	10	10	399	16	1,994	20	68,354,320	685,600
		Flyover No.1	PC-I	Pavement	Surface course, dense-grade asphalt	5,238	m2	10	10	1,336	54	6,680	67	349,898,400	3,509,460
				Pavement	Binder course (modified asphalt), waterproofing	5,238	m2	30	3	1,595	64	7,976	80	125,334,864	1,257,120
				Catch pit	Steel	27	nos	50	2	98,703	110	109,670	1,100	5,922,180	59,400
				Repair of accessories (partial)	Cleaning, patching, repair	105	m2	5	20	1,994	80	9,970	100	20,889,144	209,520
				Repair of main girder (partial)	PC	524	m2	15	6	14,955	350	49,850	500	156,668,580	1,571,400
				Expansion joint	Steel	44	m	40	2	358,920	400	398,800	4,000	34,775,360	348,800
				Repair of substructure (partial)	RC	35	m2	10	10	9,970	400	49,850	500	17,447,500	175,000
			Steel Box	Pavement	Surface course, dense-grade asphalt	4,850	m2	10	10	1,336	54	6,680	67	323,980,000	3,249,500
				Pavement	Binder course (modified asphalt), waterproofing	4,850	m2	30	3	1,595	64	7,976	80	116,050,800	1,164,000
				Pavement	Sidewalk, asphalt	1,250	m2	30	3	798	32	3,988	40	14,955,000	150,000
				Catch pit	Steel	38	nos	50	2	98,703	110	109,670	1,100	8,225,250	82,500
				Repair of accessories (partial)	Cleaning, patching, repair	122	m2	5	20	1,994	80	9,970	100	24,326,800	244,000
				Re-painting	Weathering steel, equivalent to Class C-5	12,686	m2	40	2	9,870	11	10,967	110	278,261,304	2,790,986
				Re-painting (partial)	Equivalent to Classes C-5,D-5	300	m2	15	6	9,870	11	10,967	110	19,740,600	198,000
				Scaffolding for re-painting		4,850	m2	40	2	997	40	4,985	50	48,354,500	485,000
				Repair of deck slab (partial)	RC	305	m2	15	6	9,970	400	49,850	500	91,225,500	915,000
				Expansion joint	Steel	104	m	40	2	358,920	400	398,800	4,000	82,631,360	828,800
				Repair of substructure (partial)	RC	60	m2	10	10	34,895	150	49,850	500	29,910,000	300,000
		Flyover No.2	PC-I	Pavement	Surface course, dense-grade asphalt	6,942	m2	10	10	1,336	54	6,680	67	463,725,600	4,651,140
				Pavement	Binder course (modified asphalt), waterproofing	6,942	m2	30	3	1,595	64	7,976	80	166,108,176	1,666,080
				Catch pit	Steel	26	nos	50	2	98,703	110	109,670	1,100	5,702,840	57,200
				Repair of accessories (partial)	Cleaning, patching, repair	139	m2	5	20	1,994	80	9,970	100	27,684,696	277,680
				Repair of main girder (partial)	PC	694	m2	15	6	14,955	350	49,850	500	207,635,220	2,082,600
				Expansion joint	Steel	58	m	40	2	358,920	400	398,800	4,000	46,420,320	465,600
				Repair of substructure (partial)	RC	35	m2	10	10	9,970	400	49,850	500	17,447,500	175,000
			Steel Box	Pavement	Surface course, dense-grade asphalt	12,816	m2	10	10	1,336	54	6,680	67	856,108,800	8,586,720
				Pavement	Binder course (modified asphalt), waterproofing	12,816	m2	30	3	1,595	64	7,976	80	306,661,248	3,075,840
				Pavement	Sidewalk, asphalt	2,400	m2	30	3	798	32	3,988	40	28,713,600	288,000
				Catch pit	Steel	72	nos	50	2	98,703	110	109,670	1,100	15,792,480	158,400
				Repair of accessories (partial)	Cleaning, patching, repair	304	m2	5	20	1,994	80	9,970	100	60,681,408	608,640
				Re-painting	Weathering steel, equivalent to Class C-5	50,955	m2	40	2	9,870	11	10,967	110	1,117,841,487	11,210,045
				Re-painting (partial)	Equivalent to Classes C-5,D-5	300	m2	15	6	9,870	11	10,967	110	19,740,600	198,000
				Scaffolding for re-painting		12,816	m2	40	2	997	40	4,985	50	127,775,520	1,281,600
				Repair of deck slab (partial)	RC	761	m2	15	6	9,970	400	49,850	500	227,555,280	2,282,400
				Expansion joint	Steel	118	m	40	2	358,920	400	398,800	4,000	94,276,320	945,600
				Repair of substructure (partial)	RC	70	m2	10	10	34,895	150	49,850	500	34,895,000	350,000
	4th Panama Canal Bridge	East Approach Bridge	Steel Box	Pavement	Surface course, dense-grade asphalt	14,231	m2	10	10	1,336	54	6,680	67	950,637,480	9,534,837
				Pavement	Binder course (modified asphalt), waterproofing	14,231	m2	30	3	1,595	64	7,976	80	340,521,761	3,415,464
				Pavement	Sidewalk, asphalt	2,665	m2	30	3	798	32	3,988	40	31,884,060	319,800
				Catch pit	Steel	80	nos	50	2	98,703	110	109,670	1,100	17,536,233	175,890
				Repair of accessories (partial)	Cleaning, patching, repair	338	m2	5	20	1,994	80	9,970	100	67,381,647	675,844
				Re-painting	Weathering steel, equivalent to Class C-5	77,978	m2	40	2	9,870	11	10,967	110	1,710,379,322	17,155,259
				Re-painting (partial)	Equivalent to Classes C-5,D-5	300	m2	15	6	9,870	11	10,967	110	19,740,600	198,000
				Scaffolding for re-painting		14,231	m2	40	2	997	40	4,985	50	141,884,067	1,423,110
				Repair of deck slab (partial)	RC	845	m2	15	6	9,970	400	49,850	500	252,681,176	2,534,415
				Expansion joint	Steel	118	m	40	2	358,920	400	398,800	4,000	94,276,320	945,600
				Repair of substructure (partial)	RC	70	m2	10	10	34,895	150	49,850	500	34,895,000	350,000
		Main Bridge	Arch	Pavement	Surface course, dense-grade asphalt	22,428	m2	10	10	1,336	54	6,680	67	1,498,190,400	15,026,760
				Pavement	Binder course (modified asphalt), waterproofing	22,428	m2	30	3	1,595	64	7,976	80	536,657,184	5,382,720
				Pavement	Sidewalk, asphalt	3,360	m2	30	3	798	32	3,988	40	40,199,040	403,200
				Catch pit	Steel	126	nos	50	2	98,703	110	109,670	1,100	27,636,840	277,200
				Repair of accessories (partial)	Cleaning, patching, repair	516	m2	5	20	1,994	80	9,970	100	102,842,544	1,031,520
				Re-painting	Weathering steel, equivalent to Class C-5	243,650	m2	40	2	9,870	11	10,967	110	5,344,219,100	53,603,000
				Re-painting (partial)	Equivalent to Classes C-5,D-5	600	m2	15	6	9,870	11	10,967	110	39,481,200	396,000
				Scaffolding for re-painting		67,284	m2	40	2	997	40	4,985	50	670,821,480	6,728,400
				Repair of deck slab (partial)	RC	1,289	m2	15	6	14,955	350	49,850	500	385,659,540	3,868,200
				Expansion joint	Steel	118	m	40	2	358,920	400	398,800	4,000	94,276,320	945,600
				Repair of substructure (partial)	RC	30	m2	10	10	44,865	50	49,850	500	14,955,000	150,000
		West Approach Bridge	Steel Box	Pavement	Surface course, dense-grade asphalt	21,627	m2	10	10	1,336	54	6,680	67	1,444,683,600	14,490,090
				Pavement	Binder course (modified asphalt), waterproofing	21,627	m2	30	3	1,595	64	7,976	80	517,490,856	5,190,480
				Pavement	Sidewalk, asphalt	4,050	m2	30	3	798	32	3,988	40	48,454,200	486,000
				Catch pit	Steel	122	nos	50	2	98,703	110	109,670	1,100	26,649,810	267,300
				Repair of accessories (partial)	Cleaning, patching, repair	514	m2	5	20	1,994	80	9,970	100	102,399,876	1,027,080
				Re-painting	Weathering steel, equivalent to Class C-5	103,781	m2	40	2	9,870	11	10,967	110	2,276,335,744	22,831,853
				Re-painting (partial)	Equivalent to Classes C-5,D-5	300	m2	15	6	9,870	11	10,967	110	19,740,600	198,000
				Scaffolding for re-painting		21,627	m2	40	2	997	40	4,985	50	215,621,190	2,162,700
				Repair of deck slab (partial)	RC	1,284	m2	15	6	9,970	400	49,850	500	383,999,535	3,851,550
				Expansion joint	Steel	118	m	40	2	358,920	400	398,800	4,000	94,276,320	945,600
				Repair of substructure (partial)	RC	110	m2	10	10	34,895	150	49,850	500	54,835,000	550,000
			PC-I	Pavement	Surface course, dense-grade asphalt	9,612	m2	10	10	1,336	54	6,680	67	642,081,600	6,440,040
				Pavement	Binder course (modified asphalt), waterproofing	9,612	m2	30	3	1,595	64	7,976	80	229,995,936	2,306,880
				Catch pit	Steel	36	nos	50	2	98,703	110	109,670	1,100	7,896,240	79,200
				Repair of accessories (partial)	Cleaning, patching, repair	192	m2	5	20	1,994	80	9,970	100	38,332,656	384,480
				Repair of main girder (partial)	PC	961	m2	15	6	14,955	350	49,850	500	287,494,920	2,883,600
				Expansion joint	Steel	58	m	40	2	358,920	400	398,800	4,000	46,420,320	465,600
				Repair of substructure (partial)	RC	45	m2	10	10	9,970	400	49,850	500	22,432,500	225,000
		West Approach Bridge	Road	Pavement	Concrete	23,824	m2	30	3	2,592	104.00	12,961	130	926,348,592	9,291,360
				Pavement	Surface course, dense-grade asphalt	4,451	m2	10	10	1,336	53.60	6,680	67	297,326,800	2,982,170
				Repair of embankment slope	Mortar spraying	0	m2	20	5	399	16.00	1,994	20	0	0
				Side ditch, catch pit		1,309	m	15	6	3,390	136.00	16,949	170	133,117,446	1,335,180
				Repair of guardrails	Flexible guard fence	2,618	m	10	10	399	16.00	1,994	20	52,202,920	523,600
	East Side Connection Road	Road		Pavement	Concrete	7,200	m2	30	3	2,592	104.00	12,961	130	279,957,600	2,808,000
				Pavement	Surface course, dense-grade asphalt	2,400	m2	10	10	1,336	53.60	6,680	67	160,320,000	1,608,000
				Repair of embankment slope	Mortar spraying	0	m2	20	5	399	16.00	1,994	20	0	0
				Side ditch, catch pit		1,020	m	15	6	3,390	136.00	16,949	170	103,727,880	1,040,400
				Repair of guardrails	Flexible guard fence	2,000	m	10	10	399	16.00	1,994	20	39,880,000	400,000
	Access Road to the Bridge of the Americas	Common		Repair of road marking		1,582	m	10	10	199	8.00	997	10	15,772,540	158,200
				Repair of road signs		1,582	m	10	10	4,985	200.00	24,925	250	394,313,500	3,955,000
		Road		Pavement	Concrete	16,992	m2	30	3	2,592	104.00	12,961	130	660,699,936	6,626,880
				Pavement	Surface course, dense-grade asphalt	5,664	m2	10	10	1,336	53.60	6,680	67	378,355,200	3,794,880
				Repair of embankment slope	Mortar spraying	0	m2	20	5	399	16.00	1,994	20	0	0
				Side ditch, catch pit		2,360	m	15	6	3,390	136.00	16,949	170	239,997,840	2,407,200
				Repair of guardrails	Flexible guard fence	4,720	m	10	10	399	16.00	1,994	20	94,116,800	944,000
		Bridge	PC-I	Pavement	Surface course, dense-grade asphalt	7,372	m2	10	10	1,336	54	6,680	67	492,449,600	4,939,240
				Pavement	Binder course (modified asphalt), waterproofing	7,372	m2	30	3	1,595	64	7,976	80	176,397,216	1,769,280
				Catch pit	Steel	30	nos	50	2	98,703	110	109,670	1,100	6,667,936	66,880
				Repair of accessories (partial)	Cleaning, patching, repair	147	m2	5	20	1,994	80	9,970	100	29,399,536	294,880
				Repair of main girder (partial)	PC	737	m2	15	6	14,955	350	49,850	500	220,496,520	2,211,600
				Expansion joint	Steel	44	m	40	2	358,920	400	398,800	4,000	34,775,360	348,800
				Repair of substructure (partial)	RC	50	m2	10	10	9,970	400	49,850	500	24,925,000	250,000
Total														**33,450,952,943**	**335,514,843**

99.71 JPY/1USD

8-2 O&M Cost for Electrical and Mechanical Facilities

Appendix 8 O&M Cost (Preliminary Design Section) (Electrical and Mechanical Facilities)

Road	Category	Item	Specifications	Qty		Time		Unit Rate				Amount	
				Qty	Unit (/1 time)	Frequency (Year)	Times (100 Years)	F/C (JPY)	L/C (USD)	Equiv. in F/C (JPY)	Equiv. in L/C (USD)	Equiv. in F/C (JPY/100 Years)	Equiv. in L/C (USD/100 Years)
4th Panama Canal Bridge/ East Side Connection Road/ Access Road to the Bridge of the Americas	Power Supply	Cubicle		3	unit	30	3	3,090,700		3,090,700	31,000	27,816,300	279,000
		Inspection	1 time/year	1	set	1	100		500	49,850	500	4,985,000	50,000
		Piping wiring		44,500	m	30	3		55	5,484	55	732,114,000	7,342,500
	Road Lighting	Lamp	LED	1,102	set	15	6	299,100		299,100	3,000	1,977,649,200	19,836,000
		Pole	h=12m	551	set	30	3		1,500	149,550	1,500	247,206,150	2,479,500
		Foundation of pole	Concrete	422	set	30	3		750	74,775	750	94,665,150	949,500
		Electric bill	1 time/year	1,102	set	1	100		37	3,689	37	406,527,800	4,077,400
		Inspection	2 times/year	2	set	1	100		3,306	299	3,306	59,800	661,200
	Road Lighting (Bridge)	Lamp	LED	352	set	15	6	299,100		299,100	3,000	631,699,200	6,336,000
		Pole	h=12m	176	set	30	3		1,500	149,550	1,500	78,962,400	792,000
		Electric bill	1 time/year	352	set	1	100		37	3,689	37	129,852,800	1,302,400
		Inspection	2 times/year	2	set	1	100		1,056	299	1,056	59,800	211,200
	Illumination	Floodlight	Including piping wiring	84	set	30	3	498,500		498,500	5,000	125,622,000	1,260,000
		Lamp	LED	848	set	15	6	199,400		199,400	2,000	1,014,547,200	10,176,000
		Inspection	2 times/year	2	set	1	100		2,000	199,400	2,000	39,880,000	400,000
		Piping wiring		6,720	m	30	3		55	5,484	55	110,557,440	1,108,800
	Airplane Warning Light	Airplane warning light	LED	1	set	15	6	1,994,000		1,994,000	20,000	11,964,000	120,000
		Solar cells for power supply	Including piping wiring	1	unit	20	5	9,970,000		9,970,000	100,000	49,850,000	500,000
		Solar cells panel		1	set	15	6	9,970,000		9,970,000	100,000	59,820,000	600,000
		Inspection	2 times/year	2	set	1	100		2,000	199,400	2,000	39,880,000	400,000
	Marine Warning Light	Marine warning light	LED	4	set	15	6	1,994,000		1,994,000	20,000	47,856,000	480,000
		Solar cells for power supply	Including piping wiring	1	unit	20	5	19,940,000		19,940,000	200,000	99,700,000	1,000,000
		Solar cells panel		4	set	15	6	9,970,000		9,970,000	100,000	239,280,000	2,400,000
		Inspection	2 times/year	2	set	1	100		2,000	199,400	2,000	39,880,000	400,000
	Variable Messege Signboard (VMS)	VMS	LED	2	set	15	6	15,952,000		15,952,000	160,000	191,424,000	1,920,000
		Operations panel		2	unit	15	6	498,500		498,500	5,000	5,982,000	60,000
		Pole	h=7m (steel pole), including piping wiring	2	set	30	3		5,000	498,500	5,000	2,991,000	30,000
		Inspection	2 times/year	2	set	1	100		3,000	299,100	3,000	59,820,000	600,000
	Meteorological Observation Facilities	Mo equipment		1	unit	15	6	9,970,000		9,970,000	100,000	59,820,000	600,000
		Pole	h=3m (steel pole)	1	set	30	3		2,000	199,400	2,000	598,200	6,000
		Temperature meter		1	set	15	6	418,740		418,740	4,200	2,512,440	25,200
		Rain meter		1	set	15	6	418,740		418,740	4,200	2,512,440	25,200
		Visibility meter		1	set	15	6	4,985,000		4,985,000	50,000	29,910,000	300,000
		Anemometer		1	set	15	6	453,635		453,635	4,550	2,721,810	27,300
		Precipitation meter		1	set	15	6	857,420		857,420	8,600	5,144,520	51,600
		Inspection	2 times/year	2	set	1	100		3,000	299,100	3,000	59,820,000	600,000
	Closed-circuit Television (CCTV)	CCTV camera		3	set	15	6	3,489,500		3,489,500	35,000	62,811,000	630,000
		CCTV device		3	unit	15	6	3,489,500		9,970,000	100,000	179,460,000	1,800,000
		Pole	h=10m (steel pole)	3	set	30	3		8,000	797,600	8,000	7,178,400	72,000
		Fiber optic		2,520	m	15	6		10	997	10	15,074,640	151,200
		Inspection	2 times/year	2	set	1	100		2,000	199,400	2,000	39,880,000	400,000
	Elevator Facilities	Elevator equipment		2	unit	20	5	19,940,000		19,940,000	200,000	199,400,000	2,000,000
		Drive unit		2	unit	20	5	9,970,000		9,970,000	100,000	99,700,000	1,000,000
		Shaft		2	unit	50	2	24,925,000		24,925,000	250,000	99,700,000	1,000,000
		Operations panel		2	unit	20	5	498,500		498,500	5,000	4,985,000	50,000
		Inspection	2 times/year	2	set	1	100		5,000	498,500	5,000	99,700,000	1,000,000
		Piping wiring		400	m	20	5		60	5,982	60	11,964,000	120,000
Total												7,453,543,690	75,630,000

99.71 JPY/1USD

Appendix 9：Pre-F/S Review Report (Main Bridge, 4th Panama Canal Bridge)

The Feasibility Study
on
Panama City Urban Transportation Line-3 Project

(4th Panama Canal Bridge Study)

Pre-F/S Review Report
(Main Bridge, 4th Panama Canal Bridge)

July 2014

Japan International Cooperation Agency

Nippon Koei Co., Ltd.
Tonichi Engineering Consultants, Inc.
TOSTEMS, Inc.
Nippon Koei LAC Co., Ltd.

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Chapter 1 Outline

1.1 Background

The Feasibility Study on Panama City Urban Transportation Line-3 Project (Metro Line-3 Study) is being conducted by NK-Tonichi-TOSTEMS-NKLAC under JICA Technical Assistance from June, 2013.

Metro Line-3 is planned to cross the Panama Canal by the 4th Panama Canal Bridge, whose study has been implemented in Pre-F/S; therefore, the 4th Panama Canal Bridge was excluded from the scope of works in the Metro Line-3 Study (hereinafter referred to as "the Study") while the Study targets to review the Pre-F/S.

After commenced the Metro Line -3 Study, GOP also expressed an intention to formulate the 4th Panama Bridge Construction Project (the Project) by Japanese Yen Loan. Therefore, GOP and GOJ held a meeting on July 12, 2013 and agreed to conduct its study under the Metro Line-3 Study.

In accordance with the above agreement, the Minutes of Meeting on the Study was signed on September 3, 2013 between SMP and JICA.

Type of the 4th Panama Canal Bridge is explored based on two type of design, one is composite cable-stayed bridge in Pre-F/S and the other is arch bridge in the Study, and the final decision shall be made according to both preliminary designs.

1.2 Objective of the Review

The objective of the Review is to verify preliminary design of Pre-F/S in order to arrange both studies in same conditions before comparing composite cable-stayed bridge plan in Pre-F/S and arch bridge plan in the Study.

1.3 Subject of the Review

The subject of the Review is the Draft Final Report (December 2013) of Pre-F/S of 4th Panama Canal Bridge Construction Project conducted by ACP.

1.4 Items and Results of the Review

The followings are the items of the Review:

- Planning and Design Conditions
- Cross Sections
- Bridge Planning and Preliminary Design
- Construction Quantities
- Construction Planning
- Cost Estimate

Table 1.1 shows the summary of review results.

Table 1.1 Summary of Review Results

No.	Items			Confirmation Required	Adjustment Required in Comparison Study	Reference (This Report)
1	Planning and Design Conditions	Planning Conditions	Topographical Conditions	Not required		3.1.1
2			Geological Conditions	Not required		3.1.2
3			Navigation Clearance	Not required		3.1.3
4			Airspace Conditions	Not required		3.1.4
5			Cross Conditions	Not required		3.1.5
6			Condition for Election and Construction	Required		3.1.6
7			Arrangement Plan of Metro Line-3	Required		3.1.7
8		Design Conditions	Alignment	Required		3.2.1
9			Design Life	Required		3.2.2
10			Design Live Load	Not required		3.2.3
11			Seismic Load	Not required		3.2.4
12			Wind Load	Required		3.2.5
13			Temperature Load	Not required		3.2.6
14	Cross Sections			Required	Ref. 1.5.2(1)	4
15	Bridge Planning and Preliminary Design	Bridge Length and Span Arrangement		Required	Ref. 1.5.2(2)	5.1
16		Superstructure	Superstructure Type	Required		5.2.1
17			Analysis and Design of Superstructure	Required		5.2.2
18		Substructure/ Foundation	Substructure and Foundation Type	Required		5.3.1
19			Design of Substructure and Foundation	Required		5.3.2
20		Accessories	Expansion Joint	Required		5.4.1
21			Bearing	Required		5.4.2
22			Sidewalk	Required		5.4.3
23			Inspection Path	Required		5.4.4
24	Construction Quantities			Required		6
25	Construction Planning	Erection Method		Required		7.1
26		Duration of Construction		Required		7.2
27	Cost Estimate	Initial Const. Cost	Cost Estimate Method	Required		8.1.1
28			Initial Construction Cost	Required	Ref. 1.5.2(3), (4)	8.1.2
29		Maintenance Cost		Required	Ref. 1.5.2(5), (6)	8.2

Source: JICA Study Team

1.5 Conclusion

1.5.1 Confirmation Required

It is necessary to confirm some results of the Review, shown in Table 1.1, with ACP.

1.5.2 Adjustment Criteria in Comparison with the Study

The following adjustment is required in comparison with the Study of arch bridge plan.

(1) Linear metro (width: 9m) is selected as system of Metro Line-3 in Pre-F/S while monorail (width: 8.4m) is selected in the Study; Width in Pre-F/S shall be adjusted by reducing 0.6 m in comparison in order to set same condition with monorail.
(2) There is a difference between Pre-F/S and the Study in the length of main bridge, 1,118m in Pre-F/S and 840m in the Study, which shall be revised to 1,118m by including Approach Bridge (278m) in the Study.
(3) Since initial construction cost of Pre-F/S includes Metro Line-3 track, and machinery and electronics plan of road is also different from the Study, civil work cost is only targeted in comparison.
(4) About (1) above, initial construction cost of Pre-F/S shall be calculated by multiplying -1.2% as decrease of width in comparison.
(5) Since maintenance cost of Pre-F/S does not include repair cost for binder course and waterproof layer of bridge deck pavement, it needs to add an amount calculated by same unit price and equal frequency of the Study.
(6) Maintenance cost shall be adjusted by decrease rate 4% as JICA policy.

Chapter 2 Outline of Main Bridge Plan

2.1 Location

The main bridge location map is shown in Figure 2.1.

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

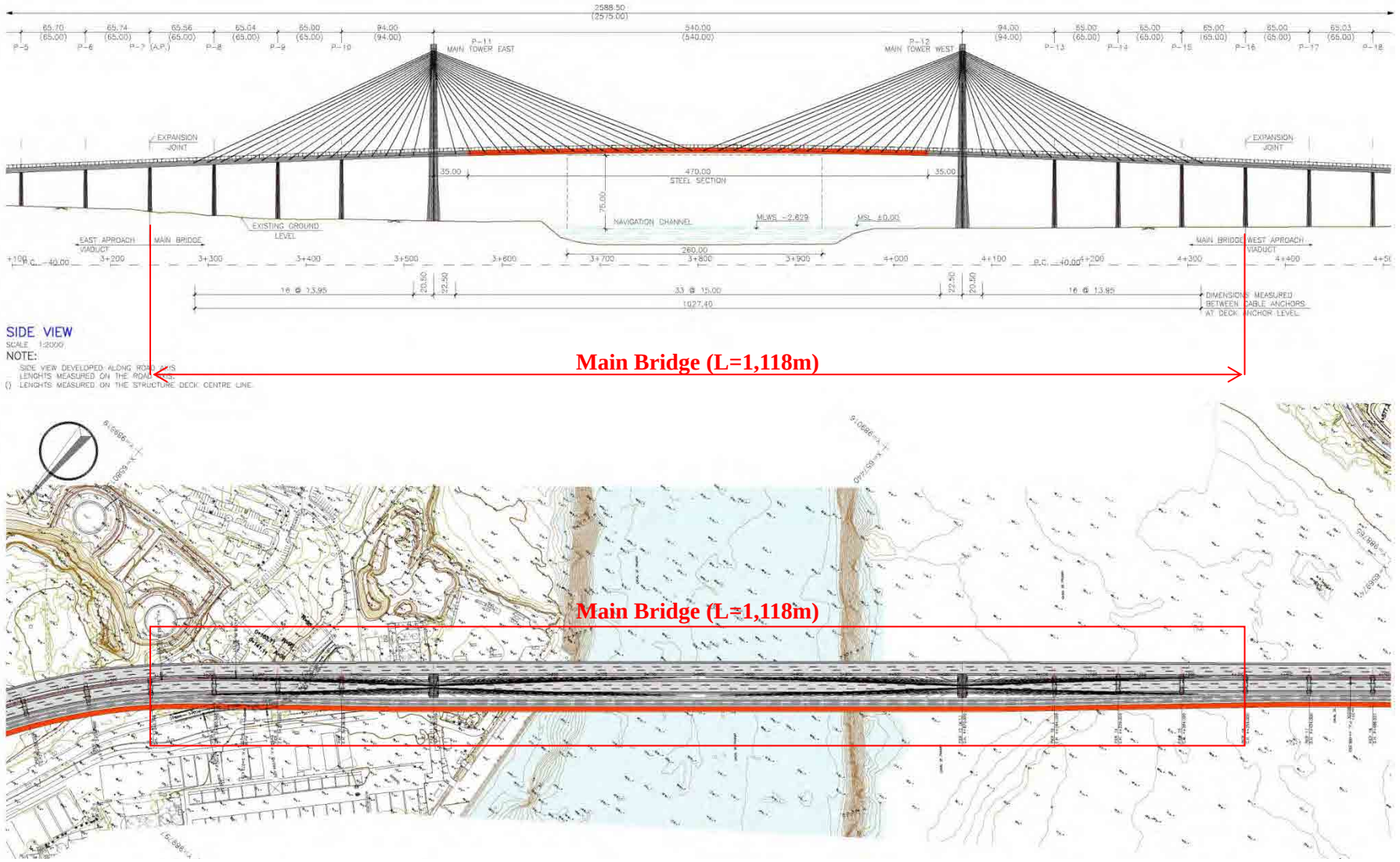
Figure 2.1 Main Bridge Location Map

Features in main bridge plan are shown in Table 2.1 and general view of main bridge is shown in Figure 2.2.

Table 2.1 Features in Main Bridge Plan

No.	Item		Plan
1	Beginning and	Beginning Point	P7 Pier
2	Ending Point	Ending Point	P16 Pier
3	Bridge Length	Bridge Length	1,118m
4	Span Arrangement	Span Arrangement	3@65m+94m+540m+94m+3@65m
5	Cross Section	Numbers of Lane	3 lanes each way
6		Total Width	54.3m (except wind barriers: 51.9m)
7		Effective Width	40.2m
8		Cross Section Elements	4.5m+9.0m (Metro)+1.2m+3@3.65m+1.2m+1.2m+3@3.65m+1.2m
9	Bridge Structure	Superstructure	Composite Girder, Concrete Girder Cable Stayed Bridge
10		Substructure	Y-shaped RC Pier
11		Foundation	Spread Foundation, Pile Foundation (φ2.25m)
12	Construction	Construction Method	Cantilever Erection
13	Planning	Construction Period	4 Years
14	Cost Estimate	Initial Construction Cost	426 Million USD (includes other than civil structures)
15		Maintenance Cost	DR=2.5%: 31 Million USD (100 years, includes other than civil structures) DR=5.0%: 14 Million USD (100 years, includes other than civil structures)

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



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

Figure 2.2 General View of Main Bridge

Chapter 3 Planning and Design Conditions

3.1 Planning Conditions

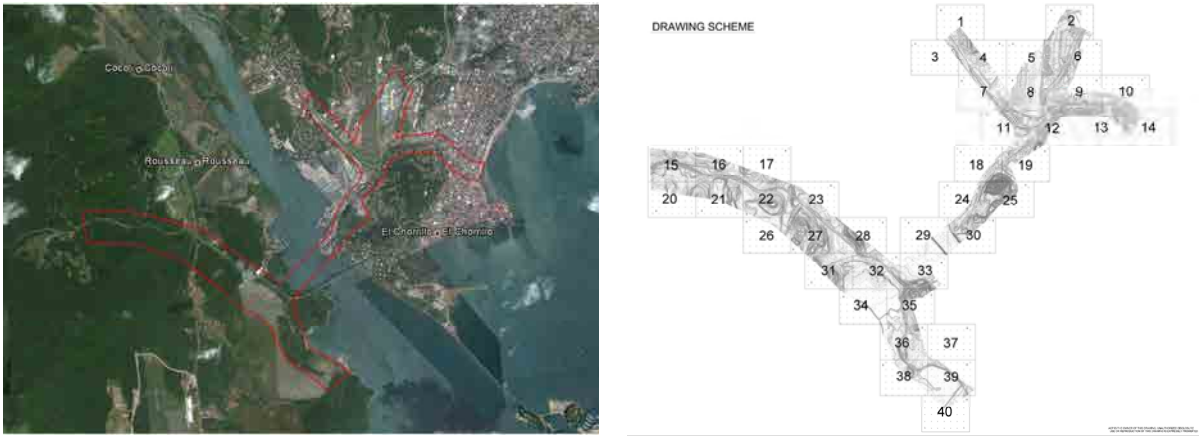
3.1.1 Topographical Conditions

(1) Summary of Pre-F/S

The ASTER Global Digital Elevation Model (ASTER GDEM) is a joint product developed by the Ministry of Economy, Trade, and Industry (METI) of Japan and United States National Aeronautics and Space Administrations (NASA). Topographical map in Pre-F/S is based on the data transformed from ASTER GDEM by the following specifications.

- Contour line of 10 meters in AutoCAD format/UTS/WGS84 ellipsoid

Topography data in Pre-F/S is as shown below.



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

Figure 3.1 Topography Data in Pre-F/S

(2) Comments/Confirmation Required to ACP

Accuracy is considered to be reactively high as detail mapping was carried out in preliminary design stage for assuring accuracy of the topography data.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre-F/S since the same topographical condition is used in both the Study and Pre F/S.

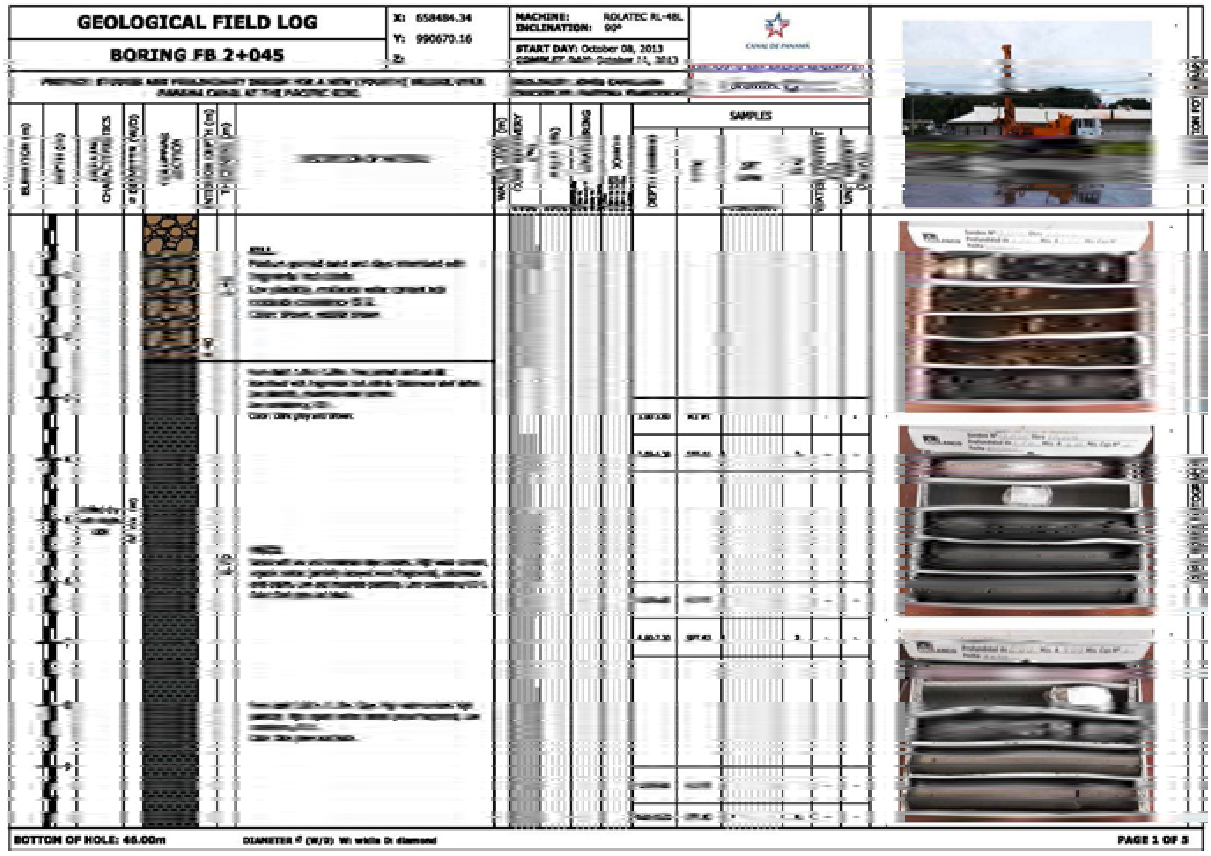
3.1.2 Geological Conditions

(1) Summary of Pre-F/S

The drilling survey was conducted at 48 places (46 places at 4th Panama Canal Bridge, 2 places in Panamerican Highway).

(2) Comments/Confirmation Required to ACP

Boring log included core photography with geological conditions and N-value. Hence, these drilling data are more accurate than data for conceptual design.



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

Figure 3.2 Boring Log in Pre-F/S

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre F/S since the same geological condition is used in both the Study and Pre-F/S.

3.1.3 Navigation Crearance

(1) Summary of Pre-F/S

Vertical Navigation Clearance: 75m

Horizontal Navigation Clearance: 224.8m (Current Navigation Prism Line)

260.09m (Future Navigation Prism Line)

(2) Comments/Confirmation Required to ACP

Conditions on navigation clearance provided by ACP is as shown below.

Vertical Navigation Clearance: 75m

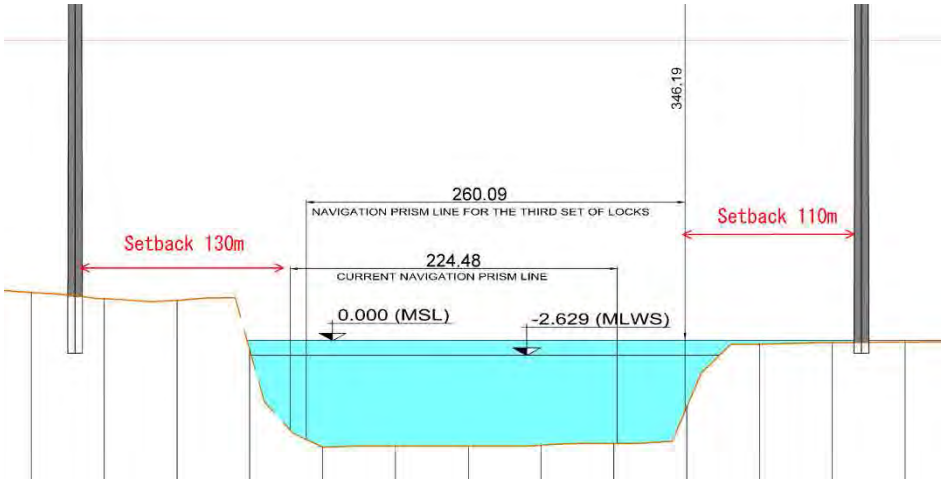
Horizontal Navigation Clearance: 300.5m (Future Navigation Prism Line)

The proposed location of the arch bridge piers follows the same location of the cable stayed bridge piers determined by the Pre-F/S. The pier locations had been agreed upon among the concerned organizations through various meetings, so that the pier locations were set back a sufficient distance from the Prism Line. Accordingly, the main span length was decided to be 540m, which is the same as in the Pre-F/S. The prism lines between Pre-F/S and JICA Study are slightly different; however, both set-backs satisfy the requirements determined by vessel impact simulation in Pre-F/S (west side>100m).

Table 3.1 Comparison with Set-Back

	Pre-F/S	JICA Study
East set-back	130m	119m
West set-back	100m	120m

Source：JICA Study Team



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

Figure 3.3 Navigation Clearance in Pre-F/S

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre-F/S since length of main span planned in the Study and Pre-F/S is the same, in which setback is more than 100m and enough to reduce the vessel impact force.

3.1.4 Airspace Conditions

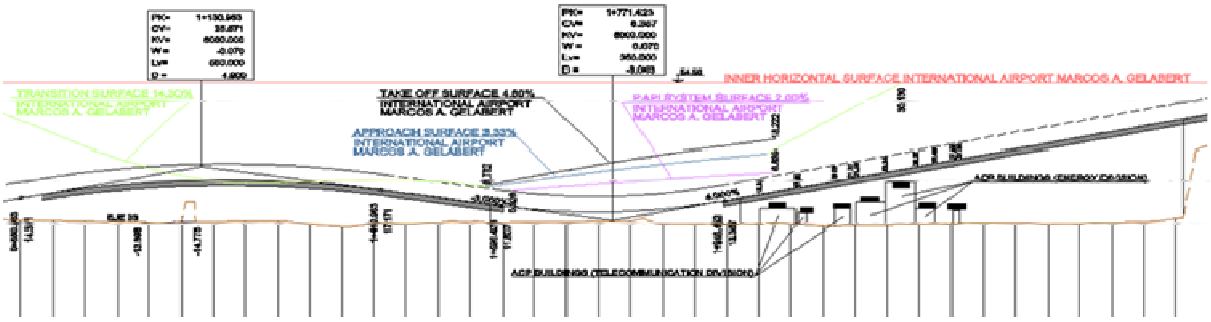
(1) Summary of Pre-F/S

Limited surface is as shown below in conformity with the condition given by AAC.

Table 3.2 Limited Surface Conditions

No.	Item	Limitation Surface
1	Inner Horizontal Surface	54.5m (radius 4km)
2	Conical Surface	129.5m
3	Transition Surface	14.3%
4	Approach Surface	3.3%
5	PAPI system	2.0%

Source: AAC



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

Figure 3.4 Limitation Surfaces in Pre-F/S

(2) Comments/Confirmation Required to ACP

Airspace condition of Morcos A. Gelabert (Albrook) International Airport conforms to AAC standard. Although airspace condition of Howard Air Force in the west side couldn't be confirmed, 4km interval from edge of run-way of Howard Air Force is assured.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre-F/S since the same Airspace condition is used in both the Study and Pre-F/S.

3.1.5 Cross Conditions

(1) Summary of Pre-F/S

Vertical clearance for road is 5.5m in Pre-F/S.

Table 3.3 Vertical Clearance in Pre-F/S

VERTICAL PARAMETERS	DESIGN SPEED	
	100 km/h	90 km/h
Minimum gradient %	0.5	0.5
Maximum gradient %	5	5
Minimum sag vertical curve K	45	38
Minimum crest vertical curve K	52	39
Vertical clearance for roads (m)	5.5	5.5
Vertical clearance railway (m)	9.15	9.15
Minimun vertical clearance for Panama Canal (m) above mean low water springs (MLWS)	75	75

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

(2) Comments/Confirmation Required to ACP

Vertical clearance for road is considered to be set by ensuring surplus on clearance limit of 4.9m in the standards of AASHTO.

Vertical clearance for monorail is also set by ensuring surplus on clearance limit.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Clearance with surplus on clearance limit based on AASHTO (4.9m) is ensured in the road plan of the Study, as with Pre-F/S.

In the main bridge section, preconditions for comparison could be regarded as common between the Study and Pre-F/S since road and monorail place is on the surface of bridge in both the Study and Pre-F/S.

3.1.6 Conditions for Erection and Construction

(1) Summary of Pre-F/S

In order to avoid influence to the running ship, cantilever method using main-cable has been adapted as the election method.

(2) Comments/Confirmation Required to ACP

Cantilever method is common with many achievements for long cable-stayed bridges in the water, which is appropriate erection plan to minimize the impact on the ship. Since water use can be considered for the erection of arch bridge proposed in the Study, confirmation is required for the use of the canal route.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre-F/S since erection method is appropriate and suitable for the bridge type. Erection method will be examined on both cases in which navigation channel can be utilized/ cannot be utilized.

3.1.7 Arrangement Plan of Metro Line-3

(1) Summary of Pre-F/S

Metro at main bridge section is set on north side. It was changed to north side to avoid adverse effect on the approach bridge though examined to place Metro-Line 3 on center at first.

(2) Comments/Confirmation Required to ACP

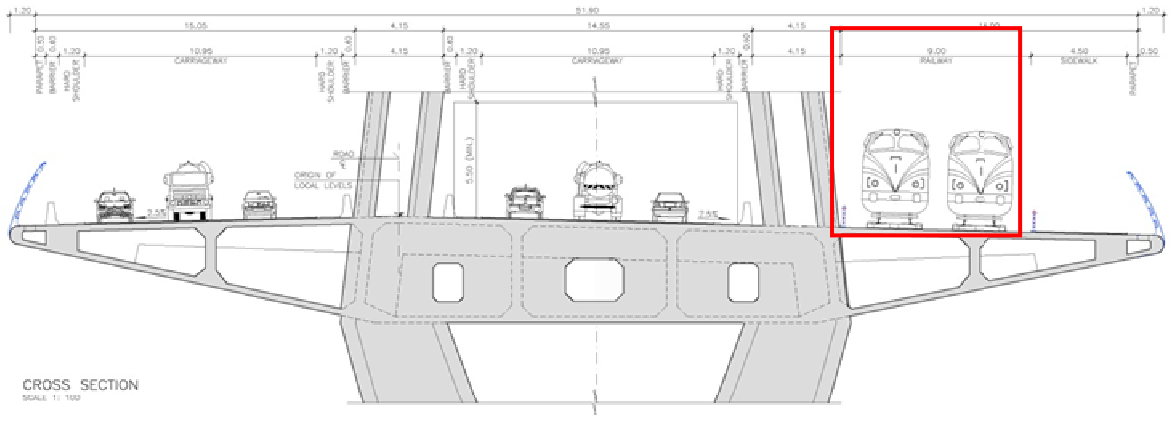
Introduction of concept design report describes advantages of one side arrangement at the approach bridges.

- Any structural measure will not be required on crossing as there is no crossing of metro with a roadway.
- Piers can be reduced from three to two as road section can be supported by one pier.
- More elegance can be assured with more unity in shapes for roadway approaches and the main bridge.

Crossing the metro with a roadway, however, will be required the approach bridge because metro station on both side of the 4th Bridge is planned to place on south side (Balboa, Panama Pacific) while metro is arrange on north side. Therefore, the above structure cannot be found, and superstructure will have to be divided into one and three structures in the approaches. Substructures are divided into 1 to 3 structures.

Integrated section with road and Metro is from large cutting section to the end of the bridge.

Width of Metro is 9m for considering maintenance. 4m of Sidewalk is arranged outside Metro.



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

Figure 3.5 Cross Section of Main Bridge in Pre-F/S

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

In the Study, Monorail is arranged on south side after comparing examination and discussion with SMP. Although arrangement of track is different in south and north, precondition of comparison could be regard as common between the Study and Pre-F/S since they are placed on the same surface at main bridge section in both the Study and Pre-F/S.

Track width of Metro in Pre-F/S is 9m, and Track width of monorail in the study is 8.4m. In order to set the same conditions, adjustment is made by reducing 0.6m to the track width of the Pre-F/S.

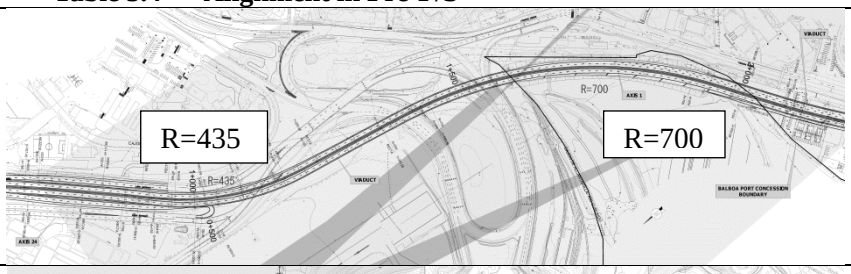
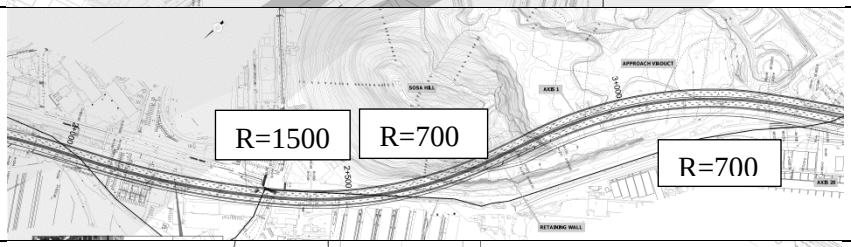
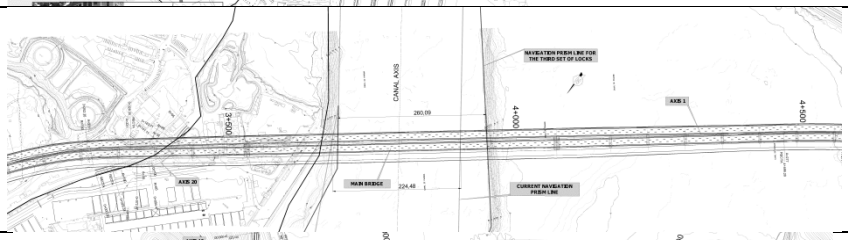
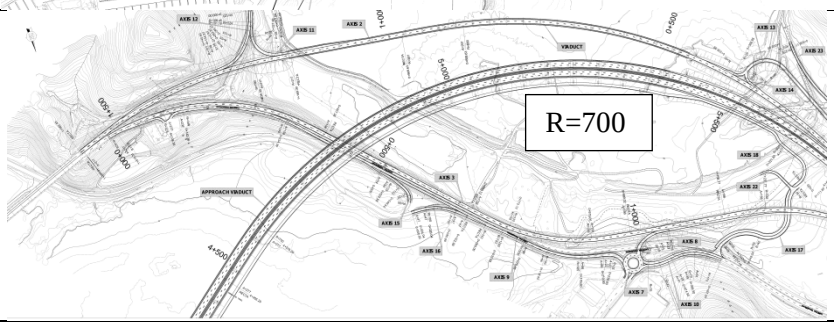
3.2 Design Conditions

3.2.1 Alignment

(1) Summary of Pre-F/S

Alignment is as follows.

Table 3.4 Alignment in Pre-F/S

Flyover-1	
Flyover-2 East Approach Bridge	
Main Bridge	
West Approach Bridge Access Bridge (American Bridge)	

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

(2) Comments/Confirmation Required to ACP

Minimum curve radius is R=435m in the road section, while main bridge section is planned to be straight.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

In the Study, linear alignment is planned in consideration of Monorail and airspace conditions.

Preconditions for comparison could be regarded as common between the Study and Pre-F/S since the same condition with straight linear alignment and 75m navigation clearance are used in both the Study and Pre-F/S.

3.2.2 Design Life

(1) Summary of Pre-F/S

Design lifetime is supposed to be 120 years. Design life of structural components is as follows.

Table 3.5 Design Life by Structural Component in Pre-F/S

Structural Component	Design Life [years]
Foundations	120
Piers	120
Concrete Deck	120
Bearings (minor components shall have service life of 20 years)	50
Movement Joint (minor components shall have service life of 20 years)	50
Parapets (metal parts only)	50
Parapets (concrete parts only)	120
Drainage System	20

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

(2) Comments/Confirmation Required to ACP

Lifetime in AASHTO is 75 years, while 100 years in Japan. LCC is calculated essentially by setting lifetime as 100 years though Pre-F/S described it as 120 years.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre-F/S since the same design lifetime (100 years) is used in both the Study and Pre-F/S.

Table 3.6 Design Life in the Study

Structural Component	Design Life (years)
Foundations	100
Piers	100
Deck	100
Bearings	100
Movement Joint	40
Parapets（steel）	100
Parapets（concrete）	100
Drainage System	50

Source：JICA Study Team

3.2.3 Design Live Load

(1) Summary of Pre-F/S

Applied design live load for the vehicle is HL-93 in conformity with AASHTO.

Applied design load for the Metro is SW/O in EN 1991-2:2013, in which dead load of track girder is 44kN/m and live load is 66.5kN/m.

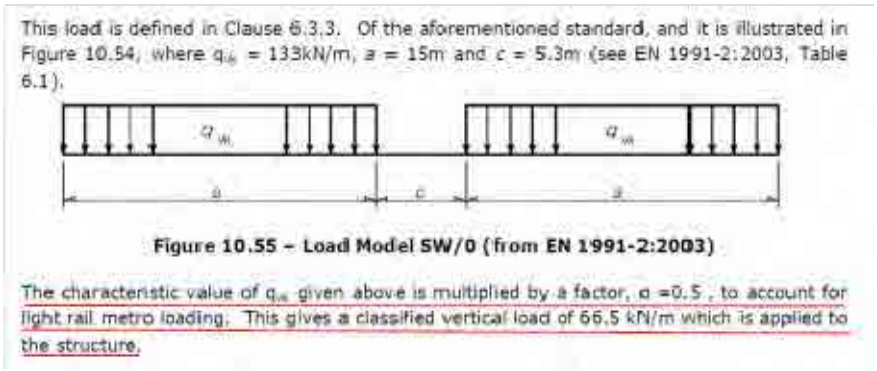

This load is defined in Clause 6.3.3. Of the aforementioned standard, and it is illustrated in Figure 10.54, where q_{vk} = 133kN/m, a = 15m and c = 5.3m (see EN 1991-2:2003, Table 6.1).

Figure 10.55 – Load Model SW/0 (from EN 1991-2:2003)

The characteristic value of q_{vk} given above is multiplied by a factor, α =0.5 , to account for light rail metro loading. This gives a classified vertical load of 66.5 kN/m which is applied to the structure.

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

Figure 3.6 Design Loads of Metro Line-3 in Pre-F/S

(2) Comments/Confirmation Required to ACP

Design live load in the Study is heavier than Pre-F/S supposing Monorail as load of Metro..

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

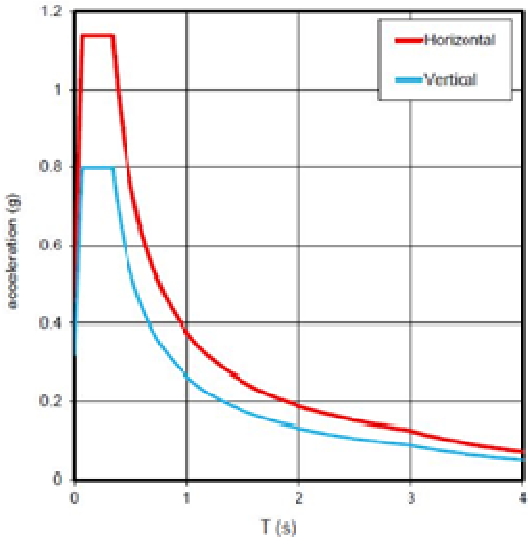
Live load of vehicle used in the Study is HL-93, as with Pre-F/S.

Preconditions for comparison could be regarded as common between the Study and Pre-F/S since difference of live load for metro is considered to minor.

3.2.4 Seismic Load

(1) Summary of Pre-F/S

Return Period (Design Response Spectrum): 2,475 years



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

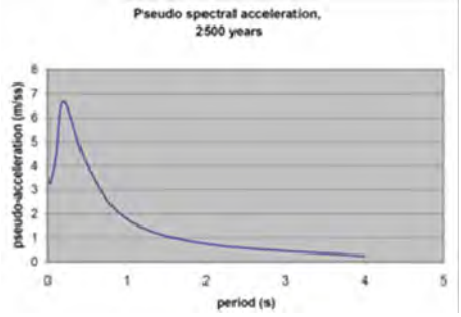
Figure 3.7 Design Spectrum

(2) Comments/Confirmation Required to ACP

Design spectrum in Pre-F/S was based on ASCE (American Society of Civil Engineers). Calculation method of seismic load from the spectrum, however, could not be found in the Pre-F/S.

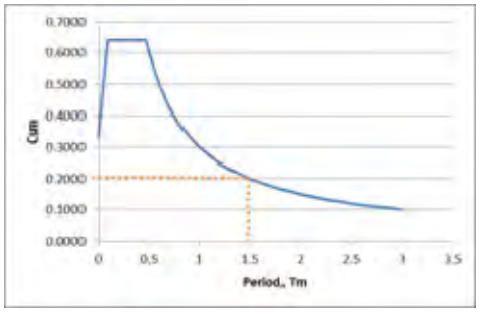
(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Return Period (Design Response Spectrum9 in the JICA Study: 2,500 years



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

Figure 3.8 Design Spectrum



Source : JICA Study Team

Figure 3.9 Seismic Design Load

It was agreed with ACP and SMP that same condition of the study for Centenario Bridge ("Seismic Hazard Assessment of the Second Panama Canal Crossing") will be used in the Study. Shapes of the both are similar. Preconditions for comparison could be regarded as common between the Study and Pre-F/S since seismic load used in Pre-F/S is equal with the Study as for design horizontal seismic coefficient.

3.2.5 Wind Load

(1) Summary of Pre-F/S

Maximum wind load in Pre-F/S is 86km/hr (actual measurement 50 years return period) based on actual measurement of 50 years return period.

(2) Comments/Confirmation Required to ACP

Although basis for 50 years return period could not be found in Pre-F/S report, wind load applied for Centenario Bridge is100 years return period in conformity with AASHTO.

As the result of comparison with 100 years return period in Blboa FAA and Panama standard, Panama standard is more safety than actual measurement. Therefore, 115km/hr in Panama standard is adopted as maximum wind load.

Table 3.7 Design Wind Load

	Actual Measurement		Panama Standards
Design Wind Load	50 Years Return Period	100 Years Return Period	
	86km/hr	93.7km/hr	115km/hr

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

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Although design wind speed in the study is higher than Pre-F/S, the difference is little. Therefore, precondition of comparison could be regarded as common between the Study and Pre-F/S.

3.2.6 Temperature Load

(1) Summary of Pre-F/S

Temperature load based on actual measurement in Balboa FAA is as follows:

- Maximum: 39.84
- Minimum: 19.77
- ΔT=19.77

(2) Comments/Confirmation Required to ACP

Maximum temperature and minimum temperature are based on actual measurement of 50 years return period.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Average temperature in the study is 27C based on actual measurement in Balboa FAA, and temperature range is ±10C based on AASHTO LRFD.

Precondition of comparison could be regarded as common between the Study and Pre-F/S since the same temperature range (Δt=20C) is used in both the Study and Pre-F/S.

Chapter 4 Cross Sections

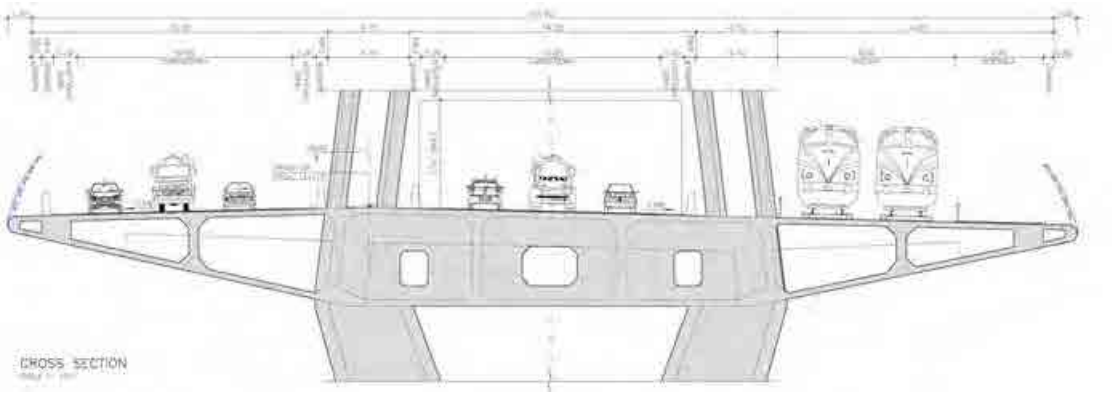
(1) Summary of Pre-F/S

Bridge cross section elements are in the followings:

Table 4.1 Bridge Cross Section Elements

Bridge Cross Sections	Width
Parapet Upstand/Wind Shield	1.70m
Barrier	0.60m
Hard Shoulder(Onside)	1.20m
3no. Traffic Lanes	10.95m
Hard Shoulder(Offside)	1.20m
Barrier	0.60m
Cable Support Zone/Tower Leg Clearance Zone	Varies (1.38m to 4.15m)
Barrier	0.60m
Hard Shoulder(Onside)	1.20m
3no. Traffic Lanes	10.95m
Hard Shoulder(Offside)	1.20m
Barrier	0.60m
Cable Support Zone/Tower Leg Clearance Zone	Varies (1.38m to 4.15m)
Trackway Transverse Clearance	9.00m
Separation Barrier	0.50m
Sidewalk and Cycleway	4.00m
Parapet Upstand/Wind Shield	1.70m
Total Width (Main Bridge)	48.0m to 54.0m

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



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

Figure 4.1 Cross Section (Main Bridge)

(2) Comments/Confirmation Required to ACP

Transverse clearance of Metro is 9m in Pre-FS/ Report, which is different from width of 8.4m proposed in the Study. Space for cable and main tower transitions from 4.15 to 1.38 at side span section, and interval between inbound and outbound lane is 1.0m at typical section of approach bridge after the transition.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Regarding the system of Metro Line-3, the width of Metro-Linear is 9m in Pre-F/S while Monorail is 8.4m in the Study. 1m would be reduced to the width in Pre-F/S in order to set precondition equal to the Study, as the comparison shall be made under the same system and width.

Chapter 5 Bridge Planning and Preliminary Design

5.1 Bridge Length and Span Arrangement

(1) Summary of Pre-F/S

Bridge length and span arrangement of each bridge is as shown below:

Table 5.1 Bridge Length and Span Arrangement in Pre-F/S

Name	Bridge Type	Bridge Length	Span Arrangement
Main Bridge	Cable-stayed	1,118m	289m/540m/289m
East Approach Bridge	PC Box Girder	435m	65m/45m/32m
West Approach Bridge	PC Box Girder	1,022m	65m/45m/32m
Flyover 1 (Bridge1)	PC Box Girder	709.2m (704.5m)	24.28m/60m
Flyover 2 (Bridge2)	PC Box Girder	768m (748m)	40m/42m/57m
Access Bridge to the Bridge of the Americans on West Bank (Bridge3)	PC-I Girder	721m	30m

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

(2) Comments/Confirmation Required to ACP

Span length is decided based on the condition of navigation channel at the main span. Span of approach bridges and other bridges are arranged considering cross roads. The span arrangement of main bridge is planned as 289m+540m+289m; however, this is optimal ration of center and side span lengths in steel cable-stayed bridge. The optimal ration of side span and center span in the composite cable-stayed bridge is 0.3 to 1.0 from the past experiences.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Main span is designed in the Study based on the same condition of navigation channel as Pre-F/S. Bridge length and span arrangement are as shown below. The main bridge length is 1,118m in Pre-F/S while 840m in the Study, which should be adjusted to be equal 1,118m for comparison by including 278m of approach bridge.

Table 5.2 Bridge Length and Span Arrangement in JICA Study

Name	Bridge Type	Bridge Length	Span Arrangement
Main Bridge	Arch	740m	150m/540m/150m
East Approach Bridge	Steel Box Girder	533m	43m/60m/50m/90m/100m/100m/90m
West Approach Bridge	Steel Box Girder PC-I Girder	810m 360m	90m/3@100m/80m/5@60m/40m 9@40m
Flyover 1 (Bridge1)	PC-I Girder Steel Box Girder	270m 250m	2@40m/30m/4@40m 50m/2@60m/45m/35m
Flyover 2 (Bridge2)	PC-I Girder Steel Box Girder	260m 480m	5@40m/2@30m 60m/4@90m/60m
Access Bridge to the Bridge of the Americans on West Bank (Bridge3)	PC-I Girder	760m	9@40m/10@40m

Source：JICA Study Team

5.2 Design of Superstructure

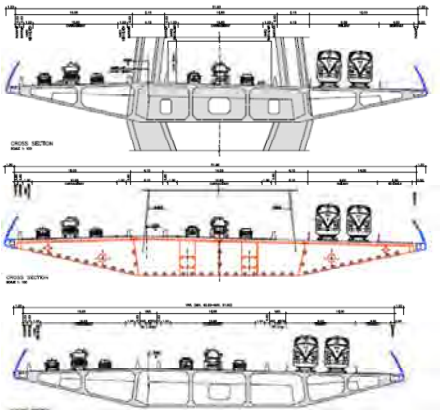
5.2.1 Superstructure Type

(1) Summary of Pre-F/S

Superstructure type in the Pre-F/S is as follows:

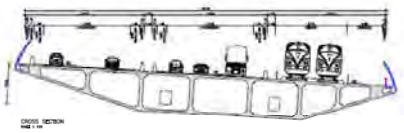
1) Main Bridge: 3+240.396 to 4+359.0

Centre span of cable-stayed bridge is 540m, of which 470m is composite girder cable-stayed bridge, 578m(289m×2) at back span and 70m(35m×2) at both side of centre span is concrete girder cable-stayed bridge.



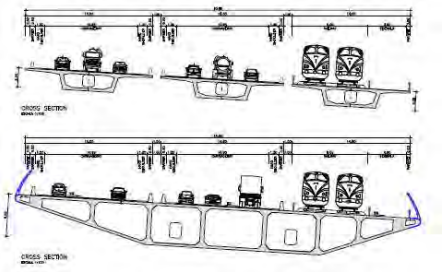
2) East Approach Viaduct: 2+801.345 to 3+240.396

East Approach Viaduct is curve bridge with R700, whose superstructure is 1BOX concrete box girder (girder height 5m).



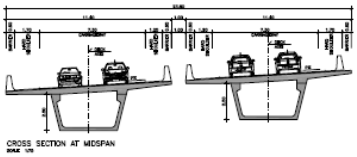
3) West Approach Viaduct: 4+801.345 to 5+389.840

Superstructure has two types; 1BOX concrete box girder bridge with 5m clearance is adopted for section with longer span at origin side from P26, while 3BOX concrete box girder bridge with 2.25m clearance is adopted for section with shorter span at destination side.



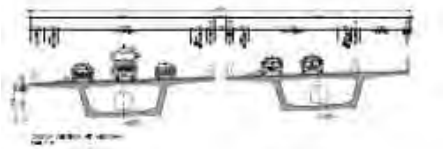
4) Viaduct: 0+882 and 1+600

Viaduct with 2 lanes with S curve is planned at the section over Omar Interchange. Continuous cantilever PC box girder bridges are adopted as superstructure both for inbound and outbound lanes. Girder thickness is 2.9m at section with longer span from P13 pier while 1.55m at the section with shorter span from P13 to destination side. Girder height is increased from 2.9m to 3.9m at the section with over-60m span arrangement.



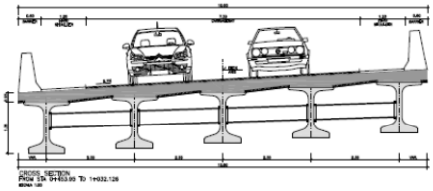
5) Viaduct: 1+944 and 2+770

Viaduct with three lanes each way is planned at section passing northern side of Roosevelt Street. Continuous cantilever PC box girder bridge is adopted for superstructure, as with at Omar cross road. Bridge length is planned to be 708m and span arrangement is 24m-57m.



6) Link Road: 0+450 to 1+170

West Side Access Road to Bridge of the Americans is planned to be two lanes. Concrete precast girder is adopted for superstructure. Bridge length is 720m, while span length is 30m.



(2) Comments/Confirmation Required to ACP

Bridge type of main bridge is steel cable-stayed bridge while all approach bridges are concrete based on concept design, which is appropriate considering span arrangement.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

The main bridge length in the Study is adjusted to be equal 1,118m of Pre-F/S for comparison by including a part of approach bridge.

Table 5.3 Superstructure Type in the JICA Study

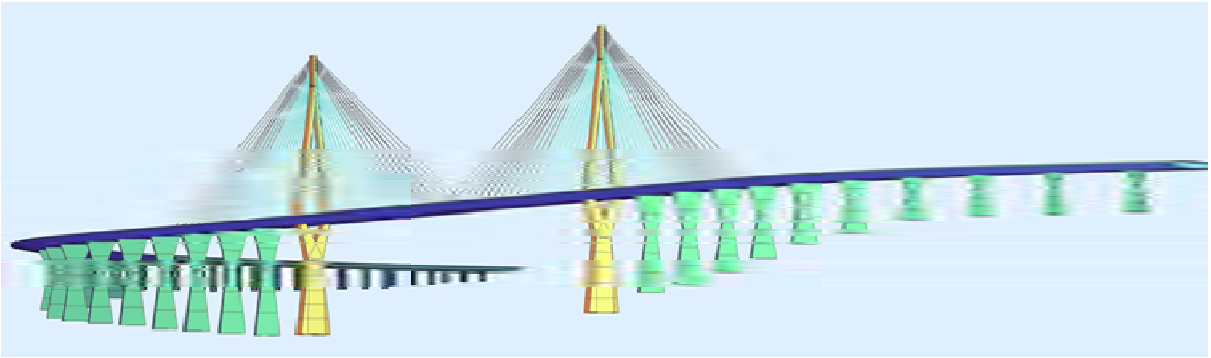
Name	Pre-F/S	JICA Study
Main Bridge	Cable-stayed bridge	Arch
East Approach Bridge	PC Box Girder	Steel Box Girder
West Approach Bridge	PC Box Girder	Steel Box Girder/ PC-I Girder
Flyover 1 (Bridge1)	PC Box Girder	PC-I Girder/ Steel Box Girder
Flyover 2 (Bridge2)	PC Box Girder	PC-I Girder/ Steel Box Girder
Access Bridge to the Bridge of the Americans on West Bank (Bridge3)	PC-I Girder	PC-I Girder

Source：JICA Study Team

5.2.2 Analysis and Design of Superstructure

(1) Summary of Pre-F/S

Attached documents of Pre-F/S are only model drawings and input data though analysis has been performed on total model.



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

Figure 5.1 Structural Design Model

(2) Comments/Confirmation Required to ACP

The result of analysis and cross section calculation cannot be confirmed, but only model drawings and input data.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre-F/S assuming structure analysis in Pre-F/S is appropriate.

5.3 Design of Substructure and Foundation

5.3.1 Substructure and Foundation Type

(1) Summary of Pre-F/S

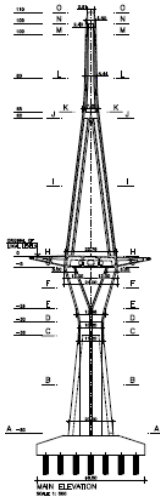
Substructure and foundation type in the Pre-F/S are as follows:

1) Main Bridge: 3+240.396 to 4+359.0

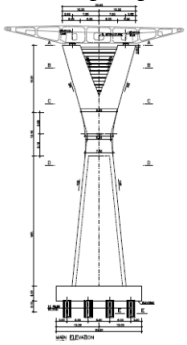
Height of main tower is 150m from road surface. Piers are Y-shaped RC, whose height is 80m measured from crown of foundation to road surface.

Foundation of main tower at land side (east side) is direct foundation, while foundation at marine side (west side) is cast-in-place pile of φ2.25m.

Main Tower



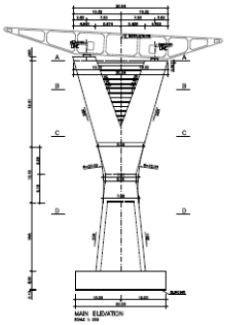
Backspan pier



2) East Approach Viaduct: 2+801.345 to 3+240.396

Pier is Y-shape RC and foundation type is direct foundation. Height of hollow part in Y-shape is 21m since pier is quite high.

Single pier

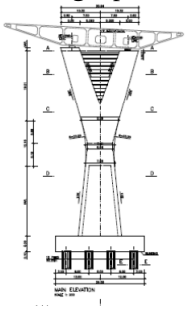


3) West Approach Viaduct: 4+801.345 to 5+389.840

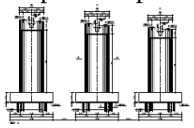
Pier type at 1 box section is Y-shape as with east side, while foundation type is planned to be pile foundation (φ2.25m).

Each of three independent piers individually supports its superstructure at 3 BOX section.

Single pier



Independent pier

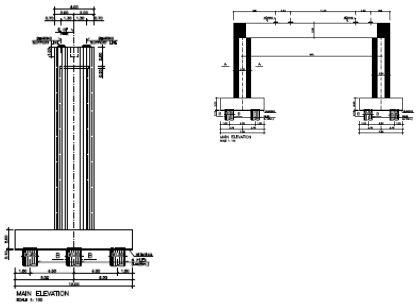


4) Viaduct: 0+882 and 1+600

Piers are single-column type, though portal rigid-frame type is adopted for the site over channel.

Pile foundation (φ1.5) is adopted as the foundation.

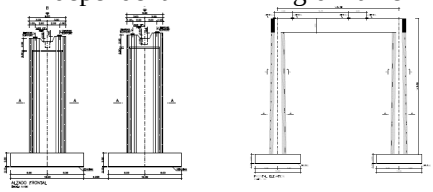
single-column rigid-frame



5) Viaduct: 1+944 and 2+770

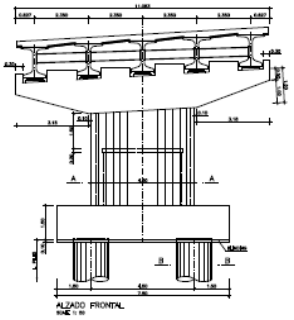
Single-column type and portal rigid-frame type are adopted for piers as with Flyover1 section. Rigid-frame type is adopted for the site over road at the entrance of Balboa Port. Foundation types of both are direct foundation.

independent rigid-frame



6) Link Road: 0+450 to 1+170

Cantilever pier is planned with pile foundation (φ1.5m).



(2) Comments/Confirmation Required to ACP

Pile foundation is adopted as foundation at main bridge and west approach bridge, while direct foundation is adopted at east approach bridge. Substructure type is supposed to be appropriate considering superstructure type and the scale.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison could be regarded as common between the Study and Pre-F/S assuming substructure and foundation type are appropriate.

Table 5.4 Substructure and Foundation Type in the JICA Study

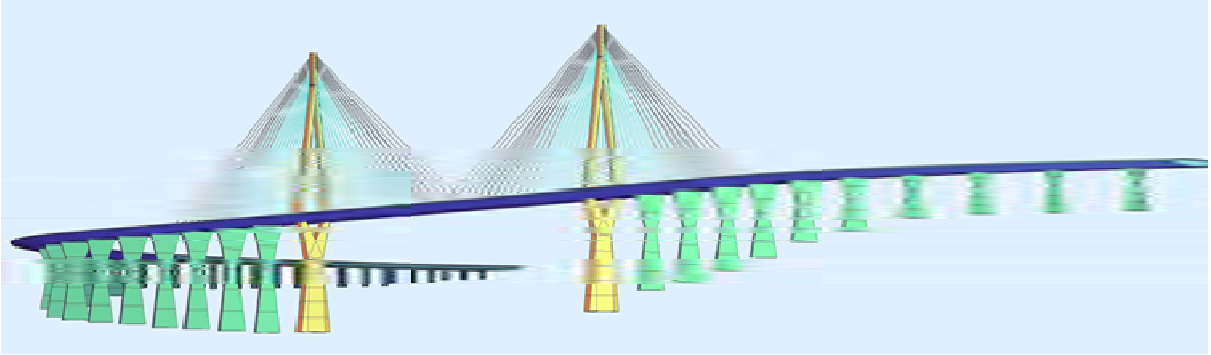
Name	Pre-F/S		JICA Study	
	Pier	Foundation	Pier	Foundation
Main Bridge	Concrete Y-shape	Pile Foundation (φ2.25m)	Concrete	Spread Foundation/ Steel Pipe Sheet Pile Foundation
East Approach Bridge	Concrete Y-shape	Spread Foundation	Concrete Rigid Frame	Spread Foundation
West Approach Bridge	Concrete Y-shape	Pile Foundation (φ2.25m)	Concrete Rigid Frame/ Cantilever	Pile Foundation (φ1.8m)
Flyover 1	Single-column/ Concrete Rigid Frame	Pile Foundation (φ1.5m)	Cantilever/ Concrete Rigid Frame	Pile Foundation (φ1.5m)
Flyover 2	Single-column/ Concrete Rigid Frame	Pile Foundation (φ1.5m)	Cantilever/ Concrete Rigid Frame	Pile Foundation (φ1.5m)
Access Bridge to the Bridge of the Americans on West Bank	Cantilever	Pile Foundation (φ1.5m)	Cantilever	Pile Foundation (φ1.5m)

Source：JICA Study Team

5.3.2 Design of Substructure and Foundation

(1) Summary of Pre-F/S

Attached documents of Pre-F/S are only model drawings and input data though analysis is performed on total model.



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

Figure 5.2 Structural Design Model

(2) Comments/Confirmation Required to ACP

Validation cannot be performed since the result of analysis and cross section calculation cannot be confirmed, but only model drawings and input data.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

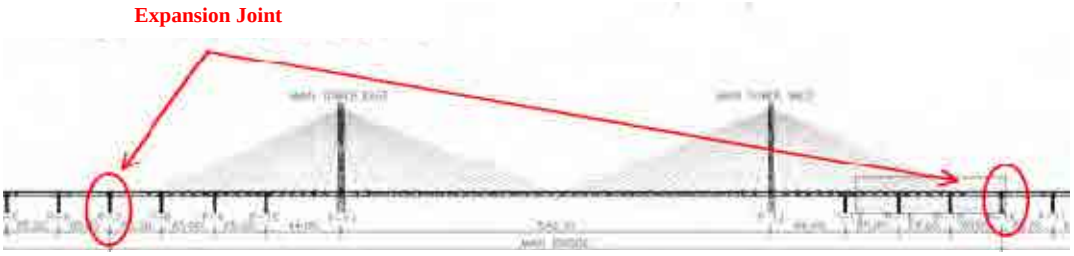
Preconditions for comparison could be regarded as common between the Study and Pre-F/S assuming that analysis in Pre-F/S is appropriate based on planning and design condition.

5.4 Planning and Design of Accessories

5.4.1 Expansion Joint

(1) Summary of Pre-F/S

Expansion joints are planned to be placed at P-7 pier and P-16 pier. Joint length is decided to be 1500-3000mm based on the result of Eigenvalue analysis.



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

Figure 5.3 Location of Expansion Joint in Pre-F/S

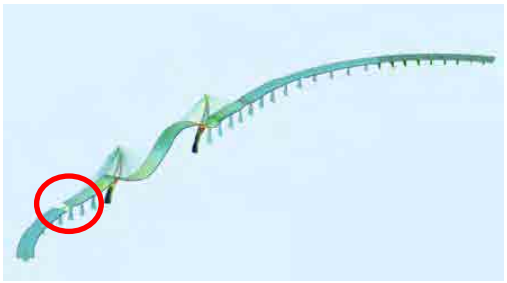
Table 5.5 Expansion Joint Plan in Pre-F/S

PRELIMINARY CONSTRUCTION COST ESTIMATE				
Item	Unit	Quantity	Rate [$ / Unit]	Estimated Cost [$]
Superstructure				
Bridge Deck				
Composite Deck	m²	10,741	$668	$7,179,974
Concrete Deck	m²	35,654	$991	$35,328,229
Formwork Deck				
Composite Deck - Exposed Surfaces	m²	2,236	$150	$338,400
Concrete Deck - Exposed Surfaces	m²	36,840	$150	$5,526,072
Concrete Deck - Hidden Surfaces	m²	66,011	$100	$6,601,085
Reinforcement Deck				
Composite Deck	t	2,479	$2,950	$7,191,835
Concrete Deck	t	11,782	$2,950	$34,756,364
Prestressing Steel Concrete Deck	t	842	$16,400	$13,801,559
Composite Deck Structural Steel	t	9,757	$5,000	$48,788,000
Corrosion Protection of Steelwork	m²	24,910	$100	$2,491,000
Cable Stays	t	1,972	$16,520	$32,583,979
Cable Stay Testing	Item		$750,000	$750,000
Expansion Joints (1500-3000mm)	m	104	$47,990	$4,962,010
Superstructure Sub-total				**$201,897,608**

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

(2) Comments/Confirmation Required to ACP

Bridge structure can considered to be drastically deformed at the earthquakes. Compatibility of Monorail shall be confirmed in case of drastic deformation. Countermeasure will be required for reducing deformation if not compatible.



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

Figure 5.4 Result of Eigenvalue Analysis

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Preconditions for comparison between could be regarded as common between the Study and Pre-F/S supposing that details of expansion joint scarcely affect main structure though they are not obtained from Pre-F/S.

5.4.2 Bearing

(1) Summary of Pre-F/S

No specific description on bearing types can be found in Pre-F/S.

(2) Comments/Confirmation Required to ACP

Bearings are used for middle pier of side span of cable-stayed bridge, edge of approach bridge, and PC-I girder bridge. Bearing type assumed at cost estimation is unknown.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Precondition for comparison could be regarded as common between the Study and Pre F/S supposing that the bearings are considered in the design though the type is not unknown in Pre- F/S.

5.4.3 Sidewalk

(1) Summary of Pre-F/S

Sidewalk is planned from Sta.2+050 (at the middle of Flyover 2) to Sta.5+400 (the end of west approach bridge).

(2) Comments/Confirmation Required to ACP

Sidewalk is parallel with motorway at the section not to go with monorail, while it is adjacent to monorail after the section where sidewalk goes parallel to monorail. Monorail crosses sidewalk at the confluence point of monorail and motorway, where crossing structure is not clear.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Precondition for comparison could be regarded as common between the Study and Pre-F/S since sidewalk arrangement is the same at main bridge section.

5.4.4 Inspection Path

(1) Summary of Pre-F/S

Stairs for inspection will be attached inside main tower of cable stayed bridge. It is described in Pre-F/S that inspection of other bridges will be performed using Bridge Inspection Vehicle.

(2) Comments/Confirmation Required to ACP

The above is considered to be appropriate since it is difficult to place inspection path at superstructure as all bridges are concrete including approach bridges. Space inside stiffing girder can be used as for stiffing girder at center span of cable-stayed bridge, which will not require new inspection path.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Precondition for comparison could be regarded as common between the Study and Pre-F/S since inspection path scarcely affects main bridge section.

Chapter 6 Construction Quantities

(1) Summary of Pre-F/S

Construction quantity is calculated by divided roughly into two sections; i.e. road section and bridge section.

(2) Comments/Confirmation Required to ACP

Detailed calculation basis is unknown.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Width of Metro-Linear is 9m in Pre-F/S while Monorail is 8.4m, which require adjustment by reducing 0.6m to width of Pre-F/S to ensure consistency with Monorail for the comparison.

Length of main bridge is 1,118m at Pre-F/S while 840m at the Study. Comparison will be performed at the same condition of 1,118m by including approach bridge (278m) of the Study.

Chapter 7 Construction Plannning

7.1 Erection Method

(1) Summary of Pre-F/S

Cantilever erection using main cable not affecting navigation channel is adopted as erection method for superstructure at main span of main bridge. Launching method is adopted as erection method for superstructure of approach bridge. Erection of main span will be performed after girder erection of approach bridge.

(2) Comments/Confirmation Required to ACP

The Erection method of cable stayed bridge is proven and appropriate considering the scale.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

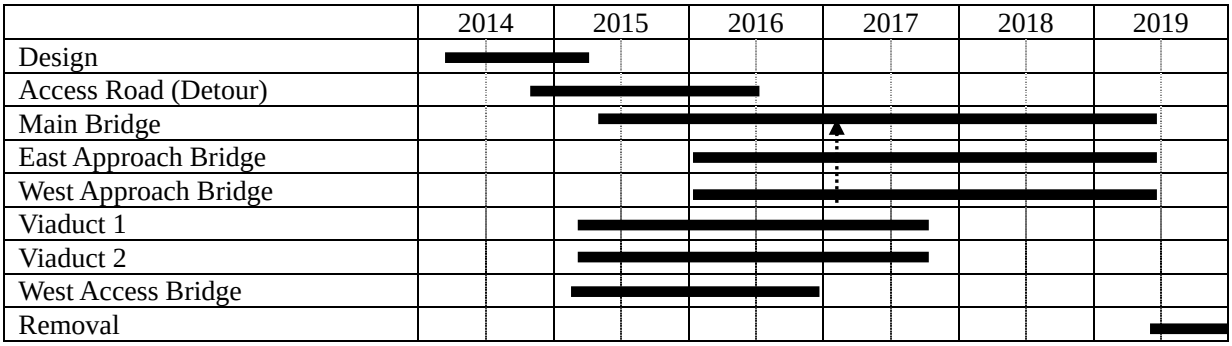
Precondition at Pre-F/S will be used for comparison since the erection method of main bridge has few effects on navigation channel.

7.2 Duration of Construction

(1) Summary of Pre-F/S

Construction requires approximately five years, dividing whole alignment into five stages considering detour of traffic. Construction of main bridge requires four years.

Table 7.1 Construction Schedule



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

(2) Comments/Confirmation Required to ACP

Erection of superstructure of main span requires 1.5 years in total (27 days x 18 blocks). Span-by-span method is adopted as the erection method of back span, where east side requires approximately two months, while west side requires approximately two and half months.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Precondition at Pre-F/S will be used for comparison since the adjustment of width, though required for the comparison of main bridge, has few effects on overall construction schedule.

Chapter 8 Cost Estimate

8.1 Initial Construction Cost

8.1.1 Cost Estimate Method

(1) Summary of Pre-F/S

Unit price is set from the Third Bridge and other marine projects, not from accumulation of each item. Setting method of unit price is unclear under the condition without assuming types of erection equipment. The followings can be found on unit price by comparing each design.

- Unit price of concrete decrease in Pre-F/S comparing with concept design (from 1,500$/m3 to 300$/m3) while rebar increases from 1700$/t to 2,950$/t
- Unit price of steel girder is set to be 500,000/t, which is quite inexpensive, though no information can be found on material procurement and fabrication factory.

Table 8.1 Comparison of Unit Price

Type	Unit	Pre-F/S Report	
		Concept Design	Preliminary Design
Rebar	t	$1,700	$2,950
Concrete	m3	$1,500	$300
Steel Girder	t	$5,000	$5,000

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

(2) Comments/Confirmation Required to ACP

The basis of unit price setting is unknown.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Comparison is only targeted for civil works as initial cost in Pre-F/S includes track of Metro Line-3 and electricity planning of road is different.

8.1.2 Initial Construction Cost

(1) Summary of Pre-F/S

Initial construction cost of the Fourth Bridges (Main Bridge) increases 10 billion Yen from Pre-F/S, whose main reason is on substructure, especially pile.

Table 8.2 Overall Construction Cost

Type		Unit	Total Cost	Unit Cost
Road		set	$35,095,177	
Fourth Bridge	Main Bridge	set	$425,759,347 ($326,498,413)	$7,552
	East Approach	set	$87,021,867 ($185,644,917)	$4,387
	West Approach	set	$231,482,014 ($204,601,040)	$5,799
	Total	set	$744,263,228	$6,409
East Viaduct 1		set	$56,584,096	$3,321
West Viaduct 2		set	$72,691,325	$3,186
West Access Bridge		set	$25,492,020	$3,074
Environmental Improvement Cost(2%)			$18,682,517	
Miscellaneous Cost (10%)			$93,412,585	
Total			$1,046,220,949	
Escalation Cost (2%)		〃	$20,924,419	
Risk Contingency (7.5%)		〃	$78,466,571	
Construction Cost		〃	$1,145,611,939	

Note: () indicates construction cost at conception design.
Source：Pre-F/S (Draft Final Report (November, 2013)) (ACP)

(2) Comments/Confirmation Required to ACP

Cost items of Metro Line-3 and other than civil works in main bridge are as follows:

Table 8.3 Cost Items of Metro Line-3 and Other Than Civil Works in Main Bridge

Cost Items of Metro Line-3 and Other Than Civil Works	Cost ($)
Engineering and Construction Administration	15,124,924
Metro/LRT Overhead Line Equipment	111,800
Ballast, Sleepers&Track etc	72,670
Road Lighting	90,000
CCTV and Communication	47,629
Electrical System	3,120,814
Aviation Warning Light	20,000
Lighting Protection System	150,000
Navigation Cannel Lighting	30,000
Composite Deck Dehumidfer	100,000
Tower Dehumidefer	200,000
Total	19,067,837

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

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

Width of Metro-Linear is 9m in Pre-F/S while Monorail is 8.4m; which require adjustment by reducing 0.6m to the width at Pre-F/S. Initial cost at Pre-F/S shall be adjusted by reducing 1.2%.

Length of main bridge is 1,118m at Pre-F/S while 840m at the Study. Comparison will be performed at the same condition of 1,118m, including approach bridge of 278m at the Study.

Civil works cost of the main bridge is as shown below.

Table 8.4 Revised Initial Construction Cost of Main Bridge (Pre-F/S)

Main Bridge Cost (1+2)	**425,759,347 USD**
1. Main Bridge Cost (Civil Works)	406,691,510 USD
2. Items Other Than Civil Works (sum (a to k))	19,067,837 USD
a. Engineering and Construction Administration	15,124,924 USD
b. Metro/LRT Overhead Line Equipment	111,800 USD
c. Ballast, Sleepers&Track etc.	72,670 USD
d. Road Lighting	90,000 USD
e. CCTV and Communication	47,629 USD
f. Electrical System	3,120,814 USD
g. Aviation Warning Lights	20,000 USD
h. Lighting Protection System	150,000 USD
i. Navigation Channel Lighting	30,000 USD
j. Composite Deck Dehumidfer	100,000 USD
k. Tower Degumidifers	200,000 USD
Revised Initial Construction Cost (Civil Works of Main Bridge)	
USD406,691,510*(51.9m-0.6m)/51.9m=	401,989,874 USD

Source：JICA Study Team

8.2 Maintenance Cost

(1) Summary of Pre-F/S

Cost calculation period is set to be 100 years. Initial cost ratio is approximately 10% since 2.5% discount is considered in maintenance cost.

Table 8.5 Maintenance Cost

Type		Unit	Cost
Fourth Bridge	Main Bridge	set	$31,290,575(22,104,769)
	East Approach	set	$8,510,269(20,455,578)
	West Approach	set	$17,895,215(21,866,775)
East Viaduct 1		set	$10,238,349
West Viaduct 2		set	$11,127,546
West Access Bridge		set	$5,324,114
Total			$84,386,068

Note: () indicates construction cost at conception design.
Source：Pre-F/S (Draft Final Report (November, 2013)) (ACP)

Table 8.6 Maintenance Items

Description	Unit	Unit Cost	Quantity	Item Cost
Preliminaries				
Safety Barriers	m	$190	4,474	$850,136
Drainage	m	$0.37	2,236	$820
Pavement	m²	$450	993	$446,993
Metro/LRT OH	m	$50	2,236	$111,800
Ballast and Sleepers etc.	m²	$0.80	10,062	$8,050
Road Signs / Markings	Item	-	-	$104,174
Road Lighting	no	$100	90	$9,000
Structural Concrete	-	-	-	$334,124
Steelwork	-	-	-	$241484
Cable-stays	t	$16,520	1,972	$32,580,979
Bridge Bearings	no	$17,229	16	$275,664
Pedestrian Guardrails	m	$210	3,356	$704,718
Wind Barrier	m	$600	2,237	$1,342,320
Bridge Expansion Joints	m	$43,950	104	$4,562,010
Aviation Warning Lights	Item	-	-	$20,000
Lightning Protection	Item	-	-	$150,000

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

(2) Comments/Confirmation Required to ACP

Breakdown is unknown since the repair cost of concrete and steel member is provided in a lump sum. Maintenance cost does not include repair of base and waterproof layer of pavement of bridge surface.

(3) Adjustment Required in Comparison Study between Option by Pre-F/S and Option by the JICA Study

As the maintenance cost at Pre-F/S does not include repair of base and waterproof layer of pavement of bridge surface, maintenance cost calculated by the same frequency and unit cost as with the Study shall be added to the cost at Pre-F/S.

Maintenance cost shall be adjusted by decrease rate of 4% proposed by JICA.

Table 8.7 Revised Maintenance Cost of Main Bridge (Pre-F/S)

Item	Unit	Unit Cost (USD)	Qty	Frequency (year)	Maintenance Cost (100 years) DR=0.00%	DR=2.5%	DR=5.0%
Maintenance Cost					**146,007,484**	**31,290,575**	**13,877,120**
C. Maintenance Cost (Civil Structures)					**143,378,924**	**30,345,170**	**13,386,025**
a. Safety Barriers	m	190	4,474	40	1,700,120	431,756	129,782
b. Drainage	m	0.37	2,236	1	82,732	32,777	18,772
c. Pavement	m3	450	993	10	4,468,500	1,464,701	697,918
d. Road Signs/Markings	item	-	-	15	625,044	207,604	93,721
e. Structural Concrete	-	-	-	1	33,412,400	13,357,938	7,650,118
f. Steelwork	-	-	-	1	24,148,400	1,930,852	1,105,803
g. Cable-stays	t	16,520	1,972	50	65,154,880	9,423,024	2,638,887
h. Bridge Bearings	no	17,229	16	40	551,328	140,001	42,083
i. Pedestrian Guardrails	m	210	3,356	40	1,409,520	357,903	107,583
j. Wind Barrier	m	600	2,237	40	2,684,400	681,720	204,919
k. Bridge Expansion Joints	m	43,950	104	40	9,141,600	2,316,894	696,439
D. Maintenance Cost (Other Than Civil Structures)					**2,628,560**	**945,405**	**491,095**
l. Road Lighting	no	100	90	1	900,000	359,810	206,064
m. Metro/LRT OH	m	50	2,236	40	223,600	73,138	28,506
n. Ballast and Sleepers etc.	m2	0.80	10,062	1	804,960	321,814	184,304
o. Aviation Warning Lights	item	-	-	20	100,000	28,642	11,695
p. Lighting Protection	item	-	-	25	600,000	162,001	60,526
Revised Maintenance Cost (Civil Structures)							
Pavement (Base and Waterproofing Layer) = (993m3/0.03m)*USD80/m2*3 times (frequency: 30 years)=						7,944,000	USD
Revised Maintenance Cost (DR=0%)=						151,322,924	USD

Source: JICA Study Team

Appendix 10：Risk Analysis Report (Main Bridge, 4th Panama Canal Bridge)

Results of Risk Analysis

due to Closure of Pacific Approach Channel

for Erecting the Rib Arch Segment of the 4th Bridge over the Panama Canal

1. BACKGROUND:

The Secretaría del Metro de Panamá (SMP) is conducting a feasibility study for the construction of the 4th Bridge over the Panama Canal with technical assistance from a Japanese Survey Team financed by the Japan International Cooperation Agency (JICA).

The feasibility study for the 4th Bridge over the Panama Canal includes a section on the evaluation of alternative bridge types. Among the different bridge types evaluated, the Cable-stayed (refer to Figure #1) and Steel Arch (refer to Figure #2) stood out based on a multi-criteria analysis. One element which differentiates between these two bridge types is the level of interference with Panama Canal operations. If no interference with Canal operations is assumed, the Cable-stayed type bridge ranks above the Steel Arch type in the multi-criteria evaluation, based on lower cost, construction period and risk. Under this same prerequisite, the Steel Arch Bridge requires significant temporary works for assembling the arch which results in higher cost and longer construction period. The Steel Arch Bridge does offer some advantages over other bridge types by providing a more rigid structure and distinctive architectural features.

The JICA Survey Team conducting the feasibility study has proposed an alternative construction method for the Steel Arch Bridge that requires closure of the Pacific Approach navigational channel for a short period in order to erect the central rib arch segment of the bridge structure that would be prefabricated simultaneously with the rest of the on-site bridge structure. This construction method would eliminate the need for mayor temporary works reducing construction of the Steel Arch Bridge by 10 to 12 months and its cost. Under this premise, one element that needs to be evaluated and quantified is the impact of the Pacific Approach Channel closure upon the Panama Canal, the local ports and other primary elements of the container logistic system which might be impacted when the rib arch is assembled around year 2019.

The proposed erection method of the large rib arch segment of the bridge has no precedence. Consequently, the SMP in conjunction with the Autoridad del Canal de Panamá (ACP) conducted a risk analysis of the proposed Pacific Approach channel closure to identify associated risks, define mitigation measures & contingency plans and quantify the economic impact of such risks. The result of this risk analysis will be included as part of the feasibility study for the 4th Bridge over the Panama Canal.

Figure # 1 Cable-Stayed Bridge Type

Figure # 2 Steel Arch Bridge Type

2. IDENTIFICATION AND QUANTIFICATION OF RISKS:

The risk analysis performed by SMP and ACP involved several workshops, some in which members of the JICA Survey Team participated. From these workshops and other meetings with ACP personnel from operations, engineering and risk management, the different risks were identified. This process concluded with the identification of three (3) significant risks.

Risk #1: Closure of Pacific Approach Channel during the Erection of Rib Arch Segment:

To determine the probability and impact of the rib arch segment erection, the JICA Survey Team provided the list of work activities directly associated with the erection process which requires the closure of the Pacific Approach navigational channel. The SMP together with the ACP evaluated these work activities and established minimum and maximum times for the rib arch erection process, which resulted in a time range of navigational channel closure. The erection work activities and times are the following:

Step Number	Work Item	Min. Time	Maxi. Time
Step 1	Towing by tugboats	0.5 Hours	1.0 Hour
Step 2	Anchoring	1.0 Hour	2.0 Hours
Step 3	Setting of Hooks for Lifting	2.0 Hours	4.0 Hours
Step 4 ** Note 1*	Lifting Up of Arch Rib Segment	8.0 Hours	12.0 Hours
Step 5	**Temporary Fixing of Arch Rib Segment**	**1.0 Hour**	**3.0 Hours**
Step 6	Final Inspection	1.0 Hour	2.0 Hour
Channel Using Time Total		13.5 Hours	24.0 Hours

For the risk analysis of channel closure for erecting the rib arch segment, the maximum time was used for quantifying the impact of erecting the rib arch segment.

The scenario for the risk analysis corresponds to the year 2019 when the rib arch segment will be erected. In that year, the post-panamax locks (Third Set of Locks) will be fully operational and as would be ACP´s port of Corozal on the east bank of Balboa Reach. Traffic of post-panamax vessels is expected at 8 vessels per day and container movements at the three Pacific ports is projected at close to 20,000 TEU per day.

The 24-hour closure of the Pacific Approach channel of the Panama Canal would result in one full day of delayed transits, generating a queue (backlog) of between 20 to 30 transits above normal levels, of which 8 queued transits would be post-panamax. Also, loss of revenue from the Transit Reservation System would accrue to one full day. Such a relative small backlog will not result in any lost transits. However, in order to reduce the backlog of waiting vessels to normal levels, the ACP must operate at a level of capacity beyond normal for a period averaging 5 days. To achieve

this additional capacity on a daily basis, more pilot assignments are required, as are additional crews at the locks and extra towboat assignments and overtime. To mitigate the one-day impact of delayed transits, before the channel closure takes effect, between 3 to 4 transiting vessels could be anchored within Balboa Reach and Pacific Basin area. Also, to mitigate adverse effects from unfavorable meteorological phenomena, the ACP recommends to program the rib arch segment erection between the months of June and August.

To quantify the effects on port operations by the channel closure, a cursory evaluation was made to determine potential economic impact. The timing and day of the week selected for the rib arch segment erection could have considerable impact on the Pacific ports and the Panama Canal Railway; therefore, the day of the week selected for the erection operation is important. Since at this point such micro planning is not possible, for the analysis of ports and railway an average condition was considered. Most of the containership berthing at the Pacific ports are from Northbound (navigating from the Pacific coast to the Atlantic coast) transits moving through the Panama Canal, these ports would be impacted by the Pacific Approach channel closure. Berthing delays due to channel closure should result in idle berth space and resources, and a backlog of containers at the port yards resulting in double handling of some of these containers. No loss of revenue for the ports is expected. However, to normalize port operations, increased cost from overtime and additional container handling will be required. When taking into account mitigation measures for reducing impact to Pacific port operations, it is estimated that during the 24-hour channel closure, 75 percent of Pacific ports container movements will be delayed, or approximately 15,000 movements in a 24-hour span. The economic impact analysis for the ports does not consider penalties for late cargo delivery.

Most berths at the Atlantic ports are generated from Southbound transits through the Panama Canal with small portion from Northbound transits. An important portion of container movements in the Atlantic ports represent the repositioning of empty units. The effect on the Atlantic ports will be negligible (at less than 10 percent of container movements) since container vessel arriving from the Atlantic Ocean to the Atlantic ports are not impacted by the Pacific Approach channel closure.

Container transshipment movement using the Panama Canal Railway Company (PCRC) is expected at 18,000 containers per week for 2019. But considering that the Pacific ports container yards can stack more containers than the railroad can move in a single day, the PCRC operation would not be affected.

Direct economic compensation to affected key stakeholders is anticipated for the 24-hour channel closure. This economic compensation is summarized below and represents a rough approximation in order to establish cost values to include in the cost estimate of the Arch Bridge construction.

Impact	Stakeholder affected	Amount of Compensation
Loss of revenue from Transit Reservation System	ACP	US$731,022.00

Incremental transit capacity for 5 days to reduce backlog:	ACP	
- Pilot assignments	ACP	US$325,000.00
- Towboats	ACP	US$24,320.00
- Lock crews	ACP	US$55,000.00
- Contingency (10% of above)	ACP	US$40,750.00
Loss of Pacific Port berths	Pacific ports	US$650,000.00
Loss of Atlantic Port berths	Atlantic ports	US$65,000.00
Loss of container transshipment movements for PCRC	PCRC	US$0.00
Total Direct Compensation		US$1,891,092.00

Channel closure for erecting the rib arch segment will require contingency plans and special preventive measures, in addition to the equipment and resources required for executing the rib arch segment erection process that has been recommended by the JICA Survey Team. The additional resources and/or plans required for the erection of the rib arch segment are summarized as follows:

a. At least two standby generators to power the strand-jacks, one on each side of the main bridge support sections

b. Two spare (emergency) hydraulic jacks one on each side of the main bridge support sections in case of a hydraulic jack failure

c. Rental of the ACP´s floating crane Titan for a minimum period of 40 hours at a cost of US$110,000.00, for each erection plan occurrence.

d. At least two standby generators one for each of the two floating barges supporting the rib arch Segment to operate anchor mechanisms in case of failure of the on-board electrical power

e. At least two standby towboats in addition to those required to position the floating barges supporting the rib arch segment

f. All the equipment and resources required for floating and swinging out of the channel of the rib arch segment, within a period of 72 hours, if it happens to fall into the navigational channel (refer to Risk #3). This includes the use of ACP floating cranes plus additional back-up cranes and sufficient human resources to accomplish the rescue mission in case of an emergency. All cables used in the lifting and rescue operation shall have sufficient strength and an adequate safety factor in case of movements beyond those normally expected. The lifting operation must be halted if any malfunction occurs.

g. The temporary method of fixing the rib arch segment to the permanent structural elements on both sides of the bridge, upon lifting the rib arch, needs to be evaluated in more detail and redundancy methods need to be identified and incorporated to mitigate all risks associated with fixing of the rib arch segment to the rest of the bridge structure.

h. Given the significant and negative impact that failing to erect the rib arch segment properly would have on the operations of the Panama Canal, the Pacific ports and the Panama Canal Railway, especially if the rib arch segment falls into the navigational channel, it would be prudent to conduct one or more simulated lifts at the factory site where the rib arch segment is fabricated prior to its deployment to Panama. The test lift of the rib arch segment should be performed high enough and under similar conditions to permit the evaluation of all elements, procedures and equipment that will be involved in the erection process. Such test lift; however, could be performed on land and not necessarily over water. All costs associated with the test lift should be charged to the Arch Bridge project and included in its cost estimate.

i. All critical activities involving the lift of the Arch Bridge shall be scheduled during daylight hours and under favorable meteorological conditions during the months of June and August.

All associated cost and resources required for complying with contingency plans and measures listed in this document must be included in the construction cost of the Arch Bridge.

Risk #2: Short notice postponement of Pacific Approach Channel closure date:

This risk contemplates the possible postponement of the original scheduled date for the Pacific Approach channel closure for rib arch segment erection. The probability assigned to the risk of postponing the original scheduled date for the channel closure is considered moderate (at 50 percent) due to the many contingency plans and special requirements that must be in place before initiating the channel closure for erecting the rib arch segment.

This risk contemplates a change in the scheduled date within short notice of less than 12 hours. Because of the short notice, the ACP cannot offset the original impact of the closure of the channel; therefore, roughly 50 to 75 percent of the transits that could have navigated the Panama Canal on a normal day would be delayed causing an abnormal but small backlog in the neighborhood of 15 to 20 vessels. The ACP must reduce this backlog to normal levels before rescheduling the Pacific Approach Channel closure for erecting the rib arch segment. Consequently, the revenue of the Transit Reservation System from the original scheduled date will be loss plus that of the postponed closure. The incremental Canal capacity needed to reduce the resulting backlog with all its associated costs would be required for a period of 3 days. Some minor impact to Pacific and Atlantic ports, as well as for the PCRC may materialize if they are not able to reschedule ship berthing. However, the economic impact to ports and railroad was not considered for this risk.

Impact	Stakeholder affected	Amount of Compensation
Loss of revenue from Transit Reservation System	ACP	US$548,266.50
Incremental transit capacity for 3 days to reduce backlog:		

- Pilot assignments	ACP	US$195,000.00
- Lock crews	ACP	US$14,592.00
- Towboat	ACP	US$33,000.00
- Contingency (10% of above)	ACP	US$24,450.00
Loss of Pacific port berths	Pacific ports	n/a
Loss of Atlantic port berths	Atlantic ports	n/a
Loss of container transshipment movements for PCRC	PCRC	n/a
Total Direct Compensation		**US$815,308.50**

The economic consequence of this risk must be considered as part of the direct compensation package to the ACP by the contractor building the Arch Bridge.

Risk #3: Rib Arch Segment falling into the Pacific Approach channel causing an extended closure beyond the 24-hour period:

This risk considers the possibility that the rib arch segment being erected for the Arch Bridge fails and the rib arch structure falls into the Pacific Approach navigational channel blocking the transit of vessels in and out of the Panama Canal and the Pacific ports. Because of the many technical and safety requirements for the erection and fastening of the rib arch segment and the contingency plans contemplated to mitigate the impact of this risk, the likelihood of this risk materializing is considered low (below 10% probability); however, its impact on the Panama Canal, Pacific and Atlantic ports operations is considerable.

To quantify the impact of such risk, a preliminary analysis was conducted using the ACP´s computer simulation model for Canal Operations. ACP executed computer simulation runs for a 3-day closure, which indicated that the backlog of vessels awaiting to transit the Panama Canal would increase to levels between 80 to 95 vessels. Above the 100-vessel backlog with a heavy mix of post-Panamax vessels, it is possible for traffic diversion to take place, causing loss of transit revenue to the ACP. At this backlog level, it would take the ACP several weeks, working at full capacity with the post-panamax locks, to recover the queue of waiting vessels to normal levels. Any backlog that exceeds 100 vessels is considered unacceptable to the Panama Canal. Under high vessel traffic, a 3-day closure of the Panama Canal would produce backlogs nearing the threshold level of 100 waiting vessels. Consequently, the maximum period of channel closure shall not exceed 3 days.

Under the scenario of a maximum closure of 3 days, the JICA Survey Team presented a contingency plan to float and swing out-of-the-way the rib arch segment to open the navigational channel in a time period bellow 72 hours. The total buoyancy required to partially float the rib arch segment is estimated at 2,535 tons. The contingency plan proposed by the JICA Survey Team involves the use of buoyancy bags with floating capacity of 35 tons each. Therefore, for partially lifting the rib arch segment a total of 75 lift bags will be required. These air bags must be attached

underwater to the rib arch structure employing around 20 industrial divers. The process of attaching and inflating 75 lift bags is possible but impractical. In all, a total of 6 air compressors will be required to fill the floating bags. These air compressors must be outfitted on top of floating barges with portable generators. Also, at least 4 tow or pusher boats with on-board cranes will be required to move the barges with the air compressors and to attach the floating bags. Powerful towboats will be required for swinging out the rib arch segment to open the navigational channel for vessel traffic. In conclusion, the solution presented by the JICA Survey Team needs to be refined to develop a contingency plan that is more practical to execute and has higher potential for success within the 72-hour envelop available to retrieve the fallen rib arch segment.

All the equipment and resources required to execute the proposed contingency plan need to be estimated and costed, and added to the cost estimate of the project. In case of a fallen rib arch segment, the cost of remanufacturing the fallen arch structure plus the incurred delays must be quantified and added to the estimate of the project cost by way of a special purpose insurance policy.

The cost to principal stakeholder as a consequence of a 3-day channel closure involve the following:

a. Loss revenue from 3 days of the ACP´s Transit Reservation System.

b. Increased transit capacity of the Canal for a period of 19 days after the navigational channel is cleared and opened to reduce the accumulated backlog of transiting vessels. No loss in transit revenue was considered; although, if closure exceeds 3 days, loss of transit revenue is possible.

c. Mobilization and demobilization of salvage equipment in the region and daily operating cost of such equipment.

d. Increased cost due to idle (unproductive) berths and resources, additional port crews and overtime to load/unload backlog of berthing vessels accumulated due to channel closure, and the need for double handling of some container movements accumulated (transshipment) because of idle berthing space at the Pacific ports at 75% of daily container volume on the first day (similar to 24-hour closure) and 100% of container volumes for second and third days of closure.

e. Idle berth space at the Atlantic ports due to Northbound vessel delayed by channel closure in Pacific side and additional cost of overtime to handle containers delayed by closure of Pacific ports (that will be working overtime to makeup delays) at 10% of Pacific ports on first day and 25% on days two and three.

f. Cost of negotiated contract clauses with shippers on late delivery of cargo that is applicable to all ports is not considered, since it is assumed that berthing vessels trapped in the Canal´s transit backlog would be moved to Atlantic ports for berthing as soon as a slot is available and then returned to the Atlantic anchorage to await transit through the Panama Canal. The cost associated with these additional vessel movements is considered for the vessels delayed for as

many as 18 vessels (2 berths for 3 days of channel closure for the 3 Atlantic ports). The estimated cost of the 18 additional vessel movements to and from anchorages includes extra pilot assignments, channel fees, launches and towboats.

g. PCRC could mitigate impact by transferring empty containers and performing maintenance on railway track.

The above cost are summarized in the following table:

Impact	Stakeholder affected	Amount of Compensation
Loss of revenue from Transit Reservation System for 3 days	ACP	US$2,193,066.00
Incremental transit capacity for 19 days to reduce backlog:		
- Pilot assignments	ACP	US$1,235,000.00
- Lock crews	ACP	US$92,416.00
- Towboat	ACP	US$405,654.18
- Contingency (10% of above)	ACP	US$173,307.02
Mobilization and demobilization of salvage equipment	Subcontractors	US$750,000.00
Operation of salvage equipment	Subcontractors	US$300,000.00
Loss of Pacific port berths	Pacific ports	US$2,350,000.00
Loss of Atlantic port berths	Atlantic ports	US$500,000.00
Extra vessel movements in Atlantic from anchorage to ports and back	Pacific ports	US$88,000.00
Loss of container transshipment movements for PCRC	PCRC	n/a
Replacement of rib arch segment	Contractor	To be estimated by JICA Survey Team
Construction delays of 4th Bridge and star-up of Line 3 of the Metro	Government of Panama	To be estimated by JICA Survey Team
Total value of Compensation		**US$8,087,443.20**

Because the probability of the rib arch segment falling into the Pacific Approach channel is low, it is recommended that the economic compensation from such risk be covered by a special purpose insurance policy with the principal stakeholders (APC, Pacific and Atlantic ports) as beneficiaries. Additionally, since this insurance is unique in the sense that it is directly related to the construction methodology chosen for the Arch Bridge that requires the use of the navigational channel, it must also cover the cost of fabricating a new rib arch segment and the economic impact of delaying the execution of the 4th Bridge Project and postponement of the start of operations of Metro Line 3.

The cost of this special purpose insurance policy to cover the economic compensation to principal stakeholders and the cost of building a new rib arch segment and related implementation delay

costs could be in the neighborhood of 10 to 15% of the total insurance coverage. The cost of the insurance policy is a direct cost to the project. Additionally, the cost of the project shall borne the minimum deductible that must be covered by the contractor multiplied by the probability of occurrence of this risk. Giving that this is a unique risk, the cost of collateral, which may be demanded by the insurance company and/or its underwriters, should be quantified.

3. CONCLUSIONS:

The risk analysis conducted by the SMP and ACP to assess the impacts of channel closure for the erection of the rib arch segment of the 4th bridge over the Panama Canal identified and evaluated the following risks:

Risk	Event	Risk cause	Consequence	Probability	Impact	Recommended Mitigation
1	Erection of rib arch segment	24-hour closure of Pacific Approach Channel	Backlog of around 20 to 30 vessels and some berth losses at Pacific and Atlantic ports and backlog of container transshipment movements	100%	Low	- Redundancy of rib arch lifting and fixing method - Lifting of rib arch should take place between June and August when meteorological conditions are most favorable - Qualified personnel to execute the erection of the rib arch - Robust contracting clauses and requirements that the contractor must comply with - Simulation test of erection method at rib arch fabrication site - Contingency plan for a 72-hour removal of the fallen rib arch segment from channel - Full economic compensation to ACP, Pacific and Atlantic ports
2	Postponement of erection of rib arch segment	Reprogramming of 24-hour channel closure within short notice	Transit capacity for original closure not fully recovered, causing a low backlog and minor berth losses a Pacific and Atlantic ports	50%	Low	- Coordination of closure with sufficient lead-time between ACP, SMP, Contractor, port operators and railway operator - Full economic compensation to ACP, Pacific and Atlantic ports
3	Fall of rib arch segment into channel	Closure of navigational channel beyond 24-hours but not exceeding 72 hours	Major backlog of transiting vessels and losses for several days of berths at Pacific and Atlantic ports and container transshipment movements	10%	High	- All contractors risk insurance, civil responsibility and loss of revenue (refer to details in ACP Risk Evaluation) - Performance and payment bonds

						- Bank guarantees to insure payment of direct economic compensations - Robust contracting clauses and requirements that the contractor must comply with - Have in place a contingency plan with capability for retrieving the rib arch segment within a period of less than 72-hour - Redundancy systems and equipment available (standby) in case of mechanical and electrical failures that would delay the lifting and installation of the rib arch - Improve fallen rib arch segment retrieval method to add redundancy for critical tasks - Insurance must also cover cost of replacing the rib arch segment and the economic impact on project implementation and delay on startup of Metro Line 3

- A critical component of the proposed rib arch segment erection method are the contingency plans required to add redundancy to the erection processes and to generate the capability for retrieving the fallen rib arch segment from the navigational channel within the threshold of 3 days to resume normal navigation.
- Since the lift of the rib arch segment has no precedence, it is highly recommended to perform simulation tests of the erection plan at the rib arch fabrication site before transporting the rib arch to Panama.
- Means of economic compensation to ACP and Pacific and Atlantic ports are recommended in this risk analysis to cover cost incurred directly due to erection of rib arch segment closing the Pacific Approach navigational channel. Also, the insurance cost for replacing a damaged rib arch segment and for compensating delays caused by any accident must be quantified and included for the 4th Bridge Project and the startup of Line 3 of the Metro. These impacts must be included in the cost estimate of the 4th Bridge Project.
- The SMP must coordinate with ACP during the elaboration of terms and conditions of the solicitation documents for the 4th Bridge to insure clear establishment of the economic compensations to mayor affected stakeholders and the mechanisms to ensure payment to the ACP and ports.

- Finally, all cost associated with the rib arch bridge construction methodology, including associated costs, contingency plans and resources to execute the contingency plans listed in this document must be included in the cost estimate of the Arch Bridge over the Panama Canal. Also attributed and derived cost such as direct economic compensation, insurance policies and loss of revenue to affected stakeholders, plus the replacement of the rib arch and delays to 4th Bridge Project and Line 3 of the Metro must be accounted for.

Appendix 11 : Environmental and Social Considerations

Appendix 11-1 Summary of Focus Group Discussion

(1) Focus Group Discussion with Women User of Public Transportation

[Women User of Public Transportation] February 17, 2014 16:00~17:30 Location: Specialized University of Las Americas Seven participants (Invited participants in the Albrook Bus Terminal)	 Source: URS Holdings, Inc.

Main opinions

- All participants agreed to the installation of the Metro Line 3. At the same time, they suggested that the route should reach until La Chorrera.
- They expressed a great dissatisfaction with the current transport system, buses and taxis, especially because of bad travel conditions (problem with safety, no seat, no air conditioning, long travel time, bad driving manner, etc.).
- They also pointed out that the *piratas*, "alternative transportation", is important transportation which has more frequent services, with good conditions, and with short travel times. The problem is taht they do not have insurance to cover passengers, and the fee is quite high.
- They have willingness to pay from USD 0.25 (normal bus rate) to USD 1.50 (*piratas*, illegal bus rate) if the travel time is reduced and a good quality service is provided. For example, a lady who gains US$20 per day pays US$8 for transportation.
- They indicated that it is necessary of public education to build a culture oriented to care for these public goods.

(2) Focus Group Discussion with University Students

[University Students] February 18, 2014 14:30~16:10 Location: Specialized University of Las Americas Eight participants plus 15 observers (Selected by drawing)	 Source: URS Holdings, Inc

Main opinions

- The participants expected that the Metro Line 3 will be an efficient and well organized transportation system.
- They are worried about the disorder of the exiting transportation system.
- They emphasized the importance of educating school students to keeping the system in good condition.
- They insisted that it is very important to educate/guidance on how to use Metro.

(3) Focus Group Discussion with Community Leaders and Workers in Burunga, Arraijan

[Community leaders and workers in Burunga, Arraijan] February 20, 2014 17:00~18:30 Location: El Diamante, Burunga 10 participants	 Source: URS Holdings, Inc.

Main opinions

- Burunga workers consider that the Metro will be a viable alternative transportation that can help to improve transport in the area. For example, it takes around only 15 minutes without traffic jam, but it takes 1 hour to 1.5 hour with traffic from Albrook to Burunga.
- They are aware of their responsibility in the invasion of RoW.

(4) Summary of Focus Group Discussion with Transportation Sector

[Transportation Sector] March 17, 2014 10:00~11:30 Location: Panama International Maritime University (La Boca) Six participants (Four taxi drivers, one administrator of Bus Association, one *pirata*, *"alternative transportation"*, driver)	 Source: JICA Study Team

Main opinions

- The participants have strong perception for transportation system, because it is they who have been providing services for a long time.
- They agreed with the Metro Line 3 Project, but at the same time, they do not want to leave the current transportation system.
- They strongly recommended improving the internal routes in Arraijan. It is required to pave existing small roads.
- They emphasized the necessity to integrate all transportation sectors.

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

Appendix 11-2 Route Alternatives Analysis - Environmental and Social Considerations

Ref	Issue	Autopista Route		Panamericana Route	
		Advantages	***Disadvantages***	***Advantages***	***Disadvantages***
1	Land acquisition and resettlement	• Resettlement unlikely			• Resettlement is quite likely, particularly for associated infrastructure • Compensation for lost business premises etc is likely to be high
2	Local economy, employment and livelihoods	• Business generation is likely to occur around stations and other infrastructure • May better serve future needs?	• Will not serve the existing community as well, and fewer passengers are likely if this route is selected (initially)	• Will better serve the existing community, and more passengers are likely if this route is selected • Business generation is likely to occur around stations and other infrastructure • Existing businesses are likely to benefit • The service will be most beneficial to existing settlements in the project area	• Construction process may adversely affect local businesses • Some businesses may be permanently affected by the project
3	Land use and local resources usage	• More space is available for working areas • Greater opportunity for land use planning • This route option could allow for advanced integrated town planning, though it is unlikely	• The number of new feeder roads required, as well as the establishment of stations in relatively uninhabited areas means that significant development at these sites is to be expected	• Less space is available for working areas • Less opportunity for land use planning	• Possible perception that the project is serving current needs without considering future land development
4	Social capital and Local organizations	• Unknown	• Unknown	• Unknown	• Unknown
5	Existing infrastructure and public services	• Likely to be few conflicts with existing services such as water and electricity supply	• Possibilities for new services/systems could be seen as an advantageous opportunity	• Existing infrastructure and services is already in place and could potentially be adapted as needed	• Likely to be many conflicts with existing services such as water and electricity supply
6	Ethnic minorities and indigenous community	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
7	Unbalanced distribution of benefits and damages	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
8	Local conflicts caused by common interests	• Unknown	• Unknown	• Unknown	• Unknown
9	Cultural heritage	• Unknown	• Unknown	• Unknown	• Unknown
10	Right of water use	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
11	Infectious diseases such as HIV/AIDS	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
12	Safety		• Likely to be high risk of workers accident	• Unlikely to be much difference	• Likely to be high risk of accidents involving the public
13	Topography and geography	• Likely to be less civil works.			• The volume of civil works for construction of stations is likely to be bigger.
14	Underground water	• Unknown	• Unknown	• Unknown	• Unknown
15	Soil erosion		• Soil erosion is likely to be increased	• Soil erosion is likely to be less	
16	Hydrology	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
17	Flora, fauna and biodiversity		• Risk of adverse impacts is slightly higher	• Possibility of redeveloping brownfield land for depots etc could reduce impacts	
18	Landscape	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
19	Protected Natural Areas (PNAs)	• No PAs near route	• No PAs near route	• No PAs near route	• No PAs near route
20	Global warming	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
21	Air pollution	• Construction related air quality impacts are likely to be less significant due to lack of sensitive receptors	• Operational air quality impacts are likely to be more significant due to the expected increased need of feeder buses	• Operational air quality impacts are likely to be less significant	• Construction related air quality impacts are likely to be more significant due to sensitive receptors
22	Water pollution	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
23	Soil pollution	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
24	Waste management	• Waste management during both construction and operation is likely to be easier to manage and control	• New collection routes will be required during operation	• Existing collection routes can be modified (if they exist)	
25	Noise and vibration	• Both construction and operational noise and vibration impacts are likely to be lower			• Both construction and operational noise and vibration impacts are likely to be higher
26	Land subsidence	• Unknown	• Unknown	• Unknown	• Unknown
27	Offensive odors	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference	• Unlikely to be much difference
28	Traffic	• Disruption during construction likely to be less significant • Accidents likely to be fewer	• Any accidents could be more serious	• Any accidents likely to be less serious	• Disruption during construction likely to be more significant • More accidents likely

Source: JICA Study Team

Appendix 11-3 System Alternatives Analysis - Environmental and Social Considerations

Ref	System	Advantages	Disadvantages
1	Automated Guideway Transit (AGT)	• Running performance for hill-climbing and small curvature, Low noise and vibration	• Electric consumption is larger than the system which is using steel wheel. • Basically, slab structure which gives large impact to the landscape is installed
2	Monorail	• Ditto • Generally, transport capacity is larger than that of AGT. • Since no slab structure is installed, impact to the city landscape is low.	• Electric consumption is larger than the system which is using steel wheel.
3	Linear metro	• Hill-climbing performance, and lower noise from steel wheel than MRT. • R.O.W is smaller than that of MRT.	• Basically, slab structure which gives large impact to the landscape is installed
4	Urban Railway / MRT	• Large transport capacity, Large number of manufacturer in the world. • Low electric consumption per transport capacity	• Basically, slab structure which gives large impact to the landscape is installed • Bigger noise and vibration compared with other system. • Flexibility of an alignment is lower than that of other system. And this system can't adapt to small curvature and steep gradient. It may cause land acquisitions.
5	LRT (Tramway with segregated RoW)	• Low construction cost when it is constructed at grade.	• Since R.O.W is installed in road space, this system gives large impact to road traffic.

Ref	System	Construction									Operation	
		Needs tunnel?	***Construction period below, at or above average?***	***Nature of line – raised or ground level?***	***Civil works requirement below, at or above average?***	***Overhead line?***	***Number of required substations***	***Difference in working area required during construction?***	***Earthworks requirement below, at or above average?***	***Piling / dewatering requirement below, at or above average?***	***Safety***	***Noise/ vibration***
1	Automated Guideway Transit (AGT)	No Applicable maximum gradient is 6%	Average	Raised	Average	Side	Various kind of voltage	Average	Average	Average	Secured by ATP (Automatic train protection)	Lower Because of rubber tire
2	Monorail	No Ditto	Below	Raised	Below	Side	DC1500V or DC750V	Smaller	Below	Below No slab structure	Secured by ATP (Automatic train protection)	Lower Because of rubber tire
3	Linear metro	No Ditto	Average MRT + Reaction plate installation	Raised or Ground level	Average	Overhead	DC1500V	Average	Average	Average	Secured by ATP (Automatic train protection)	Lower Because of bogie with steering system
4	Urban Railway / MRT	Yes Applicable maximum gradient is 3.5%	Above	Raised or Ground level	Above	Overhead	Various kind of voltage	Larger Because of large structure	Above	Above Axle load of train and dead load of structure are heavy	Secured by ATP (Automatic train protection)	Average
5	LRT (Tramway with segregated RoW)	Yes Ditto	Below Because of at grade	Ground level	Below Because of at grade	Overhead	Various kind of voltage	Larger Because of ground level	Below Because of at grade	Below Because of at grade	Secured by driver	Lower Because of steel wheel of sandwich structure with rubber
	The System of Metro Line 1, elevated section		**Average**		**Average**			**Average**	**Average**	**Average**		**Average**

Note:
Regarding Construction period, Civil works requirement, Difference in working area, Earthworks requirement and Piling dewatering requirement, the system of Metro Line 1 was considered to be an "Average" and each system was compared.
AGT, Linear metro, MRT and HSST have slab structure in superstructure. In this table, adoption of U-shape slab structure which is used in Line-1 was assumed.
LRT can be installed as a Raised line. However, LRT in this table is assumed as at grade.
Number of required substations is depending on voltage of the system. Since some systems are adopting various kind of voltage, please ask this question to an electric specialist.
Source: JICA Study Team

Appendix 11-4 Terrestrial Flora Species Identified during the Baseline Surveys

Family	Scientific Name	Vernacular Name	IUCN Red List	Panamanian Law (Resolution AG-0051)
Acanthaceae	*Aphelandra scabra*	-	-	VU
Adiantaceae	*Adiantun lunulatum*	Walking Maidenhair Fern	-	-
Anacardiaceae	*Anacardium excelsum*	Wild Cashew	-	-
	Anacardium occidentale	Cashew	-	-
	Astronium graveolens	Glassywood	-	VU
	Spondias mombin	Hog Plum	-	-
Annonanceae	*Annona purpurea*	Soncoya	-	-
	Xylopia frutescens	-	-	-
	Guatteria sp.	-	-	-
	Porcelia magnifructa	-	-	-
Apocynaceae	*Thevetia peruviana*	Yellow Oleander	-	-
Araceae	*Dieffenbachia sp.*	-	-	-
	Rodospatha sp.	-	-	-
	Philodendron sp.	-	-	-
	Monstera sp.	-	-	-
Araliaceae	*Schefflera morototoni*	Morototo	-	-
	Dendropanax arboreus	-	-	-
Arecaceae	*Attalea butyracea*	Yagua Palm	-	-
	Bactris cf.coloniata	Uvito Palm	VU	VU
	Desmoncus orthacanthos	-	-	-
	Elaeis oleifera	American Oil Palm	-	-
	Oenocarpus mapora	Don Pedrito's Palm	-	-
	Roystonea regia	Cuban Royal Palm	-	-
	Chryosophila warscewiczii	-	-	-
	Cryosophila warscewiczii	-	-	-
Asteraceae	*Delilia biflora*	-	-	-
	Mikania sp.	-	-	-
	Vernonanthura patens	Salvión	-	-
Bignoniaceae	*Arrabidaea sp.*	-	-	-
	Tecoma stans	Yellow Trumpetbush	-	-
	Tabebuia guayacan	Guayacan Trumpet Tree	-	VU
	Tabebuia rosea		-	VU
Bombacaceae	*Ochroma pyramidale*	Balsa	-	-
	Pseudobombax septenatum	-	-	-
Boraginaceae	*Cordia alliodora*	Spanish Elm	-	-
	Cordia panamensis	Guacalmanono	-	-
Bromeliaceae	*Bromelia pinguin*	Penguin	-	-
Burseraceae	*Bursera simarouba*	Copperwood	-	-
	Protium panamense	Jennywood	NT	-
Cactaceae	*Epiphyllum phyllanthus*	-	LC	VU
Capparaceae	*Capparis cf. frondosa*	-	-	-
	Cleome sp.	-	-	-
Caricaceae	*Vasconcellea cauliflora*	Carica	-	-
Cecropiaceae	*Cecropia sp.*	-	-	-
	Cecropia peltata	-	-	-
Chrysobalanaceae	*Hirtella americana*	Pigeon Plum	-	-
	Hirtella racemosa	-	-	-
Clusiaceae	*Vismia billbergiana*	Sangrillo	-	-
Cochlospermaceae	*Cochlospermum vitifolium*	-	-	-
Combretaceae	*Laguncularia racemosa*	White Mangrove	LC	EN
	Terminalia oblonga	-	-	VU

Family	Scientific Name	Vernacular Name	IUCN Red List	Panamanian Law (Resolution AG-0051)
	Terminalia amazonia	-	-	VU
Convolvulaceae	*Ipomoea sp.*	-	-	-
Costaceae	*Costus villosissimus*	Porcupine Ginger	-	-
Cyatheaceae	*Cyathea petiolata*	-	-	VU
Cychlanthaceae	*Carludovica palmata*	Panama Hat Plant	-	-
Cucurbitaceae	*Gurania makoyana*	-	-	-
Dilleniaceae	*Curatella americana*	Sandpaper tree	-	-
Euphorbiaceae	*Acalypha diversifolia*	-	-	-
	Acalypha macrostachya	-	-	-
	Croton schiedeanus	Coegalasapi	-	-
	Sapium glandulosum	Gumtree	-	-
Fabaceae-Caesalpinioideae	*Andira inermis*	Cabbage bark tree	-	-
	Cassia sp.	Cassia	-	-
	Copaifera aromatica	-	-	-
	Hymenaea courbaril	Jatobá	-	-
	Peltophorum pterocarpum	Copperpod	-	-
	Swartzia simplex	-	-	-
Fabaceae-Mimosoideae	*Acacia collinsii*	Bull Horn Acacia	-	-
	Cojoba rufescens	Coral Snake tree	-	-
	Leucaena multicapitula	Frijolillo	-	-
	Enterolobium cyclocarpum	Elephant Ear Tree	-	-
	Inga sp.	-	-	-
	Pithecellobium unguis-cati	-	-	-
	Zygia longifolium	Sota caballo	-	-
	Pseudosamanea guachapele	Guachapele	-	-
	Samanea saman			
Fabaceae-Papilionoideae	*Andira inermis*	-	-	-
	Flemingia strobilifera	-	-	-
Flacourtiaceae	*Hasseltia floribunda*	-	-	-
	Casearia sp.	-	-	-
	Lacistema aggregatum	Cemp wood tree	-	-
	Lindackeria laurina	-	-	-
	Zuelania guidonia	Cagajón	-	-
Gesneriaceae	*Codonanthe sp.*	-	-	-
Haemadoraceae	*Xiphidium caeruleum*	-	-	-
Heliconiaceae	*Heliconia latispatha*	Lobster claw Heliconia	-	-
	Heliconia platystachys	Sexy Orange Heliconia	-	-
Lauraceae	*Cinnamomum triplinerve*	-	-	-
	Ocotea sp.	-	-	-
	Nectandra sp.	-	-	-
Lecythidaceae	*Gustavia superva*	Membrillo	-	-
Loganiaceae	*Strychnos sp.*	-	-	-
Loranthaceae	*Phoradendron piperoides*	-	-	-
Marantaceae	*Ischnosiphon sp.*	-	-	-
Malvaceae	*Sida sp.*	Mallow	-	-
	Taliparitiliaceum var. pernambucensis			
Melastomataceae	*Miconia impetiolaris*	Mule's Ear Miconia	-	-
	Miconia argentea	-	-	-
	Mouriri myrtilloides	-	-	-
	Miconia elata	-	-	-
Meliaceae	*Trichilia sp.*	-	-	-
	Cedrela odorata	Spanish Cedar	VU	VU

Family	Scientific Name	Vernacular Name	IUCN Red List	Panamanian Law (Resolution AG-0051)
	Guarea sp.	-	-	-
	Guarea multiflora	-	-	-
Moraceae	*Ficus insipida*	-	-	-
	Ficus obtusifolia	Strangler Fig	-	-
	Castilla elastica	Panama Rubber Tree	-	-
Muntingiaceae	*Muntingia calabura*	Panama berry	-	-
Myristicaceae	*Virola sebifera*	Red Ucuuba	-	-
Myrsinaceae	*Ardisia sp.*	Coralberry	-	-
	Alibertia edulis	Puruí	-	-
Myrtaceae	*Eugenia sp.*	-	-	-
Nyctaginaceae	*Guapira costaricana*	-	-	-
Orchidaceae	*Epidendrum sp.*	-	-	VU
	Coryanthes sp.	-	-	-
Passifloraceae	*Passiflora vitifolia*	Passiflora	-	-
	Passiflora biflora	Two-flowered passion flower	-	-
Pellicieraceae	*Pelliciera rhizophorae*	Tea Mangrove	VU	EN
Piperaceae	*Piper reticulatum*	-	-	-
	Piper marginatum	Marigold pepper	-	-
	Piper culebranum	-	-	-
	Piper aequale	-	-	-
Poaceae	*Saccharum spontaneum*	Kans Grass	-	-
	Panicum maximum	Guinea grass	-	-
	Panicum pilosum	-	-	-
	Pharus latifolius	-	-	-
	Chusquea simpliciflora	-	-	-
	Rottboellia conchinchinensis	-	-	-
Polygonaceae	*Triplaris cumingiana*	Ant tree	-	-
	Coccoloba sp.	-	-	VU
	Coccoloba Caracasana	-	-	-
	Coccoloba manzanillensis	-	-	-
Rhamnaceae	*Gouania sp.*	-	-	-
Rhizophoraceae	*Rhizophora mangle*	Red Mangrove	LC	EN
	Cassipourea elliptica	Goat wood	-	-
Rubiaceae	*Alseis blackiana*	-	-	-
	Calycophyllum candidissimum	Harino o alazano	-	-
	Faramea occiddentalis	-	-	-
	Genipa americana	Genipapo	-	-
	Macrocnemum roseum	-	-	-
	Palicourea guianensis	Recadito	-	-
	Pittoniotis trichantha	Aguacatillo	-	-
	Posoqueria latifolia	Needle-flower Tree	-	-
	Psychotria carthagenensis	Amyruca	-	-
	Psychotria horizontalis	-	-	-
	Psychotria micrantha	-	-	-
	Psychotria sp.1	-	-	-
Sapindaceae	*Allophylus occidentalis*	-	-	-
	Cupania rufescens	-	-	-
	Cupania scrobiculata	Gorgojero	-	-
	Matayba glaberrima	-	-	-
	Matayba scrobiculata	-	-	-

Family	Scientific Name	Vernacular Name	IUCN Red List	Panamanian Law (Resolution AG-0051)
	Sapindus saponaria	Wingleaf soapberry	-	-
	Serjania sp.	-	-	-
Solanaceae	*Solanum sp.*	-	-	-
Sapotaceae	*Chrysophyllum cainito*	Star Apple	-	-
	Pouteria sp.	-	-	-
Scrophulariaceae	*Scoparia dulcis*	Goatweed	-	-
Siparunaceae	*Siparuna pauciflora*	-	-	-
Sterculiaceae	*Guazuma ulmifolia*	Guácima	-	-
	Herrania purpurea	-	-	-
	Sterculia apetala	Panama tree	-	-
Tectariaceae	*Cyclopeltis semicordata*	-	-	-
	Tectaria incisa	-	-	-
Thelypteraceae	*Thelypteris poiteana*	-	-	-
Tiliaceae	*Luehea seemannii*	-	-	-
	Apeiba tibourbou	-	-	-
Verbenaceae	*Tectona grandis*	Teak	-	-
	Aegiphila sp.	-	-	-
Vitaceae	*Cissus sp.*	-	-	-

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

Appendix 11-5 Terrestrial Fauna Species Identified during the Baseline Surveys

Family Name	Scientific Name	Vernacular name	IUCN Red List	Panamanian Law (Resolution AG-0051)
Mammals				
Agoutidae	*Agouti paca*	Spotted Paca	-	VU
Cebidae	*Saguinus geoffroyi*	Geoffroy's Tamarin	-	VU
Dasypodidae	Dasypus novemcinctus	Nine-banded Armadillo	-	-
Dasyproctidae	*Dasyprocta punctata*	Central American Agouti	-	-
Didelphidae	*Didelphis marsupialis*	Black-eared Opossum	-	-
Echimyidae	*Proechimys semispinosus*	Tome's Spiny Rat	-	-
Leporidae	Sylvilagus brasiliensis	Tapeti/ Forest Rabbit	-	-
Muridae	*Sigmodon hirsutus*	Southern Cotton Rat	-	-
Phyllostomidae	*Glossophaga soricina*	Pallas's Long-tongued Bat	-	-
	Carollia perspicillata	Seba's Short-tailed Bat	-	-
	Uroderma bilobatum	Tent-making Bat	-	-
	Artibeus jamaicensis	Jamaican Fruit-eating Bat	-	-
	Platyrrhinus helleri	Heller's Broad-nosed Bat	-	-
Procyonidaqe	*Nasua narica*	White-nosed Coati	-	-
	Procyon sp.	-	-	-
Sciuridae	*Sciurus granatensis*	Red-tailed Squirrel	-	-
Birds				
Alcedinidae	*Chloroceryle americana*	Green Kingfisher	-	-
Ardeidae	*Tigrisoma mexicanum*	Bare-throated Tiger-heron	-	-
	Ardea alba	Great Egret	-	-
	Egretta caerulea	Little Blue Heron	-	-
Cathartidae	*Coragyps atratus*	Black Vulture	-	-
	Cathartes aura	Turkey Vulture	-	-
Charadriidae	*Charadrius wilsonia*	Wilson's Plover	-	-
Columbidae	*Columba cayennensis*	Pale-vented Pigeon	-	VU
	Columbina talpacoti	Ruddy Ground-dove	-	-
	Leptotila verreauxi	White-tipped Dove	-	-
	Patagioenas cayennensis	Pale-vented pigeon	-	-
Cracidae	*Ortalis cinereiceps*	Grey-headed Chachalaca	-	-
Cuculidae	*Crotophaga ani*	Smooth-billed Ani	-	-
Emberizidae	*Volatinia jacarina*	Blue-black Grassquit	-	-
Falconidae	*Milvago chimachima*	Yellow-headed Caracara	-	-
Fregatidae	*Fregata magnificens*	Magnificent Frigatebird	-	-
Icteridae	*Quiscalus mexicanus*	Great-tailed Grackle	-	-
Laridae	*Larus Sp.*	Seagull	-	-
Pelecanidae	*Pelecanus occidentalis*	Brown Pelican	-	-
Phalacrocoracidae	*Phalacrocorax brasilianus*	Neotropic Cormorant	-	-
Picidae	*Melanerpes rubricapillus*	Red-crowned Woodpecker	-	-
Psittacidae	*Amazona autumnalis*	Red-lored Amazon	-	VU
	Amazona ochrocephala	Yellow-crowned Amazon	-	VU
Strigidae	*Otus choliba*	Tropical Screech-owl	-	-
Sulidae	*Sula leucogaster*	Brown Booby	-	-
Thraupidae	*Ramphocelus dimidiatus*	Crimson-backed	-	-
	Thraupis episcopus	Blue-grey Tanager	-	-
Trochilidae	*Phaethornis anthophilus*	Pale-bellied Hermit	-	-
Tyrannidae	*Tyrannus melancholicus*	Tropical Kingbird	-	-

Family Name	Scientific Name	Vernacular name	IUCN Red List	Panamanian Law (Resolution AG-0051)
	Myiocetetes cayanensis			
Reptiles				
Alligatoridae	*Crocodylus acutus*	American Crocodile	VU	EN
Boidae	*Boa constrictor*	Boa constrictor	-	VU
Colubridae	*Oxybelis fulgidus*	Green vine snake	-	-
Corytophanidae	*Basiliscus basiliscus*	Common basilisk	-	-
Gekkonidae	*Gonatodes albogularis*	Yellow-headed gecko	-	-
Gymnophthal-midae	*Leposoma southi*	Northern Spectacled Lizard	-	-
Iguanidae	*Iguana iguana*	Green Iguana	-	VU
Polychrotidae	*Anolis limifrons*	Slender Anole	-	-
	Anolis tropidogaster	Tropical Anole	-	-
	Anolis lionotus	Lion Anole	-	-
Scincidae	*Mabuya unimarginata*	Central American Mabuya	-	-
Teiidae	*Ameiva ameiva*	Giant Ameiva	-	-
Amphibians				
Bufonidae	*Chaunus marinus*	Cane toad	-	-
	Rhaebo haematiticus	Truando Toad	-	-
Centrolenidae	*Teratohyla spinosa*	Spiny Cochran frog	-	-
Dendrobatidae	*Dendrobates auratus*	Green And Black Poison Frog	-	VU
Eleutherodac-tylidae	*Silverstoneia flotator*	Rainforest Rocket Frog	-	-
	Diasporus diastema	Common Tink frog	-	-
	Diasporus vocator	Agua Buena Robber Frog	-	-
Hylidae	*Smilisca phaeota*	Masked Tree Frog	-	-
	Smilisca sordida	Veragua cross-banded tree frog	-	-
Leiuperidae	*Engystomops pustulosus*	Tungara Frog, Túngara Frog	-	-
Leptodactylidae	*Leptodactylus savagei*	Savage's Thin-toed Frog	-	-
	Leptodactylus fragilis	American White Lipped Frog	-	-

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

Appendix 11-6 Aquatic Species Identified during the Baseline Surveys

Family Name	Scientific Name	Vernacular name
Fish		
Atherinidae	*Atherinella panamensis*	Panama Silverside
	Melaniris pachylepis	Thick scale Silverside
Carangidae	*Caranx caninus*	Crevalle Jack
	Oligoplites altus	Longjaw Leatherjacket
Clupeidae	*Lile stolifera*	Pacific Piquitinga
Engraulidae	*Anchoa argentivittata*	Silverstripe Anchovy
	Anchoa panamensis	Panama Anchovy
Gerreidae	*Diapterus peruvianus*	Peruvian Mojarra
Haemulidae	*Anisotremus dovii*	Spotted head Sargo
Mugilidae	*Mugil curema*	Silver Mullet
Scianidae	*Cynoscion squamipinnis*	Scalyfin Corvina
Tetraodontidae	*Sphoeroides annulatus*	Bullseye Puffer
Bivalves		
Arcidae	*Anadara concinna*	-
	Anadara grandis	Mangrove Cockle
Cardiidae	*Laevicardium elenense*	-
	Trachycardium elenense	-
	Trigoniocarda obovalis	-
	Trigoniocardia granifera	-
Corbulidae	*Caryocorbula nasuta*	-
Mactridae	*Mactra fonsecana*	-
	Mulinia pallida	-
Solecurtidae	*Tagelus sp.*	-
Tellinidae	*Macoma siliqua*	-
	Psammotreta aurora	-
	Tellina eburnea	-
	Tellina inaequistriata	-
	Tellina rubescens	-
Veneridae	*Dosinia dunkeri*	-
	Protothaca aspérrima	-
Echinoderms		
Cidaridae	*Eucidaris thouarsii*	Slate Pencil Urchin
Brissidae	*Brissus obesus*	-
	Metala nobilis	-
Clypeasteridaae	*Clypeaster rotundus*	-
Cynoglossidae	*Symphurus elongatus*	-
Schizasteridae	*Agassizia scrobiculata*	-
Scutellidae	*Encope micropora*	-
	Mellita longifissa	-
Diadematidae	*Diadema mexicanum*	-
Echinometridae	*Echinometra vanbrunti*	-
Toxopneustidae	*Toxopneustes roseus*	-
	Tripneustes depresus	White Sea Urchin
Gastropods		
Buccinidae	*Phos fusoides*	-
Calyptraea	*Calyptraea conica*	Chinese Hat Snail
	Calyptraea mamillaris	-

Family Name	Scientific Name	Vernacular name
	Crepidula onyx	Onyx slippersnail
	Crucibulum spinosum	Spiny Cup-and-Saucer Snail
Cancellariidae	*Cancellaria albida*	-
Columbellidae	*Cosmioconcha modeta*	-
Conidae	*Conus fergusoni*	-
	Conus gradatus	-
	Conus patricius	Patrician Cone
Melongenidae	*Melongena sp.*	-
Nactidae	*Natica elenae*	-
	Polinices uber	-
Nassariidae	*Strombina recurva*	-
Neritidae	*Nerita funiculata*	-
Terebridae	*Terebra formosa*	-
Crustaceans		
Ocypodidae	*Uca sp.*	Fiddler Crab
Balanidae	*Balanus sp.*	Barnacle
Calappidae	*Hepatus kossmanni*	-
	Raninoides benedicti	-
Stelleroidea		
Ophiotrichidae	*Ophiothrix spiculata*	Brittle Star
Linckiidae	*Pharia pyramidata*	Yellow Spotted Star

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

Appendix 11-7 Estimated Cost of EMP for the Metro Line 3 Project

(1) Construction Phase

USD

Environmental Management Plan	Description	Unit Cost	Unit	Quantity	Costs	Sub Total
Mitigation Programs						
Climate, Air, Noise and Vibrations Quality Control Program						251,750.00
	Installation of acoustic barriers	9,500	km	26.5	251,750.00	
Soil Protection						930,150.00
	Construction of containment barriers, ditches and sediment traps	16,000	km	26.5	424,000.00	
	Setup of drainage works	19,100	km	26.5	506,150.00	
Surface Water Quality Control						380,275.00
	Petroleum absorbers and floating barriers	9,550	km	26.5	253,075.00	
	Oil traps in drains	4,800	km	26.5	127,200.00	
Flora Protection						482,210.50
	Tree and Grass Planting Plan in affected grassy areas (includes maintenance for 5 years)	8,750	ha	14	122,500.00	
	Flora Rescue and Recovery Plan (forest, mangroves and plantations throughout the alignment)	350	ha	28	9,800.00	
	Reforestation Plan (forest, mangroves and plantations sectors of the alignment)	7,700	ha	28	215,600.00	
	Environmental Compensation:					
	Mature secondary forest	5,000	ha	24.146	120,730.00	
	Intermediate secondary forest	3,000	ha	1.501	4,503.00	
	Young secondary forest	1,000	ha	1.873	1,873.00	
	Grassy plants	500	ha	14.409	7,204.50	
Fauna Protection						14,116.00
	Placing signs in construction areas in stations and forest areas to instruct regarding good behavior toward fauna	200	sign	36	7,200.00	
	Fauna Rescue and Relocation Plan (forest and mangrove sectors of the alignment)	247	ha	28	6,916.00	
Environmental Education Plan						120,000.00
	Preparation and Execution of the Environmental Education Plan	120	worker	1000	120,000.00	
Socio economic, Historical and Cultural						111,200.00
	Disclosure of hiring policies for labor and employment opportunities for the local population	33	worker	1000	33,000.00	
	Notification to communities of the development of construction	300	locations	20	6,000.00	

Environmental Management Plan	Description	Unit Cost	Unit	Quantity	Costs	Sub Total
	activities					
	Placement of warning and safety signalization in risk areas	3,800	area	19	72,200.00	
Environmental Supervisor						98,550.00
	Salary	19,500	year	4.5	87,750.00	
	Material and work equipment	2,400	year	4.5	10,800.00	
Social Aspects Manager						127,800.00
	Salary	26,000	year	4.5	117,000.00	
	Materials and work equipment	2,400	year	4.5	10,800.00	
Community Liaison Officer						101,475.00
	Salary	19,550	year	4.5	87,975.00	
	Materials and work equipment	3,000	year	4.5	13,500.00	
Environmental and Social Management Personnel Transportation						72,000.00
	Vehicle's (4x4)	36,000	veh.	2	72,000.00	
				Subtotal		2,689,526.50
Monitoring Plan						
Air Quality Monitoring						199,650.00
	Quarterly monitoring of vehicular emissions	14,300	year	4.5	64,350.00	
	Air quality monitoring before starting construction in Ancon Sector.	1,000	site	3	3,000.00	
	Quarterly air quality monitoring - Construction.	29,400	year	4.5	132,300.00	
Noise Emissions Monitoring (Ambient and Occupational)						233,250.00
	Quarterly occupational noise monitoring - Construction.	28,600	year	4.5	128,700.00	
	Baseline noise monitoring before construction in Ancon Sector.	750	site	3	2,250.00	
	Baseline noise monitoring before construction along the alignment.	750	site	8	6,000.00	
	Quarterly noise monitoring - Construction.	21,400	year	4.5	96,300.00	
Vibration Level Monitoring (Ambient and Occupational)						309,090.00
	Quarterly full-body vibration monitoring - Construction.	36,600	year	4.5	164,700.00	
	Baseline ambient vibration monitoring before construction in Ancon sector and alignment.	930	site	11	10,230.00	
	Quarterly ambient vibration monitoring - Construction.	29,400	year	4.5	132,300.00	
	Monitoring in case of blasts - Construction	930	site	2	1,860.00	
Surface Water Quality Monitoring						131,400.00
	Quarterly surface water quality monitoring– Construction.	29,200	year	4.5	131,400.00	
Soil Quality Monitoring						53,100.00
	Quarterly soil quality monitoring - Construction.	11,800	year	4.5	53,100.00	

Environmental Management Plan	Description	Unit Cost	Unit	Quantity	Costs	Sub Total
				Subtotal		926,490.00
				Total		3,616,016.50

Source: URS Holdings, Inc. (2014)

(2) Operation Phase

USD

Monitoring Plan	Description	Unit Cost	Unit	Quantity	Costs	Sub Total
Air Quality Monitoring						30,000.00
	Biannual air quality monitoring – Year 1 Operation.	15,000	year	1	15,000.00	
	Annual air quality monitoring – Year 2 and 3 Operation.	7,500	year	2	15,000.00	
Noise Emissions Monitoring (Ambient and Occupational)						22,000.00
	Biannual noise monitoring – Year 1 Operation.	11,000	year	1	11,000.00	
	Annual noise monitoring – Year 2 and 3 Operation.	5,500	year	2	11,000.00	
Vibration Level Monitoring (Ambient and Occupational)						22,500.00
	Annual ambient vibration monitoring - Operation.	7,500	year	3	22,500.00	
Surface Water Quality Monitoring						29,200.00
	Biannual surface water quality monitoring– Year 1 Operation.	14,600	year	1	14,600.00	
	Annual surface water quality monitoring– Year 2 and 3 Operation.	7,300	year	2	14,600.00	
Soil Quality Monitoring						12,400.00
	Biannual soil quality monitoring – Year 1 Operation.	6,200	year	1	6,200.00	
	Biannual soil quality monitoring – Year 2 and 3 Operation.	3,100	year	2	6,200.00	
Waste water monitoring						54,900.00
	Biannual monitoring of wastewater effluent at stations and at Depot area– Year 1 Operation.	27,450	year	1	27,450.00	
	Annual monitoring of wastewater effluent at stations and in Depot area (1 site) – Year 2 and 3 Operation	13,725	year	2	27,450.00	
				Total		171,000.00

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

Appendix 11-8 Estimated Cost of EMP for the Fourth Panama Canal Bridge Project

(1) Construction Phase

USD

Environmental Management Plan	Description	Unit Cost	Unit	Quantity	Costs	Sub Total
Mitigation Plan						
Noise and Vibrations Control Program						64,125.00
	Acoustic barriers barriers	9,500	km	6.75	64,125.00	
Soil Protection						108,000.00
	Construction of containment barriers, ditches and sediment traps	16,000	km	6.75	108,000.00	
Surface Water Quality Control						378,000.00
	Petroleum absorbers, dispersants, clean-up equipment and floating barriers	56,000	km	6.75	378,000.00	
Flora Protection						49,958.65
	Tree and Grass Planting Plan in affected grassy areas (includes maintenance for 5 years)	8,750	ha	1.655	14,481.25	
	Flora Rescue and Recovery Plan (forest and mangroves)	350	ha	2.878	1,007.30	
	Reforestation Plan (forest and mangroves)	7,700	ha	2.878	22,160.60	
	Environmental Compensation: o Mangroves	5,000	ha	0.363	1,815.00	
	o Mature secondary forest	5,000	ha	1.668	8,340.00	
	o Intermediate secondary forest	3,000	ha	0.240	720.00	
	o Young secondary forest	1,000	ha	0.607	607.00	
	o Grassy plants	500	ha	1.655	827.50	
Fauna Protection						123,039.00
	Placing signs in construction areas in stations and forest areas to instruct regarding good behavior toward fauna	200	sign	8	1,600.00	
	Fauna Rescue and Relocation Plan (forest and mangrove sectors of the alignment)	500	ha	2.878	1,439.00	
Environmental Education Plan	Preparation and Execution of the Environmental Education Plan	120	worker	1000	120,000.00	
Socio economic, Historical and Cultural						61,100.00
	Disclosure of hiring policies for labor and employment opportunities for the local population	33	worker	1000	33,000.00	
	Notification to communities of the development of construction activities	900	location	3	2,700.00	
	Placement of speed control signalization	200	sign	13	2,600.00	
	Placement of warning and safety signalization in risk areas	3,800	area	6	22,800.00	
Environmental Supervisor						87,600.00
	Salary	19,500	year	4	78,000.00	

Environmental Management Plan	Description	Unit Cost	Unit	Quantity	Costs	Sub Total
	Material and work equipment	2,400	year	4	9,600.00	
Social Aspects Manager						113,600.00
	Salary	26,000	year	4	104,000.00	
	Materials and work equipment	2,400	year	4	9,600.00	
Community Liaison Officer						90,200.00
	Salary	19,550	year	4	78,200.00	
	Materials and work equipment	3,000	year	4	12,000.00	
Environmental and Social Management Personnel Transportation						72,000.00
	Vehicle's (4x4)	36,000	vehicle	2	72,000.00	
				Subtotal		1,147,622.65
Monitoring Plan						
Air Quality Monitoring						177,800.00
	Quarterly monitoring of vehicular emissions	14,300	year	4	57,200.00	
	Air quality monitoring before starting construction in Ancon Sector	1,000	year	3	3,000.00	
	Quarterly air quality monitoring	29,400	year	4	117,600.00	
Noise Emissions Monitoring (Ambient and Occupational)						208,250.00
	Quarterly occupational noise monitoring	28,600	year	4	114,400.00	
	Baseline noise monitoring before construction in Ancon Sector	750	site	3	2,250.00	
	Baseline noise monitoring before construction along the alignment.	750	site	8	6,000.00	
	Quarterly noise monitoring	21,400	year	4	85,600.00	
Vibration Level Monitoring (Ambient and Occupational)						276,090.00
	Quarterly full-body vibration monitoring	36,600	year	4	146,400.00	
	Baseline ambient vibration monitoring before construction in Ancon sector and alignment	930	site	11	10,230.00	
	Quarterly ambient vibration monitoring	29,400	year	4	117,600.00	
	Monitoring in case of blasts	930	site	2	1,860.00	
Surface Water Quality Monitoring						116,800.00
	Quarterly surface water quality monitoring	29,200	year	4	116,800.00	
Soil Quality Monitoring						47,200.00
	Quarterly soil quality monitoring	11,800	year	4	47,200.00	
Land Subsidence Monitoring						60,000.00
	Quarterly land subsidence monitoring	15,000	year	4	60,000.00	
				Subtotal		886,140.00
				Total		2,033,762.65

Source: URS Holdings, Inc. (2014)

(2) Operation Phase

USD

Monitoring Plan	Description	Unit Cost	Unit	Quantity	Cost	Sub Total
Air Quality Monitoring						30,000.00
	Biannual air quality monitoring – Year 1 Operation.	15,000	year	1	15,000.00	
	Annual air quality monitoring – Year 2 and 3 Operation.	7,500	year	2	15,000.00	
Noise Emissions Monitoring (Ambient and Occupational)						22,000.00
	Biannual noise monitoring – Year 1 Operation.	11,000	year	1	11,000.00	
	Annual noise monitoring – Year 2 and 3 Operation.	5,500	year	2	11,000.00	
Vibration Level Monitoring (Ambient and Occupational)						22,500.00
	Annual ambient vibration monitoring	7,500	year	3	22,500.00	
Surface Water Quality Monitoring						29,200.00
	Biannual surface water quality monitoring– Year 1 Operation.	14,600	year	1	14,600.00	
	Annual surface water quality monitoring– Year 2 and 3 Operation.	7,300	year	2	14,600.00	
Soil Quality Monitoring						67,300.00
	Biannual soil quality monitoring – Year 1 Operation.	6,200	year	1	6,200.00	
	Biannual soil quality monitoring – Year 2 and 3 Operation.	3,100	year	2	6,200.00	
Waste water monitoring						54,900.00
	Biannual monitoring of wastewater effluent at stations and at Depot area– Year 1 Operation.	27,450	year	1	27,450.00	
	Annual monitoring of wastewater effluent at stations and in Depot area (1 site) – Year 2 and 3 Operation	13,725	year	2	27,450.00	
Total						225,900.00

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

Appendix 11-9 Monitoring Plans for Metro Line 3 Project and the Fourth Panama Canal Bridge Projects

Monitoring Plan	Monitoring Activity	Parameters	Implementation Period	Q*	BA*	A*	T*	O*	Responsible for Implementation
Monitoring of Air Quality	**Monitoring of Vehicle Emissions**								
	Measurement of vehicle emissions (quarterly monitoring/ 10 vehicles/ 5 years)	Emissions parameters defined in current regulations	Construction	**X**					Owner
	Monitoring of Ambient Air Quality								
	Monitoring of the air quality in the Ancón area (3 sites/ 1 measurement)	$PM_{10,}$ NO_2, SO_2, CO, CO_2 and O_3	Before beginning construction					**X**	Owner
	Monitoring of the air quality in recipients near the project (8 sites / 5 year)	$PM_{10,}$ NO_2, SO_2, CO, CO_2 and O_3	Construction	**X**					Owner
	Monitoring of the air quality in recipients near the project (8 sites / 1 year)	$PM_{10,}$ NO_2, SO_2, CO, CO_2 and O_3	Operation 1st year		**X**				Owner
	Monitoring of the air quality in sensible receptors near the project (8 sites / 2 years)	$PM_{10,}$ NO_2, SO_2, CO, CO_2 and O_3	Operation 2nd and 3rd years			**X**			Owner
Monitoring of Occupational Noise	**Monitoring of Noise in a Work Environment**								
	Dosimeters (10 workers per sector/ 5 sectors/ 5 years)	VdB	Construction	**X**					Owner
Monitoring of Ambient Noise	**Monitoring of Ambient Noise**								
	Monitoring of ambient noise in Ancón area (3 sites / 1 measurement)	Lmax, Lmin, Leq. Daily and nightly (dBA)	Before beginning construction					**X**	Owner
	Monitoring of ambient noise in sensible receptors near the project (8 sites / 5 years)	Lmax, Lmin, Leq. Daily and nightly (dBA)	Construction	**X**					Owner
	Monitoring of ambient noise in sensible receptors near the project (8 sites / 1 year)	Lmax, Lmin, Leq. Daily and nightly (dBA)	Operation 1st year		**X**				Owner
	Monitoring of ambient noise in sensible receptors near the project (8 sites / 2 years)	Lmax, Lmin, Leq. Daily and nightly (dBA)	Operation 2nd and 3rd years			**X**			Owner
t r u c t	**Monitoring of Ambient Vibration Levels**								

Monitoring Plan	Monitoring Activity	Parameters	Implementation Period	Q*	BA*	A*	T*	O*	Responsible for Implementation
	Inspections of existing structures along the alignment to verify their current condition, up to a radius of 200 meters. In the zones where blasting must be applied, the radius must be expanded up to 1,000 meters.	Presence of fissures, cracks or damages in general to the walls, floors, ceiling or beams	Before beginning construction					**X**	Owner
	Monitoring of baseline vibrations in Ancón (3 sites) and alignment (8 sites). One time measurement.	Peak Particle Velocity (mm/s)	Before site preparation					**X**	Owner
	Monitoring of ambient vibration along the alignment. (8 sites / 5 years)	Peak Particle Velocity (mm/s)	Construction	**X**					Owner
	Monitoring of ambient vibration. Exclusively in event of blasting. (2 sites / blasting)	Peak Particle Velocity (mm/s)	Construction. During blasting					**X**	Owner
	Structural integrity inspections after the use of blasting, up to 1,000 meters from the blasting site.	Presence of fissures, cracks or damages in general to the walls, floors, ceiling or beams	Construction. After blasting					**X**	Owner
	Monitoring of ambient vibration along the alignment. (8 sites / 1 year)	Peak Particle Velocity (mm/s)	Operation 1st year		**X**				Owner
	Monitoring of ambient vibration along the alignment. (10 sites /2 years)	Peak Particle Velocity (mm/s)	Operation 2nd and 3rd years			**X**			Owner
Monitoring of Occupational Vibrations	**Monitoring of Ambient Vibration Levels in Work Environments**								
	Monitoring of complete body vibration. (10 workers per sector/ 5 sectors***/ 5 years)	VdB	Construction	**X**					Owner
Monitoring of Surface Water Quality	**Monitoring of Surface Water Quality**								
	Monitoring of surface water quality (4 water courses, up and downstream the project). In other words, 2 samples per water course, in total 8 samples). (5 years)	pH, dissolved oxygen, turbidity, biochemical oxygen demand, fecal coliforms, oils and greases, metals and detergents	Construction	**X**					Owner

Monitoring Plan	Monitoring Activity	Parameters	Implementation Period	Q*	BA*	A*	T*	O*	Responsible for Implementation
	Monitoring of surface water quality (4 water courses, up and downstream the project). In other words, 2 samples per water course, in total 8 samples). (1 year)	pH, dissolved oxygen, turbidity, biochemical oxygen demand, fecal coliforms, oils and greases, metals and detergents	Operation 1st year		**X**				Owner
	Monitoring of surface water quality (4 water courses, up and downstream the project). In other words, 2 samples per water course, in total 8 samples). (2 years)	pH, dissolved oxygen, turbidity, biochemical oxygen demand, fecal coliforms, oils and greases, metals and detergents	Operation 2nd and 3rd years			**X**			Owner
Monitoring of Waste Waters	**Monitoring of Waste Water Quality**								
	Monitoring of waste waters from metro station's bathrooms (14 samples) and Depot area and equipment yard (1 sample). (1 year)	Parameters defined in current regulations, depending on the discharge point	Operation 1st year		**X**				Owner
	Monitoring of waste waters from metro station's bathrooms (14 samples) and Depot area and equipment yard (1 sample). (2 years)	Parameters defined in current regulations, depending on the discharge point	Operation 2nd and 3rd years			**X**			Owner
Monitoring of Soil Quality	**Monitoring of Soil Quality**								
	Monitoring of soil quality in areas used as fuel depots, workshops and equipment yards. (4 sites / 5 years)	Heavy metals, Hydrocarbons, Organic material, Dehydrogenase Microbial Activity	Construction	**X**					Owner
	Monitoring of soil quality in areas used as fuel depots, workshops and equipment yards. (4 sites / 1 year)	Heavy metals, Hydrocarbons, Organic material, Dehydrogenase Microbial Activity	Operation 1st year		**X**				Owner

Monitoring Plan	Monitoring Activity	Parameters	Implementation Period	Q*	BA*	A*	T*	O*	Responsible for Implementation
	Monitoring of soil quality in areas used as fuel depots, workshops and equipment yards. (4 sites / 2 years)	Heavy metals, Hydrocarbons, Organic material, Dehydrogenase Microbial Activity	Operation 2nd and 3rd years			**X**			Owner
Monitoring of Subsidence	Monitoring of the subsidence in Omar-Torrijos Interchange by visual check and measurement (only for the Fourth Panama Canal Bridge Project)	Meters	Construction	**X**					Owner
Reports**	**Follow-Up**								
	Biannual compliance reports		Construction		**X**				Owner
	Annual compliance reports		Operation (for the first 3 years)			**X**			Owner

*:Q-quarterly; BA-biannual; A-annual; T-every two years; y O-once.
**: Proposed frequencies must be adjusted to what has been established by the ANAM.
***: Number of sectors for programming and management cost calculation. Once the activities are programmed, an adjustment may be required.
Source: URS Holdings, Inc. (2014)

Appendix 11-10 Draft of Monitoring format of EMP

Monitoring format of General Site Visit

Date:	Name and signiture:
Weather:	
General observation in the field	

Problems	Measures taken	Actual situation (still in process to resolve or resolved)	Action to be taken

Monitoring format of Ambient Quality (Construction phase)

Air quality

Item	Unit	Measured value (mean)	Measured value (Max.)	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
PM_{10}	$\mu g/m^3N$			50/year 150/24 hours			McDonalds (Balboa), ACP Building 731 (Balboa), ACP Building 910 (La Boca), SENAN (Rodman), Delta station (Arraijan), Residential Arboleda (Caceres), Global Bank (Arraijan), Gas Station Puma (Parque Oeste)	Quarterly
NO_2	$\mu g/m^3N$			100/year 150/24 hours				
SO_2	$\mu g/m^3N$			80/year 365/24 hours				
CO	$\mu g/m^3N$			10,000/8hours 30,000/1hour				
O_3	$\mu g/m^3N$			157/8hours 235/1hour				

Noise

Item	Unit	Measured value	Country's Standards		Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
			Day	Night				
Noise Level Lmax. (day and night)	dB		-	-			National Police (Albrook), ACP Building 729 (Balboa), PIPSA(La Boca), SENAN (Rodman), Super Xtra (Arraijan), Residential Arboleda (Caceres), Supermarket Rey (Vista Alegre), Cemetery Colina de la Paz	Quarterly
Noise Level Lmin. (day and night)	dB		-	-				
Noise Level Leq. (day and night)	dB		60	50				

Vibration

Item	Unit	Measured value	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
Peak Particle Velocity	mm/s		50			National Police (Albrook), ACP Building 729 (Balboa), PIPSA(La Boca), SENAN (Rodman), Super Xtra (Arraijan), Residential Arboleda (Caceres), Supermarket Rey (Vista Alegre), Cemetery Colina de la Paz	Semiannually

Surface water quality

Item	Unit	Measured value (mean)	Measured value (Max.)	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
pH							Velasquez River, Aguacate River, One stream without name (Valle Hermos, Nuevo Arraijan), River Cope	Quarterly
Dissolved Oxygen (DO)	mg/l			>5.0				
Turbidity	NTU			<100				
Biochemical Oxygen Demand (BOD)	mg/l			<5.0				
Fecal Coliforms	UFC/100ml			<1000				
Oils & greases								
Metals								
Detergents								

Soil quality

Item	Unit	Measured value (mean)	Measured value (Max.)	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
Heavy metals							Area of fuel tank, workshops, and yard	Quarterly
Hydrocarbons								
Organic material								
Dehydrogenase Microbial Activity								

Monitoring format of Ambient Quality (Operation phase)

Air quality

Item	Unit	Measured value (mean)	Measured value (Max.)	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
PM_{10}	$\mu g/m^3N$			50/year 150/24 hours			McDonalds (Balboa), ACP Building 731 (Balboa), ACP Building 910 (La Boca), SENAN (Rodman), Delta station (Arraijan), Residential Arboleda (Caceres), Global Bank (Arraijan), Gas Station Puma (Parque Oeste)	Semiannually in the 1st year, and annually in the 2nd and 3rd year
NO_2	$\mu g/m^3N$			100/year 150/24 hours				
SO_2	$\mu g/m^3N$			80/year 365/24 hours				
CO	$\mu g/m^3N$			10,000/8hours 30,000/1hour				
O_3	$\mu g/m^3N$			157/8hours 235/1hour				

Noise

Item	Unit	Measured value	Country's Standards		Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
			Day	Night				
Noise Level Lmax. (day and night)	dB		-	-			National Police (Albrook), ACP Building 729 (Balboa), PIPSA(La Boca), SENAN (Rodman), Super Xtra (Arraijan), Residential Arboleda (Caceres), Supermarket Rey (Vista Alegre), Cemetery Colina de la Paz	Semiannually in the 1st year, and annually in the 2nd and 3rd year
Noise Level Lmin. (day and night)	dB		-	-				
Noise Level Leq. (day and night)	dB		60	50				

Surface water quality

Item	Unit	Measured value (mean)	Measured value (Max.)	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
pH							Velasquez River, Aguacate River, One stream without name (Valle Hermos, Nuevo Arraijan), River Cope	Semiannually in the 1st year, and annually in the 2nd and 3rd year
Dissolved Oxygen (DO)	mg/l			>5.0				
Turbidity	NTU			<100				
Biochemical Oxygen Demand (BOD)	mg/l			<5.0				
Fecal Coliforms	UFC/100ml			<1000				

Item	Unit	Measured value (mean)	Measured value (Max.)	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
Oils & greases								
Metals								
Detergents								

Soil quality

Item	Unit	Measured value (mean)	Measured value (Max.)	Country's Standards	Standards for Contract	Referred International Standards	Proposed Measurement Point	Frequency
Heavy metals							Area of fuel tank, workshops, and yard	Semiannually in the 1st year, and annually in the 2nd and 3rd year
Hydrocarbons								
Organic material								
Dehydrogenase Microbial Activity								

Note: "Item", "Proposed measurement point", and "Frequency" will be fixed based in the requirements of ANAM and the results of monitoring.

Appendix 11-11 Draft of Monitoring format of progress of activities related to RAP

Date	Name
General observation in the field	
Results of interview with PAPs	

Problems, complains	Measures taken	Actual situation (still in process to resolve or resolved)	Action to be taken

Progress of activities

Activities	Total	Unit	Progress in quantity		Progress in %		Expected date of completion	Responsible organization
			During the week	Till	During the week	Till		
Preparation of MINI RAP								
Employment of consultants		M/M						
Update of Strategic RAP								
Implementation of census to PAPs								
Property assess								
Approval of MINI RAP by SMP								
Finalization of PAPs List		No. Of PAPs						
Progress of compensation payment		No. Of HHs						
Balboa								
Loma Coba								
Arraijan								
Nuevo Chorrillo								
Biquez								
Vista Alegre								
Nuevo Arraijan								
San Bernardino								
Hato Montana								
Progress of land acquisition		m2						
Arraijan								
Nuevo Chorillo								
Biquez								
Vista Alegre								
Hato Montana								
Progress of resplacement		No. Of HHs						
Nuevo Chorrillo								
Biquez								
Hato Montana								
Progress of economic displacement		No. Of HHs						
Balboa								
Loma Coba								
Arraijan								
Nuevo Chorrillo								
Biquez								
Vista Alegre								
Nuevo Arraijan								
San Bernardino								
Hato Montana								

Appendix 11-12 JICA Check list of Environmental and Social Considerations[1] for Metro Line 3 Project and the Fourth Panama Canal Bridge Project

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) Y (b) N (c) N (d) N	(a) The EIA reports will be submitted to ANAM on August in 2014, and the approval will be issued within around three months after submission. One EIA report was prepared for the Metro Line 3 Project, and another for the Fourth Panama Canal Bridge Project including the improvement work of Omar-Torrijos Intersection. (b) The reports will be in the process of inspection by ANAM. (c) The reports will be in the process of inspection by ANAM. (d) The various other required permits (for example tree clearance, payment for mangrove cut, permit for explosion, permit for discharge of used and waste water, permit of water use, permit for excavation and landfill, permit for solid waste disposal, permit for hazardous wastes management, permit of work in the Canal Area by ACP, etc.) cannot be applied for before the EIAs are approved via ANAM's resolution. The ANAM resolution will include a number of conditions and permits that must be fulfilled by the promoter.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the Project and the potential impacts been adequately explained to the local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the local stakeholders? (b) Have the comments from the stakeholders (such as local residents) been reflected in the Project design?	(a) Y (b) Y	(a) Numerous public consultation meetings, stakeholder meetings and focus group discussions were held (see Table 19.2), exceeding the local procedures and rules. The general consensus among civil society, local populations and even affected people, is that the projects will bring significant positive impacts, and as such there is widescale support obtained from local stakeholders. Final information disclosure will be carried out by ANAM following approval of the EIA reports. (b) The line 3 project basic design fully reflects the opinions of PAPs and other local stakeholders. For example, the overall routing was shifted from the "Autopista" alignment to the "Panamericana" alignment, stations, bus stops and other project features were added or moved according to popular request.
	(3) Examination of Alternatives	(a) Have alternative plans of the Project been examined with social and environmental considerations?	(a) Y	(a) Project alternatives have been evaluated to a significant extent, including social and environmental considerations at all times. Alternatives for the Metro Line 3 project included routing alternatives, and technology alternatives, and for the Fourth Panama Canal Bridge project, routing alternatives were considered alongside bridge type. A tunnel alternative was also studied. For both the Metro Line 3 and Fourth Panama Canal Bridge projects, the "no project" alternative was also studied.
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that air pollutants emitted from the Project related sources, such as vehicles traffic will affect ambient air quality? Does ambient air quality comply with the country's air quality standards? Are any mitigating measures taken? (b) Where industrial areas already exist near the route, is there a possibility that the Project will make air pollution worse?	(a) Y (b) N	(a) The construction of the project will of course generate air pollutants such as SOx, NOx, CO and PM10 however this impact will be minor, temporary, and easily mitigated for via standard mitigation measures proposed in the EIAs. The operation of both projects will have significant positive impacts on air quality. The Metro Line 3 monorail will be run on clean energy and will therefore offset / reduce air pollution that would have been generated by vehicular traffic. Likewise, although the new Fourth Panama Canal Bridge will cause a local reduction in air quality, it will cause an overall improvement in air quality and pollutant levels by reducing journey lengths and journey times. Panama has no ambient air quality standard (one is currently under preparation) however provisional limits are available. Most of the survey results are below the likely eventual standards, however several readings exceeded the provisional limits. (b) There is no industrial area near the route.
	(2) Water Quality	(a) Is there a likelihood that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? (b) Is there a likelihood that the project will contaminate water sources, such as groundwater? (c) Do effluents from various facilities, such as parking areas/service areas comply with the country's effluent standards and ambient water quality standards? Is there a possibility that the effluents will cause areas not to comply with the country's ambient water quality standards?	(a) Y (b) N (c) Y	(a) Water quality degradation during ground clearance activities is likely due to the high rainfall in Panama and the slopes in the forest section of Metro Line 3. However, the increased sediment level in runoff water will be a fairly insignificant increase in most water bodies, which already have high TSS levels. b) It is fairly unlikely that construction or operation of the project will contaminate groundwater. (c) Panama does not have comprehensive water quality standards in place that could be exceeded by the projects' operational effluents. Nevertheless, operational effluents will be carefully collected and treated prior to discharge, so negative impacts are not expected.
	(3) Wastes	(a) Will waste generated from the Project facilities, such as stations and depot, be properly treated and disposed of in accordance with the country's regulations?	(a) Y	(a) Solid waste management will be one of the design features to be considered during detailed design for the projects, but will be required to be in accordance with the relevant legislation (Executive Decree 34 of 2007). During construction, contractors will also be bound to carrying out their work in accordance with Panamanian Laws, as well as international standards, via the Waste Management Plan that forms part of the overall Environmental Management Plan.

[1] This table is a version created by combining tables 8 (rail) and 12 (bridges) from the JICA Website.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(4) Noise and Vibration	(a) Do noise and vibrations from the vehicle and train traffic comply with the country's standards?	(a) N	(a) The baseline surveys determined that background noise levels are already in excess of the legal limits as defined in Panamanian law at all locations where readings were taken, and at all times. The construction and operation of the new metro line and bridge will add to the already high background noise levels, but the noise increase will be restricted to the immediate project vicinity. Detailed design should include consideration for operational noise reduction. Conversely, as the metro system will offset expected increase in car numbers and traffic problems, vehicular noise will be reduced, or at least noise increase will be prevented. There is no national standard for vibrations in Panama, but the EIA determined that the negative impacts due to vibration were likely to be low to moderate.
	(5) Subsidence	(a) In the case of extraction of a large volume of groundwater, is there likelihood that the extraction of groundwater will cause subsidence (especially in case of Undergrounds/Subways)?	(a) N	(a) The metro system will be entirely above ground, and there will therefore be no significant tunneling 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.
3 Natural Environment	(1) Protected Areas	(a) Is the Project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the Project will affect the protected areas?	(a) N	(a) There is no protected area in/around the Project site, and it is extremely unlikely that the projects will affect protected areas.
	(2) Ecosystem	(a) Does the Project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the Project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate protection measures taken to prevent impacts, such as disruption of migration routes, habitat fragmentation, and traffic accident of wildlife and livestock? (e) Is there a likelihood that installation of railroads, bridges and access roads will cause impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystems due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered? (f) In cases the Project site is located at undeveloped areas, is there a likelihood that the new development will result in extensive loss of natural environments?	(a) Y (b) N (c) N/A (d) N/A (e) N (f) N	(a) The Metro Line 3 project passes through a significant area of mainly mature secondary tropical rain forest, however, as the line runs alongside the road for the majority of the alignment, a relatively small amount of clearance is required. For the same reason, the impacts of forest clearance alongside a highly disturbed area are clearly much less significant than if the clearance were occurring in an undisturbed location. The Fourth Panama Canal Bridge project element passes through a small area of mangroves on the western banks of the Canal. A Special Mangrove Management Plan has been developed as part of the EIA for the Fourth Panama Canal Bridge, to ensure that construction impacts are minimized. It should be noted that academic and NGO opinion is that the area of mangrove to be cleared during construction of the bridge is likely to regenerate fairly rapidly. Both the forest and mangrove areas to be cleared will be offset through ANAM's forestry offset program. (b) The project sites do not encompass any protected habitats, but does encompass habitats of endangered species designated by both Panamanian law and international conventions. Despite this, the EIA studies determined that the projects will not cause significant habitat loss, nor will it have effects on the protected species. (c) Severe impacts on the ecosystem are not foreseen. (d) Due to the fact that the alignment of the Metro Line 3 project is largely alongside the existing road, and due to the fact that the entire alignment is raised above ground, no impacts are expected on animal migration, severance, or habitat fragmentation. As a result, no protection measures are required. (e) No introduction of exotic species is expected. (f) The majority of the project site is not located in undeveloped areas, and passes through existing urban areas. The section that passes through forest will not result in extensive loss of natural environments due to the proximity of the alignment to the existing road, the raised nature of the alignment, and the fairly small amount of clearance required. Offset and regeneration will also take place.
	(3) Hydrology	(a) Is there a likelihood that alteration of topographic features and installation of structures, such as tunnels will adversely affect surface water and groundwater flows?	(a) N	(a) The surface water flow is unlikely to be significantly affected by the presence or operation of the project, however they may be a slight increase in runoff. The construction of the project has some potential to affect surface water and groundwater flows, but the affects, if any, will be minor, and can be fairly easily mitigated.
	(4) Topography and Geology	(a) Is there any soft ground on the route that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, and where are such needed? (b) Is there a likelihood that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? (c) Is there a likelihood that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(a) N (b) Y (c) Y	(a) The project is in a high risk area for landlsides. Although soft ground does exist in places alongside the alignment of the Metro Line 3 Project, due to the fact that the majority of the alignment is alongside or in the centre of a paved road, slope failures and landslides are not expected. (b) It is possible that cut and fill and other construction activities may cause slope failures and landslides, however it is farily unlikely, particularly when the recommended mitigation measures are implemented via the Environmental Management Plan. (c) Soil runoff is highly likely during construction, due to the nature of the terrain and the climate in Panama. Runoff will be mitigated for via the Environmental Management Plan. Example mitigation measures include installation of silt fences.
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by resettlement? (b) Is adequate explanation on compensation and resettlement assistance given	(a)Y (b)Y (c)Y (d)Y	(a) Resettlement will be required for five families. The alignment was determined minimizing relocation of inhabitants. (b) All PAPs have been involved in the community participation activities during the feasibility study. (c) The RAP in accordance with the World Bank OP 4.12 was elaborated based on the census and socioeconomic

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(e)Y (f)Y (g)Y (h)Y (i)Y (j)Y	study of PAPs carried out on February to April of 2014. (d) The Strategic RAP determines the compensation is paid prior to resettlement. (e) The Strategic RAP determines the compensation policies. (f) The Strategic RAP describes the livelihood conditions of vulnerable groups and people. Special attention will be paid for vulnerable people. (g) The Strategic RAP determines that the SMP should obtain the agreements with the PAPs prior to resettlement. (h) SMP has a unit for resettlement and land acquisition. They have a successful experience in the Metro Line 1 Project. (i) A monitoring plan was elaborated out as a part of the Strategic RAP. (j) SMP will open the offices to conduct the grievance redress in the project area.
	(2) Living and Livelihood	(a) Where railways, bridges and access roads are newly installed, is there a likelihood that the Project will affect the existing means of transportation and the associated workers? Is there a likelihood that the Project will cause significant impacts, such as extensive alteration of existing land uses, changes in sources of livelihood, or unemployment? Are adequate measures considered for preventing these impacts? (b) Is there any likelihood that the Project will adversely affect the living conditions of the inhabitants other than the target population? Are adequate measures considered to reduce the impacts, if necessary? (c) Is there any likelihood that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the Project? Are adequate considerations given to public health, if necessary? (d) Is there any likelihood that the project will adversely affect road traffic in the surrounding areas (e.g., increase of traffic congestion and traffic accidents)? (e) Is there any likelihood that railways, bridges or access roads will impede the movement of inhabitants? (f) Is there any likelihood that structures associated with roads (such as bridges) will cause sun shading and radio interference?	(a) N (b) N (c) N (d) Y (e) N (f) Y	(a) Any severe impacts are not foreseen. The railways will go along the existing highway. (b) Any severe impacts are not foreseen. The project will have positive impact on the quality of life in the project area. (c) Any severe impacts are not foreseen in the environmental management plan with regards to awareness training for the workers. (d) The traffic congestion can occur during site preparation and construction, which can be minimized by controlling the working time. However, during the operation stage, situation is expected to improve. (e) Any revere impacts are not foreseen. (f) The columns of railway and of access road to the bridge probably will cause sun shading and radio interference. However, the most section of Metro Line 3 Project will go in the medium of the exiting highway, and the impact will be minimized.
4 Social Environment	(3) Heritage	(a) Is there a likelihood that the Project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) As the projects pass along fairly highly disturbed areas, and as the baseline surveys found little evidence of archaeological interest, it is not considered likely that the projects will damage local archaeological or historical resources. Likewise, the projects do not pass in proximity to any cultural or religious facilities or sites. Considerable effort was made during the EIA studies to uncover any evidence of such resources, in excess of the legal requirements. During construction, a Chance Find Procedure will be implemented to ensure that in the unlikely event of a discovery, the incident be correctly handled.
	(4) Landscape	(a) Is there a likelihood that the Project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) The EIA assessment determined that the existing landscapes are “average”. Many of the sections of the projects are highly disturbed due to anthropogenic activity, and even the relatively unpopulated forested area to the West of the Canal already includes the highway. No specific measures are required for landscape mitigation during construction, however sympathetic architecture for stations, substations, and other infrastructure should be employed.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources to be respected?	(a) N (b) N	(a) There is neither ethnic minorities nor traditional indigenous community in/around the Project area. (b) There is neither ethnic minorities nor traditional indigenous community in/around the Project area.
	(6) Working Conditions	(a) Is the Project proponent not violating any laws and ordinances associated with the working conditions of the country which the Project proponent should observe in the Project? (b) Are tangible safety considerations in place for individuals involved in the	(a) N (b) Y (c) Y	(a) The Project will take place in accordance with the national laws and ordinances about the working conditions (b) SMP will obligate consultants and contractors to provide safety considerations for their workers. (c) SMP will obligate consultants and contractors to implement safety and health program for their workers.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		Project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the Project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers, etc.? (d) Are appropriate measures being taken to ensure that security guards involved in the Project not to violate safety of other individuals involved, or local residents?	(d) Y	(d) SMP will obligate consultants and contractors to consider security guards for the workers.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) Y (c) Y	(a) The Environmental Management Plan, which includes a number of specific sub-plans such as a waste management plan and a flora and fauna protection plan, proposes a large number of effective mitigation measures to remove or reduce negative impacts during construction. Examples include restrictions on working hours and locations, and use of modern machinery to reduce noise and emissions, use of dust suppression equipment and regular damping to reduce dust generation, installation of silt fences and settling tanks to reduce runoff sediment loads, strict controls on waste management and storage and use of hazardous liquids, to prevent soil and water contamination, and extensive measures to prevent harm to workers or the general public. (b) The Environmental Management Plan outlines measures to reduce the negative impact of the required forest clearance, as well as proposing offset measures. (c) The RAP as well as the Environmental Management Plan is prepared to reduce impacts on social environment during construction, which will include among other measures the deployment of a full time Community Liaison Officer, regular meetings with the local communities, and implementation of a Grievance Redress Mechanism.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) Y	(a) The proponent develops and implements the monitoring program In accordance with the Environmental Management Plan, with the support of ANAM and other related agencies. (b) The items, methods and frequencies of the monitoring program of air quality, noise and vibration are explained in 19.7.6 of this Report. (c) In accordance with the Environmental Management Plan as well as the national regulation of ANAM, SMP will establish adequate monitoring framework. (d) The proponent should periodically submit the monitoring reports to ANAM.

Source: JICA Study Team