

NOT FOR PUBLIC USE

THIRD DRAFT

ECONOMIC FEASIBILITY STUDY FOR THE REHABILITATION OF GEORGE PRICE HIGHWAY

SEGMENT: BELMOPAN – IGUANA CREEK JUNCTION

AND

SEGMENT: IGUANA CREEK JUNCTION – SANTA ELENA

July 31, 2018

Abbreviations

GoBL	Government of Belize
GPH	George Price Highway
GDP	Gross Domestic Product
HDM-4	Highway Development and Management Model
HMA	Hoot Mix Asphalt
IDB	Inter-American Development Bank
IRR	Internal Rate of Return
IRI	International Roughness Index
iRAP	International Road Assessment Program
MOWT	Ministry of Works and Transport
MOFED	Ministry of Finance and Economic Development
MNRE	Ministry of Natural Resources and Environment
NPV	Net Present Value
SPF	Shadow Price Factor
RUC	Road User Cost
VPD	Vehicle per Day
VOC	Vehicle Operating Cost

Contents

NOT FOR PUBLIC USE	1
1. Introduction	5
2. Background of the Project	5
3. Type of Analysis Performed	6
4. General Project Description	6
5. Assumptions and Methodology	7
5.1 Road Segments and Financing Scenarios	7
5.2 Economic Feasibility Considerations	8
5.3 Evaluation Parameters	9
6. Alternatives for Evaluation	9
7. Traffic Data Collection and Analysis	10
7.1 Link Evaluation	10
7.2 Traffic Volumes - Average Annual Daily Traffic	12
7.3 Growth Rates and Projected AADT	13
8. System Cost for the Evaluation	15
8.1 Rehabilitation Costs	15
8.2 Rehabilitation costs for the economic evaluation with the HM4	17
8.3 Activities and Maintenance Costs	18
8.4 Costs of Vehicles and Vehicle Parameters	18
9. Benefits	20
9.1 The Cost Savings Benefits for Users (RUC – Road User Costs)	20
9.2 Benefits of Normal Traffic	21
9.3 Generated, Induced, and Diverted Traffic Benefits	21
9.4 Accident Reduction Benefits and Other Exogenous Benefits	22
10. Evaluation with HDM-4	22
10.1 Discount Rate and Evaluation Period	22
10.2 The Economic Indicators	22
10.3 Comparison of Alternatives	23
10.4 Evaluation Results with HDM-4	24
11. Sensitivity Analysis	25
11.1 Additional Analysis with Accident Benefits	27
11.2 Analysis taking into account ‘Sunk Costs’	29
12. Technical Evaluation of the Wearing Course	31

13.	Conclusions and Recommendations	33
14.	Annex A. HDM-4 Outs: Road Works Summary by Link	35

1. Introduction

This report presents the analysis of the economic viability of the project included in the operation BL-L1019 "George Price Highway Rehabilitation".

This analysis has been executed based upon the information and criteria submitted to the Bank by the Ministry of Works and Transport (MOWT).

The economic evaluation, financial and economical profitability analysis was performed to verify the project's eligibility towards potential financing by the Bank. Similarly, inputs have been provided to establish indicators that have been included in the result matrix, as well as, in the monitoring and evaluation plan for this operation.

2. Background of the Project

The George Price Highway (GPH), formerly known as the Western Highway, is a two-lane road that connects: (i) Belize City, the commercial center; (ii) Belmopan, the national capital; (iii) San Ignacio and Santa Elena; and (iv) Benque Viejo on the Guatemalan Border. The GPH was originally built in the 1930s and last rehabilitated in the mid-1980s.

The route is part of the International Network of Mesoamerican Highways (RICAM). In recent years, the GPH's pavement has deteriorated significantly, particularly in Cayo District from Belmopan through Santa Elena/San Ignacio to the Guatemalan border at Benque Viejo due to: (i) inadequate design standards; (ii) an increase in trucks and buses from the expansion of the petroleum, agriculture, and tourism sectors; and (iii) limited maintenance. The pavement's poor conditions together with the absence of paved shoulders, unsafe road alignments, lack of pedestrian facilities in urban areas, and limited marking and signing add to Belize's high incidence of road fatalities. Because of these issues, the GPH suffers from a decreasing level-of-service providing a major constraint for Belize's economic and social development and integration with Central America and compromising the use of this corridor as a primary evacuation route. The Government of Belize (GOBL) through the Ministry of Works proposes to upgrade the GPH.

The rehabilitated roadway will be designed to withstand an increased incidence of severe weather due to climate change. This will result in bridges designed to remain above flood levels and sufficient drainage and elevation of the roadway to prevent localized flooding. After rehabilitation the roadway will be able to reliably perform as the primary evacuation route for Belize City during severe weather events.

The final costs for section are as follows:

- Section I (Lot 1) Construction of Roaring Creek Bridge - BZ\$11,093,450.17
- Section II (Lot 2) Roaring Creek to Iguana Creek Junction - BZ\$22,798,000.00
- Section III (Lot 3) Iguana Creek Junction to Santa Elena Town- BZ\$25,318,229.64 (estimated)
- There is also under Sections I, II, III a US\$2,442,763 amount for Utility Relocation, US\$156,000 for Maintenance, US\$2,562,515 for Supervision, US\$250,000 for Environment & Social and, US\$704,500 for additional quantities for Road Safety and Lights

3. Type of Analysis Performed

The following economic feasibility assessment includes a cost benefit analysis that identifies and quantifies the net benefits of the project. A measurable pattern resulted from the quantifiable net benefits obtained from this analysis.

Cost benefits for transportation along the segments of study have been identified and analyzed for both project options, "Without Project" and "With Project".

The term "Without project" is defined as the conditions under which the transportation system would operate without any additional investment. The assumption under these conditions is that, the maintenance monies provided on an annual basis will be affected.

The "With Project" option is defined as conditions under which the transportation system would operate after the implementation of the investment required for improvement.

Total transportation costs for each of the options were obtained from the quantification of the costs associated with the initial intervention, track maintenance, and user costs.

As such, for the evaluation of options "Without Project" and "With Project", the annual condition of the transportation system is established based on the impacts from interventions, maintenance, traffic, and weather. Subsequently, the user costs resulting from each condition are established.

Profitable indicators have been obtained from annualized profits.

4. General Project Description

The GPH, formerly known as the Western Highway, connects: (i) Belize City, the economic center; (ii) Belmopan, the national capital; (iii) San Ignacio and Santa Elena, the second largest urban area in the country; and (iv) Benque Viejo on the Guatemalan Border. See Figure 1 below for visual representation.

The GPH is a two-lane, 79.4 mile highway originally built in the 1930s and last rehabilitated in the mid-1980s. Since then, the roadway pavement has deteriorated significantly, particularly between Belmopan (mile 47.9) and the Guatemalan Border at Benque Viejo (mile 79.4), due to: (i) insufficient drainage; (ii) the steep increase in truck traffic from the expansion of, primarily, the petroleum sector and, to a lesser extent, the agriculture and tourism sectors; as well as, (iii) limited maintenance. The poor conditions of the pavement structure along with the absence of paved shoulders, unsafe road alignments, lack of pedestrian facilities in urban areas, and limited marking and signing lead to Belize's high incidence of road fatalities.

Flooding greatly restricts traffic flow along the road, increases the rate of pavement deterioration, and makes evident, the infrastructure vulnerabilities during extreme weather events. This is a significant issue as the highway is a primary evacuation route for coastal areas including Belize City. A particular concern is the Roaring Creek Bridge (mile 48), located near Belmopan, which was submerged at least twice over the course of the last ten years. These

types of flooding events allow for water straining on its superstructure, possibly undermining its structural integrity. Loss of access to the bridge cuts off a critical evacuation route during severe storm events. It also causes long-term negative impacts by severely damaging commercial trade and tourism activity between Belize sites and Guatemala.

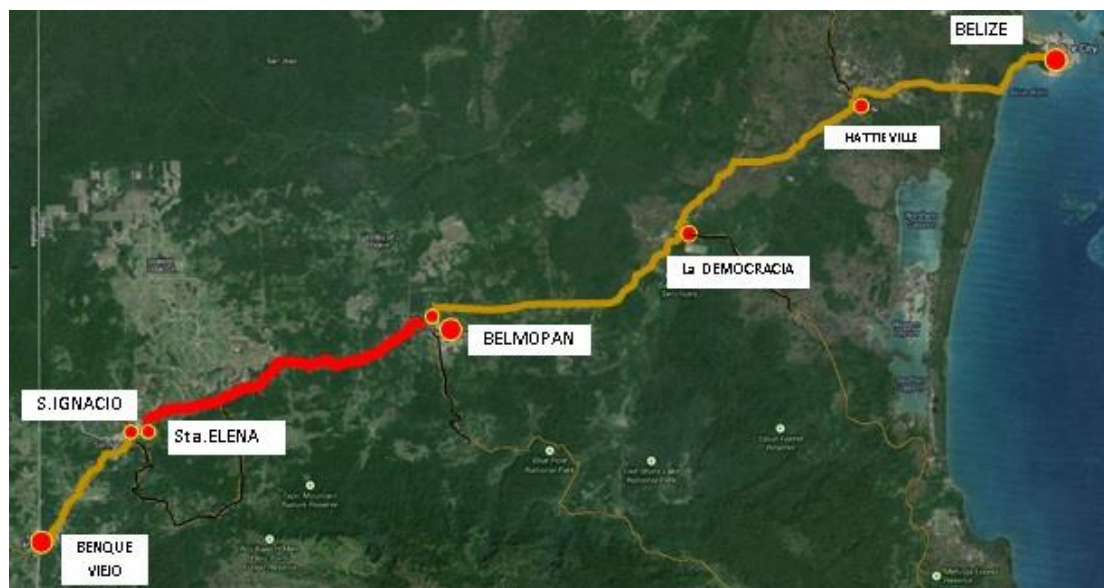


Figure 1: George Price Highway

Currently the pavement structure of the road shows areas of significant deterioration, in particular, the segment between Belmopan (Mile 47.9) and the border with Guatemala (mile 79.4). It is important to note that the Bridge Roaring Creek Bridge (mile 48), located near Belmopan, shows signs of structural and loading capacity problems.

To address these problems the Government of Belize (GoBL) has requested support from the IADB to finance the George Price Highway Rehabilitation Project (the Project) comprised of two priority elements of intervention: i) the rehabilitation of the GPH between Belmopan and the Guatemalan Border at Benque Viejo (31.5 miles); ii) and the Roaring Creek Bridge. Despite the lack of information available, the IADB's support has begun with funding provided through a Technical Cooperation to perform two preliminary studies: i) the feasibility study of both the technical and economic¹ aspects, and ii) the environmental and social impact assessment.

5. Assumptions and Methodology

5.1 Road Segments and Financing Scenarios

The GPH section of the road system under consideration addresses the problems by financing the rehabilitation and maintenance of the GPH between Belmopan (mile 47.9) and the

¹The Anthony Thurton Associated Ltd. is the Consultant that is in charge to conduct the technical and economic feasibility study.

beginning of the Santa Elena/San Ignacio bypass (mile 67.3), the replacement of the Roaring Creek Bridge (mile 48). This has been divided in three lots as follows:

- Section I (Lot 1) Replacement of the Roaring Creek Bridge (mile 48)
- Section II (Lot 2) Roaring Creek to Iguana Creek Junction
- Section III (Lot 3) Iguana Creek Junction to Santa Elena Town

The study includes the rehabilitation of the section between Belmopan (mile 47.9) and Santa Elena (mile 67.3) taking into account two road segments: (i) from the intersection of GPH with Hummingbird Highway to the intersection of the GPH and the Iguana Creek Road with a total length 9.8 miles (15.8 km) and from the intersection of the GPH and Iguana Creek Road to Red Creek Bridge in Santa Elena which extends a length of 9.5 miles (15.4 km) with a combined length of 19.3 miles (31.2 km). See Figure 2 for further illustration.

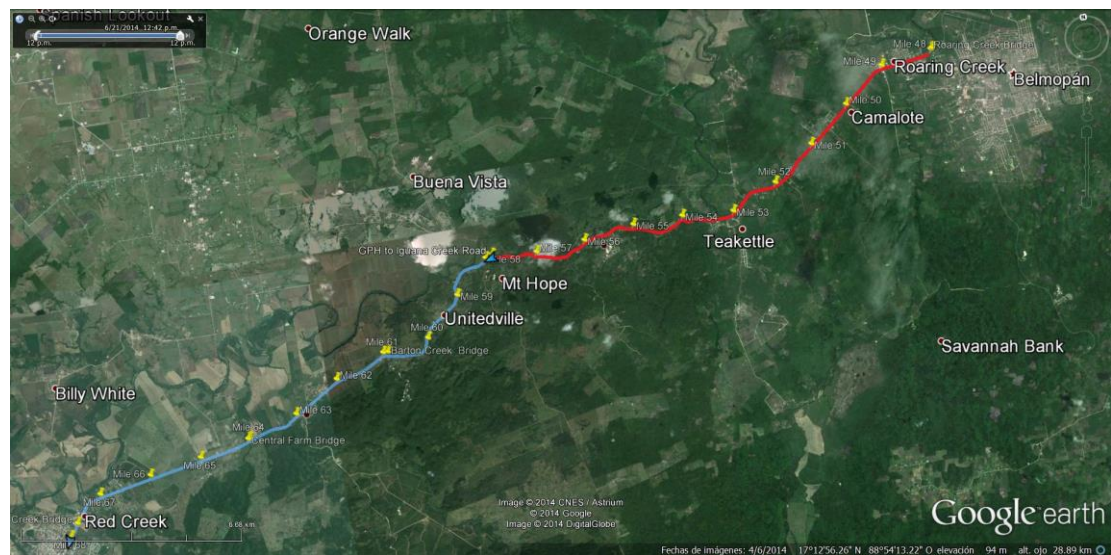


Figure 2: Scenario II – Belmopan and Santa Elena

5.2 Economic Feasibility Considerations

The economic feasibility analysis was conducted based on the following considerations:

- a) The Project consists of reconstructing and expanding the road's platform, upgrading its drainage facilities, as well as, other scope of work. Also, there is the possibility of adjustments for localized horizontal alignments and vertical profiles to the existing configuration to overcome singularities that generate road safety problems. Conservatively, it is assumed that project activities will take place over the course of a 24 months period. It is anticipated that the work will be implemented from Notice to Proceed (NTP) in 2019 to project completion in 2020.
- b) The traffic has been adopted from the *HDM 4 DRAFT FINAL REPORT GPHR-010-R001-V1.0* Consulting Service for the Preparation of Detailed Final Designs and

Support Documents for the George Price Highway (October 2016) prepared by HALCROW GROUP (TRINIDAD & TOBAGO) LTD for the Government of Belize. The traffic volume values have been obtained from traffic data collection as explained in that document.

- c) In order to establish the associated costs for transportation along the segments of study, the HDM-4 v2.10 model, was utilized. The use of this model allowed costs to be determined by existing conditions, functional characteristics, the impact of planned conservation strategies, transit, and climate. In turn, the operating costs for each type of vehicle are related to their physical, mechanical, and operating characteristics; as well as their operational costs.

5.3 Evaluation Parameters

Analysis Period

A twenty (20) year time frame was adopted as the evaluation period which begins after the 2 years period considered for the construction phase. The period of analysis is for the years 2019-2040 with both periods included.

Investment Rescue Value

The investment recovery value has been established as 30% of the total amount for alternative construction for asphalt pavement. These values have been applied in the last year of the analysis period.

Social Discount Rate

The social discount rate used in the economic evaluation of a project should reflect the opportunity cost of resources for the society. A 12% real discount rate has been adopted, in line with the IDB's guidelines.

Shadow Price Factor²

To establish the economic costs, it was applied a standard conversion factor (SPF) price paid or consideration financial or economic prices.

6. Alternatives for Evaluation

The alternatives to be considered in this study are two reflected in the following table.

² Shadow price is any price that is not a market price.

Table 1: Alternatives to Consider in the Economic Feasibility Study

WITHOUT Project	“Base Alternative” assumes that the existing road conditions can be maintained under a slightly improved maintenance program.	<ul style="list-style-type: none">• Patching• Condition Responsive Resealing• Routine Maintenance
ALT1. Alternative WITH Project DST	Assumes road rehabilitation improvement by applying a double surface treatment. Additional maintenance activities would also be implemented.	<ul style="list-style-type: none">• Patching• Condition Responsive Resealing• Condition Responsive Overlay• Routine Maintenance

Alternative “With Project” assumes in each segment, that road improvement and/or construction of the bridges is necessary to ensure a smooth flow along the road during all seasons.

7. Traffic Data Collection and Analysis

All the relevant information regarding to link characteristics, traffic volumes and vehicle fleet, was obtained from the document mentioned above i.e. *HDM 4 DRAFT FINAL REPORT GPHR-010-R001-VI.0* Consulting Service for the Preparation of Detailed Final Designs and Support Documents for the George Price Highway (October 2016). This was so because that information represents the final data obtained for the analysis of the Project. This information is as follows.

7.1 Link Evaluation

The first link comprises the road sector of ‘Belmopan to Iguana Creek Road Junction (9.8 miles or 15.98 km) as the road that proceeds west of the Belmopan junction. It was observed that along this section there are several access roads to production areas that belong to Mennonite colonies. The second link road sector considers the Iguana Creek Road Junction to the east entrance of Santa Elena (16.51 km). It is at this point that the urban area of Santa Elena begins. Tabulated below are the data associated to these links.

Table 2 - Links for evaluation and Data

ITEM	UNIT	L1	L2
		BELMOPAN - IGUANA CREECK	IGUANA CREECK - SANTA ELENA
Chainage & Rehabilitation Strategy		0+000 to 15+980 Improvement	15+940 to 32+452 Improvement
Pavement Type		Double Surface Dressing	Double Surface Dressing
GEOMETRY AND TRAFFIC			
Length	Km	15.98	16.51
Width	m	7.2	7.2
Shoulder width	m	1.5	1.5
No. of Lanes	No.	2	2
Rise & Fall	m/Km	5	12
No. of Rises and Falls	No.	2	2
Superelevation	%	2.5	2.5
Curvature	Deg/Km	50	75
Speed limit	Km/h	90	90
Flow		2-way	2-way
ENVIRONMENT			
Altitude	m	45	50
Drainage		Open Earth	Open Earth
Climate		Tropical/Humid	Tropical/Humid
Structural Number, SN	SN	2.45	2.45
Subgrade CBR	%	6	6
PAVEMENT CONDITION			
Surfacace condition IRI	m/Km	4.2	4.0
% Total Cracking	%	3.0	10.0
Potholes	No. / Km	3	1

The road surface structure along the links described in Table 2 constitutes a double surface treatment of pavement material. Areas of deterioration have been observed throughout the length of both links. In addition, chipping and complete loss of the pavement surface have been spotted along both edges of the road. The surface roughness of this pavement structure is 4 IRI³ (m / Km). This roughness value corresponds to a paved road that is in a reasonably condition. Although a considerable portion of both edges of the road has been lost. Related to drainage, it has been observed that the existing systems along the length of both links are in poor condition and should be assumed that these no longer serve their designed purpose.

³ The International Roughness Index (IRI) scale for older pavements varies from 2.5 to 6. To utilize a factor of 4.0 represents a conservative value.

The pavement structure sits on terrain that is practically flat with vertical alignments typical of topography of this type. The horizontal alignment corresponds to the design of a paved road with straight segments and horizontal curves.

7.2 Traffic Volumes - Average Annual Daily Traffic

From the document *HDM 4 DRAFT FINAL REPORTGPHR-010-R001-V1.0* Consulting Service for the Preparation of Detailed Final Designs and Support Documents for the George Price Highway (October 2016) which mentions the activities and traffic data collection performed for this parameter results in the following table where it can be seen that for the year 2016 in the first link (Belmopan – Iguana Creek Junction) there were as annual average daily traffic (AADT) 4,290 vehicles per day and for the second link (Iguana Creek Junction – Santa Elena) the AADT was 3842 vehicles per day. The general vehicle composition shows that medium cars are between 68% to 80% and trucks are in the range of 6% to 10%. Other values for the vehicle composition are shown in the table and additionally it can be seen in the histograms below the table.

Table 3 – 2016 AADT for the Study

GEORGE PRICE HIGHWAY CLASSIFIED TRAFFIC VOLUMES DATA 2016											
		1	2	3	4	5	6	7	8	9	
STATION	KM	MOTORCYCLES	MEDIUM CARS	LARGE CARS, SUVs AND PICKUPS	PASSENGER VAN	CARGO VAN	PASSENGER BUS < 27	PASSENGER BUS > 27	HEAVY TRUCKS	ASRIC/DRAW-BAR TRUCKS (> 12 TON)	TOTAL ADT
TEAKETTLE	15.98	173	2,942	391	196	0	10	62	422	94	4,290
UNITED VILLE	16.51	198	3,071	161	0	81	0	10	279	42	3,842
WINDY HILL	13.63	173	4,023	320	160	0	0	50	335	58	5,119
TOTAL/AVERAGE	46.12	181	3,345	291	119	27	3	41	345	65	4,417
PERCENT VEHICLE COMPOSITION											
TEAKETTLE		4.0%	68.6%	9.1%	4.6%	0.0%	0.2%	1.4%	9.8%	2.2%	100%
UNITED VILLE		5.2%	79.9%	4.2%	0.0%	2.1%	0.0%	0.3%	7.3%	1.1%	100%
WINDY HILL		3.4%	78.6%	6.3%	3.1%	0.0%	0.0%	1.0%	6.5%	1.1%	100%
STATION	RELATED LINK										
TEAKETTLE	BELMOPAN - IGUANA CREEK										
UNITED VILLE	IGUANA CREEK - SANTA ELENA										
WINDY HILL	SAN IGNACIO - FRONTIER WITH GUATEMALA										

Source. *HDM 4 DRAFT FINAL REPORTGPHR-010-R001-V1.0* Consulting Service for the Preparation of Detailed Final Designs and Support Documents for the George Price Highway (October 2016)

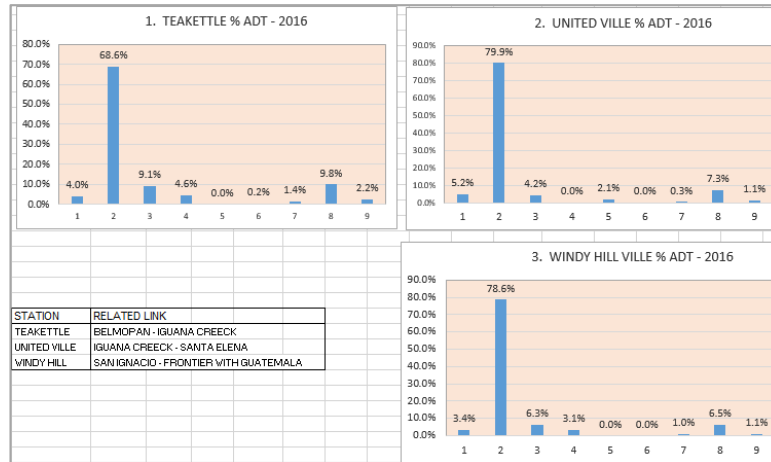


Figure 3: Histograms showing the 2016 vehicular composition

7.3 Growth Rates and Projected AADT

The traffic growth rates adopted from the document mentioned before are as follows:

- Motorcycles 2.5% per year
- Cars, Vans 1.50% per year
- Buses 0.5% per year
- Trucks) 1.5% per year

These values seem to be low as the GDP of Belize grows at higher rate (as an average 2.2%)

Once the above growth rates are assumed, projections until 2040 become straightforward. Tabulated below is the correlation between vehicle type, annual traffic volumes, and years from 2016 to 2040 per link in terms of AADT (vpd).

AADT in the Belmopan to Iguana Creek Junction link increases from 4290 vpd in the year 2016 to 6176 vpd in 2040. For the Iguana Creek junction to Santa Elena link an increment from 3842 vpd to 5564 vpd can be observed for the years 2016 and 2040 respectively.

Table4 - Projected AADT per link

LINK: BELMOPAN - IGUANA CREEK											
	Growht Rate	2.50%	1.50%	1.50%	1.50%	1.50%	0.50%	0.50%	1.50%	1.50%	
		1	2	3	4	5	6	7	8	9	
	YEAR	MOTORCYCLES	MEDIUM CARS	LARGE CARS, SUVs AND PICKUPS	PASSENGER VAN	CARGO VAN	PASSENGER BUS < 27	PASSENGER BUS > 27	HEAVY TRUCKS	ASRIC/DR AW-BAR TRUCKS (> 12 TON)	TOTAL AADT (vpd)
	2016	173	2,942	391	196	0	10	62	422	94	4,290
	2017	177	2986	397	199	0	10	62	428	95	4,355
	2018	182	3031	403	202	0	10	63	435	97	4,422
	2019	186	3076	409	205	0	10	63	441	98	4,489
	2020	191	3123	415	208	0	10	63	448	100	4,558
1	2021	196	3169	421	211	0	10	64	455	101	4,627
2	2022	201	3217	428	214	0	10	64	461	103	4,698
3	2023	206	3265	434	218	0	10	64	468	104	4,770
4	2024	211	3314	440	221	0	10	65	475	106	4,842
5	2025	216	3364	447	224	0	10	65	483	107	4,916
6	2026	221	3414	454	227	0	11	65	490	109	4,992
7	2027	227	3466	461	231	0	11	65	497	111	5,068
8	2028	233	3518	467	234	0	11	66	505	112	5,145
9	2029	238	3570	474	238	0	11	66	512	114	5,224
10	2030	244	3624	482	241	0	11	66	520	116	5,304
11	2031	251	3678	489	245	0	11	67	528	118	5,385
12	2032	257	3733	496	249	0	11	67	536	119	5,468
13	2033	263	3789	504	252	0	11	67	544	121	5,552
14	2034	270	3846	511	256	0	11	68	552	123	5,637
15	2035	277	3904	519	260	0	11	68	560	125	5,723
16	2036	283	3962	527	264	0	11	69	568	127	5,811
17	2037	291	4022	535	268	0	11	69	577	129	5,900
18	2038	298	4082	543	272	0	11	69	586	130	5,991
19	2039	305	4143	551	276	0	11	70	594	132	6,083
20	2040	313	4206	559	280	0	11	70	603	134	6,176

LINK: IGUANA CREECK – SANTA ELENA											
	Growht Rate	2.50%	1.50%	1.50%	1.50%	1.50%	0.50%	0.50%	1.50%	1.50%	
		1	2	3	4	5	6	7	8	9	
	YEAR	MOTORCYCLES	MEDIUM CARS	LARGE CARS, SUVs AND PICKUPS	PASSENGER VAN	CARGO VAN	PASSENGER BUS < 27	PASSENGER BUS > 27	HEAVY TRUCKS	ASPH/DR A/W-BAR TRUCKS (> 12 TON)	TOTAL AADT (vpd)
	2016	198	3,071	161	0	81	0	10	279	42	3,842
	2017	203	3117	163	0	82	0	10	283	43	3,902
	2018	208	3164	166	0	83	0	10	287	43	3,962
	2019	213	3211	168	0	85	0	10	292	44	4,023
	2020	219	3259	171	0	86	0	10	296	45	4,086
1	2021	224	3308	173	0	87	0	10	301	45	4,149
2	2022	230	3358	176	0	89	0	10	305	46	4,213
3	2023	235	3408	179	0	90	0	10	310	47	4,279
4	2024	241	3459	181	0	91	0	10	314	47	4,345
5	2025	247	3511	184	0	93	0	10	319	48	4,413
6	2026	253	3564	187	0	94	0	11	324	49	4,481
7	2027	260	3617	190	0	95	0	11	329	49	4,551
8	2028	266	3672	192	0	97	0	11	334	50	4,622
9	2029	273	3727	195	0	98	0	11	339	51	4,694
10	2030	280	3783	198	0	100	0	11	344	52	4,767
11	2031	287	3839	201	0	101	0	11	349	53	4,841
12	2032	294	3897	204	0	103	0	11	354	53	4,916
13	2033	301	3956	207	0	104	0	11	359	54	4,993
14	2034	309	4015	210	0	106	0	11	365	55	5,071
15	2035	317	4075	214	0	107	0	11	370	56	5,150
16	2036	324	4136	217	0	109	0	11	376	57	5,230
17	2037	333	4198	220	0	111	0	11	381	57	5,312
18	2038	341	4261	223	0	112	0	11	387	58	5,394
19	2039	349	4325	227	0	114	0	11	393	59	5,479
20	2040	358	4390	230	0	116	0	11	399	60	5,564

8. System Cost for the Evaluation

The three types of costs considered in the evaluation are investment or capital costs (costs of rehabilitation), maintenance costs corresponding to the required maintenance standards, vehicle parameters, and vehicle costs. The latter are used to determine the user costs (Road User Costs - RUC). Elaborated below are the three types of costs.

8.1 Rehabilitation Costs

Final Rehabilitation costs given by the Government of Belize by June 07, 2018 are as follows.

Table 5. Rehabilitation Costs for the GPH

COSTS FOR THE GPH
JUNE-2018

Civil Works and Maintenance	Section 1	Section 2	Section 3	Total BZ\$	Total US\$
Measured Works	\$10,516,978.26	\$18,743,248.56	\$23,093,600.00	\$52,353,826.82	\$26,176,913.41
Contingencies	\$540,324.91	\$978,134.44	\$1,178,400.00	\$2,696,859.35	\$1,348,429.68
Utilities*				\$2,285,526.00	\$1,142,763.00
Other Utility				\$2,600,000.00	\$1,300,000.00
Additional Quantities	\$36,147.00	\$3,076,617.00	\$1,046,229.64	\$4,158,993.64	\$2,079,496.82
Maintenance				\$312,000.00	\$156,000.00
Supervision				\$3,825,030.00	\$1,912,515.00
Additional Supervision				\$1,300,000.00	\$650,000.00
Environment \$ Social				\$500,000.00	\$250,000.00
Road Safety and Lights				\$1,409,000.00	\$704,500.00
				\$71,441,235.81	\$35,720,617.90

These costs by lots belong to following topics.

- Section I (Lot 1) Construction of Roaring Creek Bridge
- Section II (Lot 2) Roaring Creek to Iguana Creek Junction
- Section III (Lot 3) Iguana Creek Junction to Santa Elena Town

From these items, the global costs of Utilities, Maintenance, Supervision, etc. were distributed to each lot according to their relative length, having the costs distributed as in the table below.

Table 6. Distribution of Costs to each lot or Section for the GPH

a) in Domestic Currency

Length (Km) = 0.485 15.98 16.51 32.975

Civil Works and Maintenance	Section 1 BZ\$	Section 2 BZ\$	Section 3 BZ\$	Total BZ\$	Total US\$
Measured Works	10,516,978.26	18,743,248.56	23,093,600.00	52,353,826.82	26,176,913.41
Contingencies	540,324.91	978,134.44	1,178,400.00	2,696,859.35	1,348,429.68
Utilities*	33,615.77	1,107,587.73	1,144,322.49	2,285,526.00	1,142,763.00
Other Utility	38,241.09	1,259,984.84	1,301,774.07	2,600,000.00	1,300,000.00
Additional Quantities	36,147.00	3,076,617.00	1,046,229.64	4,158,993.64	2,079,496.82
Maintenance	4,588.93	151,198.18	156,212.89	312,000.00	156,000.00
Supervision	56,258.97	1,853,646.08	1,915,124.95	3,825,030.00	1,912,515.00
Additional Supervision	19,120.55	629,992.42	650,887.04	1,300,000.00	650,000.00
Environment \$ Social	7,354.06	242,304.78	250,341.17	500,000.00	250,000.00
Road Safety and Lights	20,723.73	682,814.86	705,461.41	1,409,000.00	704,500.00
TOTAL	11,273,353.27	28,725,528.88	31,442,353.66	71,441,235.81	35,720,617.90

b) in US\$ Currency

Civil Works and Maintenance	Section 1 US\$	Section 2 US\$	Section 3 US\$	Total US\$
Measured Works	5,258,489.13	9,371,624.28	11,546,800.00	26,176,913.41
Contingencies	270,162.46	489,067.22	589,200.00	1,348,429.68
Utilities*	16,807.89	553,793.87	572,161.25	1,142,763.00
Other Utility	19,120.55	629,992.42	650,887.04	1,300,000.00
Additional Quantities	18,073.50	1,538,308.50	523,114.82	2,079,496.82
Maintenance	2,294.47	75,599.09	78,106.44	156,000.00
Supervision	28,129.49	926,823.04	957,562.48	1,912,515.00
Additional Supervision	9,560.27	314,996.21	325,443.52	650,000.00
Environment \$ Social	3,677.03	121,152.39	125,170.58	250,000.00
Road Safety and Lights	10,361.87	341,407.43	352,730.71	704,500.00
TOTAL	5,636,676.63	14,362,764.44	15,721,176.83	35,720,617.91

8.2 Rehabilitation costs for the economic evaluation with the HDM4

From the values shown in the previous section, for the economic evaluation with the HDM4 model, costs of sections I and II (Roaring Creek Bridge and, road from Roaring Creek to Iguana Creek Junction) were added as one link and, the section 3 (Iguana Creek Junction to Santa Elena Town) was considered as another link. In this way, the economic evaluation can be taken for each link individually and for the total project as well. The Table below shows the added costs for the evaluation and the unit costs (US\$/Km) as required by the HDM4 model. The Social Cost Factor (SCF) equal to 0.91 calculated economic Costs affecting the finance costs.

The following table presents the financial and economic costs considered in this assessment. It can be seen that the unit costs for the link 1 (L1) is more than US\$ 1.2 millions, this is because that in this link is added the cost of the Roaring Creek bridge. For the second link L2) the unit cost is US\$ 0.95 millions

Table7– Budget Summary

BELIZE : GEORGE PRIZE HIGHWAY (GPH)

SUMMARY OF COSTS FOR THE HDM

Exchange Rate Bz\$ / US\$ = 2.0

SECTION	HDM LINK	NAME OF ROAD SEGMENT	ESTIMATE Amount Bz\$	ESTIMATE Amount US\$
Section 1 + 2	L1: BEIG	BELMOPAN - IGUANA CREECK (Includes Roaring Creek Bridge)	39,998,882.1	19,999,441.1
Section 3	L2: IGSE	IGUANA CREECK - SANTA ELENA	31,442,353.7	15,721,176.8
TOTAL PROJECT			71,441,235.81	35,720,617.91

UNITARY COSTS FOR THE HDM MODEL

				SCF = 0.91	
				FINANCIAL	ECONOMIC
SECTION	HDM LINK	NAME OF ROAD SEGMENT	LENGTH (Km)	UNIT COST (US\$/Km)	
Section 1 + 2	L1: BEIG	BELMOPAN - IGUANA CREECK (Includes Roaring Creek Bridge)	16.47	1,214,663.9	1,105,344.1
Section 3	L2: IGSE	IGUANA CREECK - SANTA ELENA	16.51	952,221.5	866,521.6

8.3 Activities and Maintenance Costs

Key maintenance activities and their associated execution costs are dictated by the existing state of the wearing course, as per the required format by HDM-4. The following activities are usually considered for bituminous pavement maintenance: asphalt patching (US\$/m²), resealing (US\$/m²), strengthening (US\$/m²) and routine maintenance (US\$/km/year).

All alternatives consider the routine maintenance activities such as sewer and gutter cleaning, weed removal along the sides of the road, maintaining horizontal and vertical signage, and drainage repair, among others.

The maintenance costs according to specific requirements of HDM-4 for some activities have been obtained from the *HDM 4 DRAFT FINAL REPORTGPHR-010-R001-V1.0* Consulting Service for the Preparation of Detailed Final Designs and Support Documents for the George Price Highway (October 2016), and others were obtained based on information provided by the HDM model.

Table 8 - Maintenance Costs

ACTIVITY	UNIT	FINANCING	ECONOMIC
Overlay	US\$/m ²	17.14	15.0
Resealing	US\$/m ²	5.08	4.45
Patching (S/m ²)	US\$/m ²	17.59	15.39
Before Routine Maintenance	US\$/Km/yr.	2,904.44	2,541.38
After Routine Maintenance	US\$/Km/yr.	3,090.05	2,703.79

In this regard, the maintenance costs associated with the ‘With Project’ option are higher than the “Without Project” option since it assumes that improved maintenance strategies would be implemented mainly in the areas of signage improvement and replacement, and ongoing maintenance efforts across the segments of study.

8.4 Costs of Vehicles and Vehicle Parameters

This section presents the costs of vehicles and vehicle parameters required by the HDM-4, with which the user costs (RUC) for both alternatives: ‘Without Project’ and ‘With Project’ (Vehicle Operating Costs – VOC - and time) can be determined. User costs in this study are determined utilizing the HDM-4 model.

The HDM-4 model requires the following information to calculate the user costs:

- Vehicle characteristics (weight, power, capacity, utilization rates, etc.)
- Costs of vehicle parameters (vehicle price, fuel, crew, etc.)
- Road characteristics (horizontal alignment, vertical alignment, roadway width, roughness, etc.)
- Geography and climate conditions of the place where the road under evaluation is located (altitude, soil type, rainfall, etc.)
- Vehicular volume (by vehicle type) flowing down the road.

The vehicle fleet identified in the '*HDM 4 DRAFT FINAL REPORTGPHR-010-R001-V1.0* Consulting Service for the Preparation of Detailed Final Designs and Support Documents for the George Price Highway (October 2016)' was adopted for the evaluation. Table below lists the nine types of vehicles that constitute the selected vehicle fleet.

Table 9 - Fleet Vehicle for Assessment

VEHICLE TYPE	
1	MOTORCYCLES
2	MEDIUM CARS
3	LARGE CARS, SUVs, PICKUP
4	PASSENGER VAN
5	CARGO VAN
6	PASSENGER BUS =< 27
7	PASSENGER BUS > 27
8	HEAVY TRUCK
9	ARTICULATED TRUCK

The parameters and vehicle costs prepared for evaluation are presented below.

Table 10 - Fleet Vehicle Parameters and Costs Assessment

BELIZE:		GPH: BELMOPAN - SANTA ELENA HIGHWAY REHABILITATION									
VEHICLE PARAMETERS & COSTS SUMMARY											
		1	2	3	4	5	6	7	8	9	
ITEM		UNIT	MOTORCYCLES	MEDIUM CARS	LARGE CARS, SUVs, PICKUP	PASSENGER VAN	CARGO VAN	PASSENGER BUS < 27	PASSENGER BUS > 27	HEAVY TRUCK	ARTICULATED TRUCK
BASIC CHARACTERISTICS											
PHYSICAL											
1	Passenger Car Space Equiv.		0.5	1.0	1.0	1.0	1.2	1.5	1.6	1.8	2.0
2	Number of wheels	No.	2	4	4	4	4	6	6 - 8	10 - 14	16 +
3	No. Axles	No.	2	2	2	2	2	2	2 - 3	3 - 5	5 - 7
UTILISATION											
4	Average Annual Km	Km/year	10,000	25,000	35,000	34,000	30,000	70,000	70,000	30,000	60,000
5	Hours Driven per year	Hr/year	400	600	750	859	1,300	1,750	1,750	2,050	2,000
6	Average Life	Years	10	10	10	8	10	10	10	14	8
7	No. Passengers	persons	1	4	4	20	2	27	50	2	1
LOADING											
8	Equivalent Axles (ESAL)	EE	0.00	0.001	0.004	0.04	0.01	0.70	1.21	13.91	14.92
9	Gross Vehicle Weight	Ton.	0.2	1.2	1.8	3.5	1.5	12.0	16.0	20 - 35	45 - 60
FORCES											
10	Frontal Area	m2	0.8	1.9	2	4	2	5	6.5	8.5	9
11	Driving Power (HPDRIVE)	kW	12	33	36	50	40	65	120	227	227
12	Engine Power (HPRATED)	kW	15	70	90	75	60	100	130	280	300
ECONOMIC COSTS											
13	Vehicle Cost	US\$	1,457	12,093	14,132	16,958	29,507	11,593	19,322	26,455	27,675
14	Tyre Cost	US\$/unit	43	170	170	170	170	298	298	298	298
15	Fuel Cost	US\$/lt	0.85	1.00	1.00	1.00	0.81	0.81	0.81	0.81	0.81
16	Lubricating oil Cost	US\$/lt	2.75	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40
17	Maintenance Labour	US\$/hr	1.25	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50
18	Crew Wages	US\$/hr	0.1	0.1	0.1	0.10	1.50	8.50	8.50	8.50	8.50
TIME VALUE											
19	Passenger working time	US\$/hr	1.50	1.50	1.50	1.50	1.50	1.50	9.00	1.50	1.50
20	Passenger non-working time	US\$/hr	0.10	0.10	0.10	0.00	1.50	1.50	1.50	1.50	1.50
21	Cargo time	US\$/hr					50.00	0.10	0.10	15.00	15.00
Source: HDM 4 DRAFT FINAL REPORT GPHR-010-R001-V1.0 Consulting Service for the Preparation of Detailed Final Designs and Support Documents for the G.P.H (Oct. 2016)											

9. Benefits

9.1 The Cost Savings Benefits for Users (RUC – Road User Costs)

The economical evaluation consists of identifying costs and benefits with respect to a baseline by analyzing the alternatives of the project. Benefits represent the economic returns throughout the life of the project. Whereas, costs represent increases in capital costs and other expenses (relative to the baseline) also throughout the life of the project.

Quantification of benefits is achieved by considering the reduction in transportation costs or road user costs (vehicle operation costs and time). The quantified benefits are obtained by applying the reduction or cost savings values to the projected traffic (AADT) along the over the lifetime of the project. Once this step is accomplished, the resulting values can be compared with the investment and maintenance costs which are also applied along the lifetime of the project. This conceptualization is used in the HDM-4 model and is known as the “Consumer Surplus Method”.

9.2 Benefits of Normal Traffic

Normal Traffic⁴Volumes represents the existing traffic loads exerted along the road. It has been established that the existing traffic volumes will be directly benefited with a new pavement surface that results from the road rehabilitation project. Thus, the following rationale is utilized by the HDM-4 model to obtain the Benefits of Normal Traffic.

$$\text{Ben. Traf. Norm.} = Q \times (C1 - C2)$$

Where: Q = Normal Traffic (AADT)
 C1 = RUC before the project
 C2 = RUC after the project

This process applies to each vehicle category and link considered in this evaluation.

9.3 Generated⁵, Induced⁶, and Diverted⁷Traffic Benefits

For simplicity, no generated traffic has been considered in the analysis given that:

- The analysis corresponds to the rehabilitation of an existing road.
- The existing road surface is paved and is in moderate condition.
- The existing road experiences a consolidated traffic flow.
- Normal traffic corresponds to a demand that results from the production activities and services established and consolidated over the service period of the current paved road.
- Existing traffic conditions will improve significantly upon completion of the rehabilitation activities on this road.
- It is possible that the road rehabilitation project will not generate new economic activities beyond the existing economical activities and the normal projected growth in the area.

Under these circumstances, a significant impact to change the current economic situation and current projected growth is not considered. Thus, both Traffic Development and its inherited benefits are not-accounted for in this analysis. Should Traffic Development result from the road rehabilitation project, it is assumed that it would be of minimal impact. However, should the Traffic Development generated be of considerable impact, its inclusion into the analysis should be considered.

⁴ Normal Traffic is traffic without any new road investment.

⁵ Generated Traffic is a new traffic associated with existing users of the road driving more frequently or new users that will drive now the road is improved.

⁶ Induced Traffic is traffic attracted to the project road adjacent road system, changing its origin or destination, due to increased economic activity in the road zone of influence resulting from the project.

⁷ Diverted Traffic is traffic that diverts to the project road from alternative routes to travel between two points that can also drive using the segments of study.

Another aspect that is generally reviewed is the possibility of Diverted and Induced Traffic. Unlike Traffic Development, this type of traffic refers to motorists traveling between two geographical points utilizing routes other than the segments of study. One or more alternate routes must exist to consider the use of Diverted and Induced Traffic into this analysis.

Alternative routes have not been identified that may provide the option to generate Diverted and Induced Traffic as a result from the road rehabilitation. Consequently, benefits from Diverted and Induced Traffic in this project are not possible and is not considered for this analysis.

9.4 Accident Reduction Benefits and Other Exogenous Benefits

At first Accident Reduction Benefits and Other Exogenous Benefits were no considered in the in the main analysis. Later, as a complement Accident Reduction Benefits were taken into account in the evaluation and respective economic indicators obtained as shown later.

10. Evaluation with HDM-4

10.1 Discount Rate and Evaluation Period

The year of 2019 was selected to be the base year for this assessment. The evaluation utilizes a discount rate or discount future cash flows (costs and benefits) of 12 % as recommended by the IADB and World Bank. This value is recommended to evaluate infrastructural transportation projects.

The evaluation period of the project is established by taking into account that funding review and approval will take place in 2018, thus starting construction activities that are estimated to be complete by 2020. Assuming the road opens to traffic in 2021, the evaluation considers a 20 years lifespan for the rehabilitated road. It is important to note that the assumed 20 year lifespan is less than a typical lifespan for a bridge structure. However, since the costs associated with bridge construction for this project are found within the total rehabilitation costs, the 20 years lifespan period was adopted as the only period in the evaluation.

10.2 The Economic Indicators

The principal economic indicators obtained by the HDM-4 are:

NPV ⁸	Net Present Value
IRR ⁹	Internal Rate of Return

⁸ NPV: The sum of the discounted cash flows minus the original investment, are used to compare two alternative investments. Provides which alternative is most cost-effective.

⁹ IRR: Shows the amount of money the investment returns. Determined by funding discount rate at which NPVs of two alternatives are equal.

The economic indicator NPV represents the difference between the updated benefits for the base year, generated by an improvement project under the incremental capital costs arising from its construction also updated for the base year.

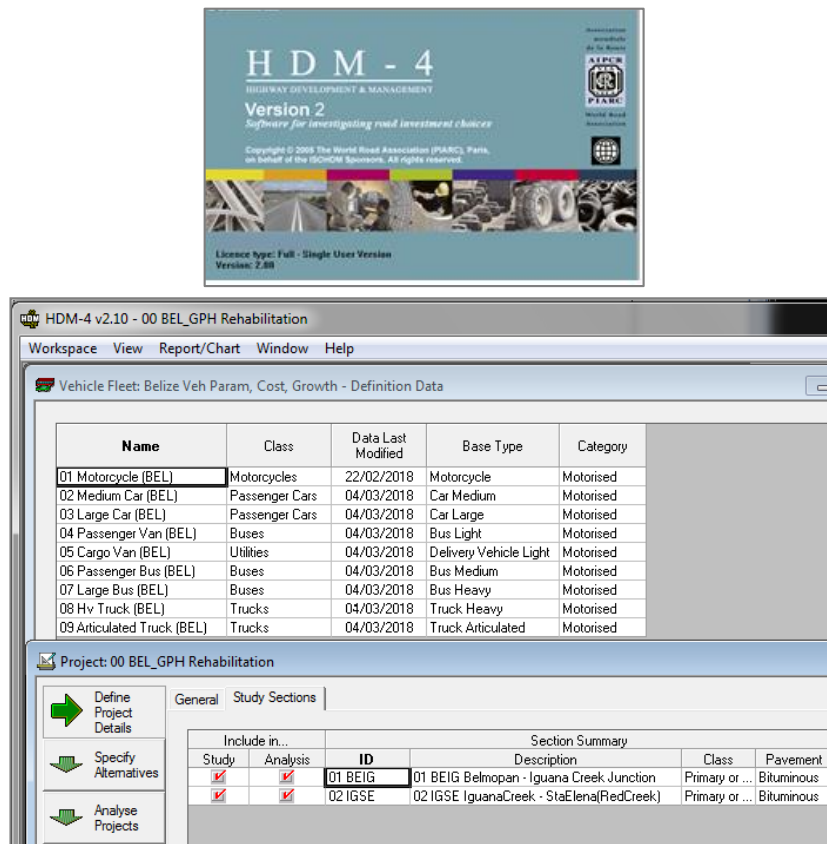
The economic indicator of the IRR is that 'discount rate' for which the benefits equal the costs (NPV equal to zero), this “Discount rate (i) – IRR” should be compared to the opportunity cost used in the assessment (i = 12.0%).

The feasibility 'of a project based on these indicators requires the NPV for discount rate' i ' be positive, and that the IRR be greater than the opportunity cost (i = 12.0%).

10.3 Comparison of Alternatives

Improvement alternative should be compared against Base Case (current situation). This comparison is carried out internally by the HDM-4 for each link considered in the evaluation.

Figure 3: HDM-4 Windows for the Assessment



Links	Pairs for Evaluation
L1: Belmopan (RoaringCreek) – Iguana Creek Junction	ALT1 Vs ALT_Base
L2: Iguana Creek Junction – GeorgeVille	ALT1 Vs ALT_Base

Being ALT1 the Rehabilitation with Double Surface Treatment

10.4 Evaluation Results with HDM-4

The following results for the assessment were determined based on all consideration presented in the preceding sections.

Table 11– Results with HDM-4

H D M - 4		Economic Indicators Summary							
HIGHWAY DEVELOPMENT & MANAGEMENT		Study Name: 00 BEL_GPH Rehabilitation							
HDM-4 Version 2.1		Run Date: 11-06-2018							
		Currency: US Dollar (millions)							
		Discount Rate: 12.00%							
Section:		01 BEIG Belmopan - Iguana Creek Junction							
Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E - C)	NPV/Cost Ratio (NPV/RAC)	NPV/Cost Ratio (NPV/CAP)	Internal Rate of Return (IRR)
Base Alternative	0.605	0.252	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ALT1 ST BLIG Belmopan - IguanaCreek	18.055	17.680	17.450	21.644	0.000	4.194	0.232	0.237	14.0
Section:		02 IGSE IguanaCreek - StaElena(RedCreek)							
Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E - C)	NPV/Cost Ratio (NPV/RAC)	NPV/Cost Ratio (NPV/CAP)	Internal Rate of Return (IRR)
Base Alternative	0.710	0.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ALT1 ST IGSE IguanaCreek - Santa Elena	14.310	13.933	13.601	14.618	0.000	1.017	0.071	0.073	12.7
Section:		00 TOTAL ALL LINKS (BEIG + IGSE + SIFR)							
Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase in Agency Costs (C)	Decrease in User Costs (B)	Net Exogenous Benefits (E)	Net Present Value (NPV = B + E - C)	NPV/Cost Ratio (NPV/RAC)	NPV/Cost Ratio (NPV/CAP)	Internal Rate of Return (IRR)
Base Alternative	1.315	0.513	0.000	0.000	0.000	0.000	0.000		0.00
ALT1 ST Belmopan-Sta Elena	32.365	31.613	31.051	36.262	0.000	5.211	0.161	0.165	13.4

H D M - 4 HDM-4 Version 2.1		
Economic Indicators Summary		
00 BEL_GPH Rehabilitation		11-06-2018
Currency: US Dollar (millions)		
Discount Rate: 12.00%		
SUMMARY		
LINK	Net Present Value (NPV = B + E - C)	Internal Rate of Return (IRR)
01 BEIG Belmopan - Iguana Creek Junction	4.194	14.0%
02 IGSE IguanaCreek - StaElena(RedCreek)	1.017	12.7%
TOTAL PROJECTT	5.211	13.5%

The economic indicators (NPV and IRR) indicate that the alternative of improvement with Double Surface Treatment results are positive, individually for each link and for the total project, which means that the benefits of the rehabilitation of the George Price Highway compensate the costs incurred in the rehabilitation. The first link (Sections I and II, Roaring Creek Bridge plus road segment from Belmopan to Iguana Creek

Junction) presents higher values than Lot 2 (road segment from Iguana Creek Junction to Santa Elena). This is because of the AADT in the first which is higher than in the second segment.

11. Sensitivity Analysis

Sensitivity analysis was performed to test the consistency of the results against their variations in parameters for costs and benefits. In the first case, the costs are increased to verify if the new results remain positive against the underestimated cost contingency. In the second case, the benefits are reduced to measure the overestimated profit contingency. This two-case procedure is individually, as well as, jointly performed for both parameters. Thus, the structure of this analysis is as follows:

	INCREASED COSTS	BENEFITS REDUCTION
1)	10 %	-
2)	20 %	-
3)	30 %	-
4)	-	10 %
5)	-	20 %
6)	-	30 %
7)	10 %	10 %
8)	20 %	20 %
9)	30 %	30 %

This analysis is processed by the HDM-4 model considering the costs for capital items, recurring (Recurrent) and Special costs (Special). As for benefits, the model takes into account the items of vehicle operating costs (VOC MT), time (MT time) and Accidents. See HDM4 window below.

Figure 4: HDM-4 Sensitivity Analysis Window

Description	Net Bens							
	Capital	Recurrent	Special	MT VOC	MT Time	NM VOC & Time	Accidents	Exogenous
Base Sensitivity Scenario	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cost_Incr_10%	1.10	1.10	1.10	1.00	1.00	1.00	1.00	1.00
Cost_Incr_20%	1.20	1.20	1.20	1.00	1.00	1.00	1.00	1.00
Cost_Incr_30%	1.30	1.30	1.30	1.00	1.00	1.00	1.00	1.00
Ben_Red_10%	1.00	1.00	1.00	0.90	0.90	1.00	0.90	1.00
Ben_Red_20%	1.00	1.00	1.00	0.80	0.80	1.00	0.80	1.00
Ben_Red_30%	1.00	1.00	1.00	0.70	0.70	1.00	0.70	1.00
C.Incr10%_B.Red10%	1.10	1.10	1.10	0.90	0.90	1.00	0.90	1.00
C.Incr20%_B.Red20%	1.20	1.20	1.20	0.80	0.80	1.00	0.80	1.00
C.Incr30%_B.Red30%	1.30	1.30	1.30	0.70	0.70	1.00	0.70	1.00

The results of this analysis are presented in the following table:

Table 12 – Results of Sensitivity Analysis

SENSITIVITY ANALYSIS								
	COSTS INCR	% RED	BLIG Belmopan – IguanaCreek.jn		IGSE IguanaCreek - SantaElena		TOTAL PROJECTT	
			NPV (i=12.0%) Mill US\$	IRR %	NPV (i=12.0%) Mill US\$	IRR %	NPV (i=12.0%) Mill US\$	IRR %
Base=	0	0	4.194	14.0%	1.017	12.7%	5.211	13.5%
1)	10	0	2.449	13.1%	-0.343	11.8%	2.106	12.6%
2)	20	0	0.704	12.3%	-1.703	11.0%	-0.999	11.8%
3)	30	0	-1.041	11.6%	-3.063	10.3%	-4.104	11.1%
4)	0	10	2.030	13.0%	-0.445	11.7%	1.585	12.5%
5)	0	20	-0.135	11.9%	-1.907	10.6%	-2.041	11.4%
6)	0	30	-2.299	10.8%	-3.368	9.5%	-5.667	10.2%
7)	10	10	0.285	12.1%	-1.805	10.8%	-1.520	11.6%
8)	20	20	-3.625	10.4%	-4.627	9.1%	-8.251	9.8%
9)	30	30	-7.534	8.6%	-7.449	7.3%	-14.983	8.1%

Sensitivity analysis shows that the profitability for the first link varying in costs and benefits individually is solid to changes beyond 20%. If changes occur to both parameters jointly, the project remains in its profitable state beyond 10%

For the second link (Iguana Creek – Santa Elena) the varying of costs, benefits and both jointly by 10% gives negative results. Threshold variation of costs (increase) is 7%, same occurs for reduction of benefits (7%). If changes occur to both parameters jointly, the project remains in its profitable state until 3%, beyond these threshold values the feasibility of the link is not achieved.

For the total project, individually variation of costs and benefits by 10% gives positive indicators although if changes occur to both parameters jointly by 10% gives negative results.

Further analysis shown that the limit variation of costs (increase) is 17%, limit variation of benefits (reduction) is 14%. If changes occur to both parameters jointly the threshold variation is 8% (NPV = 0, IRR = 12.0%), after this threshold values the project is not feasible.

These results demonstrate that the feasibility for this project is strong until 8% of jointly variations of cost increment and benefit reduction. It is noted that profitability is more sensitive to changes in benefits than in costs.

11.1 Additional Analysis with Accident Benefits

An additional analysis was run considering “accident reduction benefits”. For this, it was considered the iRAP report (Elaboration based in the International Road Assessment Program Report (iRAP) 2012) where it states that costs of accidents are US\$ 304,000 for fatalities and US\$ 76,100 for the seriously injured. With this added data the profitability of the Project increases to a NPV = US\$ 6.47 million and an IRR = 15.1% for the first link (Lot I and Lot II, Roaring Creek Bridge plus road segment from Belmopan to Iguana Creek Junction) and, a NPV = US\$ 3.53 million and IRR = 14.4% for the second Lot (Lot 2: road segment from Iguana Creek Junction to Santa Elena). For the total Project the NPV is US\$ 10.0 million and an IRR 14.8%, this NPV actually doubles the result when accident benefits are no taken into account. Table below shows the summary for this aspect.

Table 13 – Results of Economic Indicators with Accident Benefits

H D M - 4		
HIGHWAY DEVELOPMENT & MANAGEMENT		
Economic Indicators Summary		
Study Name:		00 BEL_GPH Reha
Run Date:		21-06-2018
Currency:		US Dollar (millions)
Discount Rate:		12.00%
SUMMARY (Include Accident Benefits)		
LINK	Net Present Value (NPV = B + E - C)	Internal Rate of Return (IRR)
01 BEIG Belmopan - Iguana Creek Junct	6.470	15.1%
02 IGSE IguanaCreek - StaElena(RedCre	3.530	14.4%
TOTAL PROJECTT	10.000	14.8%

As in the previous situation Sensitive Analysis for this scenario was also performed with the results shown in table below.

Table 14 – Results of Sensitivity Analysis (with Accident Benefits)

SENSITIVITY ANALYSIS (Include Accident Benefits)

	COSTS % INCR	BENEF % RED	BLIG Belmopan – IguanaCreek jn		IGSE IguanaCreek - SantaElena		TOTAL PROJECTT	
			NPV (i =12.0%) Mill US\$	IRR %	NPV (i =12.0%) Mill US\$	IRR %	NPV (i =12.0%) Mill US\$	IRR %
Base =	0	0	6.470	15.1%	3.53	14.4%	10.000	14.8%
1)	10	0	4.725	14.1%	2.17	13.4%	6.895	13.8%
2)	20	0	2.980	13.3%	0.81	12.5%	3.790	12.9%
3)	30	0	1.235	12.5%	-0.038	11.7%	0.685	12.2%
4)	0	10	4.078	14.0%	1.817	13.3%	5.895	13.7%
5)	0	20	1.686	12.9%	0.104	12.1%	1.790	12.6%
6)	0	30	-0.706	11.6%	-1.609	10.8%	-2.315	11.3%
7)	10	10	2.333	13.1%	0.457	12.3%	2.790	12.8%
8)	20	20	-1.804	11.2%	-2.616	10.4%	-4.420	10.8%
9)	30	30	-5.941	9.4%	-5.689	8.5%	-11.630	9.0%
Threshold Values	37	0	0.000	12.0%				
	0	27	0.000	12.0%				
	15	15	0.000	12.0%				
	26	0			0.000	12.0%		
	0	21			0.000	12.0%		
	11	11			0.000	12.0%		
	32						0.000	12.0%
		24					0.000	12.0%
	14	14					0.000	12.0%

Sensitivity analysis shows that the profitability for the first link varying costs beyond 30% is still positive and if benefits reduces around 20% is also positive. If changes occur to both parameters jointly, the project remains in its profitable state beyond 10%. Threshold values for the feasibility are: variation of costs (increase) of 37%, and benefit reduction 27%. If changes occur to both parameters jointly, the project remains in its profitable state until 15%.

For the second link (Iguana Creek – Santa Elena) the varying of costs and benefits individually by 20% still gives positive economic indicators and if both parameters varies 10% jointly still is positive. Threshold variation of costs (increase) is 26%, and threshold reduction of benefits is 21%. If changes occur to both parameters jointly, the project remains in its profitable state until 11%, beyond these threshold values the feasibility of the link is not achieved.

For the total project, individually variation of costs by 30% and benefits by 20% gives positive indicators and if changes occur to both parameters jointly by 20% gives negative results. Further analysis shown that the limit variation of costs (increase) is 32%, limit variation of benefits (reduction) is 24%. If changes occur to both parameters jointly the threshold variation is 14% (NPV = 0, IRR = 12.0%), after this threshold values the project is not feasible.

These results demonstrate that the feasibility for this project is strong until 14% of jointly variations of cost increment and benefit reduction.

11.2 Analysis taking into account ‘Sunk Costs’

The ‘IMC worldwide’ currently performing consulting services for the Supervision of Works for the George Price Highway Rehabilitation Project, presented in its monthly progress report (May 2018) the contract amounts for LOT1 & LOT2 which are 20% less (LOT1+LOT2) than the original value. This progress report also includes the amounts already paid in accordance with progress of the project. Generally, this progress report indicates that LOT 1 has an overall progress and an estimated total disbursement through May 2018 of 9.8% (section 3.2 of the progress report), while LOT 2 has an estimated overall disbursement of 6% (section 4.2 of the progress report).

In light of this situation, this section presents another evaluation which considers the contract amounts for LOT1+LOT2 minus the amounts already paid considered as ‘sunk costs’, meaning contract amounts minus disbursement through May 2018. The table below presents a summary of this amounts and the ‘sunk costs’ to be deducted from the contract values for the new evaluation.

Table 15 – Costs for Lot1 and Lot2 according to Contract

CONSTRUCTION SECTION	CONTRACTOR	CONTRACT AMOUNT (BZ\$)	CONTRACT AMOUNT (US\$)	% DE REDUC. POR SUNK COSTS	AMOUNT ALREADY PAYED (SUNK COSTS) Bz\$	AMOUNT ALREADY PAYED (SUNK COSTS) US\$
LOT 1 Section I Construction of Roaring Creek Bridge	M&M Engineering Consultants Limited	11,346,823.17	5,673,411.59	9.8%	1,111,988.67	555,994.34
LOT 2 Section II Roaring Creek to Iguana Creek Junction	Teichroeb & Sons Limited	20,540,823.19	10,270,411.60	6.0%	1,232,449.39	616,224.70
LOT 3 Section III Iguana Creek Junction to Santa Elena Town	Tender stage	-	-	-	-	-
		31,887,646.36	15,943,823.18	7.4%	2,344,438.06	1,172,219.03

Source: Consulting Service for the Supervision of Works for the George Price Highway Rehabilitation Project. Monthly Progress Report. May 2018. IMC Worldwide Limited, UK. IDB Project LO-3344/OC-BL: GEORGE PRICE HIGHWAY REHABILITATION PROJECT. Government of Belize – Ministry of Works – PEU

According to this, the new values for evaluation with the HDM4 model would be as follows:

Table 16 – Costs for the HDM4 Evaluations

BELIZE : GEORGE PRIZE HIGHWAY (GPH)

SUMMARY OF COSTS FOR THE HDM (According July Report reduced by Sunk costs)

		Exchange Rate Bz\$ / US\$ =	2.0	
SECTION	HDM LINK	NAME OF SECTION	ESTIMATE Amount Bz\$	ESTIMATE Amount US\$
Section I+II	L1	BELMOPAN - IGUANA CREECK (Includes Roaring Creek Bridge)	29,543,208.3	14,771,604.1
Section III	L2	IGUANA CREECK - SANTA ELENA	31,442,353.7	15,721,176.8
TOTAL =			60,985,562.0	30,492,781.0

UNITARY COSTS FOR THE HDM MODEL

SCF = 0.91			FINANCIAL	ECONOMIC
HDM LINK	NAME OF SECTION	LENGTH (Km)	UNIT COST (US\$/Km)	
L1	BELMOPAN - IGUANA CREECK (Includes Roaring Creek Bridge)	16.47	897,151.8	816,408.1
L2	IGUANA CREECK - SANTA ELENA	16.51	952,221.5	866,521.6
	TOTAL =	33.0	924,724.2	841,499.0

The result of this evaluation is presented in two cases below: Index (A) shows the NPV and the IRR without considering accident benefits, and (B) includes accident benefits.

Note that economic indicators are positive for all links and for the total project, and they all increase compared with the original values. The NPV Without accident benefits for the total project increases 83.8% % (from US\$ 5.21 to US\$ 9.58 millions) and the IRR increases 9.3% (from 13.5% to 14.8%). If we take into account the accident benefits the increment is higher: 175% for the NPV (from US\$ 5.21 to US\$ 14.369 millions) and 20.4% for the IRR (from 13.5% to 16.3%).

Table 17 – Summary of Economic Indicators taking into account Contract Costs for L1+L2 minus ‘Sunk Costs’

H D M - 4 Version 2.1		
Economic Indicators Summary		
Study Name: 00 BEL_GPH Rehab		
Run Date: 29-07-2018		
Currency: US Dollar (millions)		
Discount Rate: 12.00%		
A) SUMMARY (Without Accident Benefits)		
L1+L2 CONTRACT COSTS MINUS SUNK COSTS		
LINK	Net Present Value (NPV = B + E - C)	Internal Rate of Return IRR (%)
01 BEIG Belmopan - Iguana Creek Junction	8.563	16.9
02 IGSE IguanaCreek - StaElena(RedCreek)	1.017	12.7
TOTAL PROJECTT	9.580	14.8

B) SUMMARY (include Accident Benefits)		
L1+L2 CONTRACT COSTS MINUS SUNK COSTS		
LINK	Net Present Value (NPV = B + E - C)	Internal Rate of Return IRR (%)
01 BEIG Belmopan - Iguana Creek Junction	10.838	18.2
02 IGSE IguanaCreek - StaElena(RedCreek)	3.530	14.4
TOTAL PROJECTT	14.369	16.3

These as well as the previous results show that the feasibility of the project is solid for several type of variations to the costs and benefits.

12. Technical Evaluation of the Wearing Course

As part of the technical evaluation of the wearing course, variations in the existing condition of the road in terms of annual average roughness throughout the evaluation period are analyzed. The results of this analysis are shown in the following table, as well as, graphically represented in the charts below.

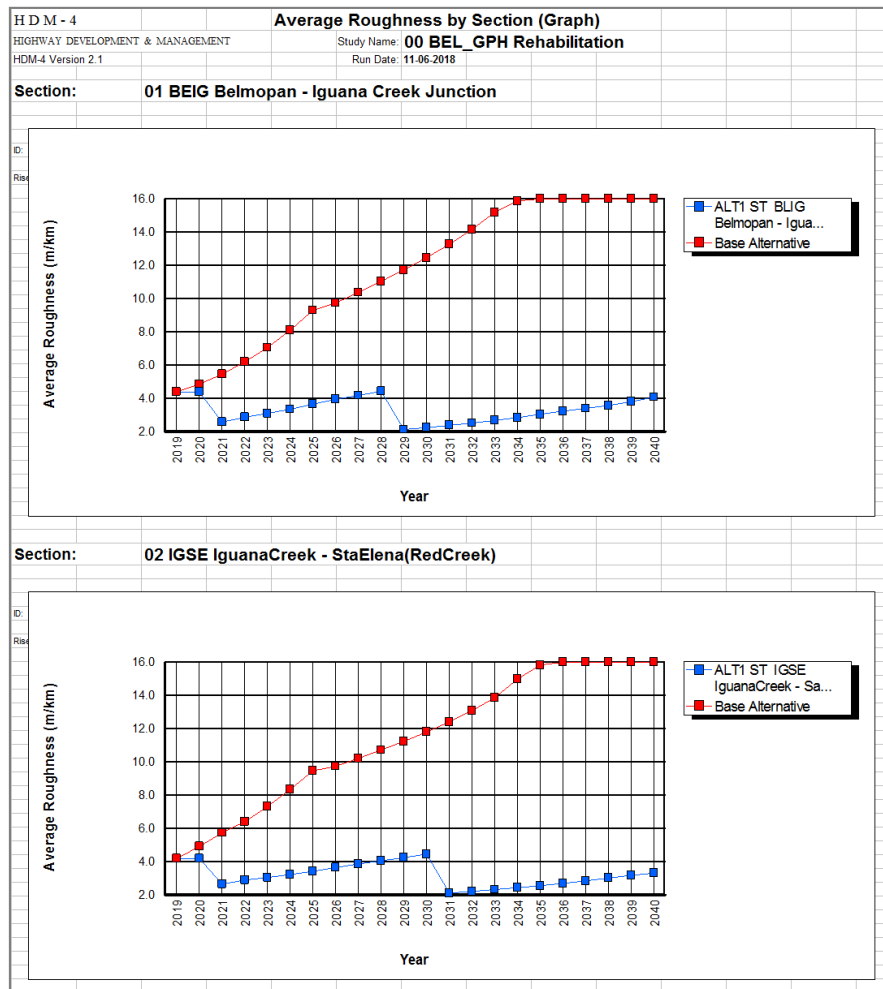
In the table, it is seen that the project alternatives (ALT1) have a good condition in terms of roughness at the end the evaluation period (year 2040). The roughness of the project does not exceed an IRI of 4.08 in the first link and an IRI of 3.32 for the second, which in technical terms is a reasonably smooth rolling surface (adequate drivable condition). On the other hand, the base alternative (existing road) would begin with an adequate IRI qualification (reasonable smooth) in 2019; however if the road continues with its current system of interventions, a roughness of IRI 16 m/km would be achieved at the end year 2040 (which corresponds to a very rough condition). It should be noted that all the links alternative projects would start with an IRI range of 2.58 to 3.66 m/km, corresponding to roughness good condition with a new tread surface.

Table 18 –Pavement Condition by Link

H D M - 4	HIGHWAY DEVELOPMENT & MANAGEMENT				
	Pavement Condition Summary				
	Study Name: 00 BEL_GPH Rehabilitation				
	Run Date: 11-06-2018				
	15.98km		16.51km		
LINK:	01 BEIG Belmopan - Iguana Creek Junction		02 IGSE IguanaCreek - StaElena(RedCreek)		
Alternative:	ALT1 ST BLIG Belmopan - IguanaCreek	Base Alternative	ALT1 ST IGSE IguanaCreek - Santa Elena	Base Alternative	
Year	IRI Avg. m/km	IRI Avg. m/km	IRI Avg. m/km	IRI Avg. m/km	
2019	4.40	4.40	4.19	4.19	
2020	4.40	4.86	4.19	4.92	
2021	2.58	5.46	2.66	5.74	
2022	2.87	6.20	2.90	6.41	
2023	3.10	7.06	3.05	7.32	
2024	3.35	8.11	3.23	8.35	
2025	3.66	9.30	3.42	9.47	
2026	3.95	9.74	3.65	9.74	
2027	4.18	10.38	3.87	10.22	
2028	4.43	11.04	4.06	10.72	
2029	2.13	11.73	4.25	11.24	
2030	2.25	12.47	4.46	11.80	
2031	2.38	13.27	2.12	12.41	
2032	2.52	14.17	2.22	13.09	
2033	2.68	15.19	2.33	13.87	
2034	2.85	15.87	2.44	14.98	
2035	3.05	16.00	2.56	15.83	
2036	3.24	16.00	2.70	16.00	
2037	3.40	16.00	2.85	16.00	
2038	3.58	16.00	3.02	16.00	
2039	3.80	16.00	3.18	16.00	
2040	4.08	16.00	3.32	16.00	
40 Average =	3.20	12.30	3.11	12.06	

The charts below show this variation visually where in each graph the upper curve represents the current condition (Base) and lower curves represent the alternative of rehabilitation of the road.

Figure 8: Scenario I Wearing Course Condition



13. Conclusions and Recommendations

The performed economic evaluation of the proposed road rehabilitation of George Price Highway (GPH) from Belmopan to Santa Elena is divided into two links:

	BELMOPAN - IGUANA CREECK	IGUANA CREECK - SANTA ELENA
	0+000 to 15+980	15+940 to 32+452
Length (Km)	15.98	16.51

The intervention alternative has been evaluated in addition to the Base Alternative, which corresponds to the existing condition of the road.

The budget cover bridge construction including the required efforts to construct the Roaring Creek Bridge located on the GPH near Belmopan.

Alternative Budget

BELIZE : GEORGE PRIZE HIGHWAY (GPH)

SUMMARY OF COSTS FOR THE HDM

Exchange Rate Bz\$ / US\$ = 2.0

SECTION	HDM LINK	NAME OF ROAD SEGMENT	ESTIMATE Amount Bz\$	ESTIMATE Amount US\$
Section 1 + 2	L1: BEIG	BELMOPAN - IGUANA CREECK (Includes Roaring Creek Bridge)	39,998,882.1	19,999,441.1
Section 3	L2: IGSE	IGUANA CREECK - SANTA ELENA	31,442,353.7	15,721,176.8
TOTAL PROJECT			71,441,235.81	35,720,617.91

The results of the economic analysis presented in this report shows that the project of the rehabilitation alternative with Double Surface Treatment (DST) is feasible, resulting in positive NPV. The profitability indicators for the project are tabulated below:

Table 20–Economic Indicators
Alternative: ST - Surface Treatment

H D M - 4 HDM-4 Version 2.1		
Economic Indicators Summary		
00 BEL_GPH Rehabilitation		11-06-2018
Currency:		US Dollar (millions)
Discount Rate:		12.00%
SUMMARY		
LINK	Net Present Value (NPV = B + E - C)	Internal Rate of Return (IRR)
01 BEIG Belmopan - Iguana Creek Junction	4.194	14.0%
02 IGSE IguanaCreek - StaElena(RedCreek)	1.017	12.7%
TOTAL PROJECTT	5.211	13.5%

It has been demonstrated through profitability indicators that the rehabilitation of the George Price Highway from “Belmopan to Santa Elena” is feasible.

It should be noted that the feasibility analysis conducted in this paper does not consider exogenous benefits. The analysis is primarily based on consumer savings which emphasize the benefits from the user cost savings (RUC). Additionally if accident benefits are taken into account the feasibility for the project increases to such extent that for the total project the NPV almost double (US\$ 10.0 million against US\$ 5.2 million).

On the other hand, if we take into account the contract amounts (for LOT1+LOT2) given in the IMC’s progress report minus the disbursement amounts already paid (called in this document as sunk costs) the positive economic indicators increases considerably to such extent

that for the total project the NPV Without accident benefits increases 83.8% % (from US\$ 5.21 to US\$ 9.58 millions) and the IRR increases 9.3% (from 13.5% to 14.8%). If we take into account the accident benefits the increment is higher: 175% for the NPV (from US\$ 5.21 to US\$ 14.369 millions) and 20.4% for the IRR (from 13.5% to 16.3%)

These values show that if any other exogenous benefits do arise and are considered for analysis purposes, they will increase the feasibility of the project which makes the selected decision even more economically attractive.

14. Annex A. HDM-4 Outs: Road Works Summary by Link

ALT1: SURFACE TREATMENT

H D M - 4		Road Works Summary (by Section)			
HIGHWAY DEVELOPMENT & MANAGEMENT		Study Name: 00 BEL_GPH Rehabilitation			
HDM-4 Version 2.1		Run Date: 12-06-2018			
Note: only sections that have works triggered are displayed.		Currency: US Dollar			
Section:	01 BEIG Belmopan - Iguana Creek Junction				
Alternative:	ALT1 ST BLIG Belmopan - IguanaCreek				
Surface Class:	Bituminous		Road Class:	Primary or Trunk	
Length:	15.98km		Width:	7.00m	
Year	Description	Code	Economic Cost	Financial Cost	Work Quantity
2019	RM Routine Maintenance	RM_bef	40,611.3	46,413.0	15.98 km
	01 BEIG ST Belmopan - Ig.Creek Improve	BEIGst	9,096,616.0	9,996,286.0	16.46 km
2020	RM Routine Maintenance	RM_bef	41,829.6	47,805.3	16.46 km
	01 BEIG ST Belmopan - Ig.Creek Improve	BEIGst	9,096,616.0	9,996,286.0	16.46 km
2021	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2022	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2023	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2024	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2025	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
	Reseal at 15% Cracking	RSL15	512,710.3	585,296.2	215.79 sq. m
	Prep. Edge Repair		0.0	0.0	171.10 sq. m
2026	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2027	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2028	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
	Overlay 50mm at 5 IRI	OVL50	1,728,236.9	1,974,798.5	215.79 sq. m
	Prep. Edge Repair		0.0	0.0	795.01 sq. m
2029	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2030	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2031	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2032	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2033	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2034	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2035	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
	Reseal at 15% Cracking	RSL15	512,710.3	585,296.2	215.79 sq. m
	Prep. Edge Repair		0.0	0.0	435.89 sq. m
2036	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2037	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2038	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2039	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
2040	Routine Maintenance	RM_aft	44,506.2	50,859.5	16.46 km
Total cost for the section:			21,919,454.4	24,249,372.0	

Section:	02 IGSE IguanaCreek - StaElena(RedCreek)				
Alternative:	ALT1 ST IGSE IguanaCreek - Santa Elena				
Surface Class:	Bituminous		Road Class:	Primary or Trunk	
Length:	16.51km		Width:	7.00m	
Year	Description	Code	Economic Cost	Financial Cost	Work Quantity
2019	RM Routine Maintenance	RM_bef	41,958.2	47,952.3	16.51 km
	02 IGSE ST Ig.Creek - Sta Elena Improve	ICSEst	7,153,139.0	7,860,592.5	16.51 km
2020	RM Routine Maintenance	RM_bef	41,958.2	47,952.3	16.51 km
	02 IGSE ST Ig.Creek - Sta Elena Improve	ICSEst	7,153,139.0	7,860,592.5	16.51 km
2021	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2022	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2023	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2024	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2025	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2026	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
	Reseal at 15% Cracking	RSL15	514,286.5	587,095.6	570.00 sq. m
	Prep. Edge Repair		0.0	0.0	181.03 sq. m
2027	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2028	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2029	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2030	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
	Overlay 50mm at 5 IRI	OVL50	1,733,550.0	1,980,869.8	570.00 sq. m
	Prep. Edge Repair		0.0	0.0	920.82 sq. m
2031	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2032	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2033	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2034	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2035	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2036	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2037	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2038	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
	Reseal at 15% Cracking	RSL15	514,286.5	587,095.6	570.00 sq. m
	Prep. Edge Repair		0.0	0.0	474.68 sq. m
2039	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
2040	Routine Maintenance	RM_aft	44,643.0	51,015.9	16.51 km
Total cost for the section:			18,045,178.1	19,992,468.5	