8 Cost Criteria

8.1 Introduction

This chapter presents details of the three cost criteria, Capital Cost, Maintenance and Operating Cost and Life Cycle Cost. Data from the assessment of the first two criteria are presented in some detail. The third criterion, Life Cycle Cost, is the sum of the costs in the first two criteria.

The geographical limits of the work included in the cost estimate are the eastern edge of Broadway Bridge over I-287 in Rockland County and the western edge of South Broadway Bridge (Route 9) in Westchester County. Costs for CRT are from abutment to abutment only. Details of the estimating methodology used are as follows:

Capital Costs

- The capital costs have been produced in 2007 dollars and escalated to the mid-point of construction, which has been taken to be 2012 using a 4.5% yearly inflation rate.
- Capital costs are based on the following:
  - Construction quantities for primary components
  - Percentage mark-up for general conditions, insurance and overhead and profit
  - Percentage mark-up for escalation, design and construction contingencies and soft costs
- Soft costs are included for design, permitting, construction management, program management and direct agency costs.
- The capital cost estimates do not include allowance for:
  - ROW acquisition
  - Third party (e.g., utility) mitigation efforts
  - Hazardous material handling

Maintenance

- Maintenance costs are based on maintaining the crossing for 150 years for both the Rehabilitation and Replacement Options.
- The predicted maintenance requirements of the Rehabilitated bridge options take into account the ongoing deck replacement efforts.
- The 'Present Value' of the future maintenance is the amount of money that would need to set aside in 2012 to cover future maintenance costs for 150 years. A discount rate of 3% is assumed. The discount rate is the difference between bank interest and inflation.
- In all options that assume supplemental or replacement Main Spans, a standard cable-stay bridge type has been assumed for cost estimating purposes only. This bridge type represents the least cost solution for the Main Spans.

8.2 Capital Cost Estimates

Capital costs for each of the Rehabilitation or Replacement Options are summarized in Table 8-1 and presented in graphical form in Figure 8-1 (page 72).

8.2.1 Rehabilitation Options

Capital costs for the four Rehabilitation Options ranged from $3.4 billion to $6.4 billion.

Rehabilitation Option 1

At a capital cost of $3.4 billion, Rehabilitation Option 1 would require the least expenditure to maintain the Tappan Zee Bridge in a structurally safe condition for the long term future. In this option, replacement of the Causeway, approximately half the overall bridge length, represented 55% of the total capital cost. Rehabilitation of the retained Deck Truss and Main Spans, in the remaining half of the bridge, was 40% of the capital cost. The remaining 5% of the capital cost in Rehabilitation Option 1 was associated with non-structural items at the maintenance facilities at each end of the Tappan Zee Bridge.

		Capital Costs (2012 millions)						
		Rehabilitation Options				Replacement Options		
		1	2	3	4	1	2	3
Existing TZB	Causeway	$56	$56	$56	$56	$56	$56	$56
	West Deck Truss Spans	$450	$715	$271	$271	$15	$15	$15
	Main Spans	$594	$1,910	$552	$552	$21	$21	$21
	East Deck Truss Spans	$429	$1,058	$387	$387	$31	$31	$31
	East Trestle	$15	$69	$10	$10	$4	$4	$4
Parallel or Replacement TZB	West Approach Supplemental or New	$1,762	$2,415	$2,592	$3,231	$2,833	$3,534	$3,679
	Main Span Supplemental or New	–	–	$587	$877	$1,173	$1,425	$1,486
	East Approach Supplemental or New	–	–	$483	$740	$965	$1,206	$1,254
	Non-Structural	$152	$152	$148	$148	$148	$148	$148
	Staff	–	–	–	–	–	–	–
	Total	$3,400	$6,400	$5,100	$6,300	$5,200	$6,400	$6,600

Table 8-1

Capital Cost Estimate

Rehabilitation Option 2

Compared to Rehabilitation Option 1, Rehabilitation Option 2 would have additional BRT lanes and new shoulders. It has an estimated capital cost of $6.4 billion, the highest cost of all the Rehabilitation Options. The substantially higher costs for Rehabilitation Option 2 are a consequence of the complex construction to and around the existing Tappan Zee Bridge structure. In this option, cost rates would be higher than the other options due to the complexities of widening the existing structure and the constraints of working around the existing traffic. These issues would also cause construction progress rates to be lower than the other options. It is possible that the complex construction involved with Rehabilitation Option 2 would require insurance costs an order of magnitude larger than for the other options, although this cost hasn't been included in the current cost estimate.

Rehabilitation Option 3

At $5.1 billion, Rehabilitation Option 3 is the minimum capital cost estimate for the inclusion of BRT on a rehabilitated Tappan Zee Bridge. It is less costly than Rehabilitation Option 2 because of its simpler construction and that all work would take place away from traffic, reducing construction rates and increasing construction progress rates

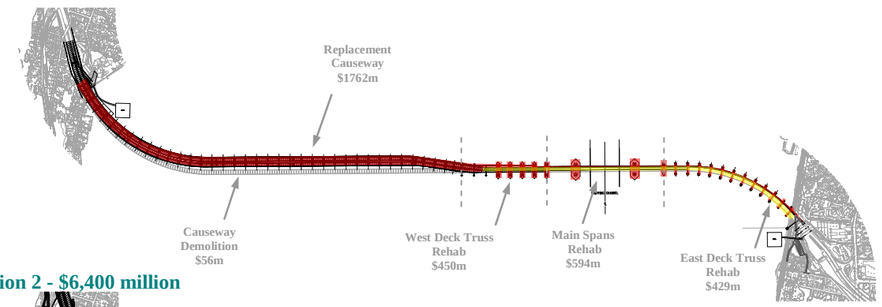
Rehabilitation Option 4

Rehabilitation Option 4 included the same traffic lanes as Rehabilitation Option 3 but added CRT, resulting in an incremental increase of $1.2 billion to total capital cost of $6.3 billion.

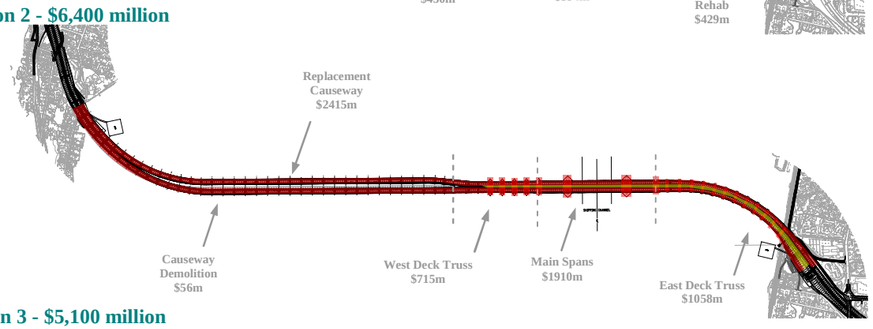
The costs presented above were derived from the engineering analysis and assessments conducted for this Alternatives Analysis. Based on comments from reviewers at the foundation workshop of March 2008, further assessment of other retrofit strategies for the superstructure may reduce the number of steelwork members in the retained spans to be modified. It was estimated that the maximum order of magnitude reduction in cost, from the differing retrofit strategies suggested, would be in the range $300-400 million. These reductions are not included in the capital costs presented in this chapter as further engineering analysis would be required to confirm feasibility and effectiveness and to ensure the absence of complementary adverse results at all locations in the structural system resulting from a change at one location.

Rehabilitation Options

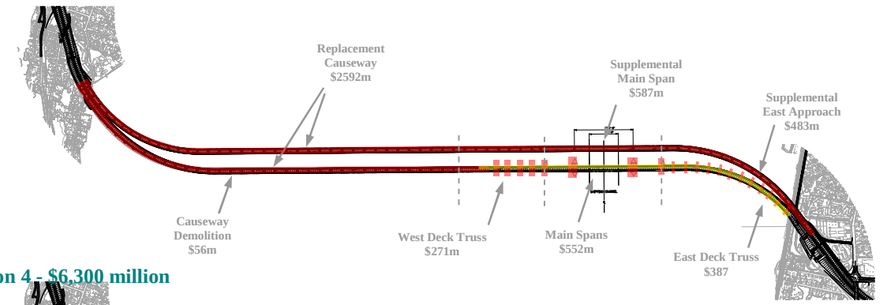
Option 1 - $3,400 million



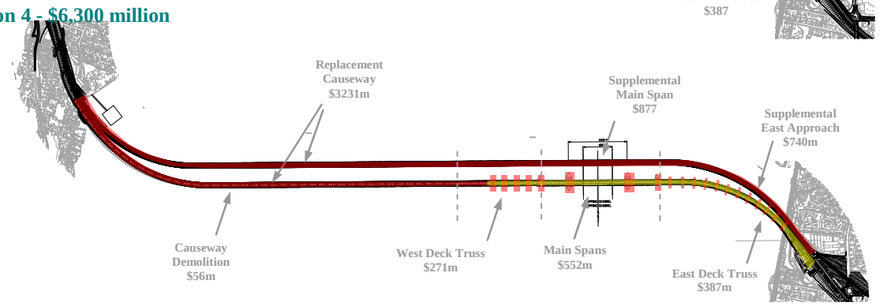
Option 2 - $6,400 million



Option 3 - $5,100 million

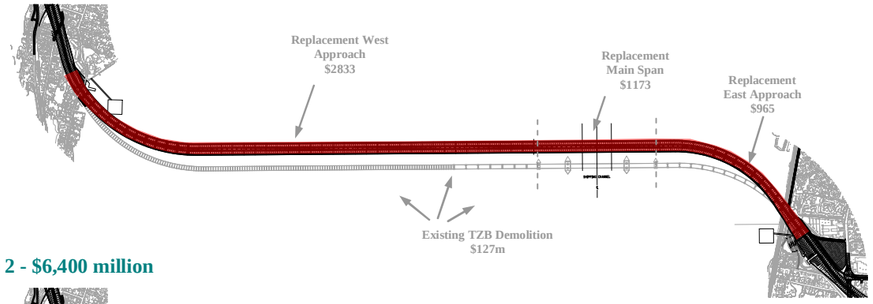


Option 4 - $6,300 million

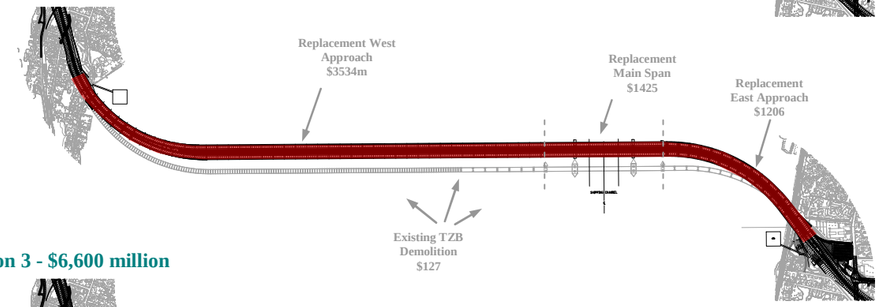


Replacement Options

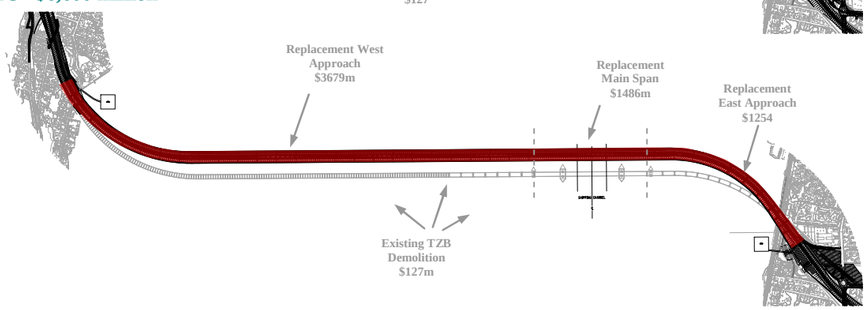
Option 1 - $5,200 million



Option 2 - $6,400 million



Option 3 - $6,600 million



Rehabilitated Structure **New Structure**

Figure 8-1
Capital Cost Estimate Allocation

This further analysis is not warranted at this stage as the majority of the costs associated with the Rehabilitation Options are associated with the foundation replacements which would remain unchanged.

8.2.2 Replacement Options

Capital costs for the three Replacement Options ranged from $5.2 billion to $6.6 billion. Representing 2-3% of the overall totals, the capital costs included for the demolition and removal of the existing Tappan Zee Bridge down to the riverbed. In all options, three primary bridge segments were reported in the capital estimates, the western approach, Main Spans and eastern approach, whose lengths represented 63%, 16% and 21% of the overall length of the bridge respectively. The approach structures (84% of the overall bridge length) have the same structural form for all Replacement Options.

Replacement Option 1
Replacement Option 1 provides only for BRT as a transit mode. Costs for the three segments are generally proportional to their individual lengths, with the exception of the Main Spans where costs are greater than for the approaches as a result of the more complex construction associated with the longer spans. As a consequence, while the approach spans represent 84% of the overall crossing length, these spans represent only 73% of the overall cost of the option.

Replacement Options 2 and 3
Replacement Options 2 and 3 both include CRT as well as BRT in a single level or dual level arrangement, respectively. These structural forms resulted in similar capital costs of $6.4 and $6.6 billion, respectively. Differences in the costs resulted from pile numbers and pier quantities and the assumption of concrete and steel superstructure forms for Options 2 and 3 respectively. For the purposes of this report, the cost difference between Replacement Options 2 and 3 is considered nominal. Further assessment of structural forms may be required at a later stage in the process depending on the Tappan Zee Bridge options progressed to the DEIS.

8.2.3 Cost of Transit Provision

The approximate cost of providing dedicated BRT/HOV lanes on a replaced or rehabilitated bridge, in addition to the general purpose lanes, shoulders and Pedestrian and Bicycle Paths, is $0.78 billion. The comparative cost for the provision of CRT on the bridge is $1.22 billion. The exact cost of transit provision on the bridge would depend upon the structural form selected for the bridge.

8.2.4 Comparison of Options

As outlined above, the minimum cost to maintain the Tappan Zee Bridge in safe working condition for the long term is $3.2 billion (Rehabilitation Option 1). This is 62% of the lowest cost replacement bridge option ($5.2 billion for Replacement Option 1). Replacement Option 1 includes enhanced functionality compared to Rehabilitation Option 1 leading to a significantly wider structure (218 feet compared to 91 feet. Comparing similar width structures, Rehabilitation Option 1 (91-foot width) and one of the two bridges of Replacement Option 1 (109-foot width), the rehabilitation cost represents 120% of the approximate comparable replacement option. As outlined in the NYSDOT bridge manual, if rehabilitation costs are 85% or more of the replacement costs, the preference is for the replacement option due to the higher performance and lower maintenance requirements of new structures.

The following options are comparable, having the same highway and BRT transit components:

- Rehabilitation Option 2 $6.4 billion
- Rehabilitation Option 3 $5.1 billion
- Replacement Option 1 $5.2 billion

The lowest cost rehabilitation option (Rehabilitation Option 3) represents 98% of the cost of the comparable replacement option (Replacement Option 1). The difference in the capital cost estimates between the two options is negligible and substantially less than the 30% contingency cost included in each option. The minimum capital costs for rehabilitation and replacement are effectively the same. This indicates that the Replacement options would be preferred on the basis of cost, as the Rehabilitation costs are more than 85% of the Replacement options.

The primary factor, leading to the above result, is the high percentage of new bridge in the Rehabilitation Options. For example, in Rehabilitation Option 3, which includes a new supplemental bridge and replacement of the Causeway Spans, 77% of the overall bridge length is new and is exactly the same as that in the comparable replacement option. If the new foundations on the rehabilitated segments are included, then 80-85% of the structure in Rehabilitation Option 3 is new.

The following options are comparable having the same highway and CRT transit components:

- Rehabilitation Option 4 $6.3 billion
- Replacement Option 2 $6.4 billion
- Replacement Option 3 $6.6 billion

Similar to the results for the BRT only options, the cost differences among the options with CRT were negligible and substantially less than the contingencies included in each option. Again, this indicates that the Replacement options would be preferred on the basis of cost, as the Rehabilitation costs are more than 85% of the Replacement options.

8.3 Maintenance Cost Estimates

8.3.1 Historic Maintenance Costs

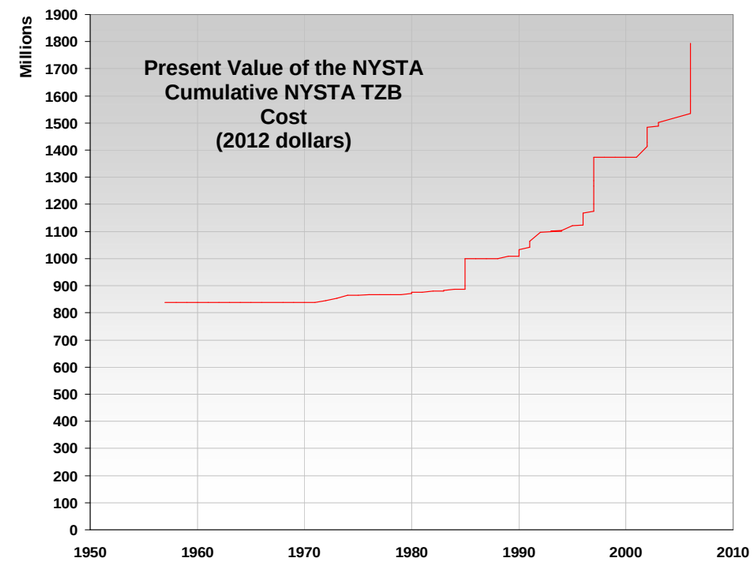
Since construction of the Tappan Zee Bridge, in response to biennial inspections, the NYSTA has been active in repairing the bridge as needed. Repairs have been conducted by a dedicated Tappan Zee Bridge maintenance crew supplemented by outside contractors when needed to increase repair rates. Since the completion of the Tappan Zee Bridge, the NYSTA has completed almost 45 repair contracts (Table 8-2, page 74). As shown on Figure 8-2 (page 74) the cumulative expenditure on the Tappan Zee Bridge since the start of construction is in excess of $1.8 billion (in 2012 dollars). Excluding the cost of the initial construction of the Tappan Zee Bridge, the cumulative NYSTA expenditure on outside contracts is almost $1.0 billion (in 2012 dollars). See Figure 8-2. Additional expenditures not included in these contract figures have been required for the dedicated maintenance crew (currently 80 personnel) whose activities are increasingly associated with traffic operations and accident recovery rather than maintenance of the Tappan Zee Bridge.

As shown in Figure 8-2 the rate of expenditure on maintenance contracts has increased in each of the decades since completion of the Tappan Zee Bridge. In the current decade, the anticipated expenditure on maintenance contracts is approaching $700 million (in 2012 dollars). Further expenditures are likely in the current decade as a result of the biennial and annual inspections by the NYSTA staff and specialist consultants scheduled for 2008 and 2009. In each of the last three decades, the increase in expenditure on the Tappan Zee Bridge has been in excess of 100%, compared to the preceding decade.

Decade	NYSTA Maintenance Contracts
1960's	Paving - Bent 173 to E Abut
1970's	Joint Rehab. - Easement Jts. On Trusses Paving - E Abut to Bent 166 Paving - Bent 166 to W Abut Conc. Median Barrier E Abut to Bent 180 Travelers Rehab & Catwalk Ext. Tram Repair (Platform) Bottom Chord Repair Median Barrier Bent 180 to Bent 62
1980's	New Fenders Bents 173, 175, 176 & 178 New Lighting System Caisson Catwalks 169 - 178 Construction of TZ Br. Bldg. Installation of Br. Test Joints, M.P. 1708 - 15.89 SB Lighting System Cleanup Contract Caisson Electrical 169 - 178 Installation of Variable Message Sign on TZ Bridge Modification of Toll Facilities, Including New Toll Utility Bldg., Canopy & Eliminate Mall, Add 7th Lane Repair Deck, Asphalt Overlay Bridge Painting
1990's	Stanchion Supported Cable Safety Lines Rehab/Replace Bearings on Deck Truss Caisson Electrical Pump Rehab Structural Steel Repairs Joint Replacement Install Moveable Barrier System Deck Repairs CCTV Steel Repairs Fender Repair (Emergency) Rehab Spans #1 - 166 Painting of Fascia Structure, Steel Piers 166 - 173 Substructure Repairs for TZ Bridge Main Channel Pier Protection & Painting of Steel Towers & Piers 175 & 176 Replace Pier Fender System at Piers 169 - 173 & 178 Paint Steel Towers at 173 Deck Reconstruction & Rail Upgrade, Deck Replacement East Truss Deck,
2000's	Deck repairs Paint east deck trusses Partial deck replacement (WDT) Painting fascia and first interior stringer (Causeway) Caisson hatch closures, dewatering and alarm Steel repairs WDT and Main Spans Steel repairs on causeway Dredging Substructure repair phase 3 Steel repairs to east deck truss and causeway spans Substructure repair phase 2 Deck rehabilitation contract 1 Deck joint #173 replacement Replacement of electrical supply transfer switch Reconstruct maintenance drive Painting WDT interior bays and steel piers Reconstruct maintenance travelers Deck rehabilitation contract 1 Painting WDT exterior and towers Causeway spans fender piles

Table 8-2

NYSTA Maintenance Contracts



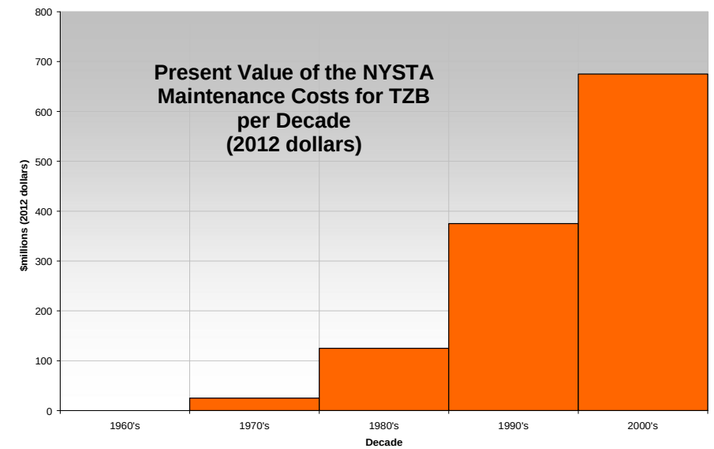


Figure 8-2

Historic NYSTA Maintenance Costs

8.3.2 Future Maintenance Costs

Table 8-3 presents the results of the assessment of maintenance costs for all seven options presented in this report. The maintenance costs were developed from individual maintenance activity plans for each option with activities planned through 150 years after the completion of construction, assumed in 2015. Resulting costs were discounted to 2012 to determine their present value. Present value may best be understood as the amount of money that would need to be put in a bank now such that this initial capital and the interest earned would be sufficient to cover the future costs of maintenance. In the analysis conducted, activities beyond 100 years had only a nominal effect on the present value cost estimate.

For all options, maintenance activities included repair or replacement of all components. These components include concrete deck, barriers, railings, steelwork, bearings, pier concrete, pedestals, pile caps and piles as well as non-structural items including pier protection and maintenance facilities. Repair intervals differed for all components and depended on age and location. For example, new concrete would be constructed to greater standards than the existing concrete on the Tappan Zee Bridge and would have a longer period between repairs. For retained components of the Tappan Zee Bridge (i.e., the Deck Truss piers), the historic rate of deterioration, repair cycles and costs were used in the development of the overall maintenance plans for each option. Costs for the maintenance crew were also included.

The present value of maintenance costs are presented in Table 8-3. These figures do not include the economic costs of delays to road users associated with maintenance activities.

		Rehabilitation Options				Replacement Options		
		1	2	3	4	1	2	3
Existing TZB	**Causeway**	_	_	_	_	_	_	_
	West Deck Truss Spans	$135	$217	$110	$154	_	_	_
	Main Spans	$260	$492	$248	$240	_	_	_
	East Deck Truss Spans	$171	$300	$171	$183	_	_	_
	East Trestle	$50	$77	$48	$48	_	_	_
Parallel or Replacement TZB	**West Approach** Supplemental or New	$133	$156	$187	$346	$262	$327	$398
	Main Span Supplemental or New	_	_	$38	$58	$100	$115	$185
	East Approach Supplemental or New	_	_	$56	$52	$121	$140	$217
	Non-Structural	$69	$69	$67	$67	$67	$67	$67
	Staff	$287	$215	$215	$215	$125	$125	$125
	Total	**$1,100**	**$1,500**	**$1,200**	**$1,400**	**$700**	**$700**	**$900**

Table 8-3

Present Value of Estimated Future Maintenance Costs (2012 $millions)

Comparison of Options

As can be seen from the information contained in Table 8-3, the predicted maintenance costs of the Replacement Options are all significantly lower than for the Rehabilitation Options. This is due to the high maintenance requirements of the retained elements of the existing bridge along with the need for some of these retained elements to be more frequently replaced.

8.4 Life Cycle Cost Estimates

For the purpose of this report, the life cycle costs are considered to be the sum of the capital costs and the net-present value maintenance costs. The life cycle costs for the seven bridge options considered are listed below in 2012 dollars:

- Rehabilitation Option 1 — No transit — $4.5 billion
- Rehabilitation Option 2 — BRT — $7.9 billion
- Rehabilitation Option 3 — BRT — $6.3 billion
- Rehabilitation Option 4 — BRT/CRT — $7.7 billion
- Replacement Option 1 — BRT — $5.9 billion
- Replacement Option 2 — BRT/CRT — $7.1 billion
- Replacement Option 3 — BRT/CRT — $7.5 billion

It can be seen from the costs presented above that the life cycle costs of options which carry the same transit modes are broadly similar to each other. The primary reason for this is that the approximately 80% of the completed Rehabilitated Options would be formed of new structures, resulting in similar maintenance requirements and life cycle costs to the Replacement Options.