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**PERPETUAL PAVEMENT5 FEASIBILITY STUDY
RED HILL CREEK EXPRESSWAY
HAMILTON, ONTARIO**

Submitted to:

The City of Hamilton
320-77 James Street North
Hamilton, ON, L8R 2R3

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1.0 CONVENTIONAL AND PERPETUAL PAVEMENT DESIGNS

As requested, this technical memorandum (memo) provides an evaluation of the two pavement designs that have been selected for use on Red Hill Creek Expressway (RHCE). The two designs, a conventional deep strength pavement design originally selected for this project, and a perpetual pavement design are as follows:

	CONVENTIONAL DEEP STRENGTH DESIGN	PERPETUAL PAVEMENT DESIGN
SMA (mm)	40	40
HL 8 (HS)	120 - 130	100
Rich-bottom Layer (mm)	-	80
Granular A Base (mm)	150	150
Subbase, Granular B Type II (mm)	450 - 650	390 - 625
Total Pavement Thickness (mm)	760 - 970	760 - 820
Structural Number (S _N) (mm)	147 - 174	165 - 193
Granular Base Equivalency (GBE) (mm)	920 - 1140	980 - 1215

A detailed comparison of the conventional deep strength pavement designs and perpetual pavement designs is given in Table 1 in the Appendix. The conventional pavement designs are as recommended in the original geotechnical investigation reports:

1. Soil-Mat Engineers & Consultants Ltd. for Section 21+170 to 23+900;
2. Peto MacCallum Ltd for Section 23+850 to 27+400; and
3. Peto MacCallum Ltd for Section 27+400 to 29+100.

The traffic loading data provided in a December 10, 2002 report by iTrnas Transportation Planning and Traffic Consultants was used in the feasibility study.

It should be noted the perpetual pavement feasibility study did not include a check of the conventional pavement designs recommended by the above consultants.

2.0 BACKGROUND

A perpetual pavement has two main attributes which are as follows:

- Total asphalt thickness of more than 200 mm. In theory, it has been shown that flexible pavements with more than 200 mm of hot mix can resist fatigue cracking (bottom-up cracking) regardless of the number of axle load repetitions. As such, damage to the pavement is limited to the surface which can be milled off and replaced periodically.
- The asphalt content of the bottom lift of hot mix asphalt (Rich-bottom lift) is increased slightly and the air voids in the mix reduced to about 2 per cent to further enhance the resistance to fatigue cracking. The increased hot mix asphalt thickness provides sufficient cover over the Rich-bottom lift to resist asphalt rutting.

To satisfy the above two criteria, the asphalt thickness was increased from 160 to 170 mm for the conventional pavement design to 220 to 230 mm for the perpetual pavement design.

An AASHTO design analysis was carried to verify that the proposed Perpetual Pavement design satisfies the minimum Structural Number (SN) required to support the traffic loading and subgrade conditions within the project limits. Table 1 in the Appendix provides a summary of the design analysis. The results indicate that the Structural Number for the Perpetual Pavement design is 163 to 194 mm compared to 147 to 174 mm, the minimum required, for the Conventional Deep Strength Pavement design. Thus, the perpetual pavement design ~~can~~ *should be able* to structurally support 93 million ESALs over 50 years compared 40 million ESALs for 20 years for the conventional pavement.

3.0 LIFE CYCLE COST ANALYSIS

Life Cycle Cost Analyses (LCCA) were carried out for both the Conventional and Perpetual Designs using the Draft Version of MTO's "Guidelines for the Use of Life Cycle Cost Analysis on MTO Freeway Projects", dated March 2003. The Maintenance/Rehabilitation Schedule given in the Guidelines for conventional pavements was used for the deep strength pavement design and the schedule for the SMA pavement was used for the perpetual pavement design. It is expected that only the surface course will need to be replaced for the perpetual pavement periodically and therefore, the milling and overlay thickness at Year 21, Year 34 and Year 46 was reduced to 40 mm for this design. Tables 2 and 3 in the Appendix summarize the initial (construction) costs of both pavements. The results of the LCCA analyses are presented in Tables 4, 5 and 6 in the Appendix and are summarized below. User delay costs are presented in Tables 7 and 8.

COST TYPE* AND RANKING	CONVENTIONAL DEEP STRENGTH DESIGN	PERPETUAL PAVEMENT DESIGN
Initial Cost	\$ 10,850,079	\$ 11,425,914
Initial Cost Rating	1	2
Maintenance and rehabilitation Costs	\$ 1,383,013	\$ 870,890
Detour	\$ 344,240	-
User Delay Costs	\$ 1,279,545	\$ 453,056
LCCA Costs without Initial Costs	\$ 2,954,596	\$ 1,265,939
LCCA Costs without Initial Costs Rating	2	1
Total LCCA Costs	\$ 13,804,675	\$ 12,691,853
Total LCCA Costs Rating	2	1

* All costs shown are present values.

It should be noted that these cost estimates are approximate and are intended for comparison purposes only.

4.0 COMPARISON OF CONVENTIONAL AND PERPETUAL DESIGNS

The pros and cons of the two designs are compared in the table below:

	PROS	CONS
Conventional Deep Strength Design	<p>Lower initial cost.</p> <p>Pavement structure typical of those used on main arterial roads in Ontario.</p>	<p>Maintenance costs are higher.</p> <p>Higher Life Cycle Costs.</p> <p>The time required to complete maintenance activities will be more and hence, user delay costs will be more.</p> <p>Lower Structural Number and GBE.</p> <p>Could be prone to fatigue cracking (bottom-up cracking) after 20 to 30 years of service. This could increase future rehabilitation costs (investigations, design and additional lifts of overlay) and user delay costs.</p> <p>A detour will be required for some sections during pavement rehabilitation/repair work.</p>
Perpetual Pavement Design	<p>Lower Life Cycle Costs.</p> <p>Maintenance costs are lower.</p> <p>The time required to complete maintenance activities will be less and hence, public inconvenience and user delay costs will also be less.</p> <p>Higher Structural Number and GBE.</p> <p>No detour will be required for pavement rehabilitation work.</p> <p>Multi-layer analysis indicates that asphalt pavements with more than 200 mm of hot mix will not be prone to fatigue cracking. In addition, the Rich-bottom mix contains a higher asphalt content that is more resistant to fatigue failure while the increased hot mix thickness makes the pavement less susceptible to rutting. This should result in reduced rehabilitation costs (investigations, design and additional lifts of overlay) and user delay costs in the future.</p>	<p>Higher initial (construction) costs.</p>

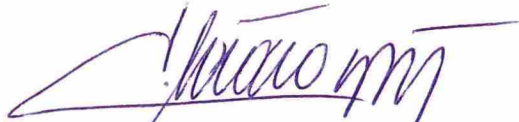
5.0 SUMMARY

A flexible pavement satisfying the requirements for perpetual pavement design is recommended for Red Hill Creek Expressway.

A review of the two types of pavement designs indicates that the initial and Life Cycle costs of the perpetual pavement is less than that for the conventional deep strength pavement design. In addition, the benefits of using the perpetual pavement design which include lower maintenance and user delay costs could outweigh the higher initial costs over the life of the pavement.

We trust this short technical report provides the information required by the City of Hamilton to proceed with the design of the project. If you have any questions regarding the proposed pavement structures, please contact us.

Yours Truly,
Golder Associates Ltd.



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APPENDIX

Table 1a
Summary of Pavement Designs

Selected Pavement Design		Design Period	Traffic Loading (Million ESAL's)	Pavement Structure						
Deep Strength	Perpetual			SN (mm)	Layer Thickness (mm)			Granular Base (Gr. A)	Subbase (Gr. B)	Total (mm)
					Surface Course	HMA Binder Course	RBL			
x		20	40	147	40	60 60	-	150	450 - 685	760
	x	50	93	163	40	50 50	80	150	390 - 625	760

Table 1b
Summary of Pavement Designs

Section	Location		Pavement Type		Design Period	Traffic Loading (Million ESAL's)	SN (mm)	Pavement Structure					Total (mm)
	From	To	Deep Strength	Perpetual				Layer Thickness (mm)					
								Surface Course	HMA Binder Course	RBM	Granular Base (Gr. A)	Subbase (Gr. B)	
1a	21+710	23+390	x		20	40	147	40	60	-	150	450	760
				x	50	93	163	40	50	80	150	390	760
1b	21+710	23+390	x		20	40	132	40	60	-	300	685	760
				x	50	93	148	40	50	80	300	675 1145	760
2a	23+850	24+975	x		20	40	156	40	65	-	150	500	820
				x	50	93	176	40	55	80	150	440	820
2b	24+975	27+400	x		20	40	174	40	65	-	150	650	970
				x	50	93	194	40	55	80	150	590	970
3a	27+400	28+950	x		20	40	174	40	65	-	150	650	970
				x	50	93	194	40	55	80	150	590	970
3b	28+950	29+100	x		20	40	156	40	65	-	150	500	820
				x	50	93	176	40	55	80	150	440	820

1145

Table 2
Construction Cost Summary for Deep Strength Pavement - Option 1

WBS Code	Description	Wide Median 2 NB & 3SB	Narrow Median 2 NB & 3SB	Wide Median 2 NB & 2 NB	Narrow Median 2 NB & 2SB	Budget Quantity	Unit	Unit Rate	Budget Total
20.03	21+000 to 21+600								
	Asphalt Surface - SMA	1911.60				1911.60	t	65.00	\$124,254.00
	Binder Course - HL8 HD	4233.60				4233.60	t	55.00	\$232,848.00
	Granular Base	8152.70				8152.70	t	7.00	\$57,068.90
	Granular Sub-Base	22387.53				22387.53	t	7.00	\$156,712.71
	Water for Compaction & Dust					763.51	m ³	4.00	\$3,054.02
	Calcium Chloride Flake					4947.52	kg	0.30	\$1,484.26
20.04	21+600 to 22+525								
	<i>21+600 to 22+425</i>								
	Asphalt Surface - SMA	2628.45				2628.45	t	65.00	\$170,849.25
	Binder Course - HL8 HD	5619.08				5619.08	t	55.00	\$309,049.40
	Granular Base	11209.97				11209.97	t	7.00	\$78,469.79
	Granular Sub-Base	30782.85				30782.85	t	7.00	\$215,479.95
	Water for Compaction & Dust					1049.82	m ³	4.00	\$4,199.28
	Calcium Chloride Flake					6802.84	kg	0.30	\$2,040.85
	<i>22+425 to 22+525</i>								
	Asphalt Surface - SMA		318.60			318.60	t	65.00	\$20,709.00
	Binder Course - HL8 HD		705.60			705.60	t	55.00	\$38,808.00
	Granular Base		1289.59			1289.59	t	7.00	\$9,027.13
	Granular Sub-Base		3413.47			3413.47	t	7.00	\$23,894.29
	Water for Compaction & Dust					117.58	m ³	4.00	\$470.31
	Calcium Chloride Flake					761.90	kg	0.30	\$228.57
20.05	22+525 to 23+895								
	<i>22+525 to 23+000</i>								
	Asphalt Surface - SMA		1513.35			1513.35	t	65.00	\$98,367.75
	Binder Course - HL8 HD		3351.60			3351.60	t	55.00	\$184,338.00
	Granular Base		6125.56			6125.56	t	7.00	\$42,878.92
	Granular Sub-Base		16213.96			16213.96	t	7.00	\$113,497.72
	Water for Compaction & Dust					558.49	m ³	4.00	\$2,233.95
	Calcium Chloride Flake					3619.00	kg	0.30	\$1,085.70
	<i>23+000 to 23+895</i>								
	Asphalt Surface - SMA	2851.47				2851.47	t	65.00	\$185,345.55
	Binder Course - HL8 HD	6315.12				6315.12	t	55.00	\$347,331.60
	Granular Base	12161.12				12161.12	t	7.00	\$85,127.84
	Granular Sub-Base	33394.73				33394.73	t	7.00	\$233,763.11
	Water for Compaction & Dust					1138.90	m ³	4.00	\$4,555.59
	Calcium Chloride Flake					7380.05	kg	0.30	\$2,214.01

20.06	23+895 to 26+020							
	23+895 to 24+400							
	Asphalt Surface - SMA	1608.93		1608.93	t	65.00		\$104,580.45
	Binder Course - HL8 HD	3563.28		3563.28	t	55.00		\$195,980.40
	Granular Base	6861.86		6861.86	t	7.00		\$48,033.02
	Granular Sub-Base	18842.84		18842.84	t	7.00		\$131,899.88
	Water for Compaction & Dust			642.62	m ³	4.00		\$2,570.47
	Calcium Chloride Flake			4164.16	kg	0.30		\$1,249.25
	24+400 to 26+020							
	Asphalt Surface - SMA		4548.96	4548.96	t	65.00		\$295,682.40
	Binder Course - HL8 HD		9763.74	9763.74	t	55.00		\$537,005.70
	Granular Base		19971.10	19971.10	t	7.00		\$139,797.70
	Granular Sub-Base		53679.19	53679.19	t	7.00		\$375,754.33
	Water for Compaction & Dust			1841.26	m ³	4.00		\$7,365.03
	Calcium Chloride Flake			11931.35	kg	0.30		\$3,579.40
20.07	26+020 to 27+850							
	Asphalt Surface - SMA		5138.64	5138.64	t	65.00		\$334,011.60
	Binder Course - HL8 HD		11029.41	11029.41	t	55.00		\$606,817.55
	Granular Base		22559.95	22559.95	t	7.00		\$157,919.65
	Granular Sub-Base		60637.60	60637.60	t	7.00		\$424,463.20
	Water for Compaction & Dust			2079.94	m ³	4.00		\$8,319.76
	Calcium Chloride Flake			13478.00	kg	0.30		\$4,043.40
20.08	27+850 to 28+800							
	Asphalt Surface - SMA		2667.60	2667.60	t	65.00		\$173,394.00
	Binder Course - HL8 HD		5725.65	5725.65	t	55.00		\$314,910.75
	Granular Base		11711.45	11711.45	t	18.00		\$210,806.10
	Granular Sub-Base		31478.54	31478.54	t	17.00		\$535,135.18
	Water for Compaction & Dust			1079.75	m ³	4.00		\$4,319.00
	Calcium Chloride Flake			6996.78	kg	0.30		\$2,099.03
20.09	28+800 to 29+120							
	Asphalt Surface - SMA		898.56	898.56	t	65.00		\$58,406.40
	Binder Course - HL8 HD		1928.64	1928.64	t	55.00		\$108,075.20
	Granular Base		3723.49	3723.49	t	18.00		\$67,022.82
	Granular Sub-Base		9586.37	9586.37	t	17.00		\$162,968.29
	Water for Compaction & Dust			332.75	m ³	4.00		\$1,330.99
	Calcium Chloride Flake			2156.20	kg	0.30		\$646.86
	E-W Ramp Mud I/C							
	Asphalt Surface - SMA			205.00	t	65.00		\$13,325.00
	Binder Course - HL8 HD			590.00	t	55.00		\$32,450.00
	Granular Base			1660.00	t	7.00		\$11,620.00
	Granular Sub-Base			2545.00	t	7.00		\$17,815.00
	Water for Compaction & Dust			120.00	m ³	4.00		\$480.00
	Calcium Chloride Flake			1500.00	kg	0.30		\$450.00

W-S Ramp Mud I/C							
Asphalt Surface - SMA				280.00	t	65.00	\$18,200.00
Binder Course - HL8 HD				806.00	t	55.00	\$44,330.00
Granular Base				1358.00	t	7.00	\$9,506.00
Granular Sub-Base				3986.00	t	7.00	\$27,902.00
Water for Compaction & Dust				155.00	m ³	4.00	\$620.00
Calcium Chloride Flake				2050.00	kg	0.30	\$615.00
S-W Ramp Mud I/C							
Asphalt Surface - SMA				233.00	t	65.00	\$15,145.00
Binder Course - HL8 HD				668.00	t	55.00	\$36,740.00
Granular Base				1179.00	t	7.00	\$8,253.00
Granular Sub-Base				2982.00	t	7.00	\$20,874.00
Water for Compaction & Dust				120.00	m ³	4.00	\$480.00
Calcium Chloride Flake				1700.00	kg	0.30	\$510.00
E-N Ramp Mud I/C							
Asphalt Surface - SMA				438.00	t	65.00	\$28,470.00
Binder Course - HL8 HD				1216.00	t	55.00	\$66,880.00
Granular Base				2372.00	t	7.00	\$16,604.00
Granular Sub-Base				5967.00	t	7.00	\$41,769.00
Water for Compaction & Dust				240.00	m ³	4.00	\$960.00
Calcium Chloride Flake				3200.00	kg	0.30	\$960.00
S-N Ramp Mud I/C							
Asphalt Surface - SMA				862.00	t	65.00	\$56,030.00
Binder Course - HL8 HD				2202.00	t	55.00	\$121,110.00
Granular Base				5463.00	t	7.00	\$38,241.00
Granular Sub-Base				8819.00	t	7.00	\$61,733.00
Water for Compaction & Dust				400.00	m ³	4.00	\$1,600.00
Calcium Chloride Flake					kg	0.30	\$0.00
N-S/E Ramp Mud I/C							
Asphalt Surface - SMA				553.00	t	65.00	\$35,945.00
Binder Course - HL8 HD				1502.00	t	55.00	\$82,610.00
Granular Base				2801.00	t	7.00	\$19,607.00
Granular Sub-Base				4785.00	t	7.00	\$33,495.00
Water for Compaction & Dust				210.00	m ³	4.00	\$840.00
Calcium Chloride Flake				4100.00	kg	0.30	\$1,230.00
N-S Ramp Mud I/C							
Asphalt Surface - SMA				564.00	t	65.00	\$36,660.00
Binder Course - HL8 HD				1315.00	t	55.00	\$72,325.00
Granular Base				2173.00	t	7.00	\$15,211.00
Granular Sub-Base				5943.00	t	7.00	\$41,601.00
Water for Compaction & Dust				230.00	m ³	4.00	\$920.00
Calcium Chloride Flake				4700.00	kg	0.30	\$1,410.00

N-E Ramp Mud I/C							
Asphalt Surface - SMA				1054.00	t	65.00	\$68,510.00
Binder Course - HL8 HD				1075.00	t	55.00	\$59,125.00
Granular Base				1736.00	t	7.00	\$12,152.00
Granular Sub-Base				4207.00	t	7.00	\$29,449.00
Water for Compaction & Dust				165.00	m ³	4.00	\$660.00
Calcium Chloride Flake				7700.00	kg	0.30	\$2,310.00
South Ramp Extension							
Asphalt Surface - SMA				448.00	t	65.00	\$29,120.00
Binder Course - HL8 HD				1215.00	t	55.00	\$66,825.00
Granular Base				2020.00	t	7.00	\$14,140.00
Granular Sub-Base				5178.00	t	7.00	\$36,246.00
Water for Compaction & Dust				210.00	m ³	4.00	\$840.00
Calcium Chloride Flake				3150.00	kg	0.30	\$945.00
N-E Ramp Greenhill I/C							
Asphalt Surface - SMA				257.00	t	65.00	\$16,705.00
Binder Course - HL8 HD				631.00	t	55.00	\$34,705.00
Granular Base				1440.00	t	7.00	\$10,080.00
Granular Sub-Base				2350.00	t	7.00	\$16,450.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake				1800.00	kg	0.30	\$540.00
E-N Ramp Greenhill I/C							
Asphalt Surface - SMA				282.00	t	65.00	\$18,330.00
Binder Course - HL8 HD				693.00	t	55.00	\$38,115.00
Granular Base				1440.00	t	7.00	\$10,080.00
Granular Sub-Base				2350.00	t	7.00	\$16,450.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake				3120.00	kg	0.30	\$936.00
E-S Ramp Greenhill I/C							
Asphalt Surface - SMA				186.00	t	65.00	\$12,090.00
Binder Course - HL8 HD				455.00	t	55.00	\$25,025.00
Granular Base				1200.00	t	7.00	\$8,400.00
Granular Sub-Base				1800.00	t	7.00	\$12,600.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake				1800.00	kg	0.30	\$540.00
S-E Ramp Greenhill I/C							
Asphalt Surface - SMA				248.00	t	65.00	\$16,120.00
Binder Course - HL8 HD				608.00	t	55.00	\$33,440.00
Granular Base				1400.00	t	7.00	\$9,800.00
Granular Sub-Base				2230.00	t	7.00	\$15,610.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake				1800.00	kg	0.30	\$540.00
Greenhill Ave Extension							
Asphalt Surface - SMA				407.00	t	65.00	\$26,455.00
Binder Course - HL8 HD				900.00	t	55.00	\$49,500.00
Granular Base				1600.00	t	7.00	\$11,200.00
Granular Sub-Base				3110.00	t	7.00	\$21,770.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake				1840.00	kg	0.30	\$552.00

N-W/E Ramp King St. I/C						
Asphalt Surface - SMA			420.00	t	65.00	\$27,300.00
Binder Course - HL8 HD			1088.00	t	55.00	\$59,840.00
Granular Base			1740.00	t	7.00	\$12,180.00
Granular Sub-Base			2970.00	t	7.00	\$20,790.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2350.00	kg	0.30	\$705.00
S-W/E Ramp King St. I/C						
Asphalt Surface - SMA			445.00	t	65.00	\$28,925.00
Binder Course - HL8 HD			1451.00	t	55.00	\$79,805.00
Granular Base			2350.00	t	7.00	\$16,450.00
Granular Sub-Base			3600.00	t	7.00	\$25,200.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2350.00	kg	0.30	\$705.00
E/W-S Ramp King St. I/C						
Asphalt Surface - SMA			256.00	t	65.00	\$16,640.00
Binder Course - HL8 HD			674.00	t	55.00	\$37,070.00
Granular Base			800.00	t	7.00	\$5,600.00
Granular Sub-Base			1450.00	t	7.00	\$10,150.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2350.00	kg	0.30	\$705.00
E/W-N Ramp King St. I/C						
Asphalt Surface - SMA			237.00	t	65.00	\$15,405.00
Binder Course - HL8 HD			686.00	t	55.00	\$37,730.00
Granular Base			925.00	t	7.00	\$6,475.00
Granular Sub-Base			1700.00	t	7.00	\$11,900.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2260.00	kg	0.30	\$678.00
E/W-S Ramp Queenston I/C						
Asphalt Surface - SMA			192.00	t	65.00	\$12,480.00
Binder Course - HL8 HD			485.00	t	55.00	\$26,675.00
Granular Base			600.00	t	7.00	\$4,200.00
Granular Sub-Base			1050.00	t	7.00	\$7,350.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2000.00	kg	0.30	\$600.00
S-W/E Ramp Queenston I/C						
Asphalt Surface - SMA			300.00	t	65.00	\$19,500.00
Binder Course - HL8 HD			869.00	t	55.00	\$47,795.00
Granular Base			1350.00	t	7.00	\$9,450.00
Granular Sub-Base			2330.00	t	7.00	\$16,310.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2000.00	kg	0.30	\$600.00
N-E/W Ramp Queenston I/C						
Asphalt Surface - SMA			394.00	t	65.00	\$25,610.00
Binder Course - HL8 HD			953.00	t	55.00	\$52,415.00
Granular Base			2000.00	t	7.00	\$14,000.00
Granular Sub-Base			3600.00	t	7.00	\$25,200.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2000.00	kg	0.30	\$600.00

W/E-N Ramp Queenston I/C						
Asphalt Surface - SMA			262.00	t	65.00	\$17,030.00
Binder Course - HL8 HD			757.00	t	55.00	\$41,635.00
Granular Base			1460.00	t	7.00	\$10,220.00
Granular Sub-Base			3350.00	t	7.00	\$23,450.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake			2000.00	kg	0.30	\$600.00
N-W/E Ramp Barton St. I/C						
Asphalt Surface - SMA			400.00	t	65.00	\$26,000.00
Binder Course - HL8 HD			1000.00	t	55.00	\$55,000.00
Granular Base			1900.00	t	18.00	\$34,200.00
Granular Sub-Base			3600.00	t	17.00	\$61,200.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake				kg	0.30	\$0.00
E/W-S Ramp Barton St. I/C						
Asphalt Surface - SMA			200.00	t	65.00	\$13,000.00
Binder Course - HL8 HD			550.00	t	55.00	\$30,250.00
Granular Base			800.00	t	18.00	\$14,400.00
Granular Sub-Base			1600.00	t	17.00	\$27,200.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake				kg	0.30	\$0.00
E/W-N Ramp Barton St. I/C						
Asphalt Surface - SMA			250.00	t	65.00	\$16,250.00
Binder Course - HL8 HD			600.00	t	55.00	\$33,000.00
Granular Base			800.00	t	18.00	\$14,400.00
Granular Sub-Base			1700.00	t	17.00	\$28,900.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake				kg	0.30	\$0.00
S-W/E Ramp Barton St. I/C						
Asphalt Surface - SMA			450.00	t	65.00	\$29,250.00
Binder Course - HL8 HD			1100.00	t	55.00	\$60,500.00
Granular Base			2200.00	t	18.00	\$39,600.00
Granular Sub-Base			4100.00	t	17.00	\$69,700.00
Water for Compaction & Dust				m ³	4.00	\$0.00
Calcium Chloride Flake				kg	0.30	\$0.00
TOTAL						\$10,850,079.25

Totals	SMA	Mainline	24,086	t	\$ 65.00	\$1,565,600.40
		Ramps	9,823		\$ 65.00	\$638,495.00
	HL8 (HS)	Mainline	52,236	t	\$ 55.00	\$2,872,964.60
		Ramps	24,089		\$ 55.00	\$1,324,895.00
	Granular Base	from stock pile	127,399	t	\$ 7.00	\$891,791.95
	Granular Base	from quarry	21,135	t	\$ 18.00	\$380,428.92
	Granular Sub-B	from stock pile	315,654	t	\$ 7.00	\$2,209,579.19
	Granular Sub-B	from quarry	52,065	t	\$ 17.00	\$885,103.47
						\$10,768,858.53

Ramps and Crossovers 2 km long

HL 1	1,400	t	\$55	\$77,000
HL8 (HS)	2,020	t	\$50	\$101,000
Granular Base	3,080	t	\$7	\$21,560
Granular Sub-Base	9,240	t	\$7	\$64,680
Grading and Drainage	2	km	\$40,000	\$80,000
Total Detour				\$344,240

Table 3
Construction Cost Summary for Perpetual Pavement - Option 1

WBS Code	Description	Wide Median 2 NB & 3SB	Narrow Median 2 NB & 3SB	Wide Median 2 NB & 2 NB	Narrow Median 2 NB & 2SB	Budget Quantity	Unit	Unit Rate	Budget Total
20.03	21+000 to 21+600								
	Asphalt Surface - SMA	1911.60				1911.60	t	65.00	\$124,254.00
	Binder Course - HL8 HD	3528.00				3528.00	t	55.00	\$194,040.00
	Rich Bottom Layer - Superpave 25	2822.40				2822.40	t	50.00	\$141,120.00
	Granular Base	8152.70				8152.70	t	7.00	\$57,068.90
	Granular Sub-Base	19402.53				19402.53	t	7.00	\$135,817.71
	Water for Compaction & Dust					688.88	m ³	4.00	\$2,755.52
	Calcium Chloride Flake					4463.95	kg	0.30	\$1,339.18
20.04	21+600 to 22+525								
	21+600 to 22+425								
	Asphalt Surface - SMA	2628.45				2628.45	t	65.00	\$170,849.25
	Binder Course - HL8 HD	4682.57				4682.57	t	55.00	\$257,541.35
	Rich Bottom Layer - Superpave 25	3746.05				3746.05	t	50.00	\$187,302.50
	Granular Base	11209.97				11209.97	t	7.00	\$78,469.79
	Granular Sub-Base	26678.47				26678.47	t	7.00	\$186,749.29
	Water for Compaction & Dust					947.21	m ³	4.00	\$3,788.84
	Calcium Chloride Flake					6137.93	kg	0.30	\$1,841.38
	22+425 to 22+525								
	Asphalt Surface - SMA		318.60			318.60	t	65.00	\$20,709.00
	Binder Course - HL8 HD		588.00			588.00	t	55.00	\$32,340.00
	Rich Bottom Layer - Superpave 25		470.40			470.40	t	50.00	\$23,520.00
	Granular Base		1289.59			1289.59	t	7.00	\$9,027.13
	Granular Sub-Base		2958.34			2958.34	t	7.00	\$20,708.38
	Water for Compaction & Dust					106.20	m ³	4.00	\$424.79
	Calcium Chloride Flake					688.16	kg	0.30	\$206.45
20.05	22+525 to 23+895								
	22+525 to 23+000								
	Asphalt Surface - SMA		1513.35			1513.35	t	65.00	\$98,367.75
	Binder Course - HL8 HD		2793.00			2793.00	t	55.00	\$153,615.00
	Rich Bottom Layer - Superpave 25		1862.00			1862.00	t	50.00	\$93,100.00
	Granular Base		6125.56			6125.56	t	7.00	\$42,878.92
	Granular Sub-Base		14052.10			14052.10	t	7.00	\$98,364.70
	Water for Compaction & Dust					504.44	m ³	4.00	\$2,017.77
	Calcium Chloride Flake					3268.78	kg	0.30	\$980.83
	23+000 to 23+895								
	Asphalt Surface - SMA	2851.47				2851.47	t	65.00	\$185,345.55
	Binder Course - HL8 HD	5262.60				5262.60	t	55.00	\$289,443.00
	Rich Bottom Layer - Superpave 25	3508.40				3508.40	t	50.00	\$175,420.00
	Granular Base	12161.12				12161.12	t	7.00	\$85,127.84
	Granular Sub-Base	28942.10				28942.10	t	7.00	\$202,594.70
	Water for Compaction & Dust					1027.58	m ³	4.00	\$4,110.32
	Calcium Chloride Flake					6658.72	kg	0.30	\$1,997.62

20.06	23+895 to 26+020								
	23+895 to 24+400								
	Asphalt Surface - SMA	1608.93		1608.93	t	65.00		\$104,580.45	
	Binder Course - HL8 HD	3042.85		3042.85	t	55.00		\$167,356.75	
	Rich Bottom Layer - Superpave 25	2212.98		2212.98	t	50.00		\$110,649.00	
	Granular Base	6861.86		6861.86	t	7.00		\$48,033.02	
	Granular Sub-Base	16581.70		16581.70	t	7.00		\$116,071.90	
	Water for Compaction & Dust			586.09	m ³	4.00		\$2,344.36	
	Calcium Chloride Flake			3797.86	kg	0.30		\$1,139.36	
	24+400 to 26+020								
	Asphalt Surface - SMA	4548.96		4548.96	t	65.00		\$295,682.40	
	Binder Course - HL8 HD	8261.63		8261.63	t	55.00		\$454,389.65	
	Rich Bottom Layer - Superpave 25	6008.46		6008.46	t	50.00		\$300,423.00	
	Granular Base	19971.10		19971.10	t	7.00		\$139,797.70	
	Granular Sub-Base	4871.76		4871.76	t	7.00		\$34,102.32	
	Water for Compaction & Dust			621.07	m ³	4.00		\$2,484.29	
	Calcium Chloride Flake			4024.54	kg	0.30		\$1,207.36	
20.07	26+020 to 27+850								
	Asphalt Surface - SMA	5138.64		5138.64	t	65.00		\$334,011.60	
	Binder Course - HL8 HD	9332.58		9332.58	t	55.00		\$513,291.90	
	Rich Bottom Layer - Superpave 25	6787.33		6787.33	t	50.00		\$339,366.50	
	Granular Base	22559.95		22559.95	t	7.00		\$157,919.65	
	Granular Sub-Base	55040.28		55040.28	t	7.00		\$385,281.96	
	Water for Compaction & Dust			1940.01	m ³	4.00		\$7,760.02	
	Calcium Chloride Flake			12571.24	kg	0.30		\$3,771.37	
20.08	27+850 to 28+800								
	Asphalt Surface - SMA	2667.60		2667.60	t	65.00		\$173,394.00	
	Binder Course - HL8 HD	4844.78		4844.78	t	55.00		\$266,462.90	
	Rich Bottom Layer - Superpave 25	3523.48		3523.48	t	50.00		\$176,174.00	
	Granular Base	11711.45		11711.45	t	18.00		\$210,806.10	
	Granular Sub-Base	28572.83		28572.83	t	17.00		\$485,738.11	
	Water for Compaction & Dust			1007.11	m ³	4.00		\$4,028.43	
	Calcium Chloride Flake			6526.05	kg	0.30		\$1,957.82	
20.09	28+800 to 29+120								
	Asphalt Surface - SMA	898.56		898.56	t	65.00		\$58,406.40	
	Binder Course - HL8 HD	1631.93		1631.93	t	55.00		\$89,756.15	
	Rich Bottom Layer - Superpave 25	1186.86		1186.86	t	50.00		\$59,343.00	
	Granular Base	3723.49		3723.49	t	18.00		\$67,022.82	
	Granular Sub-Base	8436.00		8436.00	t	17.00		\$143,412.00	
	Water for Compaction & Dust			303.99	m ³	4.00		\$1,215.95	
	Calcium Chloride Flake			1969.84	kg	0.30		\$590.95	
	E-W Ramp Mud I/C								
	Asphalt Surface - SMA			205.00	t	65.00		\$13,325.00	
	Binder Course - HL8 HD			590.00	t	55.00		\$32,450.00	
	Granular Base			1660.00	t	7.00		\$11,620.00	
	Granular Sub-Base			2545.00	t	7.00		\$17,815.00	
	Water for Compaction & Dust			120.00	m ³	4.00		\$480.00	
	Calcium Chloride Flake			1500.00	kg	0.30		\$450.00	

W-S Ramp Mud I/C							
	Asphalt Surface - SMA			280.00	t	65.00	\$18,200.00
	Binder Course - HL8 HD			806.00	t	55.00	\$44,330.00
	Granular Base			1358.00	t	7.00	\$9,506.00
	Granular Sub-Base			3986.00	t	7.00	\$27,902.00
	Water for Compaction & Dust			155.00	m ³	4.00	\$620.00
	Calcium Chloride Flake			2050.00	kg	0.30	\$615.00
S-W Ramp Mud I/C							
	Asphalt Surface - SMA			233.00	t	65.00	\$15,145.00
	Binder Course - HL8 HD			668.00	t	55.00	\$36,740.00
	Granular Base			1179.00	t	7.00	\$8,253.00
	Granular Sub-Base			2982.00	t	7.00	\$20,874.00
	Water for Compaction & Dust			120.00	m ³	4.00	\$480.00
	Calcium Chloride Flake			1700.00	kg	0.30	\$510.00
E-N Ramp Mud I/C							
	Asphalt Surface - SMA			438.00	t	65.00	\$28,470.00
	Binder Course - HL8 HD			1216.00	t	55.00	\$66,880.00
	Granular Base			2372.00	t	7.00	\$16,604.00
	Granular Sub-Base			5967.00	t	7.00	\$41,769.00
	Water for Compaction & Dust			240.00	m ³	4.00	\$960.00
	Calcium Chloride Flake			3200.00	kg	0.30	\$960.00
S-N Ramp Mud I/C							
	Asphalt Surface - SMA			862.00	t	65.00	\$56,030.00
	Binder Course - HL8 HD			2202.00	t	55.00	\$121,110.00
	Granular Base			5463.00	t	7.00	\$38,241.00
	Granular Sub-Base			8819.00	t	7.00	\$61,733.00
	Water for Compaction & Dust			400.00	m ³	4.00	\$1,600.00
	Calcium Chloride Flake				kg	0.30	\$0.00
N-S/E Ramp Mud I/C							
	Asphalt Surface - SMA			553.00	t	65.00	\$35,945.00
	Binder Course - HL8 HD			1502.00	t	55.00	\$82,610.00
	Granular Base			2801.00	t	7.00	\$19,607.00
	Granular Sub-Base			4785.00	t	7.00	\$33,495.00
	Water for Compaction & Dust			210.00	m ³	4.00	\$840.00
	Calcium Chloride Flake			4100.00	kg	0.30	\$1,230.00
N-S Ramp Mud I/C							
	Asphalt Surface - SMA			564.00	t	65.00	\$36,660.00
	Binder Course - HL8 HD			1315.00	t	55.00	\$72,325.00
	Granular Base			2173.00	t	7.00	\$15,211.00
	Granular Sub-Base			5943.00	t	7.00	\$41,601.00
	Water for Compaction & Dust			230.00	m ³	4.00	\$920.00
	Calcium Chloride Flake			4700.00	kg	0.30	\$1,410.00
N-E Ramp Mud I/C							
	Asphalt Surface - SMA			1054.00	t	65.00	\$68,510.00
	Binder Course - HL8 HD			1075.00	t	55.00	\$59,125.00
	Granular Base			1736.00	t	7.00	\$12,152.00
	Granular Sub-Base			4207.00	t	7.00	\$29,449.00
	Water for Compaction & Dust			165.00	m ³	4.00	\$660.00
	Calcium Chloride Flake			7700.00	kg	0.30	\$2,310.00

South Ramp Extension						
Asphalt Surface - SMA		448.00	t	65.00		\$29,120.00
Binder Course - HL8 HD		1215.00	t	55.00		\$66,825.00
Granular Base		2020.00	t	7.00		\$14,140.00
Granular Sub-Base		5178.00	t	7.00		\$36,246.00
Water for Compaction & Dust		210.00	m ³	4.00		\$840.00
Calcium Chloride Flake		3150.00	kg	0.30		\$945.00
N-E Ramp Greenhill I/C						
Asphalt Surface - SMA		257.00	t	65.00		\$16,705.00
Binder Course - HL8 HD		631.00	t	55.00		\$34,705.00
Granular Base		1440.00	t	7.00		\$10,080.00
Granular Sub-Base		2350.00	t	7.00		\$16,450.00
Water for Compaction & Dust			m ³	4.00		\$0.00
Calcium Chloride Flake		1800.00	kg	0.30		\$540.00
E-N Ramp Greenhill I/C						
Asphalt Surface - SMA		282.00	t	65.00		\$18,330.00
Binder Course - HL8 HD		693.00	t	55.00		\$38,115.00
Granular Base		1440.00	t	7.00		\$10,080.00
Granular Sub-Base		2350.00	t	7.00		\$16,450.00
Water for Compaction & Dust			m ³	4.00		\$0.00
Calcium Chloride Flake		3120.00	kg	0.30		\$936.00
E-S Ramp Greenhill I/C						
Asphalt Surface - SMA		186.00	t	65.00		\$12,090.00
Binder Course - HL8 HD		455.00	t	55.00		\$25,025.00
Granular Base		1200.00	t	7.00		\$8,400.00
Granular Sub-Base		1800.00	t	7.00		\$12,600.00
Water for Compaction & Dust			m ³	4.00		\$0.00
Calcium Chloride Flake		1800.00	kg	0.30		\$540.00
S-E Ramp Greenhill I/C						
Asphalt Surface - SMA		248.00	t	65.00		\$16,120.00
Binder Course - HL8 HD		608.00	t	55.00		\$33,440.00
Granular Base		1400.00	t	7.00		\$9,800.00
Granular Sub-Base		2230.00	t	7.00		\$15,610.00
Water for Compaction & Dust			m ³	4.00		\$0.00
Calcium Chloride Flake		1800.00	kg	0.30		\$540.00
Greenhill Ave Extension						
Asphalt Surface - SMA		407.00	t	65.00		\$26,455.00
Binder Course - HL8 HD		900.00	t	55.00		\$49,500.00
Granular Base		1600.00	t	7.00		\$11,200.00
Granular Sub-Base		3110.00	t	7.00		\$21,770.00
Water for Compaction & Dust			m ³	4.00		\$0.00
Calcium Chloride Flake		1840.00	kg	0.30		\$552.00
N-W/E Ramp King St. I/C						
Asphalt Surface - SMA		420.00	t	65.00		\$27,300.00
Binder Course - HL8 HD		1088.00	t	55.00		\$59,840.00
Granular Base		1740.00	t	7.00		\$12,180.00
Granular Sub-Base		2970.00	t	7.00		\$20,790.00
Water for Compaction & Dust			m ³	4.00		\$0.00
Calcium Chloride Flake		2350.00	kg	0.30		\$705.00
S-W/E Ramp King St. I/C						
Asphalt Surface - SMA		445.00	t	65.00		\$28,925.00
Binder Course - HL8 HD		1451.00	t	55.00		\$79,805.00
Granular Base		2350.00	t	7.00		\$16,450.00
Granular Sub-Base		3600.00	t	7.00		\$25,200.00
Water for Compaction & Dust			m ³	4.00		\$0.00
Calcium Chloride Flake		2350.00	kg	0.30		\$705.00

EW-S Ramp King St. I/C						
Asphalt Surface - SMA	256.00	t	65.00			\$16,640.00
Binder Course - HL8 HD	674.00	t	55.00			\$37,070.00
Granular Base	800.00	t	7.00			\$5,600.00
Granular Sub-Base	1450.00	t	7.00			\$10,150.00
Water for Compaction & Dust		m ³	4.00			\$0.00
Calcium Chloride Flake	2350.00	kg	0.30			\$705.00
EW-N Ramp King St. I/C						
Asphalt Surface - SMA	237.00	t	65.00			\$15,405.00
Binder Course - HL8 HD	686.00	t	55.00			\$37,730.00
Granular Base	925.00	t	7.00			\$6,475.00
Granular Sub-Base	1700.00	t	7.00			\$11,900.00
Water for Compaction & Dust		m ³	4.00			\$0.00
Calcium Chloride Flake	2260.00	kg	0.30			\$678.00
EW-S Ramp Queenston I/C						
Asphalt Surface - SMA	192.00	t	65.00			\$12,480.00
Binder Course - HL8 HD	485.00	t	55.00			\$26,675.00
Granular Base	600.00	t	7.00			\$4,200.00
Granular Sub-Base	1050.00	t	7.00			\$7,350.00
Water for Compaction & Dust		m ³	4.00			\$0.00
Calcium Chloride Flake	2000.00	kg	0.30			\$600.00
S-W/E Ramp Queenston I/C						
Asphalt Surface - SMA	300.00	t	65.00			\$19,500.00
Binder Course - HL8 HD	869.00	t	55.00			\$47,795.00
Granular Base	1350.00	t	7.00			\$9,450.00
Granular Sub-Base	2330.00	t	7.00			\$16,310.00
Water for Compaction & Dust		m ³	4.00			\$0.00
Calcium Chloride Flake	2000.00	kg	0.30			\$600.00
N-E/W Ramp Queenston I/C						
Asphalt Surface - SMA	394.00	t	65.00			\$25,610.00
Binder Course - HL8 HD	953.00	t	55.00			\$52,415.00
Granular Base	2000.00	t	7.00			\$14,000.00
Granular Sub-Base	3600.00	t	7.00			\$25,200.00
Water for Compaction & Dust		m ³	4.00			\$0.00
Calcium Chloride Flake	2000.00	kg	0.30			\$600.00
W/E-N Ramp Queenston I/C						
Asphalt Surface - SMA	262.00	t	65.00			\$17,030.00
Binder Course - HL8 HD	757.00	t	55.00			\$41,635.00
Granular Base	1460.00	t	7.00			\$10,220.00
Granular Sub-Base	3350.00	t	7.00			\$23,450.00
Water for Compaction & Dust		m ³	4.00			\$0.00
Calcium Chloride Flake	2000.00	kg	0.30			\$600.00
N-W/E Ramp Barton St. I/C						
Asphalt Surface - SMA	400.00	t	65.00			\$26,000.00
Binder Course - HL8 HD	1000.00	t	55.00			\$55,000.00
Granular Base	1900.00	t	18.00			\$34,200.00
Granular Sub-Base	3600.00	t	17.00			\$61,200.00
Water for Compaction & Dust		m ³	4.00			\$0.00
Calcium Chloride Flake		kg	0.30			\$0.00

E/W-S Ramp Barton St. I/C							
Asphalt Surface - SMA				200.00	t	65.00	\$13,000.00
Binder Course - HL8 HD				550.00	t	55.00	\$30,250.00
Granular Base				800.00	t	18.00	\$14,400.00
Granular Sub-Base				1600.00	t	17.00	\$27,200.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake					kg	0.30	\$0.00
E/W-N Ramp Barton St. I/C							
Asphalt Surface - SMA				250.00	t	65.00	\$16,250.00
Binder Course - HL8 HD				600.00	t	55.00	\$33,000.00
Granular Base				800.00	t	18.00	\$14,400.00
Granular Sub-Base				1700.00	t	17.00	\$28,900.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake					kg	0.30	\$0.00
S-W/E Ramp Barton St. I/C							
Asphalt Surface - SMA				450.00	t	65.00	\$29,250.00
Binder Course - HL8 HD				1100.00	t	55.00	\$60,500.00
Granular Base				2200.00	t	18.00	\$39,600.00
Granular Sub-Base				4100.00	t	17.00	\$69,700.00
Water for Compaction & Dust					m ³	4.00	\$0.00
Calcium Chloride Flake					kg	0.30	\$0.00
TOTAL							\$11,425,914.45

Totals	SMA	Mainline	24,086	t	\$ 65.00	\$1,565,600.40
		Ramps	9,823	t	\$ 65.00	\$638,495.00
	HL8 (HS)	Mainline	43,968	t	\$ 55.00	\$2,418,236.70
		Ramps	24,089	t	\$ 55.00	\$1,324,895.00
	RBL Superpave 25	Mainline	32,128	t	\$ 50.00	\$1,606,418.00
		Granular E from stock pile	127,399	t	\$ 7.00	\$891,791.95
		Granular E from quarry	21,135	t	\$ 18.00	\$380,428.92
		Granular E from stock pile	244,829	t	\$ 7.00	\$1,713,804.96
		Granular E from quarry	48,009	t	\$ 17.00	\$816,150.11
						\$11,355,821.04

Table 4
Summary of Life Cycle Cost Analysis
Mainline Only

OPTION 1 - DEEP STRENGTH PAVEMENT					
Construction Item		Quantity	Unit	Price	Cost
SMA		23,381	t	70	1,636,670
HL8 (HS)		53,913	t	55	2,965,215
Granular Base	from stock pile	91,403	t	7	639,821
Granular Base	from quarry	24,000	t	18	432,000
Granular Sub-Base	from stock pile	187,477	t	7	1,312,339
Granular Sub-Base	from quarry	105,000	t	17	1,785,000
Other		-	-	-	57,090
Total Construction					8,828,135
M&R Cost		7.5	km	398,113	2,985,848
User Delay Cost		7.5	km	170,606	1,279,545
Total LCCA Costs without Initial Construction Costs					4,265,393
TOTAL LCCA COST FOR DEEP STRENGTH OPTION					13,093,528
OPTION 2 - PERPETUAL PAVEMENT					
Construction Item		Quantity	Unit	Price	Cost
SMA		23,381	t	70	1,636,670
HL8 (HS)		44,928	t	55	2,471,040
RBL Superpave 25		32,128	t	50	1,606,400
Granular Base	from stock pile	91,403	t	7	639,821
Granular Base	from quarry	24,000	t	18	432,000
Granular Sub-Base	from stock pile	162,480	t	7	1,137,360
Granular Sub-Base	from quarry	91,000	t	17	1,547,000
Other		-	-	-	45,962
Total Construction					9,516,253
M&R Cost		7.5	km	158,636	1,189,771
User Delay Cost		7.5	km	60,407	453,056
Total LCCA Costs without Initial Construction Costs					1,642,827
TOTAL LCCA COST FOR PERPETUAL PAVEMENT OPTION					11,159,080

Discount Rate 5.3%
Width of 4 lanes 15 m
Length for Analysis 7.5 km

Table 5
Present Worth of M&R Work and Residual Value for Deep Strength Pavement - Option 1
Flexible Pavement: 170 mm of HMA; 150 mm of Gran. Base and 500 mm of Gran. Subbase
Mainline Only
Average Cost per km of 4 lane width

Construction Cost per km for 4-lane width = 10850079/7.5 = \$1,035,383

Scheduled Maint./Rehab. Year	Maintenance/Rehabilitation Activity	Quantities/km		Pay Item Price \$	Cost/km \$	Present Worth Maint./Rehab.
3	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$514
9	Rout and Seal Cracks	640	m	\$2.50	\$1,600.00	\$1,005
	Mill (40 mm) and 40-mm Patch	740	m ²	\$10.00	\$7,400.00	\$4,649
15	Rout and Seal Cracks	1,200	m	\$2.50	\$3,000.00	\$1,383
	Mill (40 mm) and 40-mm Patch	3,040	m ²	\$10.00	\$30,400.00	\$14,010
19	Mill 80-mm Asphalt Pavement	3,080	t	\$10.00	\$30,800.00	\$11,545
	Resurface SMA 40-mm	1,620	t	\$65.00	\$105,300.00	\$39,472
	HL 8 HS 40-mm	1,460	t	\$55.00	\$80,300.00	\$30,101
	Tack Coat - 2 Layers	30,000	m ²	\$0.23	\$6,900.00	\$2,586
	3% full base repairs	450	m ²	\$65.00	\$29,250.00	\$10,964
	Barrier walls, signage, paving crossovers, etc	1	km	\$230,000.00	\$230,000.00	\$86,216
22	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$193
27	Rout and Seal Cracks	960	m	\$2.50	\$2,400.00	\$595
	Mill (40 mm) and 40-mm Patch	1,500	m ²	\$10.00	\$15,000.00	\$3,720
31	Mill 80-mm Asphalt Pavement	3,080	t	\$10.00	\$30,800.00	\$6,213
	Resurface SMA 40-mm	1,620	t	\$65.00	\$105,300.00	\$21,240
	HL 8 HS 40-mm	1,460	t	\$55.00	\$80,300.00	\$16,197
	Tack Coat - 2 Layers	30,000	m ²	\$0.23	\$6,900.00	\$1,392
	6% full base repairs	900	m ²	\$65.00	\$58,500.00	\$11,800
	Barrier walls, signage, paving crossovers, etc	1	km	\$230,000.00	\$230,000.00	\$46,393
34	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$104
38	Rout and Seal Cracks	960	m	\$2.50	\$2,400.00	\$337
	Mill (40 mm) and 40-mm Patch	1,500	m ²	\$10.00	\$15,000.00	\$2,108
42	Mill 80-mm Asphalt Pavement	3,080	t	\$10.00	\$30,800.00	\$3,520
	Resurface SMA 40-mm	1,620	t	\$65.00	\$105,300.00	\$12,035
	HL 8 HS 40-mm	1,460	t	\$55.00	\$80,300.00	\$9,177
	Tack Coat - 2 Layers	30,000	m ²	\$0.23	\$6,900.00	\$789
	10% full base repairs	1,500	m ²	\$65.00	\$97,500.00	\$11,143
	Barrier walls, signage, paving crossovers, etc	1	km	\$230,000.00	\$230,000.00	\$26,287
45	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$59
48	Rout and Seal Cracks	960	m ²	\$2.50	\$2,400.00	\$201
	Mill (40 mm) and 40-mm Patch	1,500	m ²	\$10.00	\$15,000.00	\$1,258
70	Full reconstruction	1	km	\$1,035,383.00	\$1,035,383.00	\$27,869
M&R Costs						\$405,073
50	Residual Value	1	km			-\$6,960
Present Cost						\$398,113

Table 6
Present Worth of M&R Work and Residual Value for Perpetual Pavement - Option 2
Perpetual Pavement: 230 mm of HMA; 150 mm of Gran. Base and 440 mm of Gran. Subbase
Mainline Only
Average Cost per km of 4 lanes width

Construction cost per km for 4-lane width = $8341210/7.5 =$ \$1,112,161

Scheduled Maint./Rehab. Year	Maintenance/Rehabilitation Activity	Quantities/km		Pay Item Price \$	Cost/km \$	Present Worth Maint./Rehab.
3	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$514
9	Rout and Seal Cracks	640	m	\$2.50	\$1,600.00	\$1,005
	Mill (40 mm) and 40-mm Patch	740	m ²	\$10.00	\$7,400.00	\$4,649
15	Rout and Seal Cracks	1,200	m	\$2.50	\$3,000.00	\$1,383
	Mill (40 mm) and 40-mm Patch	3,040	m ²	\$10.00	\$30,400.00	\$14,010
19	Rout and Seal Cracks	1,200	m	\$2.50	\$3,000.00	\$1,125
	Mill (40 mm) and 40-mm Patch	3,040	m ²	\$10.00	\$30,400.00	\$11,396
21	Mill 40-mm Asphalt Pavement	1,616	t	\$10.00	\$16,160.00	\$5,463
	Resurface SMA 40-mm	1,616	t	\$65.00	\$105,040.00	\$35,511
	Tack Coat	30,000	m ²	\$0.12	\$3,600.00	\$1,217
	Signage and other misc. costs	1	km	\$50,000.00	\$50,000.00	\$16,903
24	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$174
28	Rout and Seal Cracks	960	m	\$2.50	\$2,400.00	\$565
	Mill (40 mm) and 40-mm Patch	1,500	m ²	\$10.00	\$15,000.00	\$3,533
31	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$121
34	Mill 40-mm Asphalt Pavement	1,616	t	\$10.00	\$16,160.00	\$2,792
	Resurface SMA 40-mm	1,616	t	\$65.00	\$105,040.00	\$18,146
	Tack Coat	30,000	m ²	\$0.12	\$3,600.00	\$622
	Signage and other misc. costs	1	km	\$50,000.00	\$50,000.00	\$8,638
37	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$89
41	Rout and Seal Cracks	960	m	\$2.50	\$2,400.00	\$289
	Mill (40 mm) and 40-mm Patch	1,500	m ²	\$10.00	\$15,000.00	\$1,805
44	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$62
46	Mill 40-mm Asphalt Pavement	1,616	t	\$10.00	\$16,160.00	\$1,502
	Resurface SMA 40-mm	1,616	t	\$65.00	\$105,040.00	\$9,764
	Tack Coat	30,000	m ²	\$0.12	\$3,600.00	\$335
	Signage and other misc. costs	1	km	\$50,000.00	\$50,000.00	\$4,648
49	Rout and Seal Cracks	240	m	\$2.50	\$600.00	\$48
70	Resurfacing	1	km	\$745,367.00	\$745,367.00	\$20,062
					M&R Costs	\$166,370
50	Residual Value	1	km			-\$7,734
					Present Cost	\$158,636

Table 7
 User Delate Cost Estimate for Deep Strength Pavement - Option 1
 Average Cost per km of 4-lane Width

Original AADT = 22900 Vehicles			Lanes = 4		Driver Truck Car Passenger					
Projected Increase = 3.0% Percent					User Costs (hr)					
Commercial Vehicles = 12% Percent					\$18.00	\$12.00	\$2.50	\$16.50		
Initial Year = 2006					Discount Rate = 5.30 Percent					
Maintenance Activity	Year	AADT	Commercial Vehicles	Delay (d)	Delay (hr)	PW Driver Costs	PW Truck Costs	PW Car Costs	PW Passenger Costs	PW Total User Delay Costs
Initial Construction	0	22900	2700			\$0	\$0	\$0	\$0	\$0
	1	23587	2781			\$0	\$0	\$0	\$0	\$0
	2	24295	2864			\$0	\$0	\$0	\$0	\$0
Rout and Seal	3	25023	2950	0.008	0.20	\$617	\$49	\$76	\$200	\$941
	4	25774	3039			\$0	\$0	\$0	\$0	\$0
	5	26547	3130			\$0	\$0	\$0	\$0	\$0
	6	27344	3224			\$0	\$0	\$0	\$0	\$0
	7	28164	3321			\$0	\$0	\$0	\$0	\$0
	8	29009	3420			\$0	\$0	\$0	\$0	\$0
Rout and Seal, Mill and Patch	9	29879	3523	0.016	0.20	\$1,081	\$85	\$132	\$350	\$1,648
	10	30776	3629			\$0	\$0	\$0	\$0	\$0
	11	31699	3737			\$0	\$0	\$0	\$0	\$0
	12	32650	3850			\$0	\$0	\$0	\$0	\$0
	13	33629	3965			\$0	\$0	\$0	\$0	\$0
	14	34638	4084			\$0	\$0	\$0	\$0	\$0
Rout and Seal, Mill and Patch	15	35677	4207	0.016	0.20	\$947	\$74	\$116	\$306	\$1,444
	16	36748	4333			\$0	\$0	\$0	\$0	\$0
	17	37850	4463			\$0	\$0	\$0	\$0	\$0
	18	38986	4597			\$0	\$0	\$0	\$0	\$0
Mill and Overlay 80/80	19	40155	4734	0.083	2.00	\$44,976	\$3,535	\$5,510	\$14,547	\$68,569
	20	41360	4877			\$0	\$0	\$0	\$0	\$0
	21	42601	5023			\$0	\$0	\$0	\$0	\$0
Rout and Seal	22	43879	5173	0.008	0.20	\$406	\$32	\$50	\$131	\$619
	23	45195	5329			\$0	\$0	\$0	\$0	\$0
	24	46551	5489			\$0	\$0	\$0	\$0	\$0
	25	47948	5653			\$0	\$0	\$0	\$0	\$0
	26	49386	5823			\$0	\$0	\$0	\$0	\$0
Rout and Seal, Mill and Patch	27	50868	5997	0.016	0.20	\$727	\$57	\$89	\$235	\$1,108
	28	52394	6177			\$0	\$0	\$0	\$0	\$0
	29	53965	6363			\$0	\$0	\$0	\$0	\$0
	30	55584	6554			\$0	\$0	\$0	\$0	\$0
Mill and Overlay 80/80	31	57252	6750	0.083	2.00	\$34,506	\$2,712	\$4,227	\$11,160	\$52,606
	32	58969	6953			\$0	\$0	\$0	\$0	\$0
	33	60738	7161			\$0	\$0	\$0	\$0	\$0
Rout and Seal	34	62561	7376	0.008	0.20	\$311	\$24	\$38	\$101	\$475
	35	64437	7597			\$0	\$0	\$0	\$0	\$0
	36	66371	7825			\$0	\$0	\$0	\$0	\$0
	37	68362	8060			\$0	\$0	\$0	\$0	\$0
Rout and Seal, Mill and Patch	38	70413	8302	0.016	0.20	\$570	\$45	\$70	\$184	\$869
	39	72525	8551			\$0	\$0	\$0	\$0	\$0
	40	74701	8808			\$0	\$0	\$0	\$0	\$0
	41	76942	9072			\$0	\$0	\$0	\$0	\$0
Mill and Overlay 80/80	42	79250	9344	0.083	2.00	\$27,064	\$2,127	\$3,316	\$8,753	\$41,260
	43	81627	9624			\$0	\$0	\$0	\$0	\$0
	44	84076	9913			\$0	\$0	\$0	\$0	\$0
Rout and Seal	45	86599	10210	0.008	0.20	\$244	\$19	\$30	\$79	\$372
	46	89197	10517			\$0	\$0	\$0	\$0	\$0
	47	91872	10832			\$0	\$0	\$0	\$0	\$0
Rout and Seal, Mill and Patch	48	94629	11157	0.016	0.20	\$457	\$36	\$56	\$148	\$697
	49	97467	11492			\$0	\$0	\$0	\$0	\$0
	50	100391	11837			\$0	\$0	\$0	\$0	\$0
Total 50 Years										\$170,606

Table 8
 User Delay Cost Estimate for Perpetual Pavement - Option 1
 Average Cost per km of 4-lane Width

Original AADT = 22900 Vehicles		Lanes = 4		<table border="1"> <tr> <td>Driver</td> <td>Truck</td> <td>Car</td> <td>Passenger</td> </tr> <tr> <td>\$18.00</td> <td>\$12.00</td> <td>\$2.50</td> <td>\$16.50</td> </tr> </table>				Driver	Truck	Car	Passenger	\$18.00	\$12.00	\$2.50	\$16.50
Driver	Truck	Car	Passenger												
\$18.00	\$12.00	\$2.50	\$16.50												
Projected Increase = 3.0% Percent		Commercial Vehicles = 12% Percent		<table border="1"> <tr> <td>Discount Rate = 5.30 Percent</td> </tr> </table>				Discount Rate = 5.30 Percent							
Discount Rate = 5.30 Percent															
Initial Year = 2006															
Maintenance Activity	Year	AADT	Commercial Vehicles	Delay (d)	Delay (hr)	PW Driver Costs	PW Truck Costs	PW Car Costs	PW Passenger Costs	PW Total User Delay Costs					
Initial Construction	0	22900	2700			\$0	\$0	\$0	\$0	\$0					
	1	23587	2781			\$0	\$0	\$0	\$0	\$0					
	2	24295	2864			\$0	\$0	\$0	\$0	\$0					
Rout and Seal	3	25023	2950	0.008	0.20	\$617	\$49	\$76	\$200	\$941					
	4	25774	3039			\$0	\$0	\$0	\$0	\$0					
	5	26547	3130			\$0	\$0	\$0	\$0	\$0					
	6	27344	3224			\$0	\$0	\$0	\$0	\$0					
	7	28164	3321			\$0	\$0	\$0	\$0	\$0					
	8	29009	3420			\$0	\$0	\$0	\$0	\$0					
Rout and Seal, Mill and Patch	9	29879	3523	0.016	0.20	\$1,081	\$85	\$132	\$350	\$1,648					
	10	30776	3629			\$0	\$0	\$0	\$0	\$0					
	11	31699	3737			\$0	\$0	\$0	\$0	\$0					
	12	32650	3850			\$0	\$0	\$0	\$0	\$0					
	13	33629	3965			\$0	\$0	\$0	\$0	\$0					
	14	34638	4084			\$0	\$0	\$0	\$0	\$0					
Rout and Seal, Mill and Patch	15	35677	4207	0.016	0.20	\$947	\$74	\$116	\$306	\$1,444					
	16	36748	4333			\$0	\$0	\$0	\$0	\$0					
	17	37850	4463			\$0	\$0	\$0	\$0	\$0					
	18	38986	4597			\$0	\$0	\$0	\$0	\$0					
Rout and Seal, Mill and Patch	19	40155	4734	0.016	0.20	\$867	\$68	\$106	\$280	\$1,322					
	20	41360	4877			\$0	\$0	\$0	\$0	\$0					
Mill and Overlay 40/40	21	42601	5023	0.028	2.00	\$14,517	\$1,141	\$1,779	\$4,695	\$22,132					
	22	43879	5173			\$0	\$0	\$0	\$0	\$0					
	23	45195	5329			\$0	\$0	\$0	\$0	\$0					
Rout and Seal	24	46551	5489			\$0	\$0	\$0	\$0	\$0					
	25	47948	5653			\$0	\$0	\$0	\$0	\$0					
	26	49386	5823			\$0	\$0	\$0	\$0	\$0					
	27	50868	5997			\$0	\$0	\$0	\$0	\$0					
Rout and Seal, Mill and Patch	28	52394	6177	0.016	0.20	\$711	\$56	\$87	\$230	\$1,084					
	29	53965	6363			\$0	\$0	\$0	\$0	\$0					
	30	55584	6554			\$0	\$0	\$0	\$0	\$0					
Rout and Seal	31	57252	6750	0.008	0.20	\$333	\$26	\$41	\$108	\$507					
	32	58969	6953			\$0	\$0	\$0	\$0	\$0					
	33	60738	7161			\$0	\$0	\$0	\$0	\$0					
Mill and Overlay 40/40	34	62561	7376	0.028	2.00	\$10,894	\$856	\$1,335	\$3,524	\$16,609					
	35	64437	7597			\$0	\$0	\$0	\$0	\$0					
	36	66371	7825			\$0	\$0	\$0	\$0	\$0					
Rout and Seal	37	68362	8060	0.008	0.20	\$291	\$23	\$36	\$94	\$444					
	38	70413	8302			\$0	\$0	\$0	\$0	\$0					
	39	72525	8551			\$0	\$0	\$0	\$0	\$0					
	40	74701	8808			\$0	\$0	\$0	\$0	\$0					
Rout and Seal, Mill and Patch	41	76942	9072	0.016	0.20	\$533	\$42	\$65	\$173	\$813					
	42	79250	9344			\$0	\$0	\$0	\$0	\$0					
	43	81627	9624			\$0	\$0	\$0	\$0	\$0					
Rout and Seal	44	84076	9913	0.008	0.20	\$250	\$20	\$31	\$81	\$381					
	45	86599	10210			\$0	\$0	\$0	\$0	\$0					
Mill and Overlay 40/40	46	89197	10517	0.028	2.00	\$8,358	\$657	\$1,024	\$2,703	\$12,742					
	47	91872	10832			\$0	\$0	\$0	\$0	\$0					
	48	94629	11157			\$0	\$0	\$0	\$0	\$0					
Rout and Seal	49	97467	11492	0.008	0.20	\$223	\$18	\$27	\$72	\$341					
	50	100391	11837			\$0	\$0	\$0	\$0	\$0					
Total 50 Years										\$60,407					