USE OF PCC PAVEMENT TO REDUCE MAINTENANCE COSTS AND ADDRESS URBAN INTERSECTION RUTTING

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ABSTRACT

Over the past several years, road Owners (Alberta Transportation and the City of Lloydminster) in the Alberta cities of Medicine Hat, Grande Prairie, and Lloydminster have had to address extreme severity rutting of flexible pavements at high-volume highway intersections in urban environments by repeatedly performing costly maintenance activities. The most common maintenance activities have typically included mill and inlay with ACP, skin patching, and maintenance overlays. A solution was needed to minimize the ongoing maintenance costs while providing a suitable driving surface that would have an acceptable service life. The construction of Portland Cement Concrete Pavement (PCCP) at the most affected intersections was considered to be a cost-effective and viable solution. The long service life (often >30 years) and reduced maintenance efforts required for PCCP have made its use an attractive alternative to traditional asphalt pavement treatments at high-volume highway intersections in urban environments.

This paper will discuss the rutting problems facing the road owners in each of the cities including the historic maintenance activities and costs. A summary of the design and construction process for PCCP installation at 5 different urban intersections within those cities over the last 3 years will be presented. Finally, a summary of the expected maintenance costs for PCCP over its service life as compared to conventional asphalt pavement treatments will be presented. The paper will conclude with a summary of the information presented and conclusions reached regarding the use of PCCP at urban intersections.

INTRODUCTION

Over the past several years, road owners in three Alberta cities – TransCanada Hwy 1 in Medicine Hat owned by Alberta Transportation, Hwy 43 (Alaska Hwy) in Grande Prairie owned by Alberta Transportation, and 44 Street (TransCanada Yellowhead Hwy 16) in Lloydminster owned by the City of Lloydminster - have had to expend precious resources addressing extreme severity rutting at signalized intersections on high-volume roadways in urban settings. These signalized intersections introduce a braking zone where traffic, especially heavy trucks, are forced to slow down or stop which places a greater load on the road surface and subgrade. This leads to the development of ruts and other surface distresses such as shoving and slippage. The most frequent methods employed to address this rutting issue have historically been Mill & Inlay with Asphalt Concrete Pavement (ACP), Cold Mill Reprofiling with thin ACP patching, ACP Rut Infills (blading in and compacting hot mix ACP to fill the rut depressions), and ACP Maintenance Overlays.

A solution was required that reduced or minimized costs while providing a suitable driving surface with an acceptable longer-term service life. The construction of Portland Cement Concrete Pavement (PCCP) provided a cost effective and viable solution with an easily achievable service life greater than 30 years.

Following is a summary of the historical maintenance activities undertaken to address extreme severity rutting in the three Alberta cities along with approximate costs, a synopsis of the design and construction process used to construct the PCCP at 5 different urban highway intersections, and a summary of the long-term maintenance and construction costs of ACP vs. PCCP solutions.

HISTORICAL AND BACKGROUND INFORMATION IN BRIEF

The highways mentioned above are crucial transportation arteries and high-profile roadways to the citizens of Medicine Hat, Grande Prairie, and Lloydminster. They are vital inter-provincial and/or international transportation links which carry significant volumes of vehicle traffic, including many heavy trucks moving goods between Canadian provinces and between Canada and Alaska, within the province of Alberta, and within the cities and their surrounding areas. All three of these highway sections have significant commercial developments adjacent to the roadway, so they are also of key importance to the local business communities in these cities and their surrounding areas. All three roadways are located in urban environments where stand-alone overlays can be limited due to width and height (curb and gutter) restrictions.

For ease of comparison, all ACP conventional maintenance treatment costs are based on 2010 unit rates published by Alberta Transportation (AT), recent

contract unit rates, and Maintenance Contract Inspector input and assume a 10% premium for mobilization and demobilization. The unit rates were as follows:

- Cold Milling @ \$5.50/m^2 (reprofiling or up to 50 mm depth), \$6.50/m^2 (70 mm depth), and \$7.50/m^2 (100 mm depth)
- ACP @ \$125/tonne (Grande Prairie and Lloydminster) and \$140/tonne (Medicine Hat)

Medicine Hat – Hwy 1 (TransCanada Hwy) , Dunmore Road Intersection

This section of highway was under the jurisdiction of the City of Medicine Hat until responsibility for the road was assumed by Alberta Transportation in 2000. At the time that AT assumed responsibility for the road, the pavement structure consisted of 130-160 mm ACP over 300 mm Granular Base Course (GBC). Within 2 years of assuming responsibility for this roadway, the high volume of traffic on the roadway had resulted in the development of extreme severity rutting leading up to the stop bars at Dunmore Road intersection. Figures 1 and 2 in the Appendix depict the historical rut profiles of this section of roadway in the years leading up to the construction of PCCP. A depiction of the road surface condition prior to PCCP construction is shown in Photo 1 below.

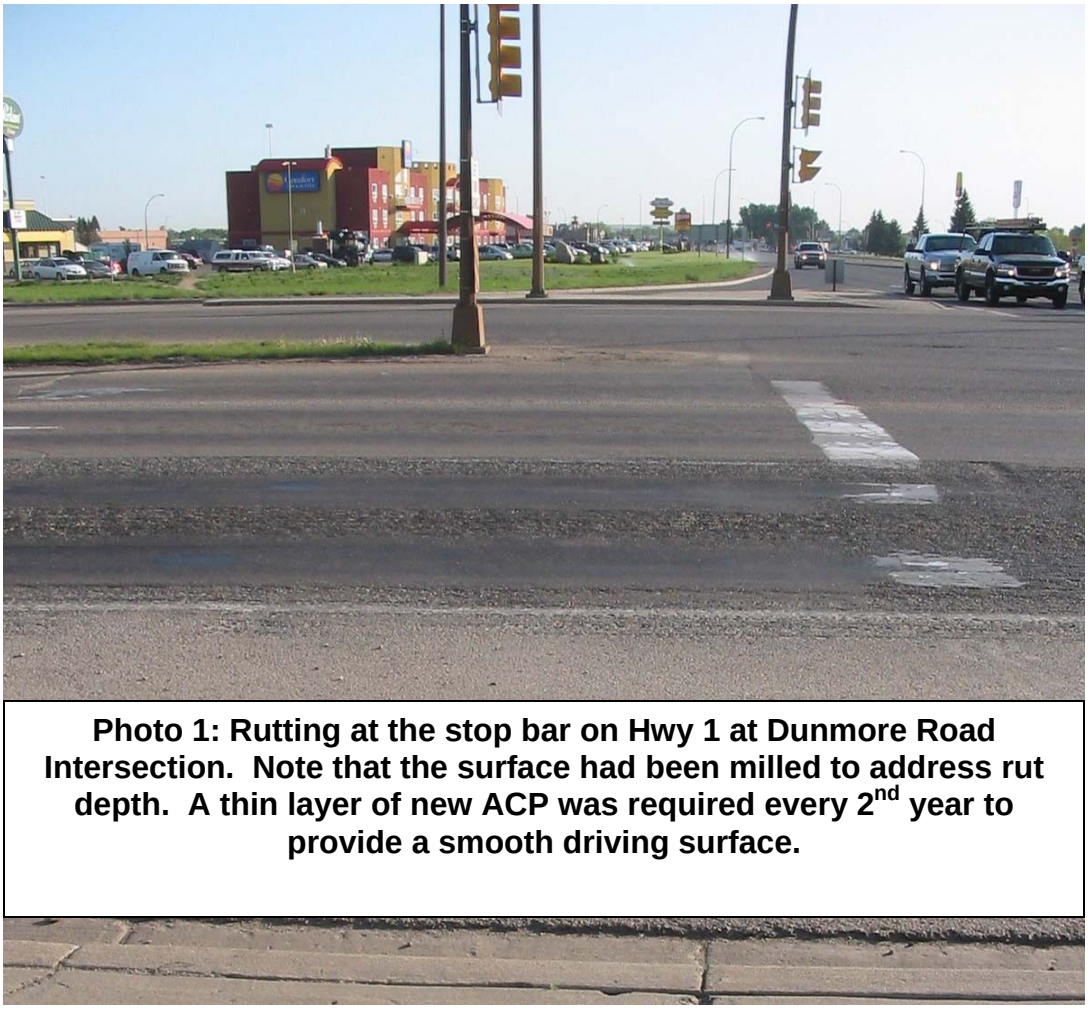


Photo 1: Rutting at the stop bar on Hwy 1 at Dunmore Road Intersection. Note that the surface had been milled to address rut depth. A thin layer of new ACP was required every 2nd year to provide a smooth driving surface.

Based on information supplied by AT's Maintenance Contract Inspector, this particular intersection was reprofiled over a distance of 100 – 150 meters (each direction) by cold milling on an annual basis. This was accomplished by milling out the existing ACP between the wheelpaths to a depth such that the rut profile in the roadway was minimized. As a result of the reduction in pavement thickness due to milling, hot mix was bladed in to provide a smooth driving surface approximately every second year. Reprofiling activity like this can only be undertaken so many times before a more comprehensive rehabilitation strategy is implemented. Consequently, a mill and inlay of the drive lanes was undertaken in 2003. The costs of these maintenance treatments were $11,000 each year for the reprofile milling, $24,000 for reprofiling plus new ACP, and approximately $44,000 for a mill and inlay of the through lanes (145 m x 7.4 m in EB lanes, 100 m x 7.4 m in WB lanes).

By the fall of 2006, the extreme severity rutting problem had recurred. In early 2007, AT approached the Maintenance Contractor to replace the ACP with PCCP in the east and west bound lanes (2 lanes each direction). EBA was retained by AT to provide the PCCP design, assemble the technical

specifications and contract package, and supervise the PCCP construction. The PCCP construction was completed in summer 2007.

Grande Prairie – Hwy 43 (Alaska Hwy North-South Trade Corridor), 100 Ave & 116 Ave Left Turn Lanes

AT assumed responsibility for this section of roadway through the City of Grande Prairie in December 2000. The existing pavement structures at that time were:

- 175-185 mm ACP over 540 mm GBC at 100 Avenue and
- 140-200 mm ACP over 500 mm GBC with a short stretch having 75-100 mm ACP over 170 mm PCCP at 116 Avenue.

The intersections at 100 Avenue @ 108 Street and 116 Avenue @ 100 Street were developing extreme severity rutting, particularly in the left turn lanes that carried traffic on Hwy 43, the only direct route through the city. In the first year (2001), thin ACP skin patching was applied to address rutting and fatigue distress. This skin patching lasted only about 2 – 4 months before wearing off due to heavy traffic and snowplow activity. The skin patching was followed by an overlay treatment in 2002 that began to show signs of failure and/or extreme severity rutting within 2 – 4 years. An example of the type of pavement condition observed at these intersections is shown in Photo 2 below.

PHOTO 2 – EXTREME SEVERITY RUTTING ON 116 AVENUE LEFT TURN LANES OF HWY 43 IN GRANDE PRAIRIE.

In subsequent years (2005 and 2006), mill and inlays were attempted at 116 Avenue and 100 Avenue left turn lanes to address the rutting issue without any long-term success. The maintenance expenditures for these mill and inlay treatments are approximately $18,000 at 100 Avenue (105 m x 7.9 m) and $27,000 at 116 Avenue (165 m x 7.5 m) for each treatment.

As can be imagined, pavement in this condition is not just a maintenance issue, but a safety issue as well. Figures 3 and 4 in the Appendix depict the historical rut profiles of these sections of roadway in the years leading up to the construction of PCCP.

In 2006, AT contracted a consultant to provide a succession plan and surfacing strategy for this section of highway. The goal was to bring this section of roadway to a 20-year service life standard before handing responsibility for the road back to the City when a new ring road was completed. The surfacing strategy was provided by EBA Engineering acting as a sub-consultant. The surfacing strategy included the mill and inlay (50-100 mm depth) of all ACP on Hwy 43 through the City with the exception of the left turn lanes at 100 and 116 Avenues which were to be re-surfaced with PCCP. The construction supervised by EBA Engineering and was completed in summer 2008.

Lloydminster – 44 Street (Hwy 16 TransCanada), 52 & 54 Ave Intersections

This section of roadway is under the jurisdiction of the City of Lloydminster. The existing pavement structure consisted of 130-350 mm of ACP over 100-150 mm of GBC. The differential ACP thickness is attributable to the fact that this was originally a 2-lane highway that was expanded to 4 lanes at a later date. The existing EB lanes were the original highway with the existing WB lanes added later.

The high traffic volume on this roadway has led to extreme severity rutting at signalized intersections. The rutting has led to repeated maintenance issues at several intersections. An example of the severity of rutting observed is shown in Photo 3 below. Historical rut depth data was not available for these sections of roadway.

Photo 3: Rut depth exceeds 70 mm in the WB lane of 44 Street (Hwy 16) in Lloydminster.

Rehabilitative maintenance activity has taken place over the past several years on this roadway. A summary of that activity is presented below.

52 Avenue Intersection (125 m x 7.8 m both directions) – Reconstructed in 1987, Milled and Inlaid (100 mm depth) in 1994, Milled and Inlaid (50 mm depth) in 2000, Rut Infill with Hot Mix Asphalt in 2008.

54 Avenue Intersection (100 m x 7.8 m both directions) - Reconstructed in 1987, Milled and Inlaid (100 mm depth) in 1994, Milled and Inlaid (50 mm depth) in 2000.

The approximate costs of those maintenance treatments were as follows:

100 mm Mill and Inlay - $79,000 (52 Avenue) and $63,000 (54 Avenue)
50 mm Mill and Inlay - $43,000 (52 Avenue) and $35,000 (54 Avenue)
Rut Infill - $12,500 (52 Avenue)

In early 2009, the City of Lloydminster retained EBA to develop a surfacing strategy for the section of 44 Street between 50 and 62 Avenues (approx. 1.6

km). In 2009, the 52 and 54 Avenue intersections were milled out, excavated, and re-surfaced with PCCP in conjunction with a mill and inlay treatment for the remainder of the ACP through this section of roadway. The ACP used for the mill and inlay was a high performance mix with a PG 70-28 asphalt binder. The construction was supervised and managed by EBA Engineering.

DESIGN AND CONSTRUCTION

The PCCP designs for the intersections were completed using StreetPave design software published by the American Concrete Pavements Association. Following are the design parameters and details for each of the roadways.

Hwy 1 Medicine Hat Dunmore Road Intersection

Design Parameters and Details

WASDT – 19300+

DESIGN ESALS – 2400+/day/direction

DESIGN RELIABILITY – 95%

DESIGN LIFE – 30 YEARS

PCCP MODULUS OF ELASTICITY – 27,580 MPa

AVERAGE PCCP FLEXURAL STRENGTH – 4.2 MPa

PCCP DESIGN THICKNESS – 230 mm

Construction

- The four lanes (2 lanes EB, 2 lanes WB) were constructed 1 lane in each direction at a time. Total area ~1850 m^2.
- The existing ACP was sawcut then excavated and removed with a back-hoe.
- The granular base was then scarified and re-compacted to 100% Standard Proctor Maximum Dry Density (SPD).
- A stringline was set to control the screed elevation for a GOMACO™ slipform paver.
- Each lane took one day for PCCP placement.
- Edge thickening was required to accommodate heavy trucks transitioning to the right turn lane.
- PCCP was cured for 5-7 days before opening to traffic and switching to the adjacent lane for construction.

- Initial sawcutting (green cut) took place within 12 hours of PCCP placement.
- Longitudinal and transverse joint widening and sealing took place 28 days after final PCCP placement.
- Construction took place in May/June 2007.

Hwy 43 Grande Prairie 100 Ave and 116 Ave Left Turn Lanes

Design Parameters and Details

WASDT – 26,000+

DESIGN ESALS – 870-1500+/day/direction

DESIGN RELIABILITY – 95%

DESIGN LIFE - 30 YEARS

PCCP MODULUS OF ELASTICITY – 27,580 MPa

AVERAGE PCCP FLEXURAL STRENGTH – 4.2 MPa

PCCP DESIGN THICKNESS – 240 mm

Construction

- The two lanes at each location were constructed 1 lane at a time. Total area 2,025 m^2.
- The existing ACP was sawcut then excavated and removed with a back-hoe.
- The granular base was then scarified and re-compacted to 100% SPD.
- A survey was conducted to set forms for hand placement of PCCP. The presence of a concrete median and space required to accommodate through traffic dictated hand placement as there was not enough space to accommodate a slipform paver.
- No edge thickening was required.
- Each lane took one day for PCCP placement.
- PCCP was cured for 1-2 days before switching to the adjoining lane for construction.
- PCCP was allowed to cure for 5-7 days before opening to traffic.
- Initial sawcutting (green cut) took place within 12 hours of PCCP placement.
- Longitudinal and transverse joint widening and sealing took place 28 days after final PCCP placement.
- Construction took place in June/July 2008.

44 Street (Hwy 16) Lloydminster 52 Ave and 54 Ave Intersections

Design Parameters and Details

WASDT – 20,000+

DESIGN ESALS – 1800+/day/direction

DESIGN RELIABILITY – 85%

DESIGN LIFE – 40 YEARS

PCCP MODULUS OF ELASTICITY – 27,580 MPa

AVERAGE PCCP FLEXURAL STRENGTH – 4.2 MPa

PCCP DESIGN THICKNESS – 240 mm

Construction

- The four lanes (2 lanes EB, 2 lanes WB) were constructed 1 lane in each direction at a time. Total area ~3,510 m^2.
- The existing ACP was removed by cold milling. The subgrade was then prepared by removing excess material with a grader and then scarifying and re-compacting the subgrade to 98% SPD.
- Granular base (200 mm thick) was then added and compacted to 100% SPD.
- A stringline was set to control the screed elevation for a GOMACO^{TM} slipform paver.
- Each lane took one day for PCCP placement.
- No edge thickening was required.
- PCCP was cured for 5-7 days before opening to traffic and switching to the opposite lanes for construction.
- Initial sawcutting (green cut) took place within 12 hours of PCCP placement.
- Longitudinal and transverse joint widening and sealing took place 28 days after final PCCP placement.
- Construction took place in July/August 2009.

LIFE CYCLE COSTS OF ACP vs PCCP TREATMENTS

A Life Cycle Cost Analysis of expected maintenance expenditures for ACP vs. PCCP surfaced roads has been conducted based on a 30-year period. A

discount rate of 4.0% was applied in accordance with AT Guidelines. Maintenance activities such as snow plowing or road sweeping are considered common to both ACP and PCCP surfaces and were not considered in the Life Cycle Cost Analysis.

PCCP Maintenance Costs

The PCCP constructed in Medicine Hat, Grande Prairie, and Lloydminster has a design service life of at least 30 years and has an assigned construction cost of $225/m^2 with a joint cutting, widening, and sealing cost of $58/lin m (PCCP costs are based on recent contract rates). The construction and joint sealing costs are inclusive of mobilization/demobilization and all materials and labour. During the life of the PCCP, the need for maintenance is expected to be minimal compared to what would be required to maintain an ACP surface. The required maintenance for PCCP would include re-sealing of the longitudinal and transverse joints (includes the removal of old sealant and backer rod and the replacement of same) and hot-pour sealing of any cracks that develop. Joint re-sealing is expected to be required every 10-15 years and would require 1-day lane closures. For the purposes of illustration of Life Cycle Costs, the re-sealing has been assumed to be required every 12 years. The cost of re-sealing the joints has been assumed as $35/lin m based on recent contract rates. The sealing of cracks has been assumed to be required once every 5 years with 10 m of crack sealing required for every 100 m of PCCP roadway at a cost of $2/lin m.

ACP Maintenance Costs

The maintenance of an ACP surface at these intersections would involve a mill and inlay or rut infill at a regular interval based on the historical performance of ACP at these intersections. The service life of the pavement has also been considered. The costs of these maintenance and overlay treatments have been calculated using the previously stated unit rates and are based on the size of the rut affected areas. It should be noted that these costs only consider conventional ACP treatments as have been historically used on these roadways. It is likely that the use of a high performance ACP mix such as Stone Mastic Asphalt or Performance Graded asphalt binders would be considered for these roadways as well. However, such treatments can be limited based on contractor availability and familiarity, the availability of high performance materials (eg. PG binder), and economies of scale that render them impractical. For that reason, these alternative treatments have not been included in the Life Cycle Cost Analysis. Following is a synopsis of the assumed conventional ACP treatments and their required intervals.

Medicine Hat - Hwy 1, Dunmore Road Intersection

It has been assumed that rut reprofiling is required every year with new ACP placed every second year (equivalent to a 20 mm overlay to restore a smooth driving surface). A mill and inlay (50 mm depth) would be required every 5 years with localized deeper milling where needed to address deeper ruts. The service life of the ACP roadway as a whole (considers the roadway both within and away from the intersections) has been assumed to be 15-18 years. This section of roadway has a rural cross section (no curb and gutter), so it can undergo a limited overlay without going to full reconstruction. Consequently, a cost has been calculated for a nominal 70 mm ACP overlay of the road after 16 years using an assumed top width of 10.4 m (2 x 3.7 m lanes + 2 x 1.5 m shoulders). The adjoining ACP surfaced turn lanes have not been included in the Life Cycle Cost Analysis. The costs of these conventional maintenance treatments are $11,000 for reprofile milling, $24,000 for reprofiling plus new ACP, and $44,000 for a 50 mm mill and inlay. The nominal 70 mm overlay would cost $62,000.

Grande Prairie - Hwy 43, 100 Ave and 116 Ave Turn Lanes

These turn lanes are located in an urban cross section with curb and gutter restricting any overlay application. The performance of a thin ACP layer has not been very good historically at these locations, so a thin ACP overlay treatment has not been considered a viable treatment. Therefore, the only maintenance treatment under consideration is a mill and inlay. Given the historical performance of ACP in these turn lanes, it has been assumed that a 50 mm mill and inlay would be required every 2 - 3 years with localized deeper milling where needed to address deeper ruts. The assumed cost of the mill and inlays are $20,000 for 100 Avenue and $29,000 for 116 Avenue. Because these are dedicated turn lanes (no through traffic), the consideration of the service life of the roadway as a whole (considering the roadway both within and away from intersections) was not considered necessary for the purposes of the Life Cycle Cost Analysis. However, after an estimated pavement service life of 14 years, a cost has been assumed to reconstruct the pavement due to deterioration and oxidation of the existing pavement. This cost has been assumed to be equivalent (in 2010 dollars) to the cost of initial construction as shown below.

Lloydminster – 44 St (Hwy 16), 52 and 54 Ave Intersections

These intersections are located in an urban cross section with curb and gutter restricting any overlay application. Based on the historical performance of ACP at these intersections, it has been assumed that a rut infill would be required every 2 years with a 50 mm mill and inlay required every 6 years with localized deeper milling where needed to address deeper ruts. Considering the service life of the roadway as whole, a deeper 100 mm mill and inlay would be required every 12 years. Although a rut infill had not been applied to the 54 Avenue intersection, recent performance suggests that it be included as a maintenance

treatment for both intersections. The cost of the rut infills would be $12,500 at each location while the cost of the mill and inlays would be $43,000 (50 mm at 52 Avenue), $39,000 (50 mm at 54 Avenue), $79,000 (100 mm at 52 Avenue), and $63,000 (100 mm at 54 Avenue).

Initial ACP Construction Costs

In order to make a fair and direct comparison, an initial construction cost of the ACP must be included. For Hwy 1 in Medicine Hat, a pavement structure of 150 mm ACP over 300 mm GBC has been assumed in consideration of the pavement structure in place prior to PCCP construction. For Hwy 43 in Grande Prairie, a pavement structure of 160 mm ACP over 500 mm GBC has been assumed in consideration of the pavement structure in place prior to PCCP construction. For 44 Street (Hwy 16) in Lloydminster, a pavement structure of 150 mm ACP over 300 mm GBC has been assumed in consideration of the pavement structure in place prior to PCCP construction.

All of the initial construction costs have been calculated assuming the road section widths and lengths as stated above plus 2 x 1.5 m shoulders for Medicine Hat and no shoulders for Grande Prairie or Lloydminster (both have curb and gutter edges). A unit rate of $27.50/tonne has been assumed for GBC. These initial construction costs include a 10% premium for mob/demob and are as follows:

- For Medicine Hat – $216,500
- For Grande Prairie - $178,000
- For Lloydminster - $243,000

LIFE CYCLE ANALYSIS RESULTS

The output from the Life Cycle Cost Analysis has been included in the Appendix. A Residual Value has been calculated for all alternatives and included in the Life Cycle Cost Analysis. The Residual Value for ACP surfaced roads is based on a linear relationship between the remaining service life of the most recently applied surfacing treatment and its initial capital cost. The Total Capital Cost is determined by subtracting the residual value from the sum of all capital costs. All values were then discounted at a rate of 4% to Year '0'. A synopsis of the results is presented below.

Location	Surface	Initial Capital Cost ($)	Residual Value ($)	Total Capital Cost ($)	Residual Value Discounted to Year '0' ($)	Total Capital Cost Discounted to Year '0' ($)
Medicine Hat	PCCP	474000	474000	554250	146143	**514733**
	ACP	216500	12000	906500	3700	**612983**
Grande Prairie	PCCP	530000	530000	620270	163409	**575818**

	ACP	178000	32667	942333	10072	**577576**
Lloydminster	PCCP	790000	790000	150450	243572	**622792**
	ACP	243000	68333	954667	21068	**643325**

For all three cities, the long term maintenance and construction costs of PCCP have the benefit of being lower than that of ACP treatments with less maintenance disruptions to the travelling public.

It should be noted that although the costs associated with the disruption of service to the travelling public is difficult to quantify, it should also be considered. Considering that PCCP will have minimal maintenance disruptions over the course of its service life, the preferred option would be PCCP for all 3 roadways or any similar relatively small localized road sections with special loading conditions. A similar case could be made for other major highways or major city thoroughfares with signalized intersections in urban environments.

CONCLUSIONS

It has been shown that the construction of PCCP at urban environment intersections where heavy traffic volumes are observed can be a viable and cost effective solution to frequently occurring extreme severity rutting compared to conventional ACP treatments. Although the initial cost is substantially higher and construction period is longer for PCCP compared to ACP surfacing, its very long service life and minimal maintenance disruptions to the travelling public are strong arguments for the consideration of PCC Pavements. However, it should be noted that a complete Life Cycle Cost Analysis should be undertaken for any roadway where PCCP has been considered as an alternative to ACP treatments.

NEW PCC PAVEMENT - 52 AVENUE INTERSECTION AT 44 STREET (HWY 16) IN LLOYDMINSTER

INFORMATION SOURCES

ALBERTA TRANSPORTATION WEIGHTED UNIT PRICE AVERAGES, SPRING 2010

ALBERTA TRANSPORTATION PEACE REGION

ALBERTA TRANSPORTATION SOUTHERN REGION

CITY OF LLOYDMINSTER

EBA ENGINEERING CONSULTANTS LTD. FILES 4101428, E12200068.001, AND E32101145

FIGURE 1
HISTORICAL RUT PROFILES
HWY 1 - DUNMORE ROAD INTERSECTION EBOL

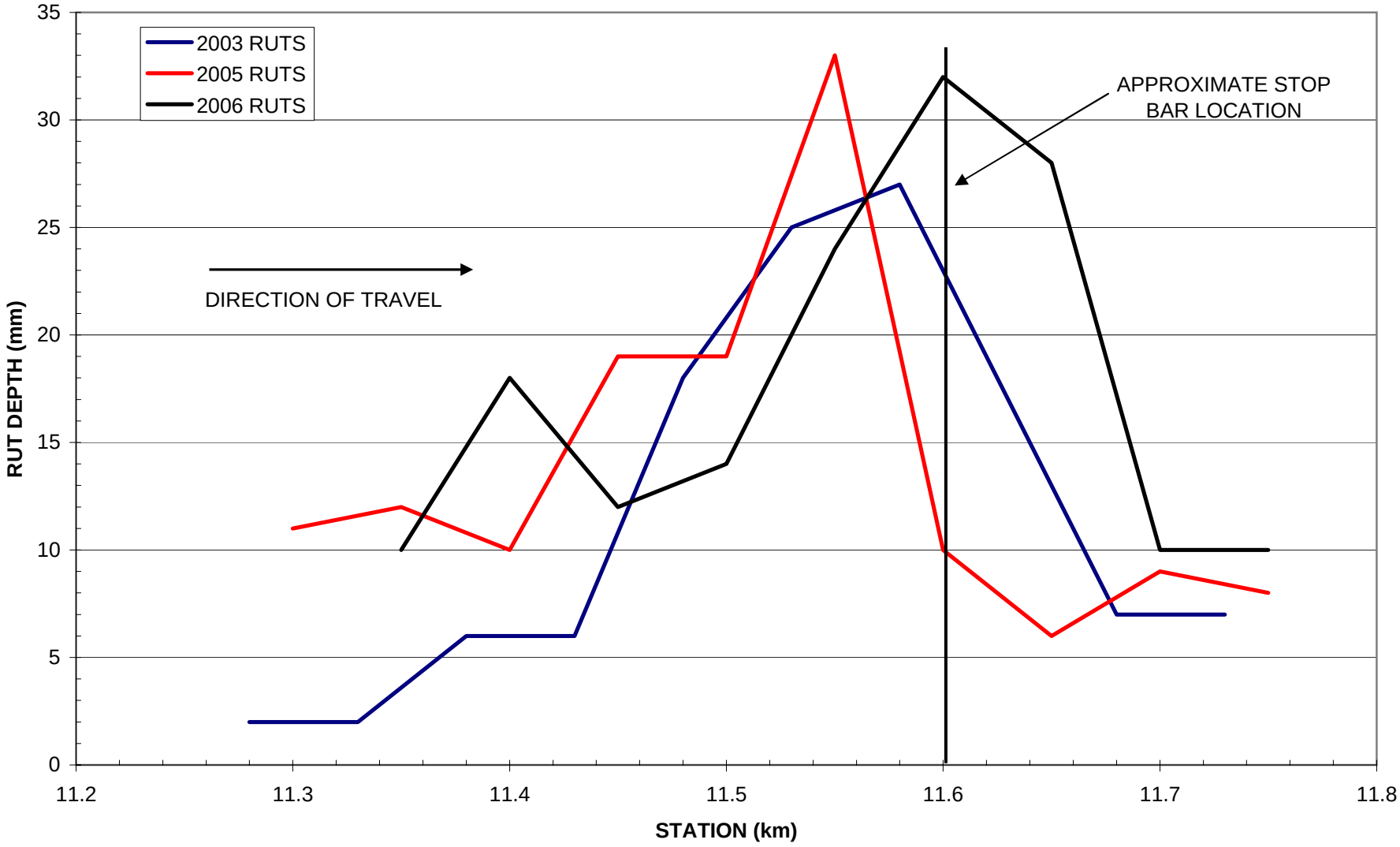


FIGURE 2
HISTORICAL RUT PROFILES
HWY 1 - DUNMORE ROAD INTERSECTION WBOL

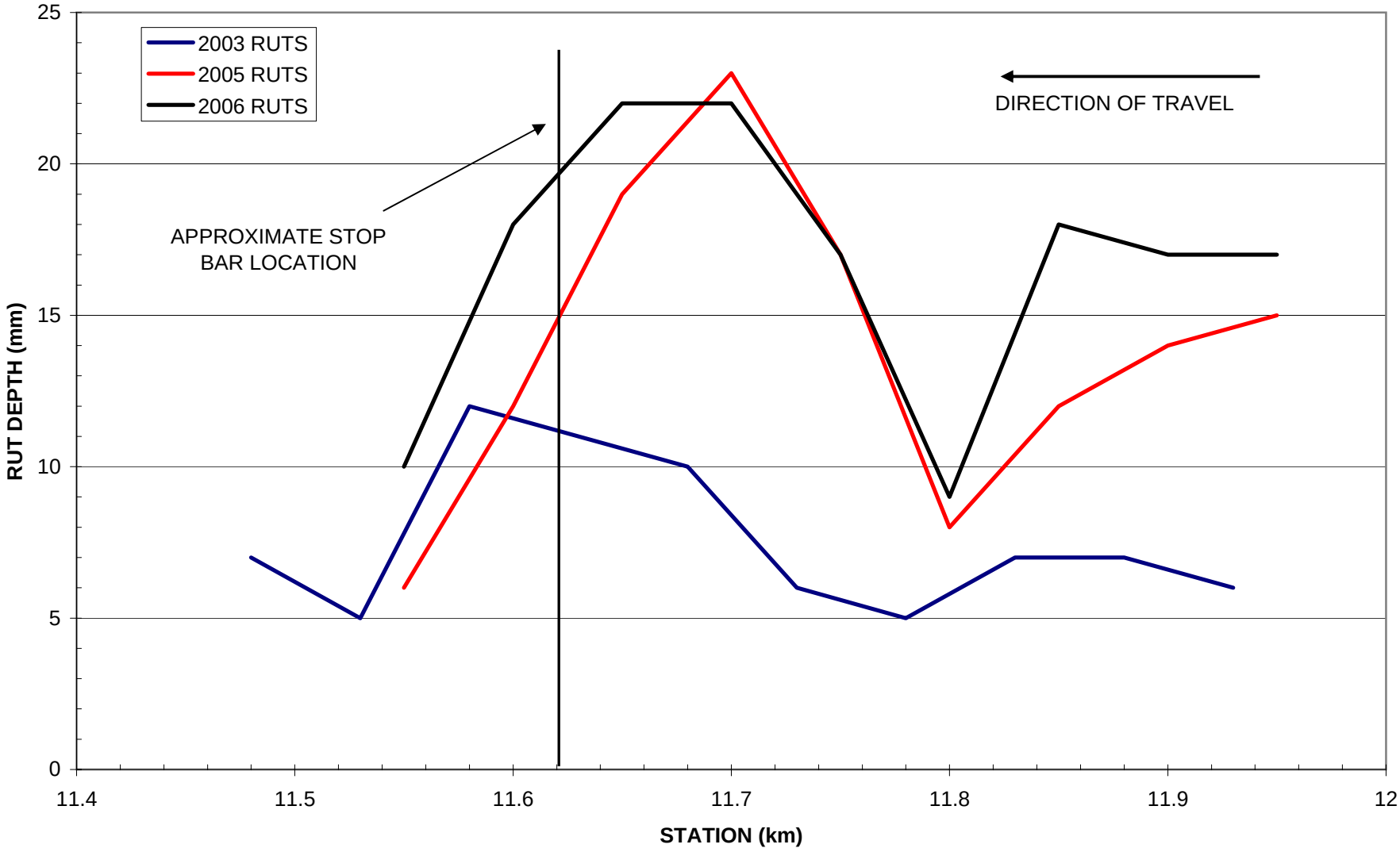


FIGURE 3
HISTORICAL RUT PROFILES
HWY 43 EB AT 100 AVENUE LEFT TURN LANE

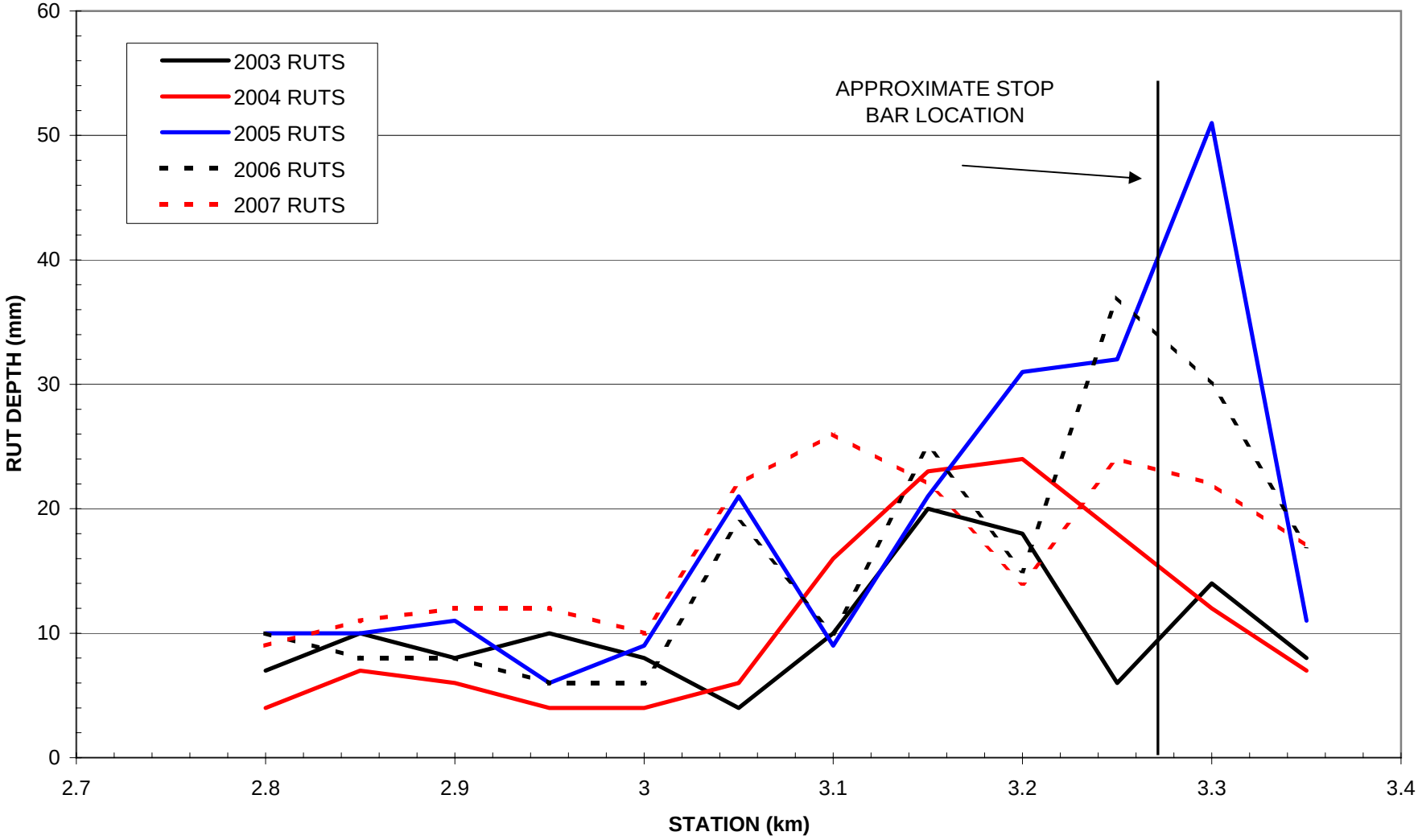
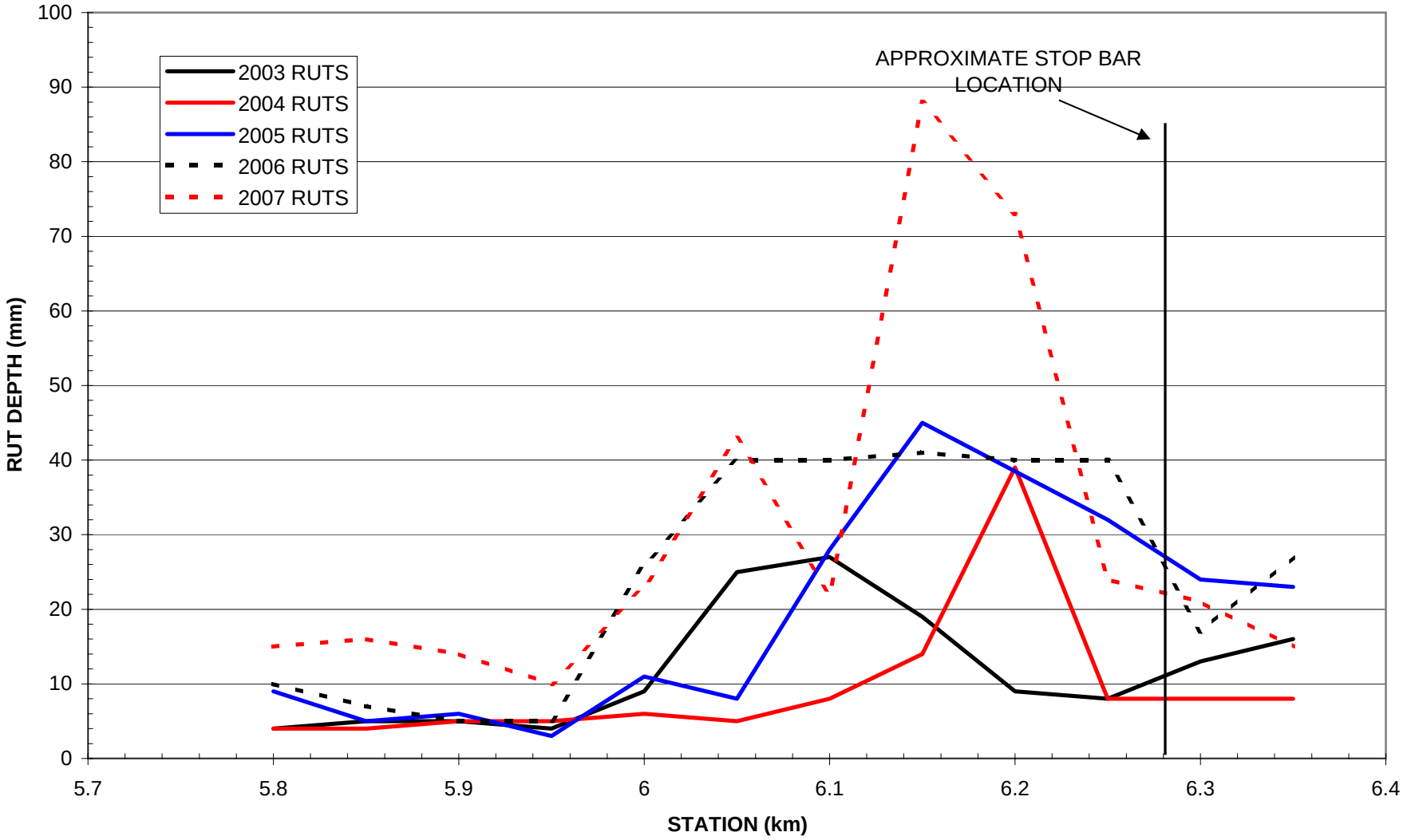


FIGURE 4
HISTORICAL RUT PROFILES
HWY 43 EB AT 116 AVENUE LEFT TURN LANE



LIFE-CYCLE COSTING ANALYSIS CHART

HWY 1 MEDICINE HAT

0.04

DISCOUNT RATE 4.00%

	CASE 1 - PCCP			CASE 2 - ACP		
YEAR	**COMMENTS**	**CAPITAL**	**DISCOUNTED TO YEAR '0'**	**COMMENTS**	**CAPITAL**	**DISCOUNTED TO YEAR '0'**
0	PCCP	$474,000	$474,000	ACP Initial Construction	$216,500	$216,500
1			$0	Reprofile Milling	$11,000	$10,577
2			$0	Reprofiling + New ACP	$24,000	$22,189
3			$0	Reprofile Milling	$11,000	$9,779
4			$0	Reprofiling + New ACP	$24,000	$20,515
5	Crack Sealing	$50	$41	Mill and Inlay	$44,000	$36,165
6			$0	Reprofile Milling	$11,000	$8,693
7			$0	Reprofiling + New ACP	$24,000	$18,238
8			$0	Reprofile Milling	$11,000	$8,038
9			$0	Reprofiling + New ACP	$24,000	$16,862
10	Crack Sealing	$50	$34	Mill and Inlay	$44,000	$29,725
11			$0	Reprofile Milling	$11,000	$7,145
12	Re-Seal Joints	$40,000	$24,984	Reprofiling + New ACP	$24,000	$14,990
13			$0	Reprofile Milling	$11,000	$6,606
14			$0	Reprofiling + New ACP	$24,000	$13,859
15	Crack Sealing	$50	$28	Mill and Inlay	$44,000	$24,432
16			$0	ACP Overlay	$62,000	$33,102
17			$0	Reprofile Milling	$11,000	$5,647
18			$0	Reprofiling + New ACP	$24,000	$11,847
19			$0	Reprofile Milling	$11,000	$5,221
20	Crack Sealing	$50	$23	Reprofiling + New ACP	$24,000	$10,953
21			$0	Mill and Inlay	$44,000	$19,309
22			$0	Reprofile Milling	$11,000	$4,642
23			$0	Reprofiling + New ACP	$24,000	$9,737
24	Re-Seal Joints	$40,000	$15,605	Reprofile Milling	$11,000	$4,291
25	Crack Sealing	$50	$19	Reprofiling + New ACP	$24,000	$9,003
26			$0	Mill and Inlay	$44,000	$15,870
27			$0	Reprofile Milling	$11,000	$3,815
28			$0	Reprofiling + New ACP	$24,000	$8,003
29			$0	Reprofile Milling	$11,000	$3,527
30	PCCP	$474,000	$146,143	Reprofiling + New ACP	$24,000	$7,400
CREDIT FOR RESIDUAL VALUE		$474,000	$146,143		$12,000	$3,700
TOTALS		$554,250	**$514,733**		$906,500	**$612,983**

LIFE-CYCLE COSTING ANALYSIS CHART

HWY 43 GRANDE PRAIRIE

0.04

DISCOUNT RATE 4.00%

	CASE 1 - PCCP			CASE 2 - ACP		
YEAR	**COMMENTS**	**CAPITAL**	**DISCOUNTED TO YEAR '0'**	**COMMENTS**	**CAPITAL**	**DISCOUNTED TO YEAR '0'**
0	PCCP	$530,000	$530,000	ACP Initial Construction	$178,000	$178,000
1			$0			$0
2			$0			$0
3			$0	Mill and Inlay	$49,000	$43,561
4			$0			$0
5	Crack Sealing	$54	$44			$0
6			$0	Mill and Inlay	$49,000	$38,725
7			$0			$0
8			$0			$0
9			$0	Mill and Inlay	$49,000	$34,427
10	Crack Sealing	$54	$36			$0
11			$0			$0
12	Re-Seal Joints	$45,000	$28,107	Mill and Inlay	$49,000	$30,605
13			$0			$0
14			$0	ACP Re-Construction	$178,000	$102,791
15	Crack Sealing	$54	$30			$0
16			$0			$0
17			$0	Mill and Inlay	$49,000	$25,155
18			$0			$0
19			$0			$0
20	Crack Sealing	$54	$25	Mill and Inlay	$49,000	$22,363
21			$0			$0
22			$0			$0
23			$0	Mill and Inlay	$49,000	$19,881
24	Re-Seal Joints	$45,000	$17,555			$0
25	Crack Sealing	$54	$20			$0
26			$0	Mill and Inlay	$49,000	$17,674
27			$0			$0
28			$0	ACP Re-Construction	$178,000	$59,359
29			$0			$0
30	PCCP	$530,000	$163,409	Mill and Inlay	$49,000	$15,108
CREDIT FOR RESIDUAL VALUE		$530,000	$163,409		$32,667	$10,072
TOTALS		$620,270	**$575,818**		$942,333	**$577,576**

LIFE-CYCLE COSTING ANALYSIS CHART

44 STREET (HWY 16) LLOYDMINSTER

0.04

DISCOUNT RATE 4.00%

	CASE 1 - PCCP			CASE 2 - ACP		
YEAR	**COMMENTS**	**CAPITAL**	**DISCOUNTED TO YEAR '0'**	**COMMENTS**	**CAPITAL**	**DISCOUNTED TO YEAR '0'**
0	PCCP	$790,000	$790,000	ACP Initial Construction	$243,000	$243,000
1			$0			$0
2			$0	Rut Infill	$25,000	$23,114
3			$0			$0
4			$0	Rut Infill	$25,000	$21,370
5	Crack Sealing	$90	$74			$0
6			$0	Mill and Inlay (50 mm)	$82,000	$64,806
7			$0			$0
8			$0	Rut Infill	$25,000	$18,267
9			$0			$0
10	Crack Sealing	$90	$61	Rut Infill	$25,000	$16,889
11			$0			$0
12	Re-Seal Joints	$75,000	$46,845	Mill and Inlay (100 mm)	$142,000	$88,693
13			$0			$0
14			$0	Rut Infill	$25,000	$14,437
15	Crack Sealing	$90	$50			$0
16			$0	Rut Infill	$25,000	$13,348
17			$0			$0
18			$0	Mill and Inlay (50 mm)	$82,000	$40,478
19			$0			$0
20	Crack Sealing	$90	$41	Rut Infill	$25,000	$11,410
21			$0			$0
22			$0	Rut Infill	$25,000	$10,549
23			$0			$0
24	Re-Seal Joints	$75,000	$29,259	Mill and Inlay (100 mm)	$142,000	$55,397
25	Crack Sealing	$90	$34			$0
26			$0	Rut Infill	$25,000	$9,017
27			$0			$0
28			$0	Rut Infill	$25,000	$8,337
29			$0			$0
30			$0	Mill and Inlay (50 mm)	$82,000	$25,282
CREDIT FOR RESIDUAL VALUE		$790,000	$243,572		$68,333	$21,068
TOTALS		$150,450	**$622,792**		$954,667	**$643,325**