Contract Report: CSIR/BE/IE/ER/2006/0017/B

March 2006

Technical Memorandum: Second and third monitoring of three LTPP experiments in association with HVS tests in Gauteng

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DOCUMENT RETRIEVAL PAGE			Report No: CSIR/BE/IE/ER/2006/0017/B
Title: Technical Memorandum: Second and third monitoring of three LTPP experiments in association with HVS tests in Gauteng			
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Client: GDPTRW	**Client Reference No**:	**Date**: March 2006	**Distribution:** Client Confidential
Project No: 59E2004	**RG:** 059E2 - Transport Infrastructure Engineering		**Version:** 1

Abstract:

This report summarizes the ongoing seasonal monitoring of three LTPP sections located adjacent to previous HVS experiments. The sections were assessed in July and November 2005. No further deterioration was noted on any of the three sections during the two evaluations detailed in this report. Some potential seasonal variation in terms of moisture content, and its influence on density and deflection, seems to be apparent, although additional monitoring will be required before any firm conclusions can be drawn. DCP measurements continue to be influenced by the stony nature of the material and additional measurements will be required before any useful trends will be observed. Data collected during this assessment have been captured in the Excel® spreadsheet, which accompanies this document on compact disc.

Some preliminary comparisons were made between HVS and LTPP data, but more LTPP data are required to enable any trends to be identified.

Monitoring of the LTPP experiments should continue at the planned intervals (begin May 2006 and begin November 2006). Further comparisons with HVS data will be made as additional data are collected, and it is expected that clearer trends will start to emerge from these comparisons. Moisture contents should be closely monitored as this appears to be influencing density, strength and deflection measurements.

Traffic counts should be repeated in 2006 to ensure that seasonal variation is considered and that realistic cumulative traffic data, since construction, is available for later analysis and comparison with HVS performance.

Keywords:

Long term pavement performance, LTPP, APT, HVS

Proposals for implementation:

Continue with monitoring at six monthly intervals.

Related documents:

CR-2003/7; CR-2003/25; CR-2004/17, CR-2005/03, CR-2005/04, CR-2005/05, CR-2005/06

Signatures:				
P Paige-Green **Language Editor**	P Paige-Green **Technical Review**	B Verhaeghe **Competency Area Leader**	E van Heerden **Info Centre**	H Maree **Executive Director**

TERMS OF REFERENCE

CSIR Built Environment was requested by GDPTRW to continue with the six-monthly monitoring of three long-term pavement performance experimental sections associated with three completed HVS experiments in Gauteng. The terms of reference for ongoing monitoring were to:

- Monitor identified LTPP sections, collect appropriate data and store this data in a database for future comparison with performance of HVS experiments
- Compare performance of LTPP and HVS experiments if sufficient data has been collected

A copy of the project proposal is attached in Appendix A.

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1. INTRODUCTION

A protocol for the establishment and monitoring of LTPP sections in conjunction with HVS experiments was completed in 2002. In 2003 a small study was commissioned to layout sections at the HVS sections on Roads P2388 and P243/1 and to complete visual assessments and DCP measurements. In terms of the protocol, responsibility for gathering or arranging for the gathering of the remaining data rested with GDPTRW. This did not materialize and a proposal for CSIR to carry out this work was accepted in 2004. The sections were comprehensively monitored, a database was created and reports on the establishment and monitoring prepared and submitted. Given that the sections had only been monitored for a relatively short period of time, no attempt was made to compare performance of the LTPP sections with that of the HVS tests. Similar experiments have been established and monitored on the HVS experiments on the N7 route and at Elandsbaai on behalf of the Provincial Administration Western Cape.

The Gauteng sections were monitored again at the end of the summer and winter seasons in 2005. This report summarises the second and third monitoring of the LTPP experiments on Roads 2388 and P243/1.

Cumulative truck traffic on the three sections since HVS testing was completed is equivalent to between 180 000 E80s (P243/1) and 200 000 E80s (2388). An initial comparison was thus made between the rut data originating from the HVS tests and the data from the LTPP sections.

The establishment and initial monitoring of the experiments have been documented previously.

2. EVALUATION DATES AND DATA COLLECTION

2.1. Evaluation Dates

Full data collection exercises, following the protocol[1], were carried out on each experiment as follows:

- Experiment H1-04-G-2388: on 27 July and 15 November 2005
- Experiment H2-04-G-2388: on 27 July and 15 November 2005
- Experiment H3-04-G-243: on 20 July and 16 November 2005

2.2. Data Collection

The following assessments/testing were carried out on each experiment:

- Visual assessment (including photographs)
- Profile assessment
- Pavement temperature
- Density and moisture content (dual probe hydro-density meter)
- Dynamic cone penetrometer
- Deflection (Falling Weight Deflectometer (FWD), Road Surface Deflectometer (RSD) and Deflectograph)

No traffic assessments were undertaken.

All assessments and testing were carried out according to the protocol[1]. All information was captured on the prescribed forms (Appendix A) and then entered into an Excel® spreadsheet (see attached CD). DCP holes were sealed with Roadfix. Moisture sample holes were filled with cement stabilized gravel, hand compacted at approximately optimum moisture content and then sealed with Roadfix.

3. EXPERIMENT H1-04-G-2388

This section should be read in conjunction with CSIR-BE Report CR-2005/05[2], which details the evaluation in February 2005. Ratings are based on TMH9[3] and the GDPTRW Visual Assessment Manual for the Calibration of HDM-III/IV[4].

There was no further deterioration on this section. However, the surface was less tacky during the July 2005 assessment as a result of lower ambient and pavement temperatures (19°C and 17°C respectively). During the November 2005 assessment (32 °C and >40°C air and pavement temperatures), shoe and tyre impressions were again left in the road. The flushed binder also adhered to shoes and the pavement monitoring equipment during the November 2005 assessment, similar to that experienced during the February 2005 assessment.

No mechanical failure, surface cracks or aggregate loss was noted and the binder condition was rated as fresh (1). In terms of structural assessment, no cracking of any type was noted. There was no pumping - discolouration on the road was attributed to carry over from the unsealed road. Although the data indicate (Figure 3.1) that rutting increased between the July 2005 and November 2005 assessments, this was attributed to a change in assessors and assessment technique and not significant deterioration of the road, as is evidenced in the photographs of the section (Figure 3.2). Attention has been given to ensure that the protocol is clear regarding measurement techniques. Information will also be obtained from international LTPP programmes to obtain an indication of typical repeatability between measurements. No new edgebreaks, potholes or patches were noted, although repairs to old edgebreaks continued to influence profile measurements.

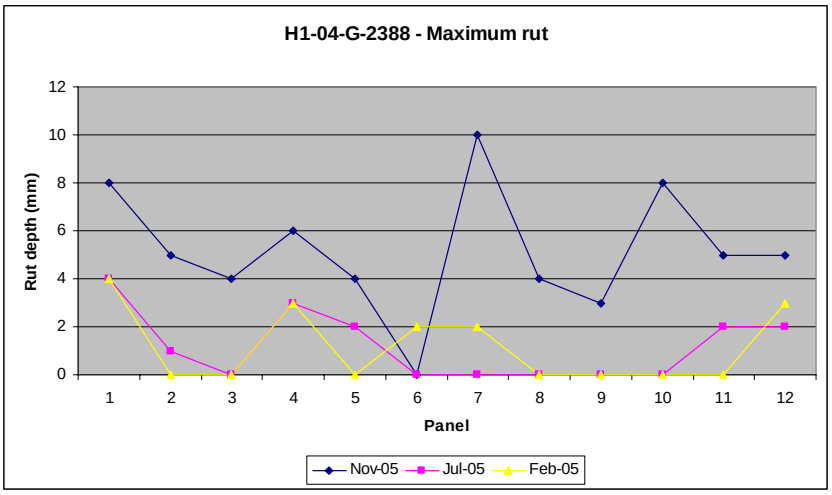

Figure 3.1: Maximum rut for Section H1-04-G-2388

Figure 3.2: General view of H1-04-G-2388

In terms of functional assessment, riding quality was again rated as 4 (poor), attributed to construction deficiencies and not to deterioration of the section. Skid resistance was rated as 3 (warning), this being attributed to the bleeding. Surface drainage was rated as 1 (good). The unsealed shoulders remained clear of vegetation.

Seven photographs were taken. Photographs of each panel were considered unnecessary given the consistency in performance of the panels.

Density measurements remained relatively constant (see Figure 3.3 for example of outer wheel track measurements), although some spurious readings were obtained. These were attributed to crumbling of the material in the hole. Moisture contents also remained relatively constant (example in Figure 3.4) with a slight increase in the July 2005 measurements, attributed to the end of the rain season.

Dynamic Cone Penetrometer measurements showed little trend with previous measurements - this was attributed to the very stony nature of the material. Longer term trends are likely to be more useful and thus measurements will be continued.

Deflection measurements remained consistent (Figure 3.5), with slightly higher measurements recorded in July 2005, attributed to the higher moisture content. RSD measurements showed similar trends to FWD measurements but were consistently lower. Conclusions on the relationship between FWD and RSD in the context of this study will only be realistic after additional measurements.

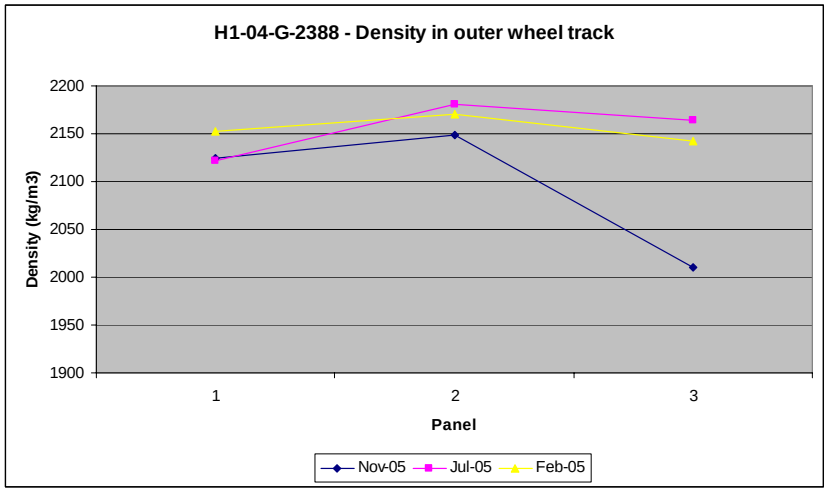

Figure 3.3: Density in outer wheel path on Section H1-04-G-2388

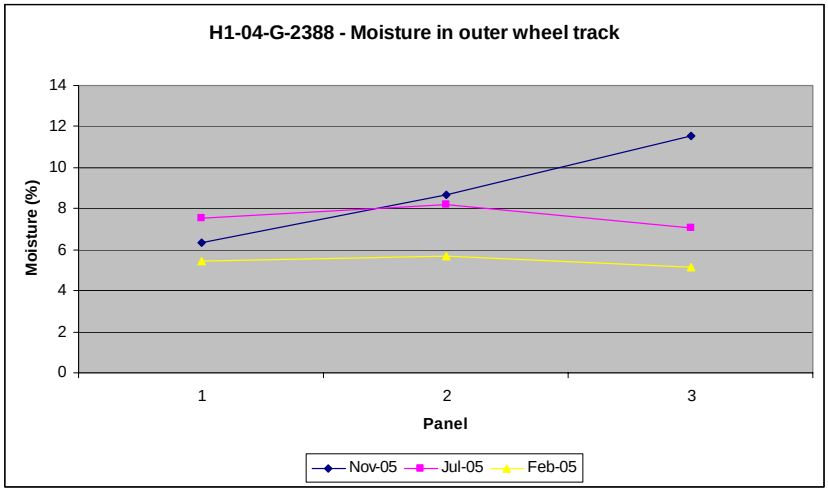

Figure 3.4: Moisture in outer wheel path on Section H1-04-G-2388

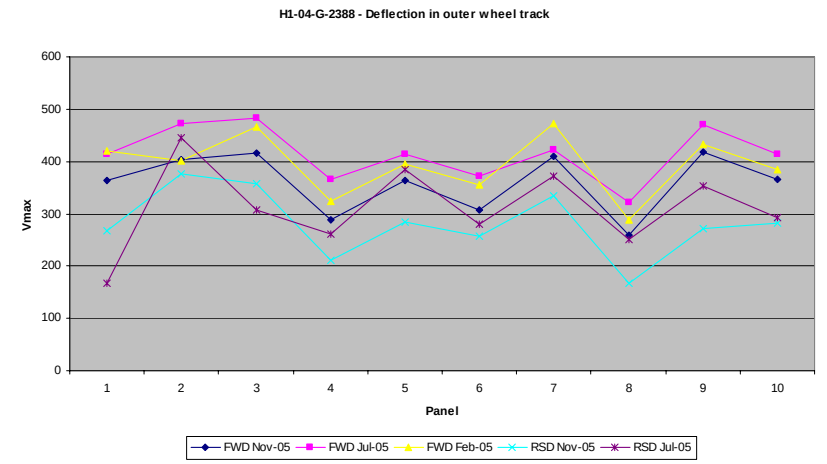

Figure 3.5: Deflection in outer wheel path on Section H1-04-G-2388

The pavement temperature was monitored using i-buttons. These buttons were installed inside the surfacing of the pavement. The diurnal temperature fluctuations became quite

clear from these data. In Table 3.1 a summary of the minimum, average and maximum temperatures measured for the period April 2005 to January 2006 are shown. Initially there were also humidity buttons installed in the surfacing, however, the data from these buttons did not prove to be reliable at this stage, and further development work is being done to improve the data and the analysis of the data from the humidity buttons.

Table 3.1: Summary of the minimum, average and maximum surface temperatures measured (H1/04-G-P2388) – April 2005 to January 2006.

	LTPP section number
	H1/04-G-P2388
Minimum temperature [°C]	5.1
Average temperature [°C]	25.3
Maximum temperature [°C]	62.0

4. EXPERIMENT H2-04-G-2388

This section should be read in conjunction with CSIR-BE Report CR-2005/05[2], which details the evaluation in February 2005.

There was no further deterioration on this section, although bleeding and the very tacky surface during hot temperatures continued to be an issue as discussed in the previous chapter.

No mechanical failure, surface cracks, aggregate loss or pumping was noted and the binder condition was rated as fresh (1). In terms of structural assessment, no cracking of any type was noted. As with Section H1-04-G-2388, rut depth (max rut) appears to have increased (Figure 4.1), but this is again attributed to a change in assessors and assessment technique rather than significant deterioration of the road (Figure 4.2). No new edgebreaks, potholes or patches were noted, although repairs to old edgebreaks continued to influence profile measurements.

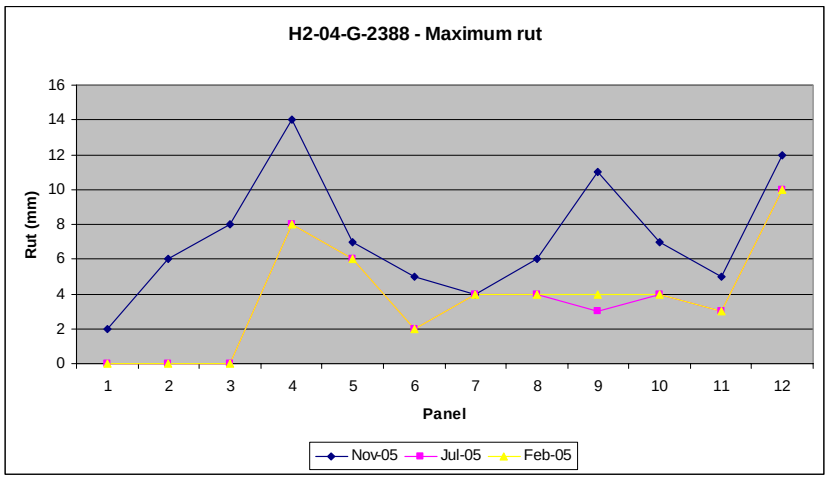

Figure 4.1: Maximum rut for Section H2-04-G-2388

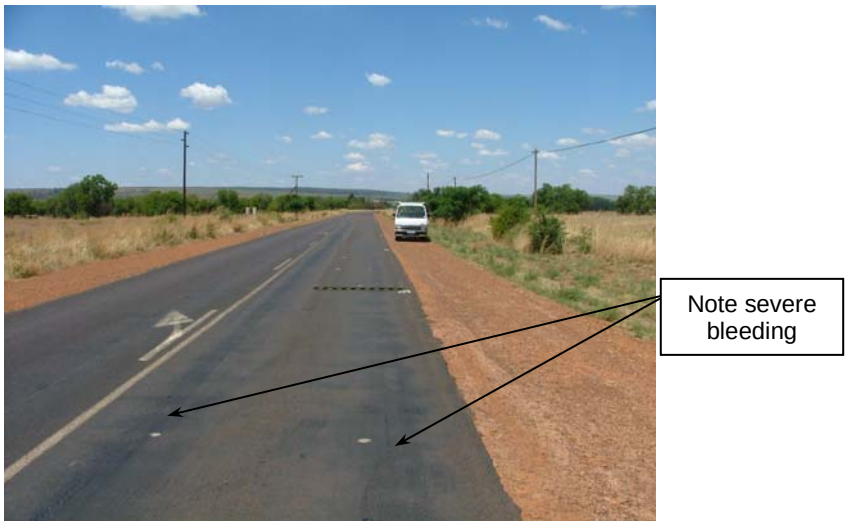

Figure 3.2: General view of H1-04-G-2388

In terms of functional assessment, riding quality was again rated as 4 (poor), attributed to construction deficiencies and not to deterioration of the section. Skid resistance was rated as 3 (warning), this being attributed to the bleeding. Surface drainage was rated as 1 (good). The unsealed shoulders remained clear of vegetation.

Six photographs were taken. Photographs of each panel were considered unnecessary given the consistency in performance of the panels.

Density measurements remained relatively constant (see Figure 4.3 for example of outer wheel track measurements), although some spurious readings were obtained. These were attributed to crumbling of the material in the hole. Moisture contents also remained relatively constant (example in Figure 4.4) with a slight increase in the July 2005 measurements, attributed to the end of the rain season. Investigations are ongoing for identifying reliable and robust moisture measurement equipment that can be installed permanently in the LTPP sections to avoid any possible external influences on moisture data..

Dynamic Cone Penetrometer measurements showed little trend with previous measurements - this was attributed to the very stony nature of the material. Longer term trends are likely to be more useful and thus measurements will be continued.

Deflection measurements remained consistent (Figure 4.5), with slightly higher measurements recorded in July 2005, attributed to the higher moisture content. RSD measurements showed similar trends to FWD measurements but were consistently lower. Conclusions on the relationship between FWD and RSD in the context of this study will only be realistic after additional measurements.

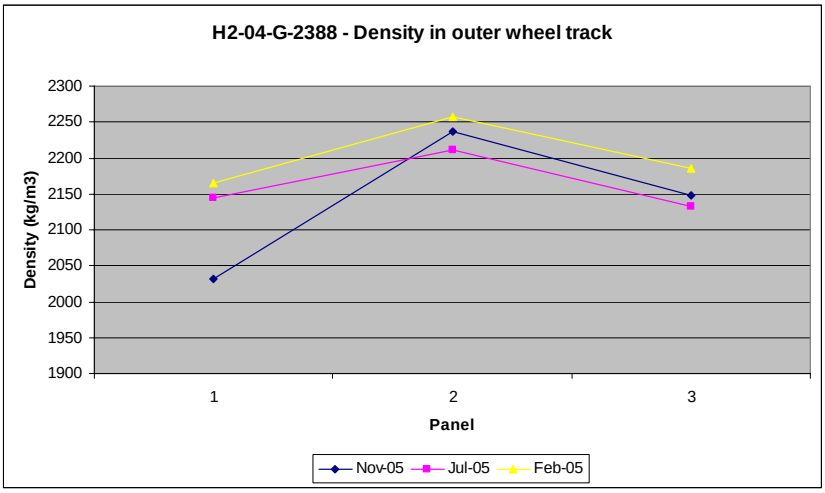

Figure 4.3: Density in outer wheel path on Section H2-04-G-2388

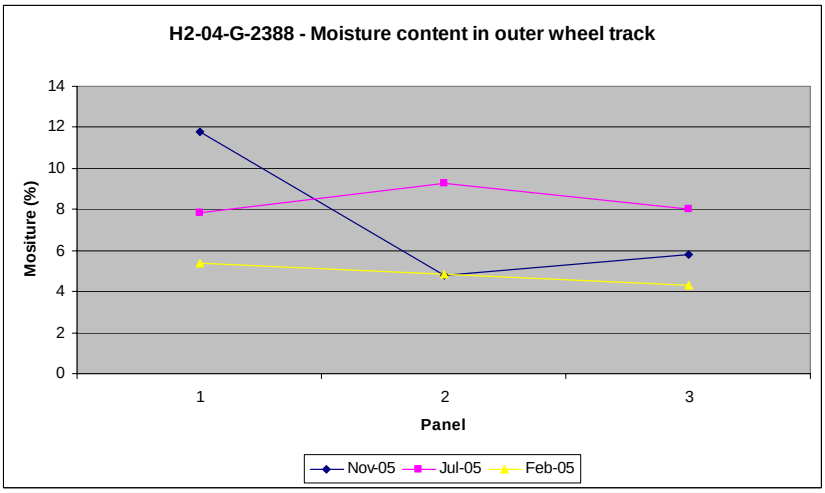

Figure 4.4: Moisture in outer wheel path on Section H2-04-G-2388

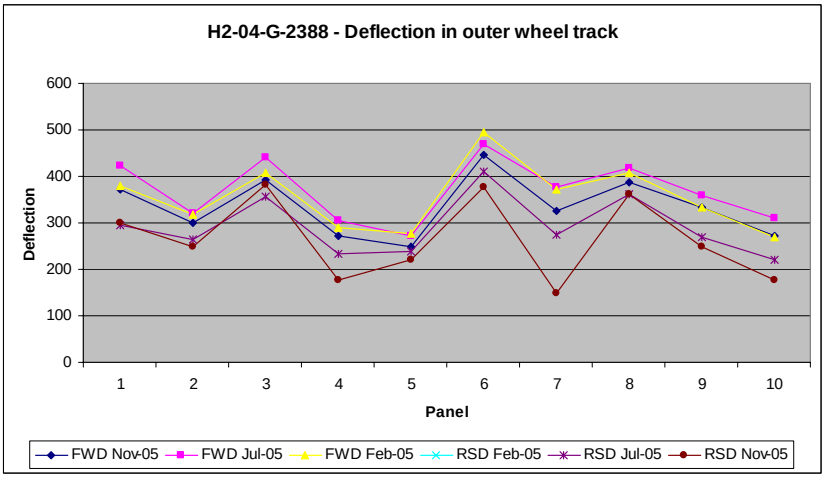

Figure 4.5: Deflection in outer wheel path on Section H2-04-G-2388

i-buttons were again installed for monitoring pavement surface temperature. In Table 3.2 a summary of the minimum, average and maximum temperatures measured for the period April 2005 to January 2006 are shown.

Table 3.2: Summary of the minimum, average and maximum surface temperatures measured (H2/04-G-P2388) – April 2005 to January 2006.

	LTPP section number
	H2/04-G-P2388
Minimum temperature [°C]	5.6
Average temperature [°C]	26.0
Maximum temperature [°C]	63.5

5. EXPERIMENT H3-04-G-243

This section should be read in conjunction with CSIR-BE Report CR-2005/06[5], which details the evaluation on 03 March 2004. Ratings are based on TMH9[3] and the GDPTRW Visual Assessment Manual for the Calibration of HDM-III/IV[4].

There was no further deterioration on this section. Bleeding was the only form of surfacing distress noted (rated as severity 1), however, the severity and extent had not changed since the previous visit (Figure 4.1).

Figure 5.1: Slight bleeding in wheel paths on H3-04-G-243, Feb and Nov'05

No mechanical failure, surface cracks or aggregate loss was noted and the binder condition was rated as fresh (1). Ambient and road surface temperatures were both 23°C in July 2005 and 37°C and 45°C respectively during the evaluation in November 2005. The binder was not tacky and there was no evidence of tyre impressions or adhesion to equipment. In terms of structural assessment, no cracking of any sort was noted, nor was there any evidence of pumping.

Rut depth had not increased (Figure 5.2) - discrepancies were attributed to change in assessors. No undulation, potholes or patching were recorded. No edgebreak was recorded, and the damage to the surfacing caused by the encroachment of grass was observed along the section had not deteriorated.

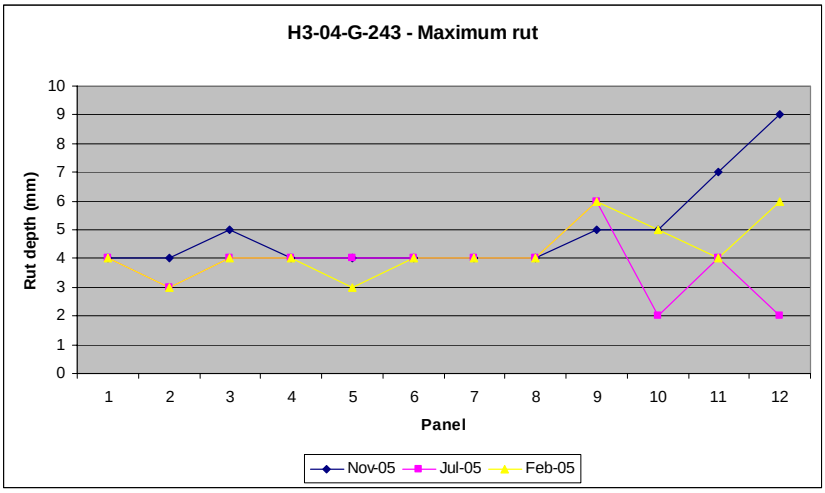

Figure 5.2: Maximum rut for Section H3-04-G-243

In terms of functional assessment, riding quality, skid resistance and surface drainage were all rated as good (1). The unsealed shoulders were mostly clear of vegetation, but the side drains were still overgrown with thick grass.

Four photographs were taken. Photographs of each panel were considered unnecessary given the consistency in performance of the panels.

The density and moisture measurements recorded in November 2005 were almost identical to those recorded in February (see Figures 5.3 and 5.4) for example of outer wheel track measurements). However, the density and moisture measurements in July 2005 were lower and higher respectively. It is unclear whether this is as a result of inconsistencies in the measurement and further seasonal measurements will be required before trends can be better understood.

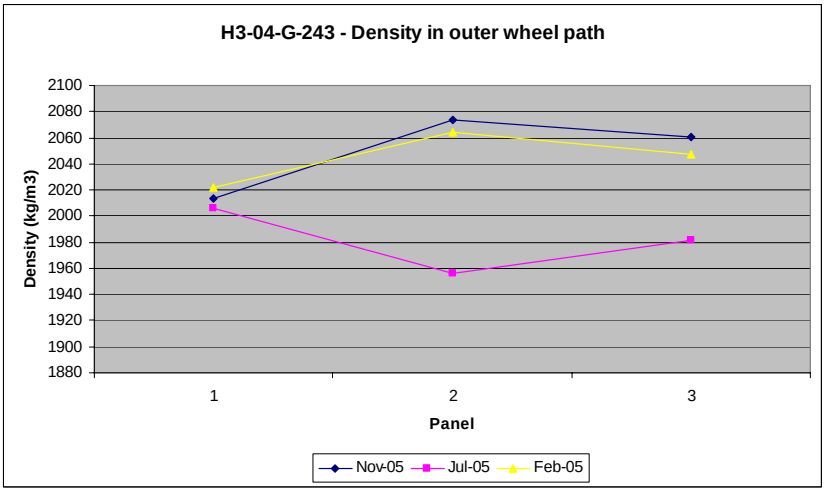

Figure 5.3: Density in outer wheel path on Section H3-04-G-243

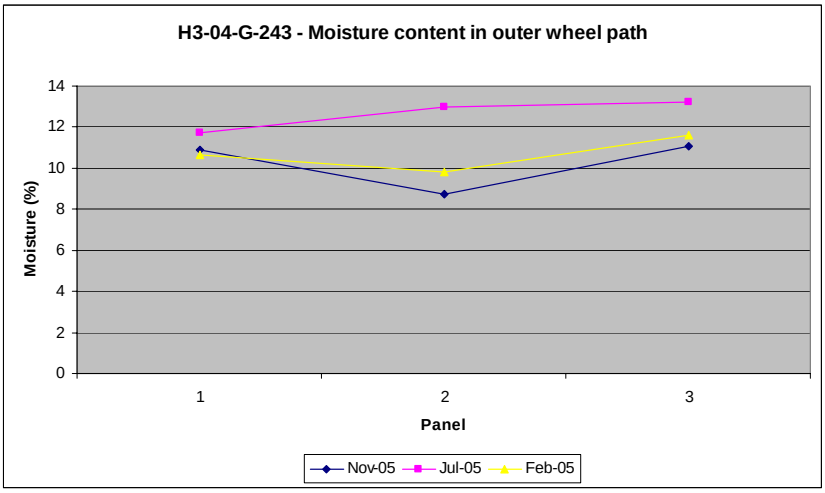

Figure 5.4: Moisture in outer wheel path on Section H3-04-G-243

Dynamic Cone Penetrometer measurements showed little trend with previous measurements - this was attributed to the stony nature/strength of the material. Longer term trends are likely to be more useful and thus measurements will be continued.

Deflection measurements remained consistent (Figure 5.5). RSD measurements showed similar trends to FWD measurements but were slightly lower. July 2005 RSD measurements at specific locations (Panels 5, 8 and 10) appear to be inconsistent with other measurements and were not included in the analysis. Conclusions on the relationship between FWD and RSD in the context of this study will only be realistic after additional measurements.

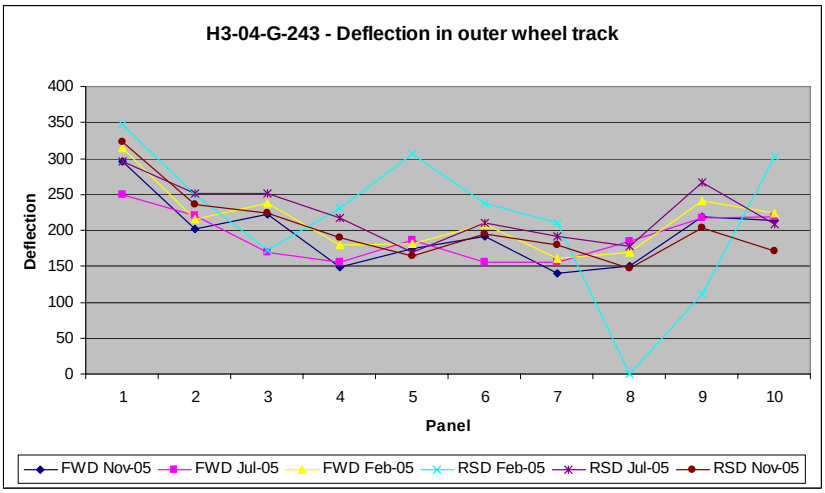

Figure 5.5: Deflection in outer wheel path on Section H3-04-G-234

i-buttons were again installed for monitoring pavement surface temperature. In Table 4.1 a summary of the minimum, average and maximum temperatures measured for the period April 2005 to January 2006 are shown.

Table 4.1: Summary of the minimum, average and maximum surface temperatures measured (H3/04-G-243) – April 2005 to January 2006.

	LTPP section number
	H3/04-G-243
Minimum temperature [°C]	2.5
Average temperature [°C]	20.6
Maximum temperature [°C]	60.0

6. COMPARISON WITH HVS DATA

Although three complete evaluations over both wet and dry seasons have been completed, there has been no deterioration in road performance. Traffic on the roads since HVS testing was completed amounts to the equivalent of between 180 000 E80s (P243/1) and 200 000 E80s (2388).

In terms of the HVS tests conducted on the two roads, the current traffic thus relates to 3.7 per cent of the test duration on road P243/1 and 6.7 per cent of the test duration on road 2388. An initial comparison of the data obtained from the HVS test and that from the LTPP test were done.

In Figure 6.1 the rut data for road 2388 (LTPP sections H1-04-G-2388 and H2-04-G-2388 and HVS test 403A4) are shown. A vertical scale of 20 mm has specifically been used as this relates to the typical failure level for surface rut. The data indicate that the rut on the LTPP sections is higher than the rut at the same stage on the HVS test section. However, the period over which the LTPP data were collected is still very short in comparison with the period (in terms of E80s) that the HVS test was conducted, and it is suspected that (looking at the current performance of the LTPP section and the performance of the HVS section) the rut will not increase radically on the LTPP sections.

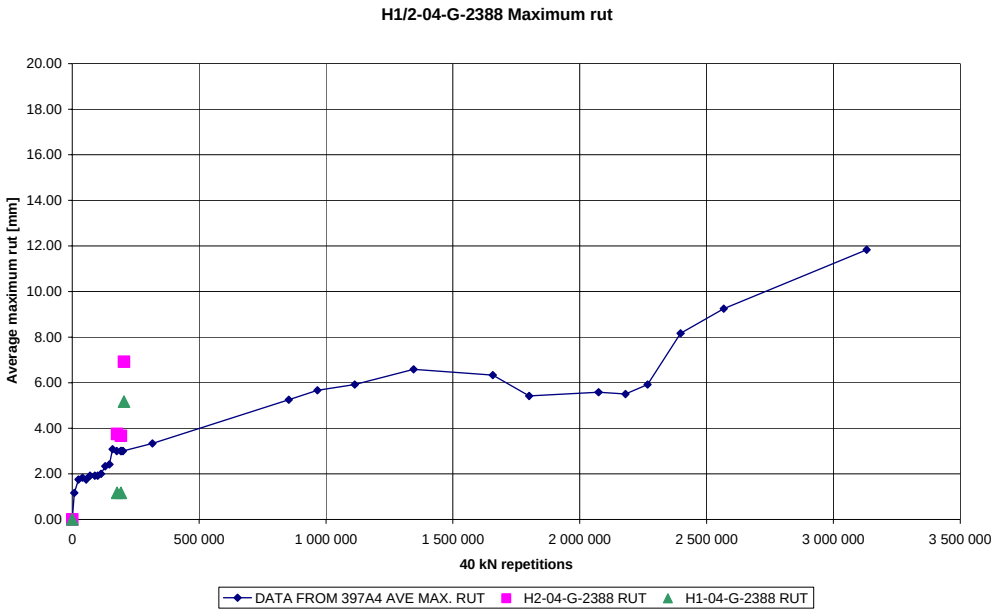

Figure 6.1: Rut from HVS test and LTPP sections on Road 2388

In Figure 6.2 the elastic surface deflection data as measured using the RSD (HVS and LTPP sections) and the FWD (only LTPP sections) are shown. The data indicate that the LTPP sections' RSD and the FWD deflections are scattered around the RSD data

obtained from the HVS test. No clear conclusions can be drawn from this data as the period for the LTPP evaluation is still relatively short.

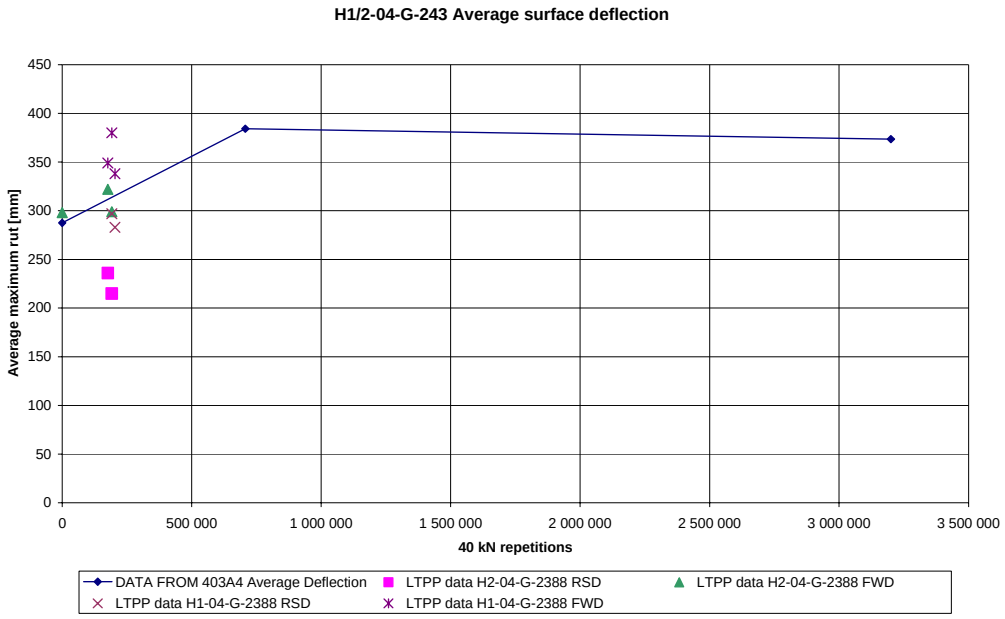

Figure 6.2: Elastic surface deflection from HVS test and LTPP sections on Road 2388

In Figure 6.3 the rut data for road P243/1 ((LTPP sections H3-04-G-243 and HVS test 409A4) are shown. A vertical scale of 20 mm has specifically been used as this relates to the typical failure level for surface rut. The data indicate that the rut on the LTPP section is higher than the rut at the same stage on the HVS test section. However, the period over which the LTPP data were collected is still very short in comparison with the period (in terms of E80s) that the HVS test was conducted, and it is suspected that (looking at the current performance of the LTPP section and the performance of the HVS section) the rut will not increase radically on the LTPP sections.

In Figure 6.4 the elastic surface deflection data as measured using the RSD (HVS and LTPP sections) and the FWD (only LTPP sections) are shown. The data indicate that both the RSD and the FWD deflections are currently lower than that measured on the HVS test section. No clear conclusions can be drawn from this data as the period for the LTPP evaluation is still relatively short.

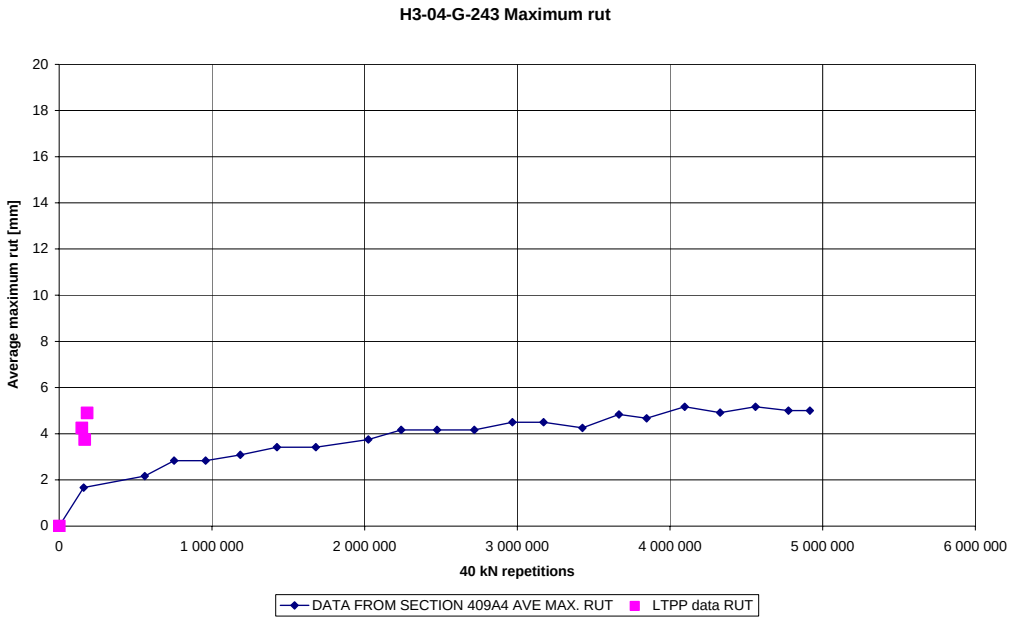

Figure 6.3: Rut from HVS test and LTPP sections on Road 243

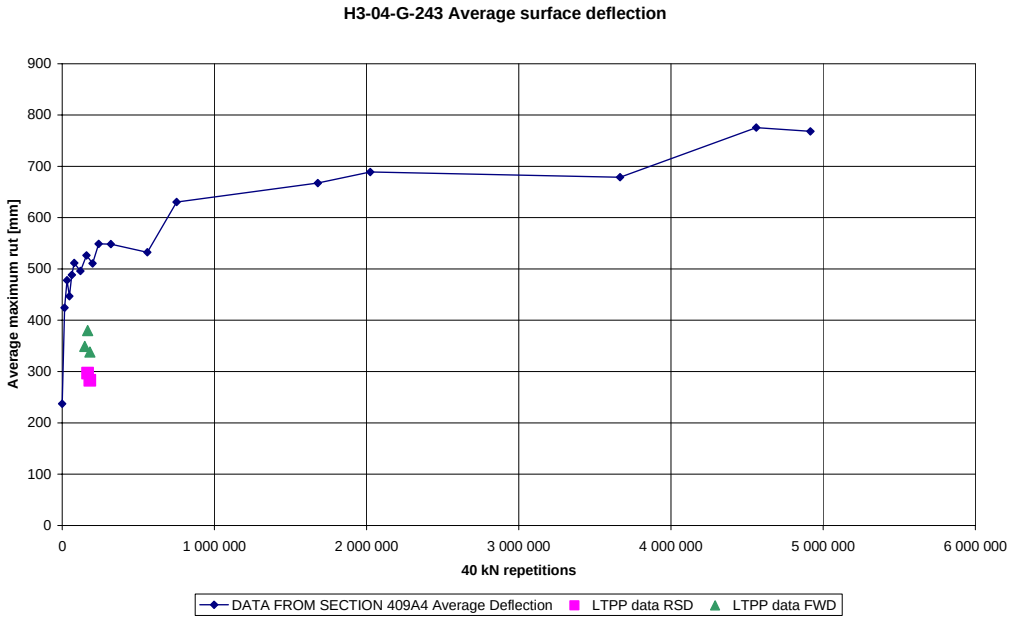

Figure 6.4: Elastic surface deflection from HVS test and LTPP sections on Road 243

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Conclusions

No further deterioration was noted on any of the three sections during the two evaluations detailed in this report. Some potential seasonal variation in terms of moisture content, and its influence on density and deflection, seems to be apparent, although additional monitoring will be required before any firm conclusions can be drawn. Investigations are ongoing for the identification of suitable moisture measurement devices that are reliable and robust and can potentially be left in the LTPP sections to ensure that moisture data are not influenced by external factors. DCP measurements continue to be influenced by the stony nature of the material and additional measurements will be required before any useful trends will be observed.

Data collected during this assessment have been captured in the Excel® spreadsheet, which accompanies this document on compact disc.

An initial comparison between HVS and LTPP data were made for all three of the LTPP sections. The rut data from the LTPP sections are currently higher than at the equivalent point in the HVS data, while the deflection data are scattered around the HVS data. It appears as if more LTPP data are required before any clear trends will start to emerge from the comparisons.

Although the procedure for measuring profiles was reviewed and on site comparisons with previous data were undertaken during the July 2005 assessment, some discrepancies were noted with the November 2005 measurements. Assessors were re-trained to ensure that consistent measurements are obtained and on-site comparisons with previous measurements were made mandatory. Information will also be obtained from international LTPP programmes to obtain an indication of typical repeatability between measurements.

7.2. Recommendations

Monitoring of the LTPP experiments should continue at the planned intervals (begin May 2006 and begin November 2006). Further comparisons with HVS data will be made as additional data are collected, and it is expected that clearer trends will start to emerge from these comparisons. Moisture contents should be closely monitored as this appears to be influencing density, strength and deflection measurements.

Traffic counts should be repeated to ensure that seasonal variation is considered and that realistic cumulative traffic data, since construction, is available for later analysis and comparison with HVS performance.

8. REFERENCES

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APPENDIX A

PROJECT PROPOSAL

APPENDIX A: PROJECT PROPOSAL

Project Proposal Number: PP/2005/11

Version 1

15 August 2005

Ongoing monitoring of the GDPTRW HVS-LTTP experiments

Submitted by:

CSIR

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Lynn East, 0039

1 Background

A protocol for the establishment and monitoring of LTPP sections in conjunction with HVS experiments was completed in 2002. In 2003 a small study was commissioned to layout sections at the HVS sections on Roads P2388 and P243/1 and to complete visual assessments and DCP measurements. In terms of the protocol, responsibility for gathering or arranging for the gathering of the remaining data rested with GDPTRW. This did not materialize and a proposal for CSIR to carry out this work was accepted in 2004. The sections were comprehensively monitored, a database was created and reports on the establishment and monitoring prepared and submitted. Given that the sections had only been monitored for a relatively short period of time, no attempt was made to compare performance of the LTPP sections with that of the HVS tests. A proposal to continue the monitoring in 2005 was accepted (first monitoring (end of summer) has been completed). This proposal motivates for monitoring and appropriate analysis until March 2007. A proposal to undertake a similar study in the Western Cape on the N7 and Elandsbaai HVS experiments was submitted to the Western Cape DoT, however, no decision has been taken on whether to proceed as yet.

2 Problem Statement

Considerable funding has been invested in HVS studies, the development of a protocol for conducting LTPP studies in association with HVS tests, the establishment of LTPP sections and initial monitoring. It is important that monitoring at the recommended intervals continues in order to collect sufficient data with which to compare performance.

3 Project Objectives

The objectives for this study are:

- Monitor identified LTPP sections, collect appropriate data and store this data in a database for future comparison with performance of HVS experiments
- Compare performance of LTPP and HVS experiments when sufficient data has been collected

4 Expected Benefits

Road authorities and their appointed consultants and researchers will have access to the data collected from both LTPP and HVS sections. In time, this information will enable the establishment of the link between APT results and real-life performance, which will realise the full potential of the large amount of HVS data that has been collected. By not collecting LTPP data, the link between APT and actual performance will never be scientifically established and the debate about the relevance of HVS testing will continue.

5 Methodology

The methodology prescribed in the Protocol for establishing and monitoring LTPP sections, and already used in the previous monitoring exercises, will be followed. Evaluations will compared with previous evaluations and depending on traffic volume carried, with the early stages of HVS testing.

6 Deliverables

The following deliverables are anticipated:

- First level reports on completion of each year of monitoring (i.e. two visits) of each LTPP experiment (2 reports). This will include comparisons with previous evaluations
- When deemed appropriate, based on first level report data trends and after discussion with GDPTRW comparison with early phases of HVS testing.
- Updated spreadsheet database with raw data from each LTPP section (3 spreadsheets)

7 Implementation of Findings

The spreadsheet database will be available together with HVS data for analysis purposes. Early findings will be documented in reports and issues the might impact on the way in which HVS testing is done will be raised with GDPTRW.

8 Project Plan

8.1 Gantt Chart

Task	Personnel	Schedule (months)																						
		2006												2007										
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
End wet season monitor	PL, Technician		xx	Xx											xx	xx									
End dry season monitor	PL, Technician								xx	xx											xx	xx			
Analysis	PL				xx					xx							xx					xx			
Report	PL									xx													xx		

8.2 Project Cost Estimate

The project cost estimate for four evaluations over two years (2006 and 2007) is provided below. It should be noted that a large component of the cost is related to vehicle operating costs which cannot be accurately predicted given the volatility of the fuel price. A more accurate quote will be submitted prior to each evaluation.

D2388			
Task	**Units**	**Unit cost**	**Cost (R)**
Time (DJ) (includes analysis & report)	48	750	36 000
Time (CF)	48	400	19 200
Time (Assistants)	96	175	16 800
DCP points	36	15	540
FWD establishment*	300	7	2 100
FWD measurements*	96	80	7 680
RSD measurements*	300	5.5	1 650
Cold mix	4	50	200
Running costs (Travel and S&T)*	2	1 950	3 900
Traffic counts/WIM*	1	17 000	17 000
Sub-total*			105 070
P243/1			
Task	**Units**	**Unit cost**	**Cost (R)**
Time (DJ) (includes analysis & report)	48	750	36 000
Time (CF)	48	400	19 200
Time (Assistants)	96	175	16 800
DCP points	18	15	270
FWD establishment*	600	7	4 200
FWD measurements*	48	80	3 840
RSD measurements*	600	5.5	3 300
Cold mix	2	50	100
Running costs (Travel and S&T)*	2	2 300	4 600
Traffic counts/WIM*	1	19 000	19 000
Sub-total*			107 310
Sub-total D2388			105 070
Sub-total P243/1			107 310
14% VAT			29 733
Total			**242 113**
Total for 2006*			**121 057**
Total for 2007* (8% escalation)			**130 741**
Total for 2006 and 2007 with estimated escalation*			**251 798**
* Costs will depend on fuel price - revised costs will be submitted prior to evaluations			

8.3 Project Team/Personnel

Project Manager/technical specialist	Dr D Jones
Technical support:	Dr P Paige-Green
	Mr C Fisher
FWD:	RST
Traffic counts:	Traffic Engineering Services

9 Approval of the Project

I …….hereby accept the content of the proposal

Ongoing monitoring of the GDPTRW HVS-LTPP experiments

PP/2005/11

And the conditions of contract on behalf of

GDPTRW (CLIENT)

Signed at ……on this ……. day of …….. 20……

As witness:

1) ……..

2) ……..

I …….. hereby undertake on behalf of CSIR Built Environment to complete the work set out in the proposal

Ongoing monitoring of the GDPTRW HVS-LTPP experiments

PP/2005/11

under the conditions of contract

Signed at ……on this ……. day of …….. 20……

As witness:

1) ……..

2) ……..

APPENDIX B

EVALUATION FORMS

APPENDIX B: EVALUATION FORMS

The completed field evaluation forms are available to be viewed at CSIR. The detailed data are available on the accompanying CD.