CITY OF CAPE TOWN & SABITA

PROGRESS OF THE GREY WATER STUDY

32nd ROAD PAVEMENT FORUM

CSIR INTERNATIONAL CONVENTION CENTRE

7-8 NOVEMBER 2016

WELCOME AND INTRODUCTION

- **Presenter**
  - André Greyling
- **Clients**
  - SABITA & CITY OF CAPE TOWN
  - Represented by:
    - Ian Bowker
    - Saied Solomon

WELCOME AND INTRODUCTION

- **Grey Water Study Group**
  - MyCube Asset Management - Gerrie Van Zyl
  - University of Stellenbosch - Kim Jenkins
    - Riaan Briedenhann
    - Marais Nel
  - BVi Consulting Engineers - André Greyling
  - Zebra Surfacing - Jonathan Pearce

WELCOME AND INTRODUCTION

- **Special thanks to**
  - Much Asphalt
  - More Asphalt
  - Colas

PRESENTATION OVERVIEW

- Section 1 – Mew Way condition overview
- Section 2 – Literature Review
- Section 3 – Laboratory Testing Phase 1
- Section 4 – Laboratory Testing Phase 2
- Section 5 – Trial Section Monitoring
- Section 6 – Conclusions & Recommendations

PROJECT LOCATION

- Specific Focus on Mew Way
- City of Cape Town Metropolitan Area
  - Khayelitsha Area
  - Includes various other roads in Informal Settlement Areas
- Found that roads & especially surfacing's just don’t last in grey water contact areas
- TCT therefore identified the need for a more sustainable solution..

PROJECT LOCATION

GREY WATER STUDY PROJECT

SECTION 1

MEW WAY CONDITION OVERVIEW

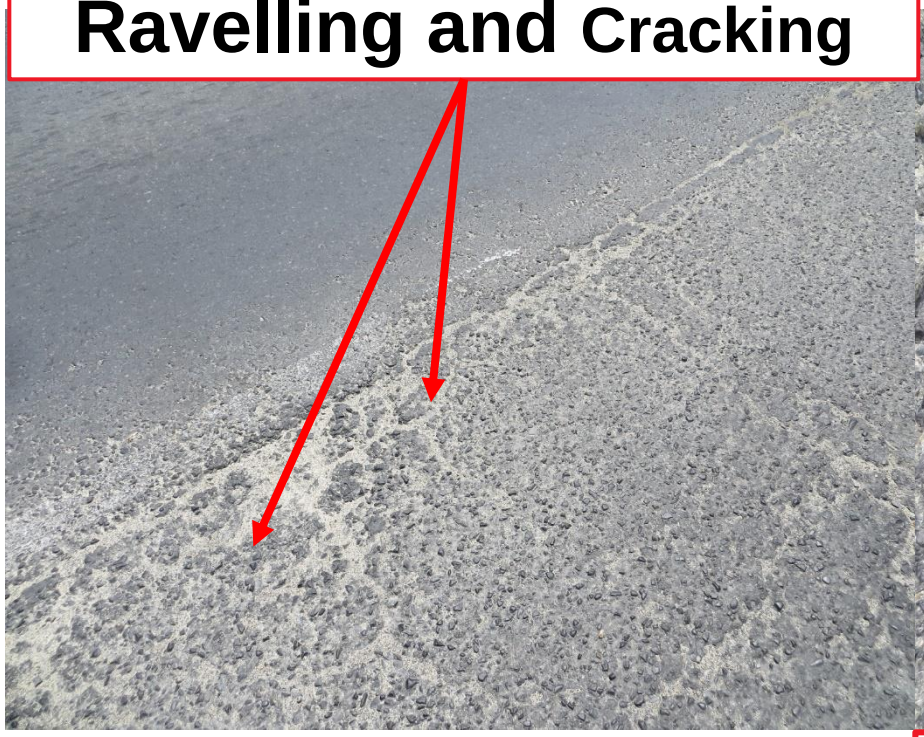
January 2014

GREY WATER ON MEW WAY

STANDPIPE & ROAD DAMAGE

SURFACING DISTRESSES

Ravelling and Cracking



Loss of Filler & Small Fractions

FAILURE MECHANISMS

- What did we find?
- Identified failure mechanisms
  - Mastic , Stone and Bitumen Loss
    - (Adhesion & Cohesion)
  - Ravelling
  - Cracking
  - Patches
  - Pavement Failure

OUTCOME

- Confirmed the issue was real !
- Solution was however not as simple
  - Move the standpipes…
- Identified a three phased approach
  - Short term - Asphalt solutions
  - Medium term – Design & pavement solutions
  - Long term - Training and education
- Focus of this study was the asphalt solution
- First step was an in-depth literature review

SECTION 2

LITERATURE REVIEW

WHAT IS GREY WATER?

- Grey Water General Definition:
  - “grey water is defined as the wastewater from bath tubs, showers, washbasins and washing machines” – **NO** Black Water
- **Most important ingredient is Water**
- Havellynn Peterson – Thesis – Door to Door Survey in the Mew Way Areas
    - Findings – Water, Washing Powder, Dishwashing Liquid

GREY WATER CONSTITUENTS

- The Major Ingredients of Washing Powder and Dishwashing Liquids are **Surfactants**
- “Surfactants can be defined as a compound that lowers surface tension (or interfacial tension) between two liquids or between a liquid and a solid.”
- Conclusion - Grey Water consist of :
  - 99% + Water
  - Dissolved Surfactants
  - Various other less concentrated ingredients

FAILURE MECHANISMS

- Moisture/water damage as a starting point to understand the effect of grey water damage on asphalt.
- The major failure mechanisms - ***Disbonding or Adhesion Failure.***
- This occurs when there is a break in the bitumen/aggregate bond leading to:
  - stripping, ravelling, loss of stiffness and strength and other adhesion related failures.

CHEMICAL RESISTANCE OF ASPHALT

- Various Literature Sources on Chemical Damage to Bitumen (Not Asphalt)
  - Most Bitumen binders and Aggregates are **not negatively** influenced by Surfactants.
  - Soap does not generally dissolve bitumen or aggregates
  - The nature of Surfactant is however to **Break Bonds** and there is an expected influence on the Bitumen Aggregate Bond

GREY WATER STUDY PROJECT

FACTORS THAT WILL INFLUENCE MOISTURE DAMAGE

- **Aggregate Properties**
  - Basic for improved adhesion
- **Bitumen Properties**
  - Modification increase adhesion & chemical resistance (EVA& SBS)
- **Asphalt Mixture Properties**
  - Continuously graded , Active Filler (Lime)
- **External Factors**
  - Compaction, layer thickness etc

THEORETICAL SOLUTION

- Continuously Graded Mixture
- Asphalt designed to have 2.5% Voids post traffic compaction
- 1-3% Hydrated Lime as filler
- EVA or SBS Polymer Modified Binder to ensure increased strength and adhesion characteristics
- F-T Wax as compaction agent and to increase chemical resistance.

THEORETICAL SOLUTION

- Constructed Field Void Content of less than 7%
- Layer thickness of more than 40mm

- These finding was used as the basis for the development of the laboratory testing plan

SECTION 3

PHASE 1 LABORATORY RESULTS

Mr Riaan Briedenhann

PHASE 1 LABORATORY RESULTS

- Tests conducted at Stellenbosch University
- Various asphalt and binder combinations
- Continuously Graded and Gap Graded mixtures
- Initial tests - briquettes was soaked in clean water and grey water – ITS Tests
- Further testing was then completed using the Moisture Inducing Testing Device (MIST)
- Retained ITS values

PHASE 1 LABORATORY RESULTS

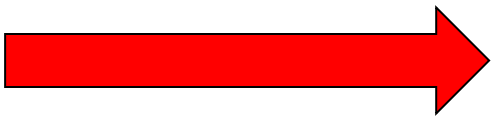
- **Conclusions:**
  - Water versus Grey Water
    - Clean water damage of asphalt is significant
    - Grey water significantly increases this damage
  - Composition
    - Continuously graded mixture performed best
    - Laboratory manufactured Semi Gap graded showed good potential

PHASE 1 LABORATORY RESULTS

- **Binder Additives**
  - Additives shown definite increase in grey water resistance
  - Plastomer (EVA) performed better that elastomer (SBS)
  - Addition of SASOBIT increased compactability and showed increased resistance to grey water
  - Addition of 2% lime proved beneficial in certain mixes

PHASE 1 LABORATORY RESULTS

- **Compaction**
  - Samples with less voids showed increased resistance to grey water damage
- **Conclusion and Recommendations**
  - Performance based tests required
    - MMLS
  - Investigation into additional gradings and availability of local supply



Second Phase

SECTION 4

PHASE 2 LABORATORY RESULTS

Mr Marais Nel

PHASE 2 LABORATORY RESULTS

- Expand test matrix - More gradings and binder combinations
- **Two grading groups**
  - Colto Medium (CM)
    - Higher volume roads
  - Colto Fine , CCC Fine & Semi Gap Graded (FM)
    - Lower volume roads

PHASE 2 LABORATORY RESULTS

- **Two staged approach**

- **Stage 1- Initial Investigation**
  - MIST & ITS
- **Stage 2 – Accelerated Pavement Testing**
  - MMLS3 , Laser Profilometer & ITS

PHASE 2 LABORATORY RESULTS

- MIST conditioning - Clean and grey water at 60ºC
- MMLS3 trafficking - 100 000 dry and wet load cycles at 40ºC
- Grey water concentration - 0.5% Sunlight® liquid + 0.5% OMO® laundry detergent per 100 litres of clean water

MIST

MMLS

PHASE 2 LABORATORY RESULTS

- **Phase 2 laboratory results included:**
  - ITS (Strength, Stiffness)
  - TSR (Moisture susceptibility)
  - Permanent Deformation (Shear resistance)
  - Texture and Material Loss (Ravelling)

PHASE 2 LABORATORY RESULTS

- Results were combined though simple rating criteria
- Determine effective grey water resistant asphalt mixture for:
  - High volume roads (Mew Way) - Medium graded asphalt
  - Low volume roads (Internal roads) - Fine graded asphalt

PHASE 2 LABORATORY RESULTS

Asphalt Mixture & Grading	Phase 1			Phase 2					
	Compact -ability	TSR %	Average	Compact - ability	TSR %	Rut Dry	Rut Wet	Ravelling	Average
EVA + 2% Lime + 1% Sasobit® + ZycoTherm® – CM	1	1	1	4	5	1	2	1	2.6
EVA + 2% Lime + 1% Sasobit® - CM	2	3	2.5	1	2	6	3	2	2.8
EVA + 2% Lime – CM	4	5	4.5	3	4	2	1	7	3.4
SBS + 2% Lime – CM	3	4	3.5	2	1	5	7	6	4.2
SBS + 2% Lime + 1% Sasobit® + Polyamine – CM	5	2	3.5	7	6	3	4	4	4.8
SBS +2% Lime + 1% Sasobit® + ZycoTherm® – CM				6	3	4	6	5	4.8
SBS + 2% Lime + 1 % Sasobit® - CM	6	6	6	5	7	7	5	3	5.4
50/70 +1% Lime – CM	7	7	7	5	8	8	8	8	7.4

PHASE 2 LABORATORY RESULTS

EVALUATION OF RESULTS – CM

- Based on simple performance position score:
  - EVA modified binder, 2% Lime, 1% Sasobit and 0.1% Zycotherm
  - EVA modified binder, 2% Lime and 1% Sasobit
  - EVA modified binder and 2% Lime

PHASE 2 LABORATORY RESULTS

EVALUATION OF RESULTS – CM

- The range of EVA modified mixtures outperformed both the SBS and unmodified mixtures, whilst the 50/70 penetration grade binder showed the least resistance to grey water

PHASE 2 LABORATORY RESULTS

EVALUATION OF RESULTS - FM

Asphalt Mixture & Grading	Phase 1			Phase 2					Average
	Compact -ability	TSR %	Average	Compact - ability	TSR %	Rut Dry	Rut Wet	Ravelling	
EVA + 1% Sasobit® + 0.1% ZycoTherm® - CF				2	3	1	1	1	1.6
EVA + 1% Sasobit® - CF	6	2	4	3	2	3	2	2	2.4
50/70 + 1% Sasobit® - CF	3	3	3						
50/70 + 1% Sasobit® - CCC	2	5	3.5						
50/70 + 0.07% ZycoTherm® - Much Fine	9	1	5	8	1	5	5	3	4.4
50/70 - CCC	4	7	5.5	4	6	4	4	4	4.4
50/70 + 1% Lime + 0.1% ZycoTherm® - CF				1	5	7	7	5	5
EVA + 1% Sasobit® - CCC	5	6	5.5	7	7	2	3	6	5
50/70 + 1% Lime - CF	1	8	4.5	6	4	6	6	7	5.8
50/70 + 1% Lime - CCC	8	4	6						
50/70 - Semi Gap	7	9	8						

PHASE 2 LABORATORY RESULTS

EVALUATION OF RESULTS – FM

- The COLTO continuously fine graded asphalt with EVA modified binder, 1% Sasobit and 0.1% Zycotherm as additives
- The COLTO continuously fine graded asphalt with EVA modified binder, 1% Lime and 1% Sasobit as additive

SECTION 5

TRIAL SECTION MONITORING

TRIAL SECTION MONITORING

- Mew Way Rehabilitation
  - Completed in September 2014
    - GIBB
  - Various trial sections was constructed
  - Ideal opportunity to monitor in service behaviour

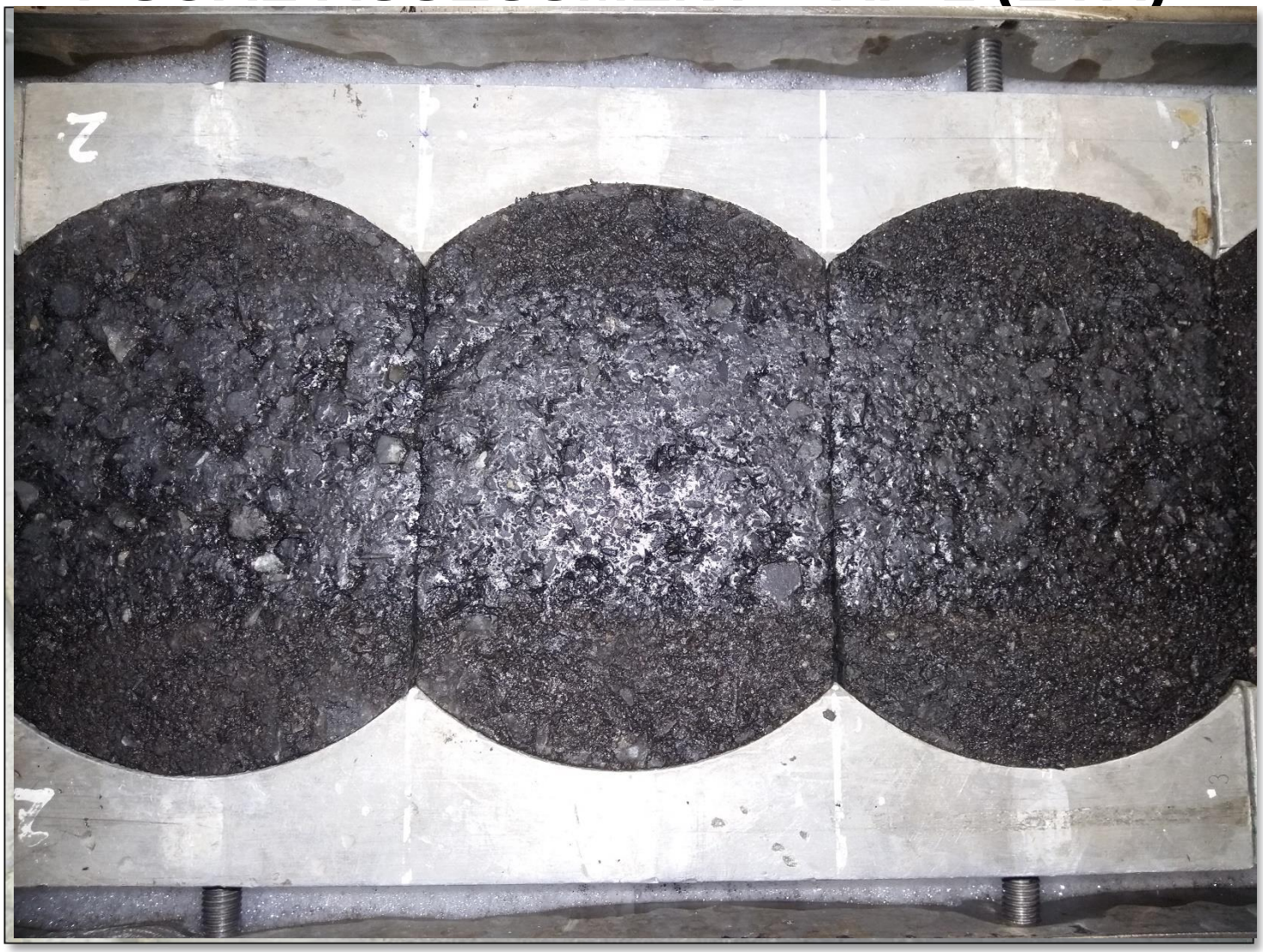
TRAIL SECTION MONITORING

- **Visual Assessment**
  - March 2016
- **Mechanical Measurement**
  - IRI
  - Rutting
  - Texture

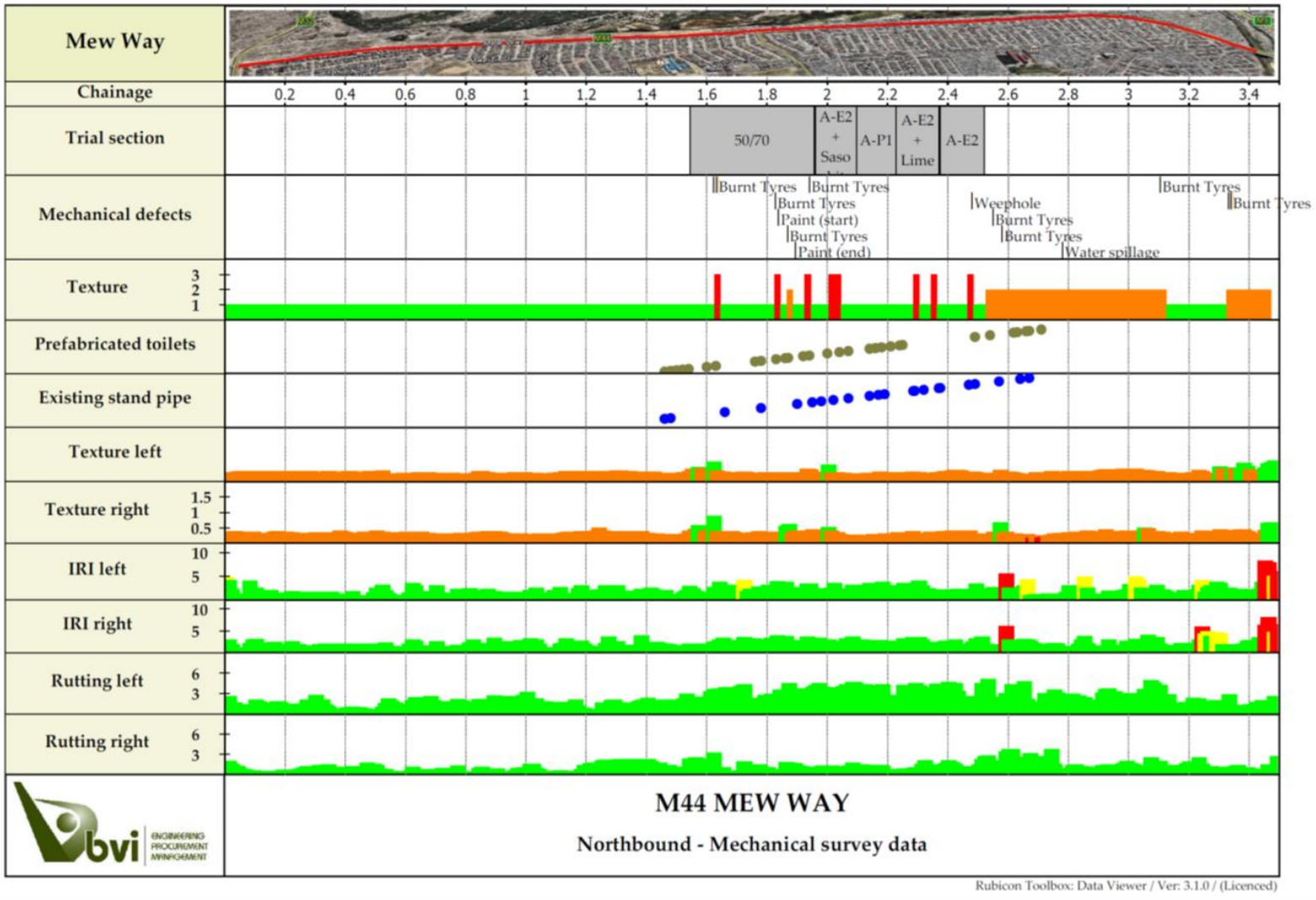
VISUAL ASSESSMENT - 50/70 PEN GRADE

VISUAL ASSESSMENT – AE-2 (SBS)

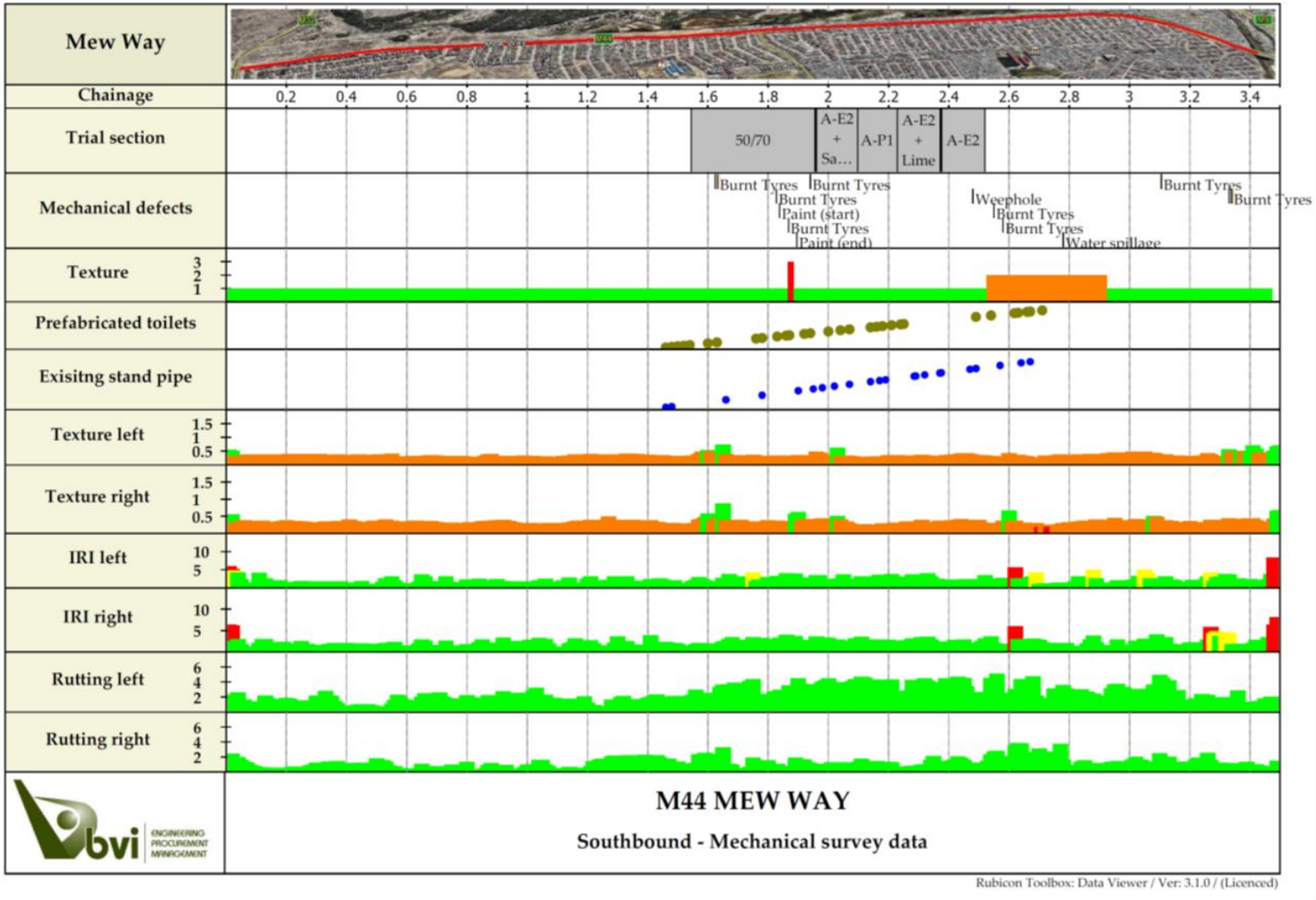
VISUAL ASSESSMENT – AP-1 (EVA)



VISUAL SURVEY RESULTS



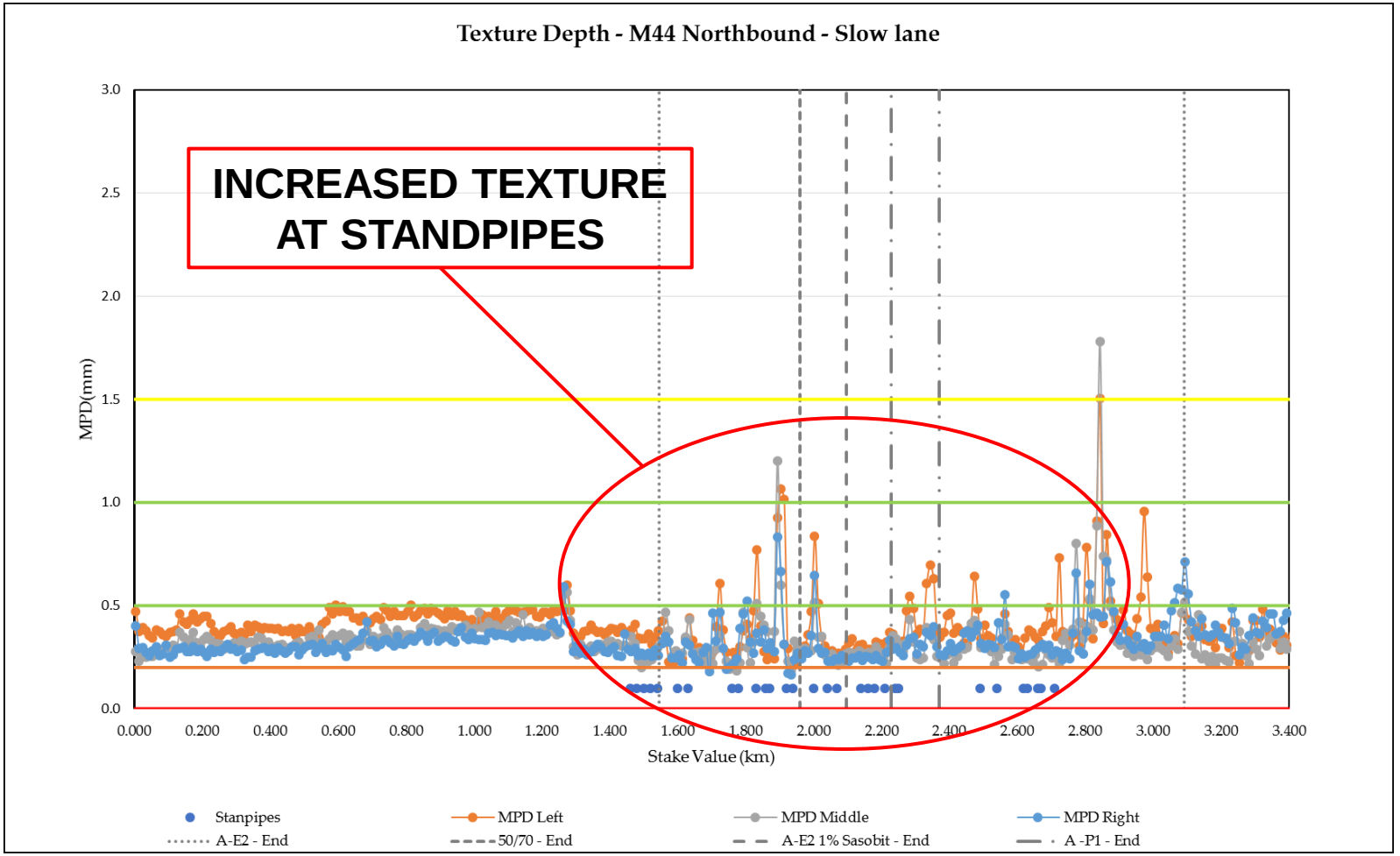
VISUAL SURVEY RESULTS



VISUAL SURVEY RESULTS

- Road still in good/fair condition
  - Expected after 2 years
- Texture/Material loss noted on all sections except A-P1 (EVA)
  - Already loss of material is visible

MECHANICAL MEASUREMENTS - TEXTURE



SECTION 6

CONCLUSION

CONCLUSION

- Found that EVA modified mixtures with a combination of additives performed the best
- Clear benefit of adding 1% SASOBIT® as compaction agent
- Zycotherm Nano Technology showed improved resistance to Grey Water damage

CONCLUSION

- Influence of gradings, voids, lime etc. confirmed
- Results further confirmed by in-service behaviour
- Confident that we have found a workable short term solution

WAY FORWARD

- Entering final phase of project
- Final recommendations and presentation to City of Cape Town on the 21st of November 2016
- Continuous monitoring of trial sections for another 2 years up to 2018

QUESTIONS & DISCUSSIONS

THANK YOU