THE NEAR REPEAT RISK CALCULATION OF RESIDENTIAL BURGLARIES IN HILLCREST, KWAZULU-NATAL, SOUTH AFRICA: A CRIMINOLOGICAL ANALYSIS

by

JAMES ANDREW GEORGE ROY CLARK

submitted in accordance with the requirements for

the degree of

MASTER OF ARTS

in the subject

CRIMINOLOGY

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROFESSOR AE HESSELINK

CO-SUPERVISOR: PROFESSOR NP DASTILE

December 2018

TABLE OF CONTENTS

DECLARATION xv

ACKNOWLEDGEMENTS xvi

SUMMARY xviii

KEY TERMS: xviii

TRANSLATION ISIZULU xix

Iqoqa: xix

Amatemu asemqoka: xix

TRANSLATION NESIXHOSA 1

Isishwankathelo: 1

Amagama aphambili: 1

ACRONYMS AND ABBREVIATIONS 2

CHAPTER 1 1

INTRODUCTION AND ORIENTATION TO THE NEAR REPEAT CALCULATOR 1

1.1 INTRODUCTION 1

1.2 CRIME ANALYSIS TOOLS USED 3

1.3 RESEARCH PROBLEM AND RATIONALE 6

1.4 RESEARCH AIMS AND OBJECTIVES 7

1.5 RESEARCH QUESTIONS 8

1.6 DEFINITIONS 8

1.6.1 Environmental Criminology 9
1.6.2 Geographic Information Systems (GIS) 9
1.6.3 Crime Mapping 10
1.6.4 Crime Analysis 10
1.6.5 Q - Geographic Information System (Q-GIS) 11
1.6.6 Mixed method research 11
1.6.7 Near Repeat Burglary 12
1.6.8 Near Repeat Calculator (NRC) 12
1.6.9 Decision Support Systems (DSS) 13
1.6.10 Residential burglary 13
1.6.11 Robbery at residential premises 14
1.7 METHODOLOGICAL OUTLAY 14
1.7.1 Broad goals of the research 14
1.7.2 Aims and objectives 14
1.7.3 Research design 15
1.7.4 Unit of analysis 16
1.7.5 Data collection methods 16
1.7.6 Validity and reliability 18
1.7.7 Ethics 19
1.7.8 Interpretation and explanation of findings 21
1.8 OUTLAY OF CHAPTERS 21

1.9 CONCLUSION 22

CHAPTER 2 24

A HISTORICAL AND CONTEXTUAL REVIEW OF NEAR REPEAT BURGLARY RESEARCH, GEOGRAPHIC INFORMATION SYSTEMS AND ENVIRONMENTAL RISK FACTORS 24

2.1 INTRODUCTION 24

2.2 INTERNATIONAL RESEARCH ON NEAR REPEAT BURGLARY PATTERNS 25

2.2.1 Australia 25

2.2.2 The United Kingdom 30

2.2.3 Multiple countries 35

2.2.4 The United States of America (USA) 37

2.2.5 Brazil 41

2.2.6 China 43

2.3 INTERNATIONAL RESEARCH AND DEVELOPMENT OF THE GIS 47

2.3.1 Research on the GIS in Africa 50

2.3.2 Research on the GIS in South Africa 55

2.3.3 Environmental risk factors relating to residential burglary 65

2.3.4 Residential burglary research in South Africa 68

2.3.5 Relevant news articles on residential burglary in KwaZulu-Natal, South Africa........ 72

2.3.6 The link between national and international research 74

2.4 CONCLUSION 74

CHAPTER 3 79

CRIMINOLOGICAL CRIME PREVENTION THEORIES 79

3.1 CRIME PATTERN THEORY (CPT) 79

3.2 THE FLAG AND BOOST THEORY (FBT) 82

3.3 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN (CPTED) 84

3.3.1 Surveillance and visibility 86

3.3.2 Territoriality 87

3.3.3 Access and escape routes 87

3.3.4 Image and aesthetics 88

3.3.5 Target Hardening 88

3.4 THE BROKEN WINDOWS THEORY (BWT) 91

3.5 CONCLUSION 92

CHAPTER 4 94

RESEARCH METHODOLOGY 94

4.1 INTRODUCTION 94

4.2 RESEARCH APPROACH 94

4.3 TYPE OF RESEARCH 95

4.4 RESEARCH DESIGN 95

4.5 AIMS AND OBJECTIVES 96

4.6 MOTIVATION FOR RESEARCH 97

4.7 RESEARCH POPULATION, SAMPLE AND SAMPLE METHOD 99

4.7.1 Research unit 100

4.7.2 Sample 100

4.7.3 Sample method (probability and non-probability) 101
4.8 DATA COLLECTION METHODS 101
4.8.1 Quantitative data collection 101
4.8.1.1 Setting 102
4.8.1.2 Duration 102
4.8.2 Qualitative data collection 103
4.8.3 Sourcing the NRC and the Q-GIS 105
4.8.4 Docket analysis 105
4.8.5 Structured interviews 106
4.9 RELIABILITY AND VALIDITY OF DATA COLLECTION INSTRUMENTS 107
4.9.1 Reliability 107
4.9.2 Validity 108
4.9.3 Trustworthiness 110
4.10 DATA ANALYSIS AND INTERPRETATION 110
4.11 ETHICAL ASPECTS 112
4.11.1 Ethical approval for research: UNISA and SAPS 113
4.11.2 Level of risk 113
4.11.3 Informed consent 114
4.11.4 Anonymity, confidentiality, and privacy 114
4.11.5 Conflict of interest 115
4.11.6 Deception of respondents 115

4.11.7 Benefits of research 116

4.11.8 Safekeeping and storage of data 116

4.11.9 Sharing of research findings and publication of data 116

4.12 CONCLUSION 116

CHAPTER 5 118

ANALYSIS AND FINDINGS 118

5.1 INTRODUCTION 118

5.2 FINDINGS OF THE SPATIAL ANALYSIS 119

5.2.1 Time of day 119

5.2.2 Environmental factors 120

5.2.3 Neighbouring land usage 121

5.2.4 Undeveloped land 121

5.2.5 Urban settlement informal 122

5.2.6 Peri-urban settlement informal 122

5.2.7 Other farming 122

5.2.8 Sugarcane fields 123

5.2.9 Railway lines 123

5.2.10 Main arterial roads 124

5.2.11 Road nodes or intersections 124

5.2.12 Cul-de-sacs or end nodes 125

5.3 ANALYSIS AND INTERPRETATION OF DATA 125

5.3.1 April 2012 166

5.3.2 May 2012 167

5.3.3 June 2012 167

5.3.4 July 2012 168

5.3.5 August 2012 169

5.3.6 September 2012 169

5.3.7 October 2012 170

5.3.8 November 2012 171

5.3.9 December 2012 172

5.3.10 January 2013 172

5.3.11 February 2013 173

5.3.12 March 2013 174

5.3.13 Interpretation of near repeat calculations 174

5.4 SUBJECT MATTER EXPERTS 175

5.4.1 What are your opinion and comments on the research focus areas and the goal of this research? 177

5.4.2 What are your comments and opinion on the background of the NRC related to this study? 177

5.4.3 What are your comments and opinion on the study aims, objectives and sample of this research? 177

5.4.4 What are your comments and opinion on the data collection and application of the NRC related to this study? 178

5.4.5 What are your comments and opinion on the possible benefits of the NRC in South Africa? 178

5.4.6 Can environmental factors, such as the location of the residence to main roads, end nodes (cul-de-sacs), various land usages, and railway lines be related to the risk of residential burglary victimisation? 179

5.4.7 Are you aware of any past or present research on the NRC or near repeat residential burglary patterns in South Africa? 179

5.4.8 To what extent is the GIS used by the SAPS at the station, provincial and national levels? 179

5.4.9 Are you aware of any past or present research on the use of the GIS at the SAPS station level? 179

5.4.10 Are you aware of any past or present research on the NRC or near repeat residential burglary in South Africa? 180

5.4.11 To what extent is the GIS used by the SAPS at the station, provincial and national levels? 180

5.4.12 To what extent are the Crime Pattern Analysis (CPA) and the Crime Threat Analysis (CTA) tools used by the SAPS? 181

5.4.13 How effective are the CPA and the CTA tools in predicting residential burglary patterns? 181

5.4.14 Are you aware of any past or present research on the Near Repeat Calculator (NRC) or near repeat residential burglary in South Africa? 182

5.4.15 Do you think the NRC could be a valuable tool for the SAPS at station level to predict near repeat residential burglary patterns? 182

5.4.16 What are the advantages and disadvantages of the SAPS using the GIS? 182

5.4.17 If the NRC results are used in conjunction with the GIS to create predictive near repeat residential burglary maps, do you think the SAPS will be better informed to allocate resources such as crime prevention patrols in areas with increased risk for residential burglaries? 182

5.4.18 At station level, do you think the SAPS has the ability, skills, and resources to run the NRC and the GIS software on a standalone computer, and create up-to-date month-to-month near repeat residential burglary risk maps? 183

5.4.19 Can the location of a neighbourhood or houses in relation to the environmental factors, like main roads, road nodes, end nodes (cul-de-sacs), railway lines and land use, play a role in the risk of residential burglaries? 183

5.4.20 Under which circumstances could a residential burglary in progress escalate to become a house robbery? 183

5.5 QUALITATIVE INTERVIEWS WITH DETECTIVES 184

5.5.1 Do you map the crimes that you investigate? 184

5.5.2 How well planned are residential burglaries? 185

5.5.3 In general, how far away do the burglars live and work from the crime scene or burgled property? 186

5.5.4 What attracts burglars to target a specific house or houses in an area? 186

5.5.5 What factors do burglars take into consideration before committing these crimes? ... 187

5.5.6 How many burglars are usually involved in residential burglaries? 188

5.5.7 What time of day and day of the week do the burglaries mostly occur? 188

5.5.8 Do criminals that commit residential burglary escalate to commit robberies at residential premises? 189

5.5.9 In your investigations, can you identify patterns for a series of crimes? 190

5.5.10 Can you predict, based on previous cases, where the next residential burglary is most likely to occur? 191

5.5.11 Would you use the NRC? 192

5. 6 CONCLUSIONS 193

CHAPTER 6 198

RECOMMENDATIONS AND CONCLUSION 198

6.1 INTRODUCTION 198

6.2 FINDINGS AND ADHERENCE TO THE RESEARCH DESIGN 198

6.2.1 Can the NRC identify near repeat residential burglary patterns in the Hillcrest (KZN) policing area? 203

6.2.2 Can the NRC predict near repeat risk of residential burglaries in the Hillcrest policing area? 203

6.2.3 Can the NRC be of any value or use to the Hillcrest police for resource allocation, crime prevention strategies and investigations in the Hillcrest (KZN) policing area? 203

6.2.4 Can the GIS be a valuable visualisation and analytical tool at Hillcrest (KZN) police station? 203

6.3 RECOMMENDATIONS 204

6.4 CONCLUSION 207

REFERENCES 264

LIST OF ANNEXURES

Annexure 1: Change of title and supervision 217

Annexure 2: Temple University permission letter 218

Annexure 3: College of Law Research ETHICS Review Committee (CLAW) approved 219

Annexure 4: Research request and SAPS approval 220

Annexure 5: SAPS research approval 222

Annexure 6: Letter of Introduction 224

Annexure 7: Consent Form 1 226

Annexure 8: Consent Form 2 227

Annexure 9: Residential burglaries (April 2012 to March 2013) 228

Annexure 10: April 2012 - Residential burglaries (Map 1 of 3) 229

Annexure 11: April 2012 - Residential burglaries (Map 2 of 3) 230

Annexure 12: April 2012 - Residential burglaries (Map 3 of 3) 231

Annexure 13: May 2012 - Residential burglaries (Map 1 of 3) 232

Annexure 14: May 2012 - Residential burglaries (Map 2 of 3) 233

Annexure 15: May 2012 - Residential Burglaries (Map 3 of 3) 234

Annexure 16: June 2012 - Residential burglaries (Map 1 of 3) 235

Annexure 17: June 2012 - Residential burglaries (Map 2 of 3) 236

Annexure 18: June 2012 - Residential burglaries (Map 3 of 3) 237

Annexure 19: July 2012 - Residential burglaries (Map 1 of 3) 238

Annexure 20: July 2012 - Residential burglaries (Map 2 of 3) 239

Annexure 21: July 2012 - Residential burglaries (Map 3 of 3) 240

Annexure 22: August 2012 - Residential burglaries (Map 1 of 3) 241

Annexure 23: August 2012 - Residential burglaries (Map 2 of 3) 242

Annexure 24: August 2012 - Residential burglaries (Map 3 of 3) 243

Annexure 25: September 2012 - Residential burglaries (Map 1 of 3) 244

Annexure 26: September 2012 - Residential burglaries (Map 2 of 3) 245

Annexure 27: September 2012 - Residential burglaries (Map 3 of 3) 246

Annexure 28: October 2012 - Residential burglaries (Map 1 of 3) 247

Annexure 29: October 2012 - Residential burglaries (Map 2 of 3) 248

Annexure 30: October 2012 - Residential burglaries (Map 3 of 3) 249

Annexure 31: November 2012 - Residential burglaries (Map 1 of 3) 250

Annexure 32: November 2012 - Residential burglaries (Map 2 of 3) 251

Annexure 33: November 2012 - Residential burglaries (Map 3 of 3) 252

Annexure 34: December 2012 - Residential burglaries (Map 1 of 3) 253

Annexure 35: December 2012 - Residential burglaries (Map 2 of 3) 254

Annexure 36: December 2012 - Residential burglaries (Map 3 of 3) 255

Annexure 37: January 2013 - Residential burglaries (Map 1 of 3) 256

Annexure 38: January 2013 - Residential burglaries (Map 2 of 3) 257

Annexure 39: January 2013 - Residential burglaries (Map 3 of 3) 258

Annexure 40: February 2013 - Residential burglaries (Map 1 of 3) 259

Annexure 41: February 2013 - Residential burglaries (Map 2 of 3) 260

Annexure 42: February 2013 - Residential burglaries (Map 3 of 3) 261

Annexure 43: March 2013 - Residential burglaries (Map 1 of 2) 262

Annexure 44: March 2013 - Residential burglaries (Map 2 of 2) 263

LIST OF TABLES

TABLE 1: PREDICITVE TOOL COMPARISON 5

TABLE 2: INTERVIEWED SMES 18

TABLE 3: MONTH-TO-MONTH NEAR REPEAT CALCULATIONS 161

LIST OF DIAGRAMS

DIAGRAM 1: 119

DIAGRAM 2 120

LIST OF APPENDIXES

APPENDIX A – TURNITIN REPORT 215

APPENDIX B – EDITOR’S LETTER 216

DECLARATION

DECLARATION

Name: Ja m e s A G R C I a ---________________________________

Student number: 4"'34=6"-73,.,9..,3,________________________________

Degree: Master of Arts in Criminology (98606)

Exact wording of the title of the dissertation as appearing on the copies submitted for examination:

THE NEAR REPEAT RISK CALCULATION OF RESIDENTIAL BURGLARIES IN HILLCREST, KWAZULU-NATAL, SOUTH AFRICA: A CRIMINOLOGICAL ANALYSIS

I declare that the above dissertation is my own woand that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE

16 January 2019.

DATE

ACKNOWLEDGEMENTS

I want to thank my parents for always supporting me and believing in everything I do.

Lass, thank you for always encouraging and believing in me.

I want to thank my supervisor Professor AE Hesselink and my co-Supervisor Professor NP Dastile, without your supervision and dedication this dissertation would not have been possible.

I want to thank Dr MG Karels for proofreading and editing this dissertation.

Further thanks to:

- C Overall, Analyst, Durban Metropolitan Police Service.
- M De Beer, Manager and part-time lecturer Durban Service Point, Tshwane University of Technology.
- F Sokolich, EduAction - GIS Solutions.

Thank you to the South African Police Service (SAPS) for allowing this research.

Thank you to the following members, and former members of the South African Police Service (SAPS) for enabling this research:

- Major General M Menziwa, Head Strategic Management.
- Major General Deputy PE Radebe, Provincial Commissioner: Operations Officer: KwaZulu-Natal.
- Lieutenant General V Moonoo, Divisional Commissioner: Detective Service: Head Office.
- Colonel J Schentler, Strategic Management.
- Lt Colonel G Joubert, Strategic Management.
- Lt Colonel K Stassen, Staff Officer: Divisional Commissioner Detective Service.

- Colonel Bezuidenhout, Divisional Commissioner - Detective Service.
- Colonel Van Der Linde, Provincial Commander: Strategic Management and CAC.
- R Moodley, KwaZulu-Natal.
- Former Colonel T Mbele, Hillcrest Station Commander.
- Former Colonel B Ndlovu, Hillcrest Station Commander.
- Lt Colonel MM Ntuli, Hillcrest Branch Commander, Head of Detectives.
- C Aingsworth, Hillcrest Detectives Clerk.
- The Detectives of Hillcrest (KZN) Police Station.

SUMMARY

THE NEAR REPEAT RISK CALCULATION OF RESIDENTIAL BURGLARIES IN HILLCREST, KWAZULU-NATAL, SOUTH AFRICA: A CRIMINOLOGICAL ANALYSIS

This research applies the Near Repeat Calculator (NRC) to identify near repeat residential burglary patterns in the Hillcrest (KZN) policing area for the first time. A total of 490 residential burglaries, over a 12-month period, reported to Hillcrest police station were mapped (geocoded) and the near repeat calculations were visualised using the Geographic Information Systems (GIS). The month-to-month near repeat calculations are analysed and suggest that the NRC is a valuable tool that can predict the space-time locations of near repeat residential burglaries in the Hillcrest policing area.

KEY TERMS:

Near Repeat Calculator (NRC); Near Repeat Burglary; Repeat Victimisation; Geographic Information Systems (GIS); Crime Pattern Theory; Flag and Boost Theory; Crime mapping; Crime Prevention through Environmental Design (CPTED); Broken Windows Theory; Burglary Patterns.

TRANSLATION ISIZULU

ISILINGANISO SAMATHUBA OKUTHI KUNOKWENZEKA ZIPHINDE ZENZEKE FUTHI IZIGAMEKO ZOKUGQEKEZWA KWAMAKHAYA E-HILLCREST, KWAZULU-NATALI, ENINGIZIMU AFRIKA: UKUHLAZIYWA KWEZIGAMEKO ZOBUGEBENGU

Iqoqa:

Lolu cwaningo lusebenzisa *i-Near Repeat Calculator* (NRC) ukuhlonza amaphethini okuphindaphindeka kwezigameko zokugqekezwa kwamakhaya endaweni eyenganyelwe yisiteshi samaphoyisa sase-Hillcrest (KZN). Izigameko zokugqekezwa kwamakhaya ezingama-490 ezabikwa esiteshini samaphoyisa sase-Hillcrest esikhathini esiyizinyanga eziyi-12 zaboniswa emfanekisweni webalazwe lendawo (*geocoded*) futhi izilinganiso zamathuba okuthi ziphinde zenzeke izigameko zokugqekezwa kwamakhaya zaboniswa ngokuthi kusetshenziswe umfanekiso owenziwe nge-*Geographic Information Systems* (GIS). Kwahlaziywa amathuba enyanga nenyanga okuphindaphindeka kwezigameko, futhi imiphumela eyatholakala kulokhu iyabonisa ukuthi i-NRC iyithuluzi eliwusizo impela elingabikezela izindawo nesikhathi lapho kungaphinda futhi kwenzeke khona izigameko zokugqekezwa kwamakhaya endaweni eyenganyelwe yisiteshi samaphoyisa sase-Hillcrest.

Amatemu asemqoka:

I-Near Repeat Calculator (NRC); Amathuba Okuthi Kuphinde Kwenzeke Isigameko Sokugqekeza; Ukuphindaphindeka Kokuba Yisisulu; ama-Geographic Information Systems (GIS); Ithiyori Yamaphethini Obugebengu; *i-Flag and Boost The*ory; Umfanekiso webalazwe obonisa izizinda zobugebengu endaweni ethile; Ukuvinjelwa Kobugebengu Ngokusebenzisa Idizayini Yesimo Sendawo (CPTED); Ithiyori Yamafasitela Aphukile; Amaphethini Ezigameko Zokugqekeza.

TRANSLATION NESIXHOSA

UBALO OLUVEZA IZIGANEKO ZOQHEKEZO EZIPHINDWAYO KWINDAWO ETHILE KWIMIZI YASEHILLCREST, KWAZULU-NATAL, EMZANTSI AFRIKA: UHLALUTYO LWENZULULWAZI YOLWAPHULO MTHETHO.

Isishwankathelo:

Olu phando lusebenzisa uhlobo lokubala olwaziwa ngokuba yi*Near Repeat Calculator (NRC)* ngenjongo yokubona isimbo sokuqhekezwa kwezindlu zabantu kummandla ophantsi kwamapolisa aseHillcrest (eKZN). Kuqwalaselwe ama-490 eziganeko zoqhekezo lwemizi ezaxelwa emapoliseni aseHillcrest kwisithuba seenyanga ezili-12, kwaye uhlobo lokubala oluqikelela ukuphindwa kweziganeko zoqhekezo luboniswe ngokusebenzisa inkqubo ekuthiwa yi*Geographic Information Systems (GIS).* Ubalo oluqikelela ukuphindwa kweziganeko luphononongiwe kwinyanga nenyanga, kwaye iziphumo zibonisa ukuba iNRC sisixhobo esinexabiso, esinokukwazi ukuqikelela indawo nexesha apho kunokuphinda kuqhekezwe khona kummandla ophantsi kwamapolisa aseHillcrest.

Amagama aphambili:

Isixhobo sokubala esiyi*Near Repeat Calculator* (*NRC*); Uqhekezo Oluphindwa Kwindawo Ekufutshane; Ukuxhatshwazwa Okuphindwayo; Iinkqubo Zolwazi Lwezelizwe (i*Geographic Information Systems (GIS*); Ingcingane Yepatheni Yolwaphulo Mthetho (*iCrime Pattern Theory);* Ingcingane Yomtsalane Kubaphuli Mthetho (*iFlag and Boost Theory);* Ukuzotywa Kommandla Wolwaphulo Mthetho (i*Crime mapping);* Uthintelo Lolwaphulo Mthetho Ngokuyila Okusingqongileyo *(iCrime Prevention through Environmental Design* (CPTED); Ingcingane Yeefestire Ezaphukileyo; Iipatheni Zoqhekezo.

ACRONYMS AND ABBREVIATIONS

ABS	Australian Bureau of Statistics
ARV	Antiretroviral
ATM	Automatic Teller Machine
BCU	Basic Command Unit
BWT	Broken Window Theory
CAS	Crime Administration System
CCTV	Closed-Circuit Television
CDA	Case Docket Analysis
CGIS	Canadian Geographic Information System
CIAC	Crime Information Analysis Centre
CID	Crime Investigation Division
CLM	Community Liaison Members
CMRC	Crime Mapping Research Centre
CPA	Crime Threat Analysis
CPA	Crime Pattern Analysis
CPF	Community Policing Forum

CPT	Crime Pattern Theory
CPTED	Crime Prevention Through Environmental Design
CRIMSA	Criminological and Victimological Society of Southern Africa
CSA	Crime Statistical Analysis
CSIR	Council for Scientific and Industrial Research
CTA	Crime Threat Analysis
DACST	Department of Arts, Culture, Science and Technology
DSS	Decision Support System
DST	Defensible Space Theory
ECU	Experimental Cartography Unit
ESRI	Environmental Systems Research Institute
FBT	Flag and Boost Theory
FOSS	Free and Open Software Source
GCA	Geographic Crime Analysis
GIS	Geographic Information System
GMP	Greater Manchester Police
GPS	Global Positioning System

HPNW	Hillcrest Park Neighbourhood Watch
HSRC	Human Sciences Research Council
IBM	International Business Machines
IED	Improvised Explosive Device
ILWIS	Integrated Land and Water Information System
ISS	Institute of Security Studies
IUDF	Integrated Urban Development Framework
KZN	KwaZulu-Natal
LCA	Linkage Crime Analysis
LCG	Laboratory for Computer Graphics
MAPS	Mapping and Analysis for Public Safety
MO	Modus Operandi
MRC	the Medical Research Council
Nam Pol	Namibian Police
NIJ	National Institute of Justice
NRBT	Near Repeat Burglary Theory
NRC	Near Repeat Calculator

PMB	Pietermaritzburg
RAT	Routine Activities Theory
RCT	Rational Choice Theory
RR	Repeat and Repeat
RTM	Risk Terrain Modelling
SA	South Africa
SAPS	South African Police Service
SCPT	Situational Crime Prevention Theory
SME	Subject Matter Expert
SR	Single and Repeat
SS	Single and Single
STAC	Spatial and Temporal Analysis of Crime
TENRM	Temporal Expanded Near Repeat Matrix
UK	United Kingdom
UNDP	United Nations Development Programme
UNISA	University of South Africa
USA	United States of America

VOCS	Victims of Crime Survey
WO	Warrant Officer

CHAPTER 1

INTRODUCTION AND ORIENTATION TO THE NEAR REPEAT CALCULATOR

1.1 INTRODUCTION

The term ‘near repeat’ was first used in 2000, by Dr Frank Morgan, a researcher who found that further residential burglaries occurred, in close proximity to one another, within one month of the first burglaries (Groff & Taniguichi, 2016: np). International research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen, Yuan & Li, 2013; Fielding & Jones, 2012; Johnson, Bernasco, Bowers, Elffers, Ratcliffe, Rengert & Townsley, 2007; Johnson & Bowers, 2004; Moreto, Piza & Caplan, 2014; Piza & Carter, 2018; Morgan, 2000; Townsley, Homel & Chaseling, 2003; Wang & Liu, 2017; Wu, Xu, Ye & Zhu, 2015), has found that a residential burglary is a good indicator of future residential burglaries, either to the same or to nearby houses for a period of time.

Near repeat residential burglary patterns have been identified in Western countries such as Australia (Johnson et al, 2007; Morgan, 2000; Townsley et al, 2003:615), the Netherlands (Johnson et al, 2007), New Zealand (Johnson et al, 2007), the United Kingdom (UK) (Bowers & Johnson, 2005; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004) the United States of America (USA) (Johnson et al, 2007; Moreto et al, 2014; Piza & Carter, 2018) and, in more recent years, in non-Western countries, like Brazil (Chainey & da Silva, 2016) and China (Chen et al, 2013; Wang & Liu, 2017; Wu et al, 2015). Johnson et al (2007) conducted research on the space-time pattern of burglary risk in five different countries (Australia, Netherlands, New Zealand, UK, and the USA), using ten different data-sets provided by the police forces responsible for the areas (Johnson et al, 2007:14, 43). These researchers found that even though patterns varied in all the areas, houses situated within 200 meters of a burgled home were at an increased risk of burglary for two weeks following the initial burglary (Johnson et al, 2007:2).

Professor Jerry Ratcliffe of Temple University in the USA developed the Near Repeat Calculator (NRC) (Ratcliffe, [sa]: np) which is supported by the National Institute of Justice (NIJ), and Office of Justice Programs from the US Department of Justice (Ratcliffe, 2009:4). The NRC was developed to calculate the temporal and spatial risk to other properties, after a series of burglaries in a specific area (Ratcliffe, [sa]: np). Furthermore, the NRC was developed to address crime analysis issues and to estimate near repeat processes for crime data using the recorded dates and coordinates of the burglaries (Ratcliffe, [Sa]: np). The NRC is copyrighted but freely available but cannot be re-sold. It was intended for use by law enforcement agencies, criminal justice researchers and educators. Prior research by Johnson (Bowers & Johnson, 2005; Johnson et al, 2007; Johnson & Bowers, 2004), Bowers (Bowers & Johnson, 2005; Johnson & Bowers, 2004), Townsley (Johnson et al, 2007; Townsley et al, 2003), Henk Elffers (Johnson et al, 2007), Bernasco (Johnson et al, 2007) and Rengert (Johnson et al, 2007) was instrumental to the development of the NRC (Ratcliffe, 2009:4) for near repeat residential burglary patterns.

Moreto et al (2014) conducted research in Newark, New Jersey, USA using the NRC, Risk Terrain Modelling (RTM) and Geographic Information Systems (GIS). The Newark Police Department's residential burglary data for 2010, together with the NRC, was used to identify the risk of future burglaries (Moreto et al, 2014:1119). The NRC identified that previously burgled residences were at a 318% (p=0.001) risk for 14 days of repeat residential burglary victimisation, and a 23% risk for houses located 900 feet (about 275m) from previously burgled houses (Moreto et al, 2014:1118-1119). In recent years, near repeat burglary patterns have been identified in China (Chen et al, 2013; Wang & Liu, 2017; Wu et al, 2015). Using the NRC, Chen et al (2013:9), found that near repeat burglary risk was extended up to three weeks, and within 100m of each burgled location. Through the application of the NRC, researchers Wu et al (2015:181, 183,187), identified near repeat burglary patterns, which highlighted that 26% of burglaries occurred within 14 days of the initial incident of burglary. Recent research (Chainey & da Silva, 2016) used the NRC in Belo Horizonte, a large Brazilian city, and recorded crime data on residential burglary from 2012 to 2014. The NRC found a statistically significant higher risk of a repeat, and near repeat patterns of burglary, to nearby residences, but these findings are lower than research findings in

Western countries (Chainey & da Silva, 2016:7).

Since the 1990s, crime mapping has been carried out using the GIS (Bachman & Schutt, 2016:232) which is a set of computer-based tools that allow one to visualise, query or analyse geographic, and tabular data for a specific area (Santos, 2017:8). The GIS is used in this research to visualise the Hillcrest policing area, residential burglaries, and the NRC results. This research aims to test the NRC's ability to identify near repeat residential burglary patterns in a South African context, based on residential burglary cases reported at the Hillcrest KwaZulu-Natal (KZN) Police Station.

1.2 CRIME ANALYSIS TOOLS USED

At station level, the SAPS make use of the Crime Threat Analysis (CTA) and the Crime Pattern Analysis (CPA) (National Crime Registrar, 2017:12). The CTA is an example of a Decision Support System (DSS) used by crime analysts at SAPS on station level (Krause, 2007:35). The CTA was implemented in 1998 and integrates crime-related findings such as crime statistical analysis, crime pattern analysis, linkage analysis, crime docket analysis, profiling, and fieldwork activities (Krause, 2007:3-4, 19, 35). The focus of the CTA is to generate core management information required for crime prevention, and to illuminate criminal activities by group offenders, repeat offenders and serial offenders (Krause, 2007:3-4). According to the NRC (2017:16-17), the CTA and the CPA are used in operational planning, resource allocation, shift tasking, and to identify hotspots to prevent crime. According to a detective at Hillcrest Police (Respondent 4, 2015: np) who participated in the qualitative interviews for this research, the CTA and the CPA are used at the Hillcrest Police Station to gauge where future residential burglaries may occur. Accordingly, the CPA can indicate the frequency when crimes may occur in time (temporal) and space (spatial) (Krause, 2007:3). According to Krause (2007:34-35), the CTA process consists of the following seven steps:

1. Step 1: Crime statistical analysis (CSA).
2. Step 2: Geographic crime analysis (GCA).
3. Step 3: Crime pattern analysis (CPA).
4. Step 4: Linkage crime analysis (LCA).

5. Step 5: Case docket analysis (CDA).
6. Step 6: Fieldwork.
7. Step 7: Profiling.

Step one to three of the CTA process demonstrates the nature and extent of crime over a specific period. It further identifies hotspots and crime pattern information in geographic areas (Krause, 2007:34-35). This information is vital to police management, for planning crime prevention strategies and resource allocation, according to the predicted day(s) of the week, time, and geographic areas where crime is likely to occur (Krause, 2007:35). Steps one to seven are for crime detection purposes and provide the crime analyst with operational information pertaining to organised crime, repeat offenders and serial offenders (Krause, 2007:35). The CTA plays a role in the SAPS Strategic Plan for 2014-2019. According to the SAPS Strategic Plan: 2014-2019, amongst critical interventions, crime intelligence gathering on a local level is to be improved to supply enough area coverage for the CTA and to promote the development of quality cases (SAPS, 2015a:17-18). The GIS is currently used by all SAPS divisions, components, and sections for the management of functional policing and for crime reporting, analysis, and prevention (SAPS, 2015b:45).

The aim of this study is to apply the NRC to identify near repeat residential burglary patterns in the Hillcrest policing area. At the time of writing, there was no known research on near repeat burglary patterns, or on the use of the NRC in South Africa or Africa as a whole. If near repeat burglary patterns are found to exist in the Hillcrest policing area, and if the NRC can spatially and temporarily predict residential burglary patterns, this research could be of value to the Hillcrest police and, via further research, to the SAPS as a whole.

If NRC results are used, in conjunction with the GIS, to form predictive risk maps, the police will be better able to allocate resources, such as crime prevention patrols in areas with an increased risk for house burglaries. Previous research findings (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Morgan, 2000; Piza & Carter, 2018; Townsley et al, 2003:615; Wang & Liu, 2017; & Wu et al, 2015) on near repeat burglary patterns and the application of the NRC in various countries, (Chainey & da Silva, 2016; Chen et al, 2013; Moreto et al, 2014; Wu et al, 2015) may be applicable to urban formal settlements in the Hillcrest policing area.

TABLE 1: Predictive Tool Comparison

Crime Analysis tools		
Tool	**Predictive Function**	**Purpose**
Crime Threat Analysis (CTA)	Can predict hotspots of crime, like residential burglaries. Hotspots are areas that have a high density or volume of crime.	The focus of the CTA is to generate core management information required for crime prevention, and to illuminate criminal activities by group offenders, repeat offenders and serial offenders. Both the CTA and CPA are used by the SAPS in operational planning, resource allocation, shift tasking, and to identify hotspots to prevent crime, such as residential burglaries.
Crime Pattern Analysis (CPA)	Can predict frequency of crime occurrence in space and time.	
Near Repeat Calculator (NRC)	Developed specifically to identify near repeat patterns of residential burglary risk. The near repeat phenomenon suggests every incident has the potential to transfer risk to the nearby vicinity. The NRC can predict clusters occurring in space and time.	The NRC can be used as a standalone tool or it can be used in conjunction with other predictive tools, like the CPA and CTA to enhance management information and decision making for resource allocation in the prevention of residential burglaries. In this research the NRC was used as a standalone tool, where the near repeat calculations of risk were illustrated and analysed by using the GIS.
Geographic Information Systems (GIS)	A mapping tool which can identify crime patterns, trends and clusters.	The GIS can visualise or map data generated by the CTA, CPA and the NRC. The GIS was used in this exploratory research to visualise the Hillcrest policing area, to map residential burglary points, to create month-month predictive maps based on

		the near repeat calculations of residential burglary risk and to analyse the data.

1.3 RESEARCH PROBLEM AND RATIONALE

International research (Groff & Taniguchi, 2016: np) has found near repeat patterns for crimes such as residential burglaries, vehicle thefts, shootings, illegal carrying of firearms and street robberies. However, the extent of the spatial and temporal near repeat patterns of distinct types of crime vary and require crime-specific crime prevention strategies (Groff & Taniguchi, 2016: np). According to Groff and Taniguchi (2016: np), the near repeat pattern has become a pivotal point for predictive forecasting of crime occurrence. When near repeat patterns are merged with other data, such as land-use, they can enhance the predictive accuracy of crime forecasts (Groff & Taniguchi, 2016: np). According to the SAPS Annual Crime Statistics from April 2017 to March 2018, 765 residential burglary cases were reported to the Hillcrest police station (SAPS, 2018: np). A clearer picture of the nature and extent of residential burglaries can be provided through closed-case analysis. This study focuses on 490 closed-case dockets for residential burglaries reported to Hillcrest Police Station between April 2012 and March 2013. Most of these residential burglaries occurred in the formal urban settlements of the Hillcrest policing area. Mabena (2017: np) opines that due to a lack of resources, the police (SAPS) are unable to carry out their duties efficiently. The high residential burglary rate in the Hillcrest policing area can be attributed to a lack of police presence and police resources (Guy, Waterworth & Gopi, 2016: np). According to news articles (Naicker, 2015:3; Nair, 2013a: np; Nair, 2013b: np), the Hillcrest policing area has experienced severe crimes waves over the past few years. The findings of this research could be valuable to the SAPS, as the application of the NRC could prevent future incidents of residential burglary and assist with on-going investigations and resource allocation for crime prevention initiatives. The NRC can, for instance, indicate which spatial areas are at an increased risk for residential burglaries so that crime prevention patrols can be focused. Thus, location prediction for house burglary would assist the police in allocating patrols and reducing response times, if they knew the areas, neighbourhoods, streets and/or even houses at increased risk of burglary (Groff & Le Vigne, 2002:31). Like the NRC, the Q-

Geographic Information System (Q-GIS) is freely available software. Both the NRC and Q-GIS are valuable and cost-effective tools for the prevention and investigation of residential burglary and could be used by the Hillcrest police at station level. The GIS was used in this research to geocode (map) residential burglary points, to illustrate NRC results, to highlight various land uses in the area (e.g. formal urban settlements, farmland, vacant land, and informal settlements) and environmental factors (such as main roads, railway lines, road nodes and end nodes or cul-de-sacs).

This research applies the NRC to identify near repeat residential burglary patterns in the Hillcrest policing area, and the GIS to visualise near repeat calculations of residential burglary risk in the form of month-to-month, predictive risk maps. The NRC can be used to identify near repeat patterns of risk and the GIS for visualisation of data and analysis. This research is by no means a replacement for any processes currently employed by Hillcrest police. Instead, it proposed additional tools to potentially increase the predictive accuracy of future residential burglaries in the Hillcrest policing area and improve the effective allocation of valuable resources.

1.4 RESEARCH AIMS AND OBJECTIVES

The research aims to apply the NRC to identify near repeat burglary patterns in the Hillcrest policing area. The GIS allows visualisation of the Hillcrest policing area, residential burglary point geo-coding (x and y coordinates), and near repeat calculations which can be analysed to create month-to-month predictive risk maps. The NRC, associated with the identification of near repeat residential burglary patterns, coupled with the visualisation and analytical capabilities of the GIS, can support Hillcrest SAPS in decision-making for resource allocation and with crime preventions strategies focused on specific areas at specific times.

The objective of this research is to test the predictive accuracy of the NRC using residential burglaries reported to the Hillcrest police over 12-months. Month-to-month predictive risk maps, based on NRC results, are then created using the GIS; and for each month the near repeat residential burglary results are measured against actual burglaries reported to ascertain the predictive accuracy of the NRC. If the NRC, and GIS predictive risk map process, are found to be accurate, they could be valuable tools for use at station level.

Qualitative interviews were conducted with five detectives from the Hillcrest police station. The detectives volunteered to be interviewed providing anonymity was assured. These interviews were carried out one-on-one, allowing the researcher to gain insight into knowledge, experiences, views, and attitudes on residential burglaries in the Hillcrest policing area. Subject Matter Experts (SME) were contacted electronically to draw on their experience and opinions relating to this research in terms of its methodology and the application of the NRC in a South African context.

1.5 RESEARCH QUESTIONS

This research is exploratory in nature which refers to specific research carried out for the first time, to gain better insight into and understanding of the research topic or phenomenon (Babbie, 2016:92; Bachman & Schutt, 2016:9, Maxfield & Babbie, 2016:313). This study thus, applies the NRC, for the first time in South Africa, to identify near repeat burglary patterns in the Hillcrest (KZN) policing area, while creating month-to-month near repeat predictive risk maps using the GIS. The GIS is further used to conduct a spatial analysis between residential burglaries and the environment in which they occurred.

The researcher aims to answer the following research questions:

- Can the NRC identify near repeat residential burglary patterns in the Hillcrest policing area?
- Can the NRC predict near repeat risk of residential burglaries in the Hillcrest policing area?
- Can the NRC be of value to the Hillcrest police for resource allocation, crime prevention strategies and investigations in the Hillcrest policing area?
- Can the GIS be of value for visualisation and analytics at Hillcrest police station?

1.6 DEFINITIONS

The following definitions are central to this research.

1.6.1 Environmental Criminology

Environmental criminology focuses on various aspects of the environment in which crime occurs, by identifying patterns of criminal behaviour and opportunities for crime to take place (Santos, 2017:39-40). According to Herbig (2016: ii-iii), environmental criminology is concerned with crime patterns, criminal behaviour, and analyses of the space and time when a crime has occurred while acknowledging environmental factors such as land use, traffic patterns, street layout and the routine activities of both victims and offenders. Environmental criminology is rooted in three criminological theories to wit the Rational Choice Theory (RCT), Routine Activities Theory (RAT) and the Crime Pattern Theory (CPT), and focuses on geographical and spatial factors related to crime (Turner, 2013:3). According to Andresen, Brantingham and Kinney (2010:6), environmental criminology consists of four theories, i.e. the Geometry Theory of crime, the RCT, the RAT and CPT, and is concerned with the environment in which the crime occurs, and not with the offender. Environmental criminology encompasses a group of related theories that share an interest in crime and the immediate environment in which crime occurs (Wortley & Mazerolle, 2011:1). In this research, environmental criminology is defined as a criminological perspective which draws on the RCT, RAT and CPT, and focuses on the immediate environment in which a crime has occurred.

1.6.2 Geographic Information Systems (GIS)

The GIS is a software tool that has gained in popularity with researchers since the 1990s because of its sophisticated crime-mapping functions (Bachman & Schutt, 2016:232). The GIS allows one to change, visualise, query, or analyse geographic and tabular data (Santos, 2017:8). It makes allowances for a crime analyst to map crime in several ways, ranging from a single point on a map, to a three-dimensional visualisation of spatial or temporal data, and can additionally store, retrieve, and display spatial data on maps (Gorr & Kurland, 2012:3; Santos, 2017:8). This valuable tool enables crime analysts, investigators and the police to access and analyse data on crime maps for the purpose of law enforcement and crime prevention strategies (Gorr & Kurland, 2012:2). In this research, the GIS is defined as a geographic software tool used by crime analysts to map crimes and to analyse and visualise data for crime prevention strategies.

1.6.3 Crime Mapping

Crime mapping often entails the use of the GIS to visualise data such as the location of the crime, distance, patterns, and links that may exist. Crime mapping enables visual and statistical analysis of crime and the environment in which it occurs. It also facilitates the linking of crime data to different data sources and presents analysed data in the form of visual maps (Bachman & Schutt, 2016:232, 312). Crime mapping is used by law enforcement agencies as a visualisation tool to map and analyse crime/crime scenes (Balogun, Okeke & Chukwukere, 2014:465; Eloff, 2013:10). This tool can assist law enforcement management in decision-making, resource allocation, strategies and tactical analysis including crime forecasting (Balogun et al, 2014:465).

According to Breetzke (2016a), the GIS has become a valuable tool for spatial analysis and the visualisation of crime data in South Africa. The GIS can report and map police activity, share information, identify hotspots, monitor, and evaluate the impact of crime prevention initiatives, and assist decision-makers with resource allocation (Mukumbira, 2012:20). Unsurprisingly the GIS has been a significant innovation for police organisations worldwide (Gorr & Kurland, 2012:2). Crime mapping involves using the GIS to conduct spatial analysis of crime, referred to as crime analysis (Santos, 2017:8). For this study, crime mapping is defined as a visualisation tool that integrates the GIS to map and analyse crime, to aid police management with decision-making, resource allocation, crime prevention strategy and prediction of crime location or area.

1.6.4 Crime Analysis

According to Eloff (2013:10), crime analysis is the process of analysing relevant information about crime patterns. Crime analysis includes tactical, strategic, academic, operational, intelligence, and investigation aspects. For crime analysis to be useful, it requires data-mining, crime-mapping, statistics, research methods, desktop publishing, charts, presentations, critical thinking, and a solid understanding of criminal behaviour (Eloff, 2006:4). Crime analysis involves the study of crime and disorder - such as a neglected neighbourhood plagued with litter and graffiti which transmits a careless community attitude - and socio-demographic, spatial and temporal factors (Winfree & Abadinsky, 2017:10). This analysis can assist the police in apprehending offenders; reducing crime and disorder, implementing crime prevention strategies, and evaluating implemented strategies (Santos, 2017:4). Crime analysis makes use of both qualitative and quantitative methods. Data obtained through qualitative methods is aimed at enhancing understanding of crime, while quantitative data involves the analysis of categories or numerical data, in the form of statistics, frequencies, percentages, means or rates (Santos, 2017:4-5). For the function of this research, crime analysis is defined as a process consisting of qualitative and quantitative data, focused on crime patterns, including tactical, strategic, academic, operational, intelligence and investigative factors relating to crime.

1.6.5 Q - Geographic Information System (Q-GIS)

The Q-GIS is a free open source software (FOSS). It is a user-friendly GIS programme registered under a public licence. It is an official project of the Open Source Geospatial Foundation. The Q-GIS operates on the Linux, Unix, Mac OSX, Windows, and Android systems. It supports various vector and raster database formats and functions (Q-GIS, [Sa]: np). Vector data is represented by points, lines and polygons, while raster data (also known as grid cells) consist of aerial photos or satellite imagery (GIS Geography, 2016: np). Q-GIS, in this research, refers to free GIS software used to map the Hillcrest policing area, geocode residential burglary points, visualise the NRC results, and carry out spatial analysis.

1.6.6 Mixed method research

Mixed method research consists of both qualitative and quantitative methods and involves combining the two to provide a better understanding of a specific research area (Bachman & Schutt, 2018:315; Bryman, 2016:692; Creswell, 2014:4, 215; Crowther-Dowey & Fussey, 2013: 207).

Qualitative research methods consist of participant observation, interviews or focus groups, with the research findings presented in the form of words or writing (Bachman & Schutt, 2018:316).

Quantitative research methods consist of surveys and experiments to measure the area of research and produce findings in the form of numbers or categories (Bachman

& Schutt, 2018:316-317). After qualitative and quantitative data collection is complete, the data is analysed and only then are the findings combined to form mixed method research (DeCuir-Gunby & Schutz, 2017:86). In this research, mixed method research refers to the combination of both qualitative and quantitative research methods focused on the topic under investigation.

1.6.7 Near Repeat Burglary

Morgan (2000) defined the term 'near repeat' to describe burglaries that occurred in close proximity to one another and within one month of the initial burglary (Groff & Taniguichi, 2016: np). According to the near repeat theory, every victimisation, like burglary, has the potential to form patterns of victimisation in the surrounding area for a period of time (Wang & Liu, 2017:1; Wu et al, 2015:178). Bernasco (2008:414) proffers that once a house has been burgled, not only is the same property at an elevated risk of repeat victimisation but so are the nearby homes. This near repeat burglary risk fades, at a similar rate as repeat burglary risk. The National Institute of Justice (NIJ) (2014: np) describes near repeat burglary as the higher risk of burglary victimisation to nearby homes, for a period of 7-14 days, after a house is burgled in the same area. A near repeat burglary occurs when two or more nearby houses are burgled within a space of time and within a set spatial neighbourhood or area (Short, D'Orsogna, Brantingham & Tita, 2009: np). For this research, near repeat burglary is defined as burglaries that occur in close proximity to one another within a period after initial burglary victimisation in the same area.

1.6.8 Near Repeat Calculator (NRC)

The Near Repeat Calculator (NRC) can calculate the near repeat risk transferred to nearby properties, using the coordinates and date(s) of the crime(s) previously committed (Ratcliffe, 2009: np). The NRC is based on an algorithm of the Knox Test (Knox, 1964) and the statistical significance is measured using the Monte Carlo Simulation (Wu et al, 2015:181). The NRC is a free software package available for download. The user enters the coordinates and dates for any type of crime, and results are calculated showing the risk of near repeat crime, the geographic area (spatial) and duration (temporal) of increased risk (Tech Beat, 2008: np). For the purpose of this research, the NRC is defined as a scientific tool that uses the coordinates and dates of previous residential burglaries, to calculate the near repeat risk (spatial and temporal) of burglary to nearby properties.

1.6.9 Decision Support Systems (DSS)

Decision Support Systems (DSS) are developed for various research studies (Canter & Youngs, 2008:12). Interdisciplinary research is required during the development of a DSS, including but not limited to, computer science, decision theory, statistics, psychology, organisational science, information knowledge and engineering (Mysiak, Giupponi & Rosato, 2005:203-204). DSS differ from expert systems in that they do not give investigators a definite answer that can lead to the arrest of an offender(s) (Canter & Youngs, 2008:12). Instead, DSS aim to systematically supply current information to the police in order to facilitate their knowledge and understanding of crime and crime patterns in their areas of policing (Canter & Youngs, 2008:12). DSS can promote investigators' skills, knowledge, and experience, and thus aid in their investigations (Canter & Youngs, 2008:12). Thus, DSS comprises systems to assist the decision-making process but do not always provide answers. DSS are a specific type of computerised information platforms that support organisational and business decision-making processes (Thakur, 2015: np). The CTA and GIS are examples of a DSS used by the SAPS (Krause, 2007:3-4; Overall, Singh & Gcina (2008:37). According to Overall et al (2008:37), the GIS, which identifies crime patterns, trends, and clusters, is a valuable DSS for crime prevention.

1.6.10 Residential burglary

Residential burglary is the illegal entry into a residential structure often using physical force or a tool; ordinarily committed in the belief that no one is home (Lehohla, 2014:x). According to the Institute of Security Studies (Institute of Security Studies, [Sa]:np), residential burglary, or housebreaking, is committed by a person or persons who illegally and intentionally break into a residential building, or structure using physical force or a tool, with the aim of committing a crime on the premises (Institute of Security Studies [Sa]: np). In this research, residential burglary refers to unlawful and intentional breaking into a home, residential structure or building in the belief that it is unoccupied, with the aim of stealing from the premises.

1.6.11 Robbery at residential premises

Robbery at residential premises is the unlawful and intentional removal and theft of tangible property from a residential premise while someone is at home (Lehohla, 2014:x). House robbery is a term used by the SAPS to describe a robbery where the offenders confront, overpower, detain, and rob the occupants of the targeted residence (Zinn, 2010:27). For purposes of this research, robbery at residential premises means the unlawful and intentional removal and theft of tangible property from the residential premises while occupied by confronting, threatening, or overpowering the residents.

1.7 METHODOLOGICAL OUTLAY

The methodological outlay outlines each section of the process undertaken by the researcher. The broad goals of the research and the aims and objectives are summarised. The choice, rationale and benefit of exploratory research design are summarised. The unit of analysis and criteria for validity and reliability fulfilment are described. The ethical processes and procedures which guide the research and its interpretation are outlined.

1.7.1 Broad goals of the research

This research aims to test the NRC's ability to identify near repeat residential burglary patterns in the Hillcrest (KZN) policing area. The value of creating predictive risk maps, applying the GIS from the NRC results, is the prevention of near repeat residential burglaries in the Hillcrest policing area.

1.7.2 Aims and objectives

This research aims to apply the NRC in order to identify near repeat burglary patterns in the Hillcrest (KZN) policing area. The GIS is used to map and visualises the Hillcrest policing area and to geocode residential burglaries. The NRC and GIS capabilities are combined to create month-to-month predictive risk maps. It is averred that the NRC and GIS are valuable instruments for policing. They can be used to aid resource allocation and crime prevention strategies at specific location and times to prevent near repeat residential burglaries. The NRC, in conjunction with the GIS, can be employed at station level by the Hillcrest police as part of their crime monitoring and prevention functions. The objective of this research is to test the predictive accuracy of the NRC and GIS using 12-months of residential burglary cases reported to the Hillcrest (KZN) police. The GIS creates month-to-month near repeat predictive risk maps, based on NRC results. The month-to-month predictive risk maps are compared over a 12-month period to prove the accuracy, or inaccuracy of the NRC, to identify and predict near repeat resident burglary patterns. Both quantitative and qualitative research methods are used to meet the aim and objective of this research, as discussed in greater detail in Chapter 4.

The research questions which the researcher aims to answer are:

- Can the NRC identify near repeat residential burglary patterns in the Hillcrest policing area?
- Can the NRC predict near repeat risk of residential burglaries in the Hillcrest policing area?
- Is the NRC valuable to the Hillcrest police for resource allocation, crime prevention strategies and investigation in their policing area?
- Is the GIS a valuable visualisation and analytical tool for the Hillcrest police station?

1.7.3 Research design

An exploratory research method is used here because the researcher is exploring an unknown and hence new problem (Babbie, 2016:92; Bachman & Schutt, 2016:9, Maxfield & Babbie, 2016:313), to wit the use of the NRC to identify near repeat residential burglary in Hillcrest (KZN). Further, there is a paucity of research relating to this topic in South Africa. Exploratory research allows the researcher to better comprehend the area of study, investigate if further research is sensible and to develop research methods for potential use in future studies (Babbie, 2016:92).

The researcher, however, acknowledges that exploratory is limited in its ability to provide a definite answer or conclusion to a specific problem (Babbie, 2016:92). Subsequently, this study focuses on the Hillcrest (KZN) policing area only, and the research findings may not necessarily apply to other areas. Most of the closed-case residential burglaries used for this research occurred in formal urban settlements. Through further and more representative research the NRC could be tested for its ability to identify near repeat burglary patterns over bigger areas, and in a uniquely South Africa context.

1.7.4 Unit of analysis

This studies unit of analysis is residential burglaries reported to the Hillcrest police between April 2012 and March 2013. In-line with the research aim - using the NRC and GIS to identify and visualise near repeat burglary patterns in Hillcrest (KZN) - docket analysis provided a detailed overview of the dynamics, factors and modus operandi (MO) of the crime, and assisted with narrowing the direction of investigation and enhancing the researcher comprehension of crime data to promote scientific research (Van Graan & Van der Watt, 2014:144). According to Van Graan and Van der Watt (2014:144), case-docket analysis can potentially assist criminal investigators, crime analysts and crime researchers, to narrow or direct investigations by highlighting dynamics and contributing factors; assist in decision-making; enable specific crime incident analysis and identify MO and case-linking. One should not understate the advantages of docket analysis provided it is carried out systematically (Van Graan & Van der Watt, 2014:144). This research is based on an analysis of 490 closed-case police dockets for residential burglaries reported to the Hillcrest Police Station between April 2012 and March 2013. Hillcrest SAPS polices a large area of 452^{km2}; 90% of which is rural and has few tarred roads (Hillcrest Community Policing Forum, 2015: np). A total of 449 (91.6%) of 490 of the analysed burglaries occurred in formal urban settlements and 38 (7.8%) on farmlands.

1.7.5 Data collection methods

In this research both the quantitative and qualitative method relies on an explanatory, sequential mixed methods approach, to gain a detailed and complete understanding of the NRC and predictive risk maps for residential burglaries, using the GIS. Mixed methods research approaches have been successfully employed to connect detailed qualitative research and broad quantitative data (Bishop & Kuula-Lummi, 2017:10). Merging the two forms of data provides a more detailed understanding of the NRC's ability to create predictive risk maps using the GIS, as opposed to a single (i.e. a qualitative or quantitative) research method. Hence, residential burglaries were geocoded, the NRC was applied to identify near repeat residential burglary patterns, and results were mapped using the GIS.

The NRC and Q-GIS are both open-source, freely available software applications. eThekwini Municipal GIS data is available from the Information Management Unit for Corporate GIS in Durban (KZN).

Secondary data refers to data previously collected which can be used for a novel analysis (Bachman & Schutt, 2016:18; Crowther-Dowey & Fussey, 2013:81; Schutt, 2017:44; Withrow, 2014:273). The researcher relied on a docket analysis which signifies secondary data, collected from closed cases of residential burglary previously reported to the Hillcrest police.

Qualitative data collection, via structured interviews with five detectives from the Hillcrest police station, occurred in this research. The researcher relied on structured interviews to gather specific information for a particular purpose (Maxfield & Babbie, 2016: 203). A structured questionnaire, including open-ended questions, was prepared in advance, and the researcher read the questions to the participants and recorded their feedback accurately. The researcher used open-ended questions to prompt answers from the participants (Bachman & Schutt, 2016:74,158; Maxfield & Babbie, 2016: 316).

SMEs were interviewed via email communication wherein the researcher requested their opinions, feedback, and comments on this research. The SMEs include:

TABLE 2: Interviewed SMEs

SME	POSITION
Dr Schmitz	Principal Researcher at the Council for Scientific and Industrial Research (CSIR), South Africa, conducted extensive research on geospatial analysis, crime analysis, logistics and forensic geography in South Africa
Professor Breetzke	Department of Geography, Geoinformatics and Meteorology, at the University of Pretoria, South Africa
Dr Landman	Previously a principal researcher at CSIR, Built Environment, South Africa, and currently a lecturer at the University of Pretoria
Professor Kruger	A principal researcher at CSIR, South Africa
Professor Zinn	University of South Africa (UNISA), College of Law, School of Criminal Justice, Department of Police Practice

1.7.6 Validity and reliability

During this study, the researcher tested the validity of the NRC using residential burglary police data; mapping residential burglary points; mapping NRC results and using the GIS for a month-to-month analysis, to determine the NRC accuracy in predicting the subsequent months near repeat burglaries. Validity refers to the extent to which an indicator, which measures a concept, is accurate (Bachman & Schutt, 2016:39; Bryman, 2016:275; Gray, 2014:150; Schutt, 2017:245). Reliability refers to the repeat consistency and stability of a measured concept when used by different researchers during different research projects (Bachman & Schutt, 2016:85; Creswell, 2014: np; Schutt, 2017:244). Reliability assessment must occur before measurement validity can be tested (Bachman & Schutt, 2016:85). In this research, validity is measured via predictive validity, statistical validity, construct validity and external validity, which are explained in-depth in Chapter 4.

1.7.7 Ethics

This research was approved by the University of South Africa (UNISA), College of Law Research and Ethics Committee (Ref: CLAW 2015 ST 11, see Annexure 3). A research request was sent to the SAPS (see Annexure 4) and subsequently approved by the SAPS's Head of Strategic Management; the Divisional Commissioner of the Detective Service; and the Provincial Commissioner. The approval was granted in terms of the SAPS Research Policy (National Instruction 1/2006) (See Annexure 5) which stipulates that the research findings may only be published with permission from the SAPS. All conditions were adhered to by the researcher, namely the research was conducted at the exclusive cost of the researcher; arrangements to access the closed-case dockets were made in advance; the research did not disrupt the duties of any SAPS members; interviews were conducted on a voluntary basis and all information was treated confidentially. To ensure compliance with the UNISA, College of Law Research and Ethics Committee, a letter of permission from Professor Jerry Ratcliffe of the Temple University, giving permission to use the NRC was sought and obtained by the researcher, notwithstanding that the software is already freely available online (see Annexure 2).

The researcher followed the Criminological and Victimological Society of Southern Africa's (CRIMSA) code of conduct. The CRIMSA code of conduct mandates that the researcher will remain professional, ethical, competent; and be aware of his or her limitations and abilities (Criminological and Victimological Society of South Africa, 2012: np). The researcher valued and respected all persons and ensured informed consent before carrying out any research or interview. The personal details of research participants remained confidential. The researcher, however, retains the right to disseminate research findings providing such distribution it will not harm any person or organisation, or breach any prior agreements. All research processes will be carried out on a high standard and findings will be reported accurately, truthfully, and within the agreed timeframe (CRIMSA, 2012: np).

The Belmont Report's (1979) ethical principles and guidelines were applied to this research. The three fundamental Belmont principles encompass respect for persons, beneficence, and justice (Bachman & Schutt, 2018:50; the Belmont Report, 1979: np). The researcher operated with respect for individual views; and remained cognisant of the need to provide protection for participants in the form of assistance, safety and security measures. In relation to beneficence, the researcher refrained from causing harm to the participants while maximising the potential benefits of the research. In respect of justice, the researcher treated all participants fairly (Bachman & Schutt, 2018:50-51; the Belmont Report, 1979: np).

No street names, numbers or personal details of residents, or victims of residential burglary are mentioned which ensures confidentiality and privacy and contributes to the low-risk categorisation of this research. Data was stored and password-protected electronically, and the researcher was the only person with access thereto. All respondents (detectives) participated voluntarily in structured one-on-one interviews and were informed of the purpose of the research beforehand. The participants were provided with a letter of introduction, containing the researcher's name and contact details, and were required to sign an informed consent before interview commencement.

E-mail interviews were conducted with SMEs. The researcher provided the SMEs with a brief outline of the research aim and objective, research questions and methodology. A structured questionnaire comprising questions related to the aforementioned areas was attached to e-mail correspondence to SMEs. The responding SMEs granted the researcher permission to include their feedback and opinions in the study.

1.7.8 Interpretation and explanation of findings

The GIS was used to geocode twelve consecutive months of residential burglary data in combination with NRC results. The resultant maps visually illustrate the area where residential burglaries have occurred, including the risk buffers (bandwidths) which represent NRC results. The researcher will discuss the month-to-month in relation to one another and compared to earlier research findings and SME feedback and opinions.

1.8 OUTLAY OF CHAPTERS

This research is presented in six chapters to wit:

CHAPTER 2:

LITERATURE REVIEW: A HISTORICAL AND CONTEXTUAL REVIEW OF NEAR REPEAT BURGLARY RESEARCH, GEOGRAPHIC INFORMATION SYSTEMS AND ENVIRONMENTAL RISK FACTORS

Earlier international research on various predictive tools used to identify near repeat burglary patterns - including the NRC - are examined in detail. At the time of writing, there was no known NRC research carried out in South Africa. The development and advantages of the GIS internationally and in South Africa, are examined along with environmental risk factors relating to residential burglary risk.

CHAPTER 3:

CRIMINOLOGICAL CRIME PREVENTION THEORIES

The researcher investigates the CPT and Flag Boost Theory (FBT) to explain near repeat burglary patterns in the Hillcrest policing area. The Crime Prevention Through Environmental Design (CPTED) and Broken Windows Theory (BWT) are examined in relation to prevention of initial residential burglary and near repeats in the Hillcrest policing area.

CHAPTER 4: RESEARCH METHODOLOGY:

The methodology used in this research is examined in Chapter 4. Therein the researcher details why this research is categorised as exploratory and why he selected the explanatory sequential mixed methodology. The researcher further explains the unit of analysis, aim and objectives, sample size, and quantitative and qualitative data collection methods that he used in this study. He then further explains the analysis and interpretation of research findings, and how validity and reliability were measured in this research. Ethical considerations, based on the Belmont Report (1979) and the CRIMSA code of conduct, and research approvals from the UNISA, College of Law Research and Ethics Committee and the SAPS are outlined.

CHAPTER 5: ANALYSIS AND FINDINGS:

Applying the NRC, month-to-month near repeat calculations of risk for residential burglaries in the Hillcrest policing area is illustrated using the GIS. The researcher relied on the GIS to conduct spatial analyses of residential burglary locations and the environments in which they occurred. Feedback garnered through qualitative interviews with five detectives from Hillcrest police, and electronic interviews with SMEs are included in the analysis and interpretation of the research findings.

CHAPTER 6: RECOMMENDATIONS AND CONCLUSION:

Research findings and conclusions are outlined and the feasibility of future studies resulting from this exploratory research are discussed.

1.9 CONCLUSION

This chapter started by recognising international research on near repeat residential burglary patterns, and Ratcliffe's development of the NRC. Current analytical tools used by the SAPS, such as the CTA, CPA and the GIS were outlined. The research questions posed by this exploratory research were highlighted, and the essential research concepts and terms were defined.

The researcher's methodological outlay was discussed and its value outlined. The aim of the research is to apply the NRC to burglary data to identify near repeat residential burglary patterns in the Hillcrest policing area. The GIS is used to illustrate the policing area, geocode residential burglary points and to visualise and analyse the month-to-month near repeat calculations of risk. The objective of the research is to test the accuracy of the NRC on month-to-month near repeat calculations of risk over a 12-month period.

An exploratory research design was chosen because scant research exists on this topic in South Africa. The unit of analysis consists of docket analysis (secondary data collection) of 490 residential burglary cases reported to the Hillcrest (KZN) police station between April 2012 and March 2013. The researcher only had permission to access closed cases. A sequential mixed methods approach was found to be the appropriate data collection method for this exploratory research. Mixed methods research entails a blending of quantitative and qualitative data to provide a better understanding of the research topic. The quantitative aspect of this research focused on secondary data collected through docket analysis, geocoding of residential burglary points and near repeat calculations of risk. The qualitative aspect consisted of qualitative interviews with five detectives from the Hillcrest (KZN) police station and electronic interviews with SMEs as detailed earlier in this Chapter.

In this chapter the researcher summarised how validity (predictive, statistical, construct and external) and reliability will be measured. The research was conducted following ethics outlined by UNISA, College of Law Research and Ethics Committee (Ref: CLAW 2015 ST 11, see Annexure 3), and permission and guidelines from the SAPS's Head of Strategic Management; the Division Commissioner of the Detective Service; and the Provincial Commissioner. The researcher followed the CRIMSA code of conduct and the fundamental ethical principles and guidelines from the Belmont Report, 1979. In conclusion, the interpretation and explanation of the research findings were summarised, and the research chapters were outlined.

CHAPTER 2

A HISTORICAL AND CONTEXTUAL REVIEW OF NEAR REPEAT BURGLARY RESEARCH, GEOGRAPHIC INFORMATION SYSTEMS AND ENVIRONMENTAL RISK FACTORS

2.1 INTRODUCTION

The first section of this chapter refers to international research on near repeat residential burglary patterns carried out in Australia (Johnson et al, 2007; Morgan, 2000; Townsley et al, 2003); Brazil (Chainey & da Silva, 2016); China (Chen et al, 2013; Wang & Liu, 2017; Wu et al, 2015); New Zealand (Johnson et al, 2007), the Netherlands (Johnson et al, 2007); the UK (Bowers & Johnson, 2005; Fielding & Jones, 2012; Johnson & Bowers, 2004; Johnson et al, 2007) and the USA (Johnson et al, 2007; Moreto et al, 2014; Piza & Carter, 2018). The most research relating to repeat residential burglaries has been conducted in these jurisdictions.

Near repeat patterns have also been found in street robberies (Haberman & Ratcliffe, 2012; Glasner & Leitner, 2016); shootings, robbery and motor vehicle theft (Youstin, Nobles, Ward & Cook, 2011; Piza & Carter, 2018), arson (Grubb & Nobles, 2016) and insurgent attacks using improvised explosive devices (IEDs) in Iraq (Townsley, Johnson & Ratcliffe, 2008). However, the researcher focusses here on near repeat residential burglaries. Near repeat, residential burglary patterns have been identified throughout the world thus making prior international research the foundation of this exploratory research carried out in Hillcrest, South Africa (SA).

The second part of this chapter begins with a historical overview of the development of the GIS (Aguirre, 2014; Coppock & Rhind, 1991; Dempsey, 2012; Tomlinson, 1962; Tomlinson, 1963) and crime analysis (Chainey & Ratcliffe, 2005; Hägerstand, 1970; National Institute of Justice, 2018:np; Tobler, 1970). Regional research on the GIS in Namibia (Mukumbira, 2012) and Nigeria (Balogun et al, 2014), followed by research carried out in South Africa (Breetzke, 2007; Cooper & Schmitz, 2003; Eloff, 2006; Schmitz, Potgieter, du Plessis, Cooper & Schwabe, 2000; Schwabe & Schurink, 1999, Snyders, 2016) is considered in detail. Potential advantages to be gained by police agencies implementing the GIS for crime mapping, crime analysis, identification of crime patterns, crime prevention strategies and resource allocation are then highlighted.

The third part of this chapter focuses on the link between residential burglary and environmental risk factors. The researcher outlines residential burglary research conducted by Winchester and Jackson (1982) in Kent (UK), including their indexing of burglary risk and vulnerability of location (environmental risk). Thereafter, research findings pertaining to environmental risk factors (e.g. house location) and residential burglary in South Africa (Mundell & Ayres, 2015; Olckers, 2007; van Zyl, 2002) is compared to Winchester and Jackson's index of environmental risks for house location. Lastly, news articles related to residential burglaries in KZN are outlined.

2.2 INTERNATIONAL RESEARCH ON NEAR REPEAT BURGLARY PATTERNS

The researcher discusses near repeat burglary pattern research under the following headings: Australia, the UK, multi-country research, the USA, Brazil, and China.

2.2.1 Australia

Morgan (2000) focused on repeat residential burglary victimisation in Perth, Australia. His contribution is of significance to this study because he was the first to identify near repeat burglary patterns, and to use the term 'near repeat', to describe residential burglaries that occurred in close proximity to one another, within one month of the initial burglary (Groff & Taniguichi, 2016: np). Morgan's research focused on repeat burglary victimisation in the small suburb of Parkville, Perth, Western Australia. He used five years of recorded police burglary and attempted burglary data, physical addresses and the value of items stolen during incidents (Morgan, 2000:83,94-95). A Life Table Method of survival analysis was used to examine statistical repeat burglary victimisation in Perth, as it was found to be appropriate for repeat burglary research (Morgan, 2000:83,110). Measurement of the hazard rate indicated the risk of burglary victimisation for households within a period of time. Survival analysis, which in this case indicated the risk of burglary victimisation for households; produces estimates which are unbiased, easy to interpret, data-based, and which produce fewer standard errors of estimate and confidence intervals. While Morgan acknowledged the role that residential location may play on the risk of victimisation, he stressed that previous burglary victimisation is a likely predictor of being burgled again in future. The attractiveness and accessibility of the surrounding area or neighbourhood to potential burglars played a more significant role than the characteristics of the home (Morgan, 2000:87, 94).

Parkville contained six districts comprising different housing types, incomes and crime rates (Morgan, 2000:94). Two of the districts consisted mostly of detached houses on large properties (like most of the properties in the formal urban settlements of the Hillcrest policing area), which had the highest burglary rates of the six districts (Morgan, 2000:94). The environmental factors in these two districts included major access to pathways leading to public transport, and several alleyways allowing rear access to properties. The other four districts consisted of flats and semi-detached houses with fewer pedestrian alleyways and paths used by (Morgan, 2000:94) vehicles.

To create a sizeable statistical base to analyse repeat victimisation, Morgan merged six of the districts in two areas, namely “Oldville” and “Newville”. Oldville consisted of homes built in the 1930s and 1940s, while Newville consisted of homes built from the 1950s onwards. The difference between the two areas was large enough to highlight heterogeneity in the analysis of repeat burglaries (Morgan, 2000:95). Morgan’s study revealed that different burglary and repeat burglary patterns existed in Perth, opportunities for burglary, accessibility to homes, the value of the items burgled, and the routine activities of residents and non-residents in the area (Morgan, 2000:110). Further analysis of the burglaries in Parksville found that other burglary patterns existed apart from repeat burglaries at the same address. For instance, one of the months (out of 60 months) had experienced so many burglaries, that the probability of this occurring by coincidence was highly unlikely (Morgan, 2000:112).

It was clear that a burglar, or a group of burglars, was targeting homes in Parksville during this period. It was also found that two repeat residential burglaries occurred along with several near repeat burglaries of homes located close to the first burgled home, which was also burgled again later in the month (Morgan, 2000:95).

The analysis of the different burglary patterns highlighted the significance of crime prevention strategies explicitly focused on near repeats. Morgan discussed the near repeat burglary patterns through the same crime prevention strategies that focus on repeat victimisation (Morgan, 2000:110,112). Morgan's (2000) research opened the door for further research by Townsley et al (2003) in Brisbane, Australia, and Johnson and Bowers (2004), and Bowers and Johnson (2005), in Merseyside, UK.

Building on Morgan's (2000) research, Townsley et al (2003) conducted the first research on the spatial and temporal dimensions of risk for residential burglary victimisation. Townsley et al (2003:615) tested the near repeat burglary theory on 34 months of recorded police burglary data, across high crime areas of Brisbane, Australia. They used a contagion model of near repeat residential burglary victimisation, which predicted that victimisation transfers from one burgled household to another in the same fashion as a disease. These researchers found that the majority of the near repeat patterns existed in the suburbs with homogenous housing (Townsley et al 2003:615, 618).

Townsley et al (2003:617) hypothesised that proximity to a burgled home increased the risk of burglary to houses in the area that share a high degree of housing homogeneity. A police division in South East Queensland, Australia, characterised by the highest burglary rate in the state was used to conduct their research. According to demographic data, this zone was found to be a low socio-economic area with elevated levels of unemployment, public housing, poverty, and crime. demographic data notwithstanding, the Australian Bureau of Statistics (ABS) did not produce or provide any statistics relating to housing homogeneity or heterogeneity (Townsley et al, 2003:619).

All recorded burglaries in the police division between 1 January 1995 and 31 October 1997 were used in the data-set and included address points, time, and dates of the burglaries (Townsley et al, 2003:19-20, 619).

Townsley et al (2003:620) geocoded the burglary data using the GIS to illustrate the burglary points and found that 85% of the burglaries occurred in five urban suburbs, for which reliable street data existed, as opposed to rural street data. The five suburbs in the police division were analysed for homogeneity and risk. The risk or vulnerability resulted from a combination of the burglary rate, demographic factors such as unemployment, public housing, low-income households; and the potential offender population resident in the suburb (Townsley et al, 2003:620-621).

George Knox (1963) developed the Knox Test to detect the spread of leukemia and other diseases in a population in the UK (Knox, 1964:17, 121). In his calculations, Knox used data which consisted of time (temporal), space (spatial) and the interaction between the two (Knox, 1963:121-122; Knox 1964:17). Townsley et al (2003:621) used the Knox Test to examine near repeat burglaries. Each burglary case (or infection) was paired with every other case so that the N value cases resulted in N (N-1) /2 distinct pairs. The spatial and temporal variations between each pair were recorded, and cases that occurred within a certain distance (d) (spatial) were considered spatially close, while cases with (t) days were considered temporally close. The number of cases that were spatially and temporally close (X) was compared to the number expected by chance. When the number of observed pairs was compared to what was expected, burglary (disease) was considered contagious. The Knox method which aimed to predict the spread of disease, was, in this case, used to predict burglary risk (Townsley et al, 2003:621-622).

A comparison was made between observed pairs and what was expected by random chance along short distances and short periods of time, to indicate if burglary risk was contagious (Townsley et al, 2003:622). A Knox Test was conducted within a specific spatial and temporal dimension, using all pairs which occurred closer than 1,000m and 365 days apart, in the analysis. The spatial dimensions were broken down into 100m intervals with temporal periods of 30 days (Townsley et al, 2003:624). Single burglary victims experienced only one burglary, and repeat burglary victims experienced more than one burglary in 34 months (Townsley et al, 2003:624). The analysis produced a contingency table consisting of ten columns and

12 rows, with each address or point representing either a single or repeat burglary victim (Townsley et al, 2003:624). There were three types of potential pairings, which were single and single (SS), single and repeat (SR) and repeat and repeat (RR). However, the Knox Test was used to identify near repeats and thus did not outline which pair occurred first. A contingency table was compiled for each of the five police divisions illustrating the three different pairs, with a total of 15 different tables of results (Townsley et al, 2003:624). Since the analysis focused on near repeats, it excluded all pairs (RR) with spatial distances equal to zero because of the burglary addresses or points which had been geocoded to the same location (Townsley et al, 2003:624).

Based on socio-economic status, the suburbs were divided into two groups. The first group consisted of suburb A and C, and the second group of suburbs B, D, and E (Townsley et al, 2003:625). All five suburbs had a similar number of homes, unemployment rates, renters, public housing, and households earning less than $500 a week (Townsley et al, 2003:625). The difference between the two groups was geographic location or area and housing density, ascribed to rural areas of land in two of the suburbs. Suburbs A and C experienced a high prevalence of burglary concentration and share of the total number of burglaries occurring within the police division. Suburbs B, D, and E shared similar rates of prevalence but where however lower than suburbs A and C (Townsley et al, 2003:625, 627). In their research, Townsley et al (2003:627) used areas consisting of homogenous housing resultant from vast scale development which made all the properties relatively new and identical.

Suburbs A and C did not meet the criteria of homogenous housing, while suburbs C and E did with most of the houses being less than ten years old. Townsley et al (2003:627) based the criteria for target vulnerability or risk, on the size of the local offender population, socio-economic status, and burglary rates in the area. Suburb C experienced a higher burglary rate than suburb A, while suburb A encountered higher concentration than suburb C (Townsley et al, 2003:627). Townsley et al's (2003:628) contagion model found that the near repeats in each suburb corresponded mostly to housing types in the area and identified near repeats in the areas with homogenous housing.

Townsley et al's (2003:629) research considered housing type, socioeconomic factors, and the vulnerability of five different suburbs in the police division. It identified the link between different housing types and burglary victimisation patterns. The near repeat patterns explained the extent of repeat burglary victimisation for other areas was rapid or increased housing development had occurred. Townsley et al, (2003:630) concluded that the link between housing diversity and target vulnerability is an infection in the form of a first burglary. If the housing types are similar in the area, the risk spreads like a contagion to nearby houses, while diverse housing types restrict the spread of contagion or risk to nearby houses (Townsley et al, 2003:630). Townsley et al's (2003) research built on Morgan's (2000) identification of near repeat burglary patterns.

2.2.2 The United Kingdom

Johnson and Bowers produced two separate research papers (Johnson & Bowers, 2004; Bowers & Johnson, 2005) on the topic under investigation here. Their 2004 research used 12-months (April 1999 to April 2000) of residential burglary records amounting to 1692 cases. Their 2005 research consisted of residential burglary data for six years and six months (1 April 1995 to 30 September 2001) producing a total of 75,101 residential burglary records. Both studies relied on similar methodology using the Knox Method, Mantel Method, and FORTRAN software programme.

Johnson and Bowers (2004) conducted research on near repeat burglary patterns in Merseyside, UK shortly after Townsley et al's (2003) research. Johnson and Bowers (2004:237) opined that the ability to predict the location (spatial) and time (temporal) where crime (in this instance residential burglary) will likely occur is essential for prioritising and allocating police resources to prevent crime.

Johnson and Bowers (2004:244) used spatially and temporally referenced police recorded data of residential burglaries in the county of Merseyside, UK. The recorded burglary data consisted of a unique reference number for each record; the street address of each burglary; grid references (x and y coordinates); date and time of each burglary; the victim's name, and the property type burgled (Johnson & Bowers, 2004:244).

To test for near repeat burglary patterns, Johnson, and Bowers (2004: 245) used the Mantel (1967) and the Knox Methods (1964), both initially developed to test disease contagion. The Mantel Method (1967), developed by Nathan Mantel (1967) was used initially to test for spatial-temporal clustering of disease (Mantel, 1967:213-214). This near repeat burglary research used the Mantel z-statistic, to measure the clustering of burglaries in space and time and compared the distribution of burglaries expected by chance. This method compared all burglaries against all other burglaries while making a total number of comparisons n (n-1) when n burglaries are considered. The Knox Method relied on standardised residuals (Johnson and Bowers, 2004, 245-246). Johnson and Bowers (2004:24) developed a software programme called FORTRAN, which they used to analyse the burglary data. The results indicated that more space-time clustering of residential burglaries occurred than could be expected by chance. The Knox contingency table and Knox residuals were calculated using the same residential burglary data. Knox residuals found that crime prevention efforts, focused on the specific area of residential burglaries, could be used successfully for up to two months (Johnson & Bowers, 2004:248).

Bowers and Johnson (2004:250) highlighted the difference between clusters of near repeats (residential burglaries) and hotspots of crime. Hotspots are areas that have a high density or volume of crime, while near repeats predicted clusters occurring in space and time. Bowers and Johnson (2004:249) concluded that police crime prevention strategies and resource allocation would be better suited to the spatial distribution of risk than hotspotting techniques. The residential burglaries in their research clustered in space and time, with a first residential burglary found to be a predictor for increased risk of residential burglaries to nearby houses (Johnson & Bowers, 2004:248).

Bowers and Johnson (2005:69-70) continued their research on space-time clusters of near repeat residential burglary using recorded police data from Merseyside Police (UK) as discussed above. The residential burglary data was cleaned and re-formatted using FORTRAN (Johnson & Bowers, 2005:69-70). Bowers and Johnson (2005:70) used the Mantel Method to measure space-time clustering of near repeat burglaries

An analysis to measure the space-time clustering of residential burglary was conducted for each of the 118 local authority wards in Merseyside for a period of one year (1 April 1999 to 31 March 2000) (Bowers & Johnson (2005:71). The following data was used: Mantel z-score to measure the spatial-temporal clustering of residential burglaries; the number of burglaries and repeat burglaries that occurred in each ward and, the total number of houses in each ward. The analysis included data on housing types (terraced, semi-detached, detached, flats) and percentage of households without a motor vehicle. An index of residential segregation measured how isolated the housing types were while an index of housing heterogeneity measured how different the housing types were from one another (Bowers & Johnson, 2005:71).

Bowers and Johnson (2005:72) conducted the Mantel z-score analysis and a one sample t-test for all 118 wards and found that all the wards had experienced a series of residential burglaries. These findings were significant because, if police resource and crime prevention strategies, focused on the space and time of a residential burglary they may have prevented further burglaries in that area (Bowers & Johnson 2005:72). Bowers and Johnson (2005:72) further examined the relationship between census variables and housing types and the extent to which the residential burglaries clustered in space and time. They found that the general burglary pattern was related to clustering and repeat burglary victimisation. The clustering of residential burglaries was found to be the highest in areas with detached and semi-detached houses with a high rate of residents owning cars. However, affluent residential areas experienced less burglary but more series of burglaries clustering in space and time (Bowers & Johnson, 2005:72). In contrast, repeat burglary victimisation was found to be the highest in areas with terraced houses or flats with a low rate of residents owning cars. Related to repeat burglary victimisation are factors attributed to the number of residential burglaries that have occurred, and the level of deprivation and/or socio-economic factors in the area (Bowers & Johnson, 2005:72). Bowers and Johnson's research (2004, 2005) using police data and the Knox and Mantel Methods, established the existence of near repeat burglary patterns (time-space clustering) of residential burglaries in all 118 wards in Merseyside. These findings could have assisted the police in crime prevention strategies and resource allocation to prevent the occurrence of further burglaries.

Fielding, an intelligence analyst with Greater Manchester Police (GMP), and Jones, the hub manager of the Trafford Division GMP, carried out research on predictive risk mapping in Trafford, Greater Manchester, UK (Fielding & Jones, 2012:30). Fielding and Jones's research aimed to disrupt the patterns of burglars who returned to the same area (optimal foragers) to carry out further burglaries. The research entailed geo-coding residential burglaries and creating spatial and temporal colour coded risk buffers using the GIS (Fielding & Jones, 2012:30). Fielding and Jones conducted the research over a 12-month period (12 May 2010 to 10 May 2011). Police and extended resources were deployed to the areas identified at increased risk of residential burglaries to act as capable guardians. The RAT and the daily foraging patterns of burglars formed a basis for their research (Fielding & Jones, 2012:31), which the researcher discussed further in Chapter 3.

A software programme called Prospective Mapping was used to identify high-risk areas based on spatial and temporal patterns of residential burglaries (Fielding & Jones, 2012:31). Fielding and Jones (2012:31) were aware of the limitations of creating predictive risk maps tailor-made for each shift, however, this approach was considered an improvement as, prior to this model, patrol officers were left to their own devices insofar as when and where to patrol, and being a reactive response when incidents occurred. Previously, officers were allowed to use their knowledge of the areas while carrying out their patrols, and while this may have had its advantages, it was not the best way to employ valuable police resources. The new model allowed supervisors to dictate resource deployment, in the form of patrols to the areas of increased risk, while monitoring required written feedback at the end of each shift. This approach was used in the Trafford Basic Command Unit (BCU) area of the GMP for 12 months (Fielding & Jones, 2012:31-32).

The aim of Fielding and Jones's research was disseminated, and the concept was explained to Neighbourhood Inspectors who carried out their duties based on the red and orange areas (buffers) indicated on weekly predictive risk maps. This process included a project leader and a project analyst who explained the details, processes, purpose of and requirements to the Neighbourhood Inspectors. The Neighbourhood Inspectors received the weekly predictive risk maps on a Wednesday, indicating shift specific visualisation of temporal and spatial risk for areas. The weekly maps were also made available via the Electronic Briefing Site accessible to all police officers. The patrol officers were informed of the significance of their presence in high-risk areas as capable guardians to prevent residential burglaries and to demonstrate a positive, reassuring presence in the area (Fielding & Jones, 2012:32).

The GIS (Map Info 9.5) was used as a visualisation tool to map the residential burglary points, and create 400m risk buffers around each burglary point, to show the changing risk periods of time (temporal) and space (spatial). The temporal aspects of this study were rooted in the aoristic temporal analysis. Aoristic temporal analysis is a method used to analyse the time of crimes where the time is unknown and used in Excel to visualise heat mapping graphs (Fielding & Jones, 2012:32-33). The aoristic analysis method calculates an estimation or probability of an event, or a series of events (in this case residential burglaries), over a specific period (temporal) in a specific area (spatial). It allows the measurement of geocoded crime locations spatially according to an estimate of probability (Ratcliffe, 2002:26-27).

Creating weekly predictive risks maps using recent residential burglary points, requires sufficient resources (such as colour printing) to map and produce the aoristic analysis as simply, consistently and efficiently as possible. Prior to this method, no maps were used to predict residential burglaries or to highlight high-risk areas or locations. Previous resources such as patrols were reactive in nature and focused on previous residential burglary locations in order to prevent further residential burglaries (Fielding & Jones, 2012:34).

Fielding and Jones’s (2012:34) research used 12-months of residential burglary data recorded from 12 May 2010 to 10 May 2011, which consisted of 17,828 burglaries which occurred in the GMP area, and 902 burglaries that occurred in Trafford BCU. This was compared to the previous 12-months (13 May 2009 to 11 May 2010) and they found a decrease of 26.6% in burglaries in the GMP area, and 9% decrease in burglaries in the Trafford BCU. The successful reduction in residential burglaries placed the Trafford BCU second out of 12 BCUs for reduction of residential burglaries for that period, and fourth overall for count reduction of residential burglaries. Residential burglaries in the GMP area decreased from 19,769 to 17,828 and Trafford BCU decreased from 1,229 to 902 (Fielding & Jones, 2012:34-35). It must be noted that additional resources had not been made available to the Trafford BCU. However, three large BCUs that had experienced more than 2,000 residential burglaries prior to this study (13 May 2009 to 11 May 2010) had access to further resources to assist with residential burglary reduction. It was found that the Trafford BCU improved over the average of the GMP force, and similar BCU's within the GMP, and throughout the UK, with regards to the reduction of residential burglaries in the previous 12-months of the study. The potential economic savings across Trafford were estimated to be over £1 million (Fielding & Jones, 2012:35).

Fielding and Jones' (2012) highlighted the importance of and successes that can result from using prospective mapping software and the aoristic analysis method, in conjunction with the GIS (Map Info 9.5). The GIS was used to geocode residential burglary points and to visualise the calculation of heightened risk buffers (spatial and temporal) in the Trafford BCU, and to efficiently use available resources to reduce residential burglaries (Fielding & Jones, 2012:38). The limitation of this method is that the GIS does not take into consideration possible environmental barriers such as rivers which are not accessible, and this method of creating predictive risk maps should not be used in isolation nor as a sole solution for preventing residential burglaries (Fielding & Jones, 2012:38-39).

Fielding and Jones (2012:40) highlighted that their research enhanced and improved the police techniques of GMP by reducing residential burglaries (Fielding & Jones, 2012:40). They emphasised that police organisations should be open to innovative approaches to tackling crime, while bridging criminological theories and practical application, to address crimes like residential burglary (Fielding & Jones, 2012:34-35).

2.2.3 Multiple countries

Johnson et al (2007:201, 207), conducted research on the spatial and temporal patterns of burglary risk in five different countries (Australia, Netherlands, New

Zealand, UK, and the USA), using ten different data-sets provided by the police forces responsible for the areas. For every data-set, there was an over-representation of burglaries occurring within 100m and within a two-week period for all the areas (Johnson et al, 2007:210). They found that even though patterns may have varied for all the areas, houses within 200m of a burgled home were at an increased risk of burglary for two weeks following an incident (Johnson et al, 2007:201). Johnson et al (2007:206) only supplied an overview of the results from the ten different data-sets. The data-set concern Canberra and Beenleigh (Australia), Hague and Zoetermeer (Netherlands), Auckland and Palmerston North (New Zealand), Wirral and Bournemouth (UK) and Pompano Beach and Philadelphia (USA) (Johnson et al, 2007:207).

The Knox Method was used to measure the existence of time-space clustering or near repeat patterns of residential burglaries. Temporal bandwidth intervals of 14 days and spatial intervals of 100m were used. A maximum of 183 days (temporal) and 2 kilometers (spatial) were considered, resulting in a contingency table of 13 by 20 (260 cells). All burglary pairs that represented repeat burglary victimisation were excluded from the analysis to ensure focus exclusively on near repeat burglaries (Johnson et al, 2007:207). A Monte Carlo Simulation took a random sample of all the permutations. The Monte Carlo Simulation can be described as a mathematical technique that provides quantitative analysis for decision-making in the form of a range of possible outcomes and probabilities (Palisade, [Sa]: np). In the application of the Knox Test, all dates are re-arranged, with this process taking place several times. A new Knox Table was generated for each permutation showing how many burglary pairs occurred in each time-space interval of one another and compared with the Knox Table used for observed distribution. Another contingency table was generated which recorded the results from these comparisons (Johnson et al, 2007:208.) For all ten data-sets, the permutation simulation found significant near repeat clustering of burglaries for all short-time (temporal) and distance (spatial) intervals, with a variance between the different data-sets. For every data-set, there was an over-representation of burglaries that occurred within 100m (spatial) and two weeks (temporal) (Johnson et al, 2007:210). There was a definite pattern of distance decay following a burglary. The transfer of risk was most significant to houses closest (spatially) to the burglary and victimisation would occur shortly after (temporally) the initial incidence. Each data-set showed an over-representation of burglaries occurring within 100m and a two-week period for all the areas. The research found that in Australia and the Netherlands, the risk of burglary transferred over further distances, while in the USA the risk was more localised. It was found that the risk persisted over more extended periods of time in Canberra, the Hague, and Philadelphia, compared to a two-week period in other cases (Johnson et al, 2007: 212-213). Johnson et al's hypothesised that the difference in the communication of risk could be attributed to different target densities in the areas. Johnson et al (2007:214) found that the communication of burglary risk was clear across all the areas in their research. In Australia, the UK, and New Zealand communication of risk extended over further distances for areas with lower target density. In contrast, in the USA, the communication of risk was over shorter distances with higher target density. There was no housing density relationship found in the Netherlands (Johnson et al, 2007:214).

In their research, Johnson et al (2007:215) consistently found the existence of near repeat patterns of burglary (space-time clustering) across all the different data sets and concluded that this could be attributed to the variance in the physical and social heterogeneity of all the data-sets and the foraging behaviour of burglars.

2.2.4 The United States of America (USA)

Moreto, Piza, and Caplan (2014) employed a two-part analytical approach to forecasting the locations of residential burglaries in the urban city of Newark, New Jersey, USA. Their research included identifying instigator incidents, which refer to the first burglary in a near repeat pairing, and near repeat incidents, which refer to incidents that are spatially and temporally close to the instigator incident. The first part consisted of measuring risk heterogeneity using the risk terrain modeling (RTM) approach (Moreto et al, 2014:1103). The RTM used the GIS, (ArcGIS 10) to map six risk factors, i.e. land use parcels, at risk housing complexes, pawn shops (second-hand shops), the residence of known burglars, public transport nodes (such as bus stops and rail stations) and drug dealing locations. The Newark Police Department supplied the GIS data for 2010 residential burglaries, at risk housing complexes, 2009 drug arrests, pawn shop locations and the residence details for known burglars (Moreto et al, 2014:1109, 1111).

Moreto et al (2014:1112-1113) applied an Exploratory Poisson Regression Model and the Pearson Chi-Square Goodness of Fit Test to measure the distribution of data. Public transport nodes were identified as non-statistically significant risk factors and were not included. The negative binomial distribution predicts the probability of occurrence of whole numbers greater than, or equal to zero (Ford, 2016: np). Negative binomial analyses suggested that at-risk housing complexes, the residence of known burglars, drug dealing locations, land use and the location of pawn shops are significantly associated with residential burglaries (Moreto et al, 2014:1114). Risk heterogeneity refers to the spatial influence of the characteristics of the environment and the interaction between individuals and their environment. Moreto et al (2014:1103) described this risk heterogeneity as a base-level of environmental risk for an area, resulting in some areas being at a higher risk of residential burglaries than others. The second part of the research entailed the application of the NRC to test whether near repeat residential burglary patterns existed in Newark in 2010. Moreto et al (2014:1103-1104) compared the baseline level of risk for instigator and near repeat residential burglaries, to analyse whether the variation of environmental risk could influence near repeat burglaries rather than instigator burglary events in isolation.

Moreto et al's (2014:1120-1121) research differed to prior research (Bowers & Johnson, 2005; Johnson & Bowers, 2004; Townsley et al, 2003), which used disease contagion models to explain near repeat residential burglaries, by highlighting that the instigator and near repeat residential burglaries, may be symptoms (and not causes) of an area where environmental risk already existed.

Moreto et al's (2014:1120) research demonstrated how the RTM and the NRC could be used in conjunction to highlight specific environments or locations (environmental factors) that are riskier than others before an initial burglary takes place. Moreto et al's (2014:1122) research promoted the use of the RTM and the NRC to forecast residential burglaries and allow police agencies to distribute resources to areas of increased risk, to prevent further residential burglaries.

Piza and Carter (2018) applied the NRC to identify near repeat patterns of residential burglary and motor vehicle theft in Indianapolis, the USA. The GIS (ArcGIS) was used to geocode crime data and used represented variables to conduct spatial analysis (Piza & Carter, 2018:10). A total of 11,536 residential burglaries and 4,991 motor vehicle thefts were used for the research (Piza & Carter, 2018:16). Piza and Carter (2018:3) incorporated near repeat research and the environmental context in which these patterns occurred. Their research aimed at identifying an isolated or single incident, initiator, and a near repeat event, in a series of residential burglary and motor vehicles thefts.

Spatio-temporal clustering was identified via application of the NRC over a 12-month study, including the application of multinomial logistic regression models to highlight any environmental factors (or variables) related to the initiator near repeat patterns of crime (Piza & Carter, 2018:1-2). These regression models comprised of 19 variables incorporated into four distinct categories: crime generators (6), geographic edges (4), social disorganisation (5) and the date when the incidents occurred (4) (Piza & Carter, 2018:2-3,19). Crime generator variables were ATMs and banks, bars, liquor stores, parks, pawn shops, and trailer parks. Geographic edge variables consisted of railroad tracks, trails, patrol zone boundaries, and rivers. Residential burglary and motor vehicle theft that occurred within two blocks (868 feet / 264.5m) were considered in close vicinity to the variable. Social disorganisation variables entailed areas with low socio-economic status, geographic mobility, housing, and population density; racial heterogeneity, and the young male population. Date occurrence grouping comprised of quarter 1 (January – March), quarter 2 (April to June), quarter 3 (July to September), quarter 4 (October to December), and weekend (Friday to Sunday) (Piza & Carter, 2018:10,12).

The residential burglary data was entered into the NRC, and the Manhattan Distance Calculator applied 4-day, 7-day, and 14-day temporal date intervals. One city block in was about 434 feet (about 132m) in length. The difference in temporal intervals was used to test for prominent or significant clustering or near repeat patterns (Piza & Carter, 2018:9-12). For residential burglary, the NRC identified near repeat patterns up to three blocks, and within four days of an initial or initiator event. Within a one block radius, near repeat residential burglaries were 78% higher than chance occurrence, one to two blocks near repeat residential burglaries were 33% more likely to occur, and two to three blocks near repeat residential burglaries were 26% more likely to occur. Near repeat, patterns were present within one block between five and 16 days. Repeat residential burglary patterns were also found to be seven times more likely to occur at the same location, within four days of the initiator incident, and the increased risk of repeat victimisation was evident up to a 20-day period. The 7-day temporal date interval was entered into the NRC, and the spatiotemporal clustering was found to extend up to two blocks (and not three blocks as was the case with the 4-day interval) for 0 to seven days. Near repeat, residential burglary patterns were at heightened risk of 39% between eight and 14-days and within one block. Near repeat, patterns were also identified for the theft of motor vehicle incidents (Piza & Carter, 2018:11). Based on these calculations by Piza and Carter (2018), it was evident that near repeat patterns of residential burglary (and motor vehicle theft) exist in Indianapolis, USA. After the near repeat analysis was concluded, another function on the NRC was used to identify the number of times an event was an initiator in a space-time cluster. Out of the 11,536 residential burglaries, the NRC found that 2,536 were initiator events and 1,712 were near repeat events. For motor vehicle theft, the NRC found 802 initiator events and 592 near repeat events out of 4, 991 events (Piza & Carter, 2018:10,16).

Spatial analysis showed that residential burglaries occurred within two blocks of the following crime generators: 20.27% from ATMs and banks, 7.74% from bars, 5.44% from liquor stores, 21.87% from parks, 1.27% from pawn shops and 3.08% from trailer parks. Residential burglaries occurred within two blocks of the following geographic edges: 12.21% from railroad tracks or a railway, 6.70% from trails, 22.85% from patrol zone boundaries and 2.85% from the river (Piza & Carter, 2018:12). The multinomial logistic regression models for the residential burglary identified two geographic edges: railroad tracks which were associated with a decrease in the likelihood of a burglary being a near repeat event, and the location in relation to a river increased the chance of a near repeat event (Piza & Carter, 2018:18). All five social disorganisation variables were contributing factors in near repeat patterns for residential burglary, while four of these variables - concentrated disadvantage, geographic mobility, population density, and risk heterogeneity - contributed to near repeat patterns in motor vehicle theft (Piza & Carter, 2018:18-19). From the date and occurrence variables, near repeat events were unlikely to occur between January and March, while residential burglaries occurring over weekends were 12% more likely to be near repeat events. These findings highlighted a statement by Fielding and Jones (2012:38-39) that the NRC should be used as part of current predictive and analytical tools, and not as a replacement for existing predictive tools.

The Flag Hypothesis, flags or attracts the attention of would-be burglars (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178) and the Boost Hypothesis boosts or heightens the risk of victimisation (Pease, 1998:8-9; Wu et al, 2015:178). According to research by Piza and Carter (2018:22), the Boost and Flag hypotheses best explain the occurrence of repeat and near repeat patterns for residential burglary, and motor vehicle theft, either at the same location or within one block. Piza and Carter's (2018:23) research highlighted that social disorganisation measures were significant for indicating an increased risk of a near repeat or initiator event and can be used to channel police resources. To a lesser effect, crime generators and geographic edges (environmental criminology) achieved statistical significance revealing a mixture of positive and negative associations for the variables (Piza & Carter, 2018:23).

Piza and Carter's (2018) research identified near repeat patterns for residential burglaries and motor vehicle theft. Relying on another function of the NRC, they established the extent of initiator and near repeat patterns in the study area. Through the application of multinomial logistic regression models, several variables were identified that may be conducive to near repeat patterns. The FBT explained residential burglary and motor vehicle theft patterns in Indianapolis, with social disorganisation variables being more significant than environmental variables.

2.2.5 Brazil

Brazil consists of twenty-six states; each policed by a Military Police Agency (*Policia Militar*) which polices' and responds to incidents of crime. The residential burglary data included the address, date, and time of each burglary. Between 2012 and 2014, there were 19 453 recorded residential burglaries and 1 668 (8.6%) repeat burglary victims in Belo Horizonte. The Policia Militar used the GIS to geocode the exact points of residential burglaries reported and applied the NRC to identify and analyse near repeat burglary patterns in Brazil (Chainey & da Silva, 2016:4-7).

Brazil has lower residential burglaries rates compared to Western countries, like Australia, the UK, and the USA, which could be attributed to different housing structures. (Chainey & da Silva, 2016:6). Like most countries, under-reporting of crime is a problem, but under-reporting alone does not explain burglary rates (Chainey & da Silva, 2016:4-5). In Brazilian cities, such as Belo Horizonte, most people live in high-rise apartment blocks. High-risk apartments may limit opportunities for burglars because it is difficult to tell if anyone is at home (occupied), or not unless the unit is situated on the ground floor (Chainey & da Silva, 2016:7-8).

Through the application of the NRC, Chainey and da Silva (2016:7) found statistically significant ($p \leq 0.05$) near repeat residential burglary patterns in Bel Horizonte. Fourteen of twenty different spatial and temporal buffers were found statistically significant ($p \leq 0.05$). All six buffers within 0 to 21-days and 1m to 200m of initial residential burglaries were found to be statistically significant and showed the highest levels of risk compared to other risk buffers. Chainey and da Silva (2016:7) found that there were 242 (2.2%) near repeat burglaries within 100m and seven days, 657 (5.8%) of near repeat burglaries within 200m and seven days, and 1 430 (12.7%) within 300m and seven days of earlier residential burglaries. Near repeat, burglary patterns were found to be lower in Bel Horizonte compared to Western countries where near repeat residential burglaries within 200m and seven days of an originator residential burglary were between 12% and 23% of all residential burglaries (Chainey & da Silva, 2016:7).

Furthermore, most properties have situational crime prevention measures in place, such as perimeter fencing, burglar bars, security gates and security guards at the entrances of apartment blocks (Chainey & da Silva, 2016:7-8). Chainey and da Silva (2016:7-8) concluded that near repeat residential burglaries occurred within seven days of the original burglary in Belo Horizonte, and stated that residential burglary programmes, such as those carried out in Trafford, Manchester (UK) by Fielding and

Jones (2012) would be less effective in reducing repeat and near repeat residential burglaries in Belo Horizonte, Brazil, where burglary patterns are already low.

2.2.6 China

Chen et al (2013) conducted research on the space-time analysis of burglary in Beijing, China. According to Chen et al (2013:1), environmental criminology and spatiotemporal analyses established crime clusters across both space and time. The development of environmental criminology and the distribution of crime have been widely studied and have identified various crime patterns which have contributed to a problem-orientated policing policy, forecasting and the allocation of police resources (Chen et al, 2013:1).

Due to the lack of police recorded data in China, extraordinarily little was known about the spatial patterns of crime. In 1986, the Chinese Police Force introduced a 110-telephone number to contact the police service. These calls were manually captured, and later, computerised recording systems were introduced, which resulted in more detailed and exact crime reports. In recent years, the introduction of the Global Positioning System (GPS) in the Beijing police allowed the exact locations (x and y or longitudes and latitudes) of crimes to be recorded. The Chinese government and the Chinese police's concern with crime grew and generated interest in the study of crime and crime prevention strategies (Chen et al, 2013:1-2). Advances in technology have enhanced crime analysis through powerful tools and methods such as the GIS and the NRC. The GIS allows the exact location of the crime, and the distribution of crime to be analysed and the NRC calculates near repeat victimisation patterns (Chen et al, 2013:4, 9).

Chen et al (2013:2-4), found that Cornish and Clarke's (1986; 2014) RCT, Cohen and Felson's (1979) RAT, and Brantingham and Brantingham's (1984; 1995) CPT, best-explained burglaries in their research area. According to Chen et al (2013:8), spatial and temporal analysis of burglaries are concentrated at hotspots, and future risk was boosted or enhanced by earlier burglaries in the area. Chen et al (2013:1) used five months of recorded burglary data in Beijing and applied spatiotemporal analysis methods to analyse the burglaries. They entered the data into the NRC and identified that near repeat burglary patterns of risk were transferred for up to three weeks (temporal) and 100m (spatial) around each previous victim (Chen et al, 2013:9). The near repeat burglary patterns identified were like the UK and other countries as indicated in the research conducted by Johnson et al (2007). Chen et al, (2013:10-11), concluded that near repeat burglary patterns (spatial-temporal patterns of crime) and crime theories were not unique and applicable only to Western countries but also to Oriental nations.

Researchers Wang and Liu (2017) used recorded burglary data for a large city (city N) in China to analyse burglary hotspots and near repeat patterns. These researchers utilised geocoded (x and y coordinates) recorded police burglary data for 4 226 burglaries from 1 January 2013 to 30 December 2013 (Wang & Liu, 2017:4). Wang and Liu (2017:1) wanted to identify the existence of near repeat burglary patterns in N city, and to further analyse displacement between hotspots and the near repeat patterns. With crime displacement, the result of crime prevention activities at the local level; and the risk levels of crime represented by a graph, allowed for crime forecasting and the allocation of police resources. The differences between a hotspot and near repeat patterns include: when many crimes cluster in space and time, they are known as hotspots', while the near repeat phenomenon suggests that every crime incident has the potential to transfer risk to the nearby vicinity (Wang & Liu, 2017:1,11).

Like Chen et al, (2013:2-4), Wang and Liu (2017:2) used Cornish and Clarke's (1986; 2014) RCT, Cohen and Felson's (1979) RAT, and Brantingham and Brantingham's (1984; 1995) CPT to explain the occurrence of burglaries in their research area. These theories support the role that environmental characteristics play in the occurrence of crime, such as the location of houses, roads, railway-lines, shops, and the environment in which the routine activities of residents and offenders take place.

In addition to the above, the FBT explain the occurrence of repeat and near repeat residential burglary patterns. The Boost Theory (event dependent) suggests that increased risk of future burglary victimisation is boosted by previous burglary victimisation (Pease, 1998:8-9). This theory suggests that burglars pass-on information about items and value to other burglars, which then motivates these burglars to carry out future burglaries at the same locations (Wang & Liu, 2017:2).

According to Pease (1998: 8-9), offenders prefer to repeat victimise the same location rather than seek out a new property to victimise. The Flag Theory (based on risk heterogeneity) suggests that certain properties are flagged, or brought to the attention of potential burglars, and future burglaries carried out at these properties are the result of target attractiveness and independent burglars sharing information (Pease, 1998:8-9; Wang & Liu, 2017:2).

Wang and Liu (2017:4) applied the Knox Method to analyse the existence of near repeat burglary patterns in city N and found that near repeat burglary risk extended for 14 days (temporal) and 300m (spatial) from each victimised location (Wang & Liu, 2017:7). The Temporal Expanded Near Repeat Matrix (TENRM) was used to analyse the risk levels before and after hotspots had formed, and they made use of two different time scales. For the experiment, the time scale for 100m and seven days revealed that hotspots contributed to the increased risk level of near repeats within 300m and 21-days. On another time scale, hotspots were found to contribute significantly to near repeats within 1000m and 42-days. These results highlighted the contribution of hotspots to near repeat risk (Wang & Liu, 2017:11). The TENRM was used to combine both the hotspot and near repeat patterns. The risk of crime was found to be continually moving in both space and time. When high-risk generates in an area, it can result in the formation of a hotspot. Once a hotspot has formed, the risk may transfer to the nearby vicinity depending on the size of the hotspot. Hotspots may even return after a few days. Where there are two spatially, or temporally adjacent, hotspots, they can merge together to form one hotspot. The levels of risk were found to decrease with the increase of space-time distance after a hotspot had formed and was similar to near repeat risk. Crime risk was found to move both in space and time, with low-risk levels before the formation of a hotspot and increased risk after the hotspot was formed. Adjacent areas were found to experience elevated levels both before and after the formation of a hotspot. This could be attributed to offenders foraging for new crime opportunities in familiar areas. Concurrently high-risk areas may exist nearby with the formation of hotspots (Wang & Liu, 2017:6,11-12). The research conducted by Wang and Liu (2017:12) considered near repeat patterns of risk as the main components attributed to the formation of hotspots, and that hotspot and near repeat patterns appear to contribute to one another.

Researchers Wu et al (2015:178) conducted research in Wuhan, a large Chinese city, on repeat and near repeat burglary patterns, and the extent to which the same burglar is involved. The Wuhan Metropolitan city consisted of various street block sizes and building densities made up of old houses and new high-rise apartment blocks (Wu et al, 2015:182).

Wu et al (2015:178,181) utilised recorded burglary data provided by the Wuhan Municipal Public Security Bureau which consisted of 10 548 geocoded burglaries for 2013. All geographic coordinates were generated at the local police station when the crime (burglary in this instance) was recorded and manually pin-pointed on a GIS map. Any unique identifiers of suspected burglars involved were included. The 10 548 residential burglaries were entered into the NRC to analyse repeat and near repeat burglary patterns (Wu et al, 2015:181,183).

Wu et al (2015:178) stated that two theories can explain repeat and near repeat burglary patterns; the Flag and Boost theories. The Flag Theory suggests that the characteristics of a location attract the attention of burglars, while the Boost Theory suggests that future burglaries are dependent on earlier burglaries (Wu et al, 2015:178). Detected burglaries were analysed and revealed that 874 burglars were involved in 2 347 detected burglaries, meaning that one burglar was responsible for three to four burglaries. The majority (90%) of the burglaries were committed by a single or solitary burglar, and 9% by multiple burglars (Wu et al, 2015:181).

The NRC was applied to calculate repeat and near repeat burglary patterns based on 10 548 reported burglaries (Wu et al, 2015:181). The Manhattan Distance Measure was used with a spatial bandwidth of 100m and a 7-day temporal bandwidth (Wu et al, 2015:182). The analysis revealed that 2 739 burglaries (26%) occurred within 120m and within 14-days of any burglarised location (Wu et al, 2015:183,187). The Spatial and Temporal Analysis of Crime (STAC) was applied to analyse the distribution of burglaries. The STAC is a quadrant method of spatial clustering analysis which produces results as a standardised deviational ellipse used to analyse the distribution of 2 739 initiator burglaries and 7 809 independent burglaries. The clusters of burglaries highlighted three different patterns in Wuhan. All the clusters were initiator clusters. In the Hanyang district of Wuhan, the majority of the clusters were independent clusters, and the Hankou district of Wuhan showed a mixture of both initiator and independent clusters (Wu et al, 2015:14-185).

Wu et al (2015:186-187) opined that near repeat burglary patterns hold a crime prevention value that can be used by the police for resource allocation and crime prevention activities, based on the repeat and near repeat patterns identified by the NRC. Their research, which concluded that burglaries cluster in space and time, is consistent with previous international research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson, Bernasco et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Piza & Carter, 2018; Morgan, 2000; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015), which demonstrated that surrounding properties are at a heightened risk of burglary victimisation following a burglary incident. The risk of repeat victimisation at the same location in Wuhan was found to be 600% greater than the average for the city (Wu et al, 2015:186). Wu et al (2015:17) were aware of the limitation of the under-reporting of crime in Wuhan. The basic premise of the Flag and Boost theories helped to explain the mechanism of repeat and near repeat burglaries in Wuhan (Wu et al, 2015:187-188).

In summation, this section highlighted international near repeat residential burglary research (Bowers & Johnson, 2004; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2005; Moreto et al, 2014, Morgan, 2000; Piza & Carter, 2018; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015) which entailed the use of police recorded residential burglary data (geocoded) for each study area. All of the discussed studies identified that near repeat residential burglary patterns hold a crime prevention value for police agencies.

2.3 INTERNATIONAL RESEARCH AND DEVELOPMENT OF THE GIS

Early research by Hägerstand (1970) and Tobler (1970) laid the foundation for a better understanding of crime (Chainey & Ratcliffe, 2005: np). Hägerstand (1970) focused on the regional science of population migration and identified the essential link that time and space co-exist with one another. Hägerstand introduced the space-time concept which could be used to develop a socio-economic web model to explain population migration (Hägerstand, 1970:10). According to Hägerstand (1970:8), the need for employment, and/or monetary remuneration alone does not explain population migration, but easy access to schools, universities, theatres, libraries, doctors, hospitals, playgrounds, and security services are also important. This highlighted the role that environmental, or geographic factors play in population migration. Tobler (1970), developed a demographic model - a computer movie simulation of the urban growth of the Detroit (USA) region. The demographic model specifically focused on the geographic distribution of population growth but did not differentiate between employment opportunities or access to transportation (Tobler, 1970:234, 236).

Research in the 1970s (Chainey & Ratcliffe, 2005: np) found that by exploring the geographic components of Hägerstand's 1970 space-time concept, and Tobler's 1970 geographic distribution of population growth, resulted in a better explanation and understanding of crime. This resulted in new techniques like identifying patterns and concentration of crime, relationships between crime and the environment (socio-economic characteristics), techniques to assess police effectiveness and crime prevention strategies focused on specific geographic areas (Chainey & Ratcliffe, 2005: np). The reduction in the cost of technology, like computer hardware and operating systems (software), has paved the way for introducing GIS technologies for policing and crime prevention (Chainey & Ratcliffe, 2005: np). These technological advances have enabled the computerisation of police data, which can be used for crime and intelligence analysis, thus enabling better identification of crime patterns for use in crime prevention strategies (Chainey & Ratcliffe, 2005: np).

Coppock and Rhind (1991:21) and Dempsey (2012: np) identified four distinct phases in the historical development of the GIS. The first phase was between the 1960s and the mid-1970s where the emerging disciplines were influenced by a few key individuals, like Tomlinson (1962, 1963) (Coppock & Rhind, 1991:21; Dempsey, 2012: np). The second phase was from the mid-1970s to early 1982 where agencies began to use GIS technologies which led to further development of the GIS. The third phase was from 1982 until the late 1980s during which GIS was developed for commercial use. The fourth phase was from the late 1990s to the present day and comprises of developments and advancements of GIS for individual use (Coppock & Rhind, 1991:21; Dempsey, 2012: np). Coppock and Rhind (1991:23) identified key individuals and organisations that influenced the development of the GIS. The work of Howard Fischer (Waldheim & Irving, 2011:np) of the Harvard Laboratory for Computer Graphics (LCG), Roger Tomlinson (Tomlinson, 1962; 1963) of the Canadian GIS (CGIS), Jack Dangermond (Waldheim & Irving, 2011:np) from Environmental Systems Research Institute (ESRI) in North America, and David P Bicksmore (Riddick, Kessler, & Giles, 2017:19) of the Experimental Cartography Unit (ECU) in the UK, contributed to the development of the GIS.

Tomlinson (1962) conducted research on computer mapping and the storage, compilation, and assessment of natural and economic data, for the evaluation of agricultural land in Ottawa, Canada (Tomlinson, 1962:2). This early use of computer input consisted of maps and tables whereby maps represented soil types from surveys. Tomlinson envisioned that one would be able to input the maps and related data, into a computer system; allowing the user to later retrieve and compare the data from another map or statistical data-set. The computer system would only require a single copy, or input, of the map of an area while visualising the data it represented (Tomlinson, 1962:2-4). Tomlinson described a computer mapping system as a system of techniques and instruments which could be applied to aerial data from both maps and statistical data. A feasibility report of computer mapping systems for agricultural rehabilitation and development under the administration of the Canadian Department of Agriculture was carried out by the staff of Spartan Air Services Ltd, Ottawa, Canada with the support of International Business Machines (IBM) (Tomlinson, 1963:1-2). This could be considered the starting point of the GIS as it is known today, and Tomlinson is credited for developing the first functional GIS, which decades later is found in a number of sectors (Aguirre, 2014: np).

The NIJ’s Crime Mapping Research Centre (CMRC) led the modernisation of crime mapping by implementing the GIS in the USA (Chainey & Ratcliffe, 2005: np). The CMRC was renamed in 2002, as the Mapping and Analysis for Public Safety (MAPS) Programme (Chainey & Ratcliffe, 2005: np; NIJ, 2018: np). The MAPS Programme funds research based on the GIS; statistical analysis, and investigation of spatial data to support effective police deployment to streamline the use of public safety resources, to strengthen crime policies and to enhance the understanding of crime issues (NIJ, 2018: np). The success of the USA's government initiative spread and laid the foundation for the development of crime mapping based on the GIS, to countries such as the UK, Australia, South Africa and across South America (Chainey & Ratcliffe, 2005: np; Mukumbira, 2012:19).

The GIS is used in policing and crime prevention for recording and mapping police activity, crime prevention initiatives, service calls and incidents of crime (Chainey & Ratcliffe, 2005: np; Mukumbira, 2012:20). The GIS is a visualisation tool (Balogun et al, 2014:462; Chainey & Ratcliffe, 2005: np; Mukumbira, 2012:43; NIJ, 2018: np) used to support the briefing of police involved in crime prevention duties; by identifying and explaining recent crimes and predicting future crime locations (Chainey & Ratcliffe, 2005:np). The GIS can also be used to identify crime hotspots (Balogun et al, 2014:464; Chainey & Ratcliffe, 2005: np) and focus on crime prevention initiatives; to help better understand the distribution of crime and the causes of criminal activity, through pattern analysis and local data (Chainey & Ratcliffe, 2005:np).

The GIS as a visualisation tool (Balogun et al, 2014:462; Chainey & Ratcliffe, 2005:np; Mukumbira, 2012:43; NIJ, 2018:np), can create maps to illustrate crime statistics to the public in different areas, and assist in the implementation and monitoring of crime prevention initiatives (Chainey & Ratcliffe, 2005:np). Furthermore, Chainey and Ratcliffe (2005: np) emphasised that the application of GIS and crime mapping has become essential for policing and crime prevention in the 21st century.

2.3.1 Research on the GIS in Africa

Very few criminological studies have been conducted on the GIS within an African context. Before detailing on research on the GIS in South Africa, two studies will be discussed; firstly, research by Mukumbira (2012) in Namibia and; secondly Balogun et al's (2014) research in Nigeria. Both these research endeavours emphasised the advantages that the GIS and crime mapping hold for police agencies. Balogun et al (2014), Breetzke (2016a), Chainey and Ratcliffe (2005), Eloff (2006), Mukumbira

(2012) and the NIJ (2018) agree, that the GIS and crime mapping can visualise and find crime patterns, highlight areas of risk, and assist with resource allocation. Using the GIS to combine geographic and police report data into a map, allows for practical analysis of crime incidents (NIJ, 2018: np). The application of the GIS allows a better understanding of the environment, which can assist law enforcement agencies and researchers to understand why specific crimes occur in certain places (Chainey & Ratcliffe, 2005: np; Mukubira, 2012:19; NIJ, 2018: np).

Mukumbira (2012:19) studied the development of crime mapping using the GIS for crime analysis and as a prediction tool for Windhoek (Namibia). In Namibia, crime mapping is in its initial stages, with the aim of becoming an integral part of the Namibian Police (Nam Pol) operations. Crime mapping would enable officers at all levels to integrate crime data and geographic data with the aim of better understanding the link between crime and the role of the environment in the occurrence of crime. Mukumbira is of the opinion that crime mapping can enable decision-makers to identify hotspots, and therefore decision-makers will be in a better position to prevent crime. Crime mapping could assist Nam Pol with resource allocation (of limited resources) to areas where they will best serve the goal of crime prevention (Mukumbira, 2012:21-22).

Mukumbira (2012:42) explained the process used by Nam Pol to record crime statistics at station level. Nam Pol records each crime reported in an Occurrence Book, and if further investigation is required the details will be entered into the Crime Register (CR) and allocated a CR number. A cell-register must be completed if a suspect is held in custody. Mukumbira highlighted the existence of a central crime register; and that each police station records their own monthly crime statistics on a Monthly Crime Return form. Monthly, the form is faxed to the sub-division which then compiles the crime statistics for the entire country (Namibia) using a system called Po16. The statistics, with each crime categorised or coded; and consisting mostly of figures and tables without maps, are printed and sent to the Inspector General, the Commissioner of Crime Investigation Division (CID) and the United Nations Development Programme (UNDP) (Mukumbira, 2012:42-43).

The Nam Pol Geopolicing Unit, under the umbrella term e-policing system, was established in 2010 in the Khomas region for the purpose of crime mapping, analysis, and identification of crime hotspots. The Nam Pol Geopolicing Unit was expected to include other regions by 2013. GPS is mounted on all police vehicles in the Khomas region; to collect the coordinate data from crime locations. However, portable GPS would be of better use for crime locations not accessible by vehicle. The GPS coordinates are included in the case-docket on the e-policing system, which is used to create crime maps, which include all coordinates and locations from all police stations throughout Namibia (Mukumbira, 2012:43).

The Nam Pol Crime Investigation Unit, Organised Crime Division, and Internal Investigation Directorate makes use of the Geopolicing Unit. The Crime Investigating Directorate uses the Geopolicing Unit for crime analysis, crime scene visits and for statistical analysis, while the Internal Investigation Unit relies on it for crime scenes involving police officers (Mukumbira, 2012:43-44). Mukumbira (2012:45) proffers that GIS could provide police officers with information about a location, and GIS data and crime data could then be merged, which would enable visualisation of any crime patterns, and potentially forecast future crime locations. GIS data is available in Namibia and can be visualised using the GIS or other web-based tools (Mukumbira, 2012:43). Mukumbira's research went into detail on the system implementation, database design, and the geo-database necessary to establish a fully functional GIS and database system for Nam Pol, which is beyond the scope of this research (Mukumbira, 2012:49, 51, 59).

A detailed understanding of the geographic area or environment can aid police agencies to explain why specific crimes occur at certain locations or environments. The details of features at a location, such as the type of terrain, land use, and population demographics, can aid the development of crime prevention strategies and resource allocation (Mukumbira, 2012:19-20). Mukumbira's (2012) research, correlates with this research in its use of the GIS to store environmental and police data for a policing area, and as a visualisation tool to create crime maps, analyse crime locations in relation to the environment; and assist with resource allocation in areas of increased risk to prevent further crimes.

Nigerian researchers, Balogun et al (2014:455) concur with Chainey and Ratcliffe

(2005), Mukumbira (2012) and the NIJ (2018) that the GIS is essential for modern crime prevention, specifically for crimes such as rape, kidnapping, murder, burglary, and armed robbery; all of which are prevalent in the Benin Metropolis, Nigeria (Balogun et al, 2014:457). Research by Balogun et al (2014:453) commenced after drawing conclusions from questionnaires carried out on the police and the public, which revealed that crime in the Benin Metropolis was on the increase, and that Nigerian police were at a disadvantage to address crime due to a lack of resources, and outdated policing methods. Further analysis proved that the public had an extremely negative outlook of the police due to perceived levels of corruption, resulting in 80% of crimes going unreported (Balogun et al, 2014:453).

The research conducted in the Benin Metropolis highlighted the potential benefits of using the GIS (ArcGIS) for crime mapping and analyses (Balogun et al, 2014:465). The research explored the methodology to establish a digital land-use map showing all crime locations, in order to create a geospatial database, and to use spatial analysis queries and buffering; applying an Integrated Land and Water Information System (ILWIS), ArcGIS software and GPS (Balogun et al, 2014:453, 465). The authors emphasised the need for the Nigerian police to upgrade their crime control tools by employing the GIS for crime mapping; to understand crime patterns in relation to road networks, police stations, offender location and to identify hotspots for crime.

Balogun et al (2014:455) described crime as a spatial entity because it occurs in a geographic location and at a particular time. The GIS was able to merge spatial and non-spatial data by mapping and highlighting areas at risk and keeping the information up-to-date thereby allowing strategic advantage over traditional paper-methods of crime reporting and analysis. The proximity of a location to hotspots shows that some areas are more vulnerable, or at risk for the occurrence of crime compared to others, thereby allowing better resource allocation to the areas of risk (Balogun et al, 2014:455, 465).

Balogun et al (2014:462) successfully created a GIS database, and the created maps of the Benin Metropolis to visualise and pinpoint crime hotspots within a 1km risk buffer area; police stations; different roads types (express, arterial street, major road and highway); and the various land-uses ranging from agricultural and industrial, to residential use. Buffer zones were created, and spatial queries and crime pattern analyses carried out using the GIS. Single buffer zones, 500m each, were created and mapped for hotspots for robbery and rape, burglary, cultism, rape, and socio-economic activities (Balogun et al, 2014:461-462).

Three maps were created representing the Benin Metropolis: one map represented the single buffers for the different crime types; one map represented the multiple buffers of crime, with a high overlap of buffers representing the high-risk of crime in that area; and one map represented the locations of police station and crime hotspots in relation to other socio-economic activity in the area (Balogun et al, 2014:462-464). From the single buffer map, it was established that most areas in the Benin Metropolis were at high-risk for the diverse types of crime. The multiple buffer maps revealed that as one moves away from a hotspot buffer, the risk of crime decreases notably in a north-eastern direction. In contrast, the overlap of hotspot buffers represented high-risk of crime in those areas, even though a police station was in the area of overlap of multiple hotspots. This strongly indicated the prevalence of crime, the ineffectiveness of the police and the need for change (Balogun et al, 2014:461-462).

Balogun et al (2014:462) further identified that most of the banks and marketplaces in the Benin Metropolis (socio-economic activities) were located within, or near crime hotspots. Banks and marketplaces attracted a number of people, including criminals (Balogun et al, 2014:463). The single 500m buffer around the burglary hotspot showed that burglary, combined with robbery, was prevalent around Saple Road New Santana Market, Adolo College Road in Umbowo, Iwoghan at Ikpoba Hill, Etete in GRA Ugbokum Quarters, Sokponba Road and St Savious. In addition, fieldwork identified a link between the nature of housing, and the distance or location from the police station, as factors contributing to the rate of burglaries in these areas (Balogun et al, 2014:463). This information was valuable to the Nigerian police, as a guideline for resource allocation and a better understanding of which areas experienced specific crimes, such as burglary and robbery. Other crimes such as cultism, robbery and rape were prevalent in most of the areas throughout the Benin Metropolis, such as Uwelu, Uwasota, Ekosodin - an area where most Benin University students live - Nitel Junction at Ikpoba Hill along Benin-Auchi Road, and Uwa Primary School (Balogun et al, 2014:463). Again, such locations visually identified by the GIS can be used by Nigerian police as focus areas for preventing such crimes, and to prioritise areas like the Uwa Primary School, which houses a high number of vulnerable victims (i.e. children).

The study and GIS analysis carried out by Balogun et al (2014:463) highlighted the type and extent of crime in the Benin Metropolis. The buffer around the various police stations indicated a lack of security and brought the distance that police needed to travel between the various hotspots to light, as well as areas where buffers overlapped with one another and thus should be continuously patrolled. The identification of hotspot areas for the various crimes enabled the police to respond or be dispatched strategically. Another strategic advantage available, using the routing layer in the GIS analysis, is the ability to forecast routes when police are in pursuit of a suspect, thereby increasing the chances of apprehending the suspect and potentially preventing future crimes (Balogun et al, 2014:464).

These research findings strongly support the use of the GIS, as a DSS in crime management, and crime prevention by Nigerian police. Balogun et al (2014:465) concluded that effective crime control and management in Nigeria could be supported by the GIS method, which should be adjusted and integrated to make operations proactive. They suggested the establishment of the GIS, and training and of personnel on its use, by the Nigeria Police Education Department (Balogun et al, 2014:465). In addition, they suggested that police vehicles have GPS facilities for active tracking that include digitally layered maps and data for every city (Balogun et al, 2014:465). Balogun et al (2014:455) concluded that without the application of the GIS and geodatabases, contemporary crime prevention would be costly and counterproductive. The research carried out by Balogun et al (2014) concurs with research conducted by Eloff (2006) and Mukumbira (2012).

2.3.2 Research on the GIS in South Africa

Schwabe and Schurink (1999), from the Human Sciences Research Council (HSRC), outlined the need for information, and the application of the GIS by the SAPS to address the high crime rate in South Africa, during the Geographic Information Management Services User Conference in Midrand, South Africa in 1999. Schwabe and Schurink (1999: np) stressed that the basic building blocks of crime prevention in South Africa were not in place and then emphasised the need for the SAPS to map crime in order to direct crime prevention strategies. The researchers avered that it was essential for SAPS management to support and implement the GIS into existing procedures, as a management and crime prevention tool. They further added that effective communication, consultation, and integration of information from various departments of the criminal justice system (police, courts, corrections, and parole systems) were essential for developing a management system for crime prevention in South Africa (Schwabe & Schurink, 1999: np).

Schwabe and Schurink (1999: np) highlighted the necessity of crime information for crime prevention using the GIS including essential details in crime scene reports, such as the MO and the victim and suspect reports. Comprehensive crime statistics which are up-to-date and accurate, are essential. The geocoding of all the crime scenes, including the land parcel databases for police stations; and clear station boundaries, are necessary for crime management and prevention. The Crime Administration Systems (CAS), details of police resources available, along with an indication of efficacy, and the integration of crime statistics and socio-economic data, are all useful to prevent crime. Schwabe and Schurink (1999: np), emphasise the importance of crime statistics and the geo-coding of crime locations, the boundaries of policing areas and available resources.

The medium-term objectives of a management system is that it will link all police stations on the same network, to a central database for the storage of all crime statistics, using a commercial GIS which allows customisation of data; a simple and user-friendly CAS, which runs on a Windows computer operating system; controlled access and data entry to management system. The management system should be implemented at priority police stations depending on the availability of information officers, and adequate training in the use of the GIS (Schwabe & Schurink, 1999: np).

Long-term objectives of the management system would be the integration of all systems within the SAPS (firearms, personnel, vehicles, and intelligence) and relevant systems (vehicle register, population register, and property register); and the expansion of the functions of the GIS to include hotspot analysis, shortest path analysis, crime forecasting, geographic profiling of crime, statistical analysis, and decision support models and expert systems (Schwabe & Schurink,1999: np). Schwabe and Schurink (1999: np) concluded that the success of crime mapping (and analysis) using the GIS lays primarily with the understanding and implementation thereof by SAPS management and personnel.

Schmitz et al, (2000) conducted research on the implementation of the GIS for crime analysis and decision support in the SAPS. The research was funded by the Department of Arts, Culture, Science and Technology (DACST) in association with the CSIR, the HSRC and the Medical Research Council (MRC), and in consultation with the Crime Information Analysis Centre (CIAC) (Schmitz et al, 2000:3).

Schmitz et al (2000:10) described the GIS as consisting of computer hardware and software, and spatially referenced data which allows for management and analysis by a user. Schmitz et al (2000:16) further highlighted the potential use of the GIS towards saving time or working hours of staff members, and saving storage space The GIS allowed fast retrieval of data to update maps on a regular basis, allowed for interactive map production, enabled the creation of unique or standard maps, faster and lower map creation costs, and sharing of data-sets without unnecessary duplication. The disadvantages of using the GIS as outlined by Schmitz et al (2000:16), were the initial set-up cost, the initial data input and management which could be time-consuming, the training time required to use the GIS, the availability of commercial data, and the organisational changes required to successfully implement and use the GIS.

Schmitz et al (2000:78-79) worked with several others from a vendor called GIMS, to firstly standardise road name formats, and secondly to ensure a standard set of sample cadastral data projected using the ArcGIS, which covered the area around the Johannesburg Zoo, Parktown and Hillbrow. Due to the expense of the Johannesburg Municipal street data at the time (estimated between R 800 000 and R 1.2 million), vendor-supplied sample data was used, and Schmitz et al (2000:79) showed the geo-coding of carjacking cases from 1 October 1998 to 8 February 1999. The anti-carjacking initiative was a SAPS project that focused on preventing carjacking in the north-eastern and southern parts of Johannesburg. Carjacking data was collected daily which consisted of the details and descriptions of victims and offenders, and the MO used (Schmitz et al, 2000:73,78-79). However, the results were low (only 101 hijack incidents out of 419) and the poor-quality data could thus not be geocoded. Several entries did not have street names or numbers which could be geocoded, and others fell outside of the study area (Schmitz et al, 2000:79). This early study by Schmitz et al (2000) demonstrated and highlighted the need for sufficient cadastral and street data to geocode incidents using the GIS. Schmitz et al (2000:84) suggested that one can carry out hotspot analysis using a software programme called Spatial and Temporal Analysis of Crime (STAC) which was developed by the Illinois Criminal Justice Information Authority in the USA. STAC was used to identify hotspot for carjacking in Johannesburg. By mapping the hijack hots-pots in Johannesburg the SAPS were better placed to prevent further carjacking. ArcView GIS has an extension programme which can also calculate crime hotspots using various algorithms.

Using the CAS Block level in the GIS, opens an analysis function which calculates the number of points, or incidents of crime in a polygon or CAS Block, thereby aggregating at station level to show the number of crimes per square kilometer (Schmitz et al, 2000:85-86). The CSIR used both ArcGIS and MapInfo GIS software tools in their crime prevention research and application (Schmitz et al, 2000:93), and aimed to promote the different tools available to the SAPS, without favouring one over the other. The CSIR's aim was to assist the SAPS in evaluating and implementing the GIS for crime prevention and resolution (Schmitz et al, 2000:94).

The CSIR has been assisting the SAPS to develop its crime mapping and analysis capabilities. They provided specialised crime mapping and analysis for detectives working on specific priority cases. In 2001, the SAPS commenced with a national crime mapping system using the GIS at police stations in South Africa to geocode priority crimes. The system's primary objective was to improve crime prevention and management, but also included tactical crime analysis. In a number of cases, the

CSIR and SAPS created maps which were used as visualisation tools to explain complex cases in court and in some of the cases, tactical crime mapping using the GIS contributed towards the conviction of dangerous criminals (Cooper & Schmitz, 2003:269, 270, 277).

In his research, Dr. Eloff of the CSIR incorporated spatial technology to analyse and prevent crime. He focused on the use of remote sensing and GIS, and the correlation between land usage and crime in the Tshwane Municipality boundary (Eloff, 2006). Remote sensing is a method which relies on satellite or camera imagery (South African National Space Agency, [Sa]: np), used by scientists to observe the earth's surface from various distances; to gather information about various features and their distribution (Eloff, 2007:14).

Eloff's research focused on the Tshwane Municipality area, South Africa, and entailed remote sensing technology integrated with the GIS and geocoded crime data, as a foundation to carry out crime analysis for crime prevention purposes (Eloff, 2006:v). Tshwane's diverse/heterogeneous race and social classes, along with various land uses in relation to crime, made it a practical research area covering 284,057 ha. Using crime data from 28 police precincts that fell in Tshwane, 46 categories of crimes, defined by the SAPS, were geocoded for the period 2002 to 2004. ArcGIS 9.1 software was used to create maps and to carry out statistical analysis in conjunction with remote sensing imagery. Detailed crime analysis was carried out for murder, carjacking, residential burglaries, and rape (Eloff, 2006:9,14, 34, 223).

For the crime of murder, the crime analysis identified a high spatial correlation with specific land use classes of informal settlements (Eloff, 2006:14). The south-eastern part of Tshwane consisted of residential land use. Crime analysis identified a strong correlation for residential burglaries between high-density residential land use. Residential areas like Temba and Mamelodi, which grew significantly since 1994, were the same principal areas affected by residential burglaries. Areas such as Hercules and Pretoria West (Western parts of Tshwane) also showed an increase in residential burglaries, however not as high as in the south-east areas. The overall pattern of residential burglaries in the Tshwane areas was not successfully prevented or displaced from 2002 to 2004 (Eloff, 2006:15).

Carjacking incidents in Tshwane showed an increase of 15.7% from 2002 to 2003, with a slight increase of 1.4% from 2002 to 2004. The analysis found that carjackings occurred mostly in the southern, central, and north-western areas of Tshwane. The southern area of Tshwane predominantly consisted of high-density residential, industrial, and low-density residential land use classes. The main area consisted mostly of high-density residential and commercial land use classes, with the north-western areas consisting of informal settlements land use classes. The crime analysis showed a high correlation for carjacking with high-density land use classes and informal settlement areas. Carjacking patterns showed an insignificant change from 2002 to 2004, which suggested that carjacking was not successfully prevented or displaced during this period (Eloff, 2006:15-16).

The geocoded crime statistics for rape in Tshwane showed a slight increase of 0.24% from 2002 to 2003 and a slightly higher increase of 0.8% from 2002 to 2004. The crime of rape mostly occurred in the central and north-western areas of Tshwane. The main area consisted mostly of high-density residential and commercial land use classes and the north-western part of informal settlements. The Mamelodi area, located east of Tshwane, and consisting predominantly of informal settlements and high-density residential land use classes, experienced the highest incidence of rape. The crime analysis identified a high correlation between rape and high-density residential and informal settlement areas, with both areas showing growth since 1994. These findings suggest that rape in these areas was not successfully prevented or displaced during this period (Eloff, 2006:16).

Eloff concluded that it was evident that a specific type of crime correlated to dominant land use class, including heterogeneous environments. Eloff’s research findings took into consideration the role that the environment played in the incidence of crime. Eloff stated that the sciences of urban planning, remote sensing, GIS, specific statistical and crime analysis techniques; combined into an integrated system could enhance the understanding and crime prevention capabilities on a macro (national) and micro (local) level. Spatial technology, like the GIS, is a tool that can aid in the development and monitoring of crime prevention strategies (Eloff, 2006:224, 229, 240).

Eloff identified that the building, development, and training of specialised skills (such as the GIS) were challenges for SAPS and related agencies in South Africa (Eloff, 2006:240). Eloff's research paved the way for further research using remote sensing imagery and the GIS, in conjunction with geocoded crime statistics, in order to carry out crime analysis for crime prevention strategies and policing. Eloff was at the forefront of GIS, and spatial technology research in South Africa and his work detailed various spatial technologies, and the implementation of technologies like remote sensing and the GIS for crime prevention and analysis; which could be of value to the SAPS (Eloff, 2006:224, 229, 240).

Breetzke, (2007:67) in his review of the GIS and policing in South Africa, found that the GIS and crime mapping can assist the SAPS in a number of areas, namely interactive internet-based crime mapping, geographic profiling, and with the geodemographic segmentation system. Interactive internet-based crime mapping can visualise the annual crime statistics released by the SAPS on a national, provincial, and local station level. Geographic profiling, an investigative method of offender profiling developed by Rossmo, aims to narrow down the likely area that the offender lives in. The geodemographic segmentation system can be described as the clustering of the population into categories of neighbourhoods based on the demographic, socio-economic factors, and characteristics of the area (Breetzke, 2007:67).

Even with the GIS, the question remains whether the SAPS have the skills to apply it effectively (Breetzke, 2007:67). Accurate crime statistics are an essential ingredient to fully harness the GIS capabilities. Members of the SAPS must appreciate and understand the necessity of gathering accurate information at a crime incident, and precisely recording data on the SAPS system. Accurate crime statistics are essential for carrying out crime analysis (Breetzke, 2007:77-78). The importance of accurate crime statistics can be demonstrated by the fact that all the research discussed in this research, relies on police recorded data in the form of crime statistics. With the geo-coding of crime incidents, the GIS requires that each crime incident occurring in a policing area has an x and y coordinate and includes detailed information on the crime, the victim, and the suspect/offender. Areas that do not have a formal road network or even a clearly defined road system, make it difficult if not impossible to geocode. Another challenge for the SAPS is to geocode an address that does not exist or has not been entered into the SAPS GIS database. Successful geo-coding requires data cleaning and database maintenance and management (Breetzke, 2007:78-79). The use of the GIS in the SAPS can be attributed to the current technology (computer hardware and software) used by the SAPS. Policy, legislation, and funding alone cannot guarantee the successful and effective use of the GIS, which raises concern about SAPS knowledge and skill of the GIS. Breetzke (2007:82) concluded that the future success of the GIS and crime mapping in the SAPS, largely depends on the GIS private sector, local and provincial government, and GIS professionals in SA to address the problem of infrastructure, before the GIS can be widely and effectively used by the SAPS (Breetzke, 2007:82).

Breetzke (2016a:np) stated that the GIS is able to identify and map crime patterns, support decision-making for distribution of police resources, target crime in high-crime areas and aid in the development of crime prevention initiatives and projects. Breetzke (2016a:np) is in agreement with other researchers (Balogun et al, 2014; Chainey & Ratcliffe, 2005: np; Mukumbira, 2012:43; NIJ, 2018: np) regarding the importance of the GIS to policing and crime prevention. According to the SAPS (2015:45), the GIS is now widely used by the SAPS divisions, components, and sections for the organisation of spatial information used by management for reporting, for analyses and crime for prevention strategies. Following the September release of the 2015/2016 national crime statistics in South Africa, Breetzke noted that the crime levels remain very high despite crime prevention initiatives which have largely failed to decrease crime (Breetzke, 2016a:np). In contrast to the SAPS (2015:45), Breetzke (2016a: np) suggested that now is the time to re-examine current crime prevention policies and initiatives and to strongly consider the value of the GIS to future policy directives and crime prevention strategies.

Snyders (2016: ii) conducted research on the link between crime, the fear of crime and the built environment using a Built Environment Related Crime Analysis Model. The study area consisted of the Villieria SAPS Precinct Sector 2 (Kilner Park and Queenswood), Pretoria, South Africa. The Villieria Police Precinct crime statistics for the period April 2014 to March 2015 were used (Snyders, 2016: ii, 66). According to Snyders (2016: ii), the BWT, Defensible Space Theory (DST), Situational Crime Prevention Theory (SCPT) and CPTED were the most applicable to crime prevention within the built environment.

In the Villieria Precinct, between April 2014 and March 2015, it was evident that crime types varied from month-to-month. Property crimes were high in June 2014 and low in December 2014. In March 2014, 40% of all crime incidents were property related and 20% were contact crimes (Snyders, 2016:67). Property related crimes consisted of 7.9% burglary at non-residential premises, 42.5% burglary at residential premises, 27.3% theft of motor vehicles and motorcycles, 22.3% theft out of or from motor vehicles and 0% stock theft (Snyders, 2016: np). According to Snyders (2016:55), property related crimes can be related directly to the built environment. Through a structured interview with Community Liaison Members (CLM) and Community Policing Forum (CPF) members, crime hotspot areas were identified at the Queens Corner Shopping Centre and along the railway line close to the N1 freeway. The CLM added that main roads, which link with exit and escape routes in the study area, were to be considered as hotspots for crime, as well as two drug houses in the area responsible for dealing in the parks (Snyders, 2016:73).

All the crime incidents which occurred in Kilner Park and Queenswood were geocoded using the Q-GIS and Planet GIS (Snyders, 2016:67-68). The crime incidents included 13% contact crimes (crimes against the person), 8 % contact related crimes, 8% crimes detected by police action, 15% other serious crimes, 54% property-related crime and 2% subcategories of aggravated robbery (Snyders, 2016: np). Buffers were created around various environments in the study area to visualise and analyse crime incidents using the GIS. Hotspot areas were identified as follows: N1 Freeway (500m), the railway line (500m), main roads (250m), parks and open spaces (150m) and shopping nodes (300m) (Snyders, 2016:74). The analyses revealed that 60% of all crimes occurred within 250m of the main road, 46% within 500m of the railway line, 29% within 150m of parks and open spaces, 27% within 300m of shopping nodes and 26% near the N1 freeway (Snyders, 2016:74). Properties (majority residential) located opposite the N1 freeway experienced mostly residential burglary. The primary land use along the railway line was residential, special (retail) and industrial in nature. The main crimes experienced within the 500m buffer of the railway were residential burglary and theft from or out of motor vehicles (Snyders, 2016:75).

In the study area, 67% of crimes took place during the day (06:00-08:00) compared to 33% at night (18:00-06:00) (Snyders, 2016: np). The analysis showed that 55% of crimes were property related and occurred during the day (06:00-8:00), and 54% during the night (18:00-06:00) (Snyders, 2016: np). Property crime incidents during the day (06:00-18:00) consisted of 47% residential burglary, 30% theft from or out of motor vehicles, 18% theft of motor vehicles and motorcycles and 5% burglary at non-residential properties (Snyders, 2016: np). Crime incidents that occurred at night (18:00-06:00), were 24% residential burglary, 43% theft from or out of motor vehicle, 31% theft of motor vehicles and motorcycles and 3% burglary at non-residential properties (Snyders, 2016: np). The residential burglary risk was found to be significantly higher during the day compared to night. These findings are valuable and can assist the Villieria police in the decision-making process for crime prevention strategies and resource allocation, tailored to specific crimes at specific periods of the day, such as residential burglary during the day and theft of motor vehicles at night.

During the study, Snyders established, that the Villieria SAPS did not have enough tools to carry out crime trend analysis. This lacuna can be filled with the GIS, which can be used to represent and analyse the Villieria SAPS policing area, the built environment and crime incidents (Snyders, 2016:95). Using Snyder’s (2016) model (Built Environment Related Crime Analysis) and the GIS, a one-month crime prevention strategy was carried out in the Villieria SAPS precinct, along with the Metro Police, the CPF and private security companies operating in the area. The initiative successfully decreased crime incidents by 40% over that period (Snyders, 2016:95). It was evident that the BWT and CPTED theories were applied through interventions such as clean-ups; removal of drugs and the relocation of homeless people to places of safety; carried out along the N1 freeway, the railway, and open spaces because of the preliminary outcome of the research (Snyders, 2016:96).

Overall, through mapping and analysis of crime statistics using the GIS, the Villieria Police were armed with vital information to aid in decision-making, the channelling of valuable resources, and the planning of crime-specific prevention strategies in specific areas at specific times. It is clear from Synders's (2016) research in the Villieria Police Precinct, Pretoria, South Africa, that the built environment, the location of properties, and the time of day are significant factors that can attribute to various crime types in specific areas. Furthermore, the research highlighted the analysis and mapping capabilities of the GIS as a valuable tool that should be utilised by SAPS at station level.

2.3.3 Environmental risk factors relating to residential burglary

The previous section of this chapter examined the development and documentation of the GIS in South Africa by Cooper and Schmitz (2003); Eloff (2006); Schmitz et al (2000), Schwabe and Schurink (1999) and also included research conducted by Balogun et al (2014), Chainey and Ratcliffe (2005) and Mukumbira (2012). Eloff's (2006) research on the development of spatial technology to prevent and combat crime in Tshwane, identified the relationship between different land use classes and specific crimes. It is evident that land usage forms part of environmental factors relating to certain crime types and risk, in this case, residential burglaries. The following section will examine the relationship between house, neighbourhood location, and environmental risk factors.

Moreto et al (2014) posited that environmental risk factors exist in an area or neighbourhood before an initial burglary takes place, and further emphasised that specific house locations were at heightened risk. Moreto et al (2014) support Winchester and Jackson's (1982) environmental risk index for property location. South African research findings (Mundell & Ayres, 2015; Olckers, 2007; van Zyl, 2002) concur with Moreto et al (2014) and Winchester and Jackson (1982).

Winchester and Jackson's (1982) research focused on residential burglaries in Kent, UK. The Kent police area was made up of both urban and rural areas or land which brought different challenges to crime prevention efforts. The research area was confined to four adjacent subdivisions within the Kent police areas: Maidstone, Tonbridge, Malling, and Sevenoaks. These areas were chosen because they experienced a high rate of residential burglaries i.e. 920 burglaries of a total of 4,948 reported residential burglaries reported to Kent police in 1979. A total of 434 victims were interviewed over eight and a half months (Winchester & Jackson, 1982:5,35).

Winchester and Jackson (1982) analysed the various target hardening devices used in the sample areas and developed an index of burglary risk and vulnerability for house location, in order to establish the role that environmental risk can play in residential burglary victimisation (Winchester & Jackson, 1982, 9,14-15).

A house with a score of 14 variables would be most at risk and property with zero variables least at risk on the variable index. The risk variables for property location included (Winchester & Jackson, 1982:39):

- Situated in a rural area.
- Isolated.
- Located within sight of five or fewer houses.
- Located on a major town road or village lane.
- Located on the nearest major road.
- Standing at a distance from the road.
- Adjacent to the gardens of other houses.
- Adjacent to open space or open land.
- Accessible from the front and back.
- The front is obscured from view by other houses.
- Either side obscured from the view of neighbouring houses.
- Most sides are obscured from view from the roadside or by the public.
- Front side is similarly obscured.

- Located at a distance from the nearest house.

Winchester and Jackson (1982:31) compared Kent police residential burglary data from 1979 and 1978. They established that rural areas experienced consistently higher rates of residential burglaries compared to urban areas, with some areas experiencing a concentration of residential burglaries (Winchester & Jackson, 1982:31-32). While comparing the two year's data, they found that certain areas in Maidstone that were closer to the town, and areas in Sevenoaks, in more accessible locations, both experienced higher residential burglary rates than other areas (Winchester & Jackson, 1982:31-32).

Winchester and Jackson (1982) highlighted that certain housing types were more likely to be burgled than others. For example, detached houses are at higher risk compared to semi-detached houses (Winchester & Jackson, 1982:14). Some areas were more vulnerable than others at certain times, and the location and/or environmental factors played a significant role in the risk of residential burglary (Winchester & Jackson, 1982:32, 39). Winchester and Jackson (1982:22) identified the most critical risk factors between households that had experienced a burglary, and households that had not, and attributed these to environmental risk and not security levels. They further suggested that the role of environmental risk in residential burglaries was not the limited result of the various housing types found within the study area (Winchester & Jackson, 1982:22).

Even though the research carried out by Winchester and Jackson (1982) is over three decades old, the environment risk index is applicable to the current residential burglary scenarios in South Africa. In a South African context, this will be demonstrated by discussing residential burglary research (Olkers, 2007; van Zyl, 2002), the experience of security risk assessors regarding residential burglary risk, (Mundell & Ayres, 2015) and the different land uses and house locations, in relation to other establishments. Winchester and Jackson's (1982) environmental risk indicator correlates with the principles of CPTED (Kruger et al, 2016:36; Safer Spaces, ([Sa]: np) in terms of the location of the property, accessibility and the clear-line of sight to neighbouring houses.

2.3.4 Residential burglary research in South Africa

According to the Victims of Crime Survey (VOCS) 2016/2017 carried out in South Africa, residential burglary (housebreaking) was perceived to be the most common (61.7%) and the most feared crime (50.9%), followed by residential robbery (house robbery) (Lehohla, 2017a:57). Residential burglary has consistently been the most prevalent crime experienced in South Africa (2011-2016) (Lehohla, 2017b, 2017:63). In 2015/2016, 647 000 residential burglaries took place in South Africa with only 350 000 cases reported to the SAPS, which equates to a 53.4% report-rate (Lehohla, 2017b:65). The VOCS for 2016/2017 found that only 51% of residential burglaries were reported to the police (Lehohla, 2017a:1). The VOCS 2015/2016 (Lehohle, 2017b:66) established that 11% of households experienced repeat burglaries while the remaining 89% experienced a single burglary. According to a media release (11th October 2018) by Statistics South Africa, residential burglary remains the most common crime making up 54% of all household crime (Statistics South Africa, 2018: np).

Van Zyl (2002) conducted research on residential burglary in South Africa and focused specifically on two policing areas, to wit Pretoria West and Garsfontein in the east of Pretoria (Gauteng) (van Zyl, 2002:83). He made a comparison between affluent (Garsfontein) and less-affluent (Pretoria West) residential areas to establish the different risk levels for residential burglary victimisation (van Zyl, 2002:83). The Garsfontein policing area covered Lynnwood Manor, Lynnwood Ridge, Lynnwood Park, a part of Murrayfield, Die Wilgers, Wapadrand, Faerie Glen, Garsfontein, Constantiapark, Pretorius Park and Moreleta Park residential areas. The Pretoria West policing area covered Pretoria West, Proklamasie Heuwel, West Park, Danville, Kwaggasrand, Elandspoort, Loftus Gardens and Philip Nel Park residential areas (van Zyl, 2002:83). The Pretoria West policing area was made up of rural and industrial areas (land uses) which were excluded because the research aimed to compare residential areas specifically (van Zyl, 2002:83-84).

Van Zyl's (2002) research encompassed SAPS data, maps and residential values from the Property Valuation Directorate of the City Council of Pretoria and he carried out semi-structured interviews with burglary victims, convicted burglars serving sentences at the Atteridgeville prison, SMEs from the SAPS, security companies, insurance companies and CPFs (van Zyl, 2002:88). Through analysis, van Zyl (2002:70-71), like Winchester and Jackson (1982), identified a number of environmental factors that increased the risk of residential burglaries in an area. The affluence of the neighbourhood increased the risk of residential burglaries compared to less-affluent neighbourhoods. Burglars were likely to target properties in affluent neighbourhoods. The accessibility of the area and free movement of vehicles and people on the roads increased the risk of residential burglaries in the area compared to gated communities, or complexes which had controlled access. Neighbourhoods that were close to, or consisted of shopping centres, small businesses (commercial land use) and buildings under construction, were at a higher risk of residential burglaries because these activities and/or establishments attracted strangers or non-residents into the area. Criminals operating in such areas were thus able to blend in easier (van Zyl, 2002:70-71).

Through semi-structured interviews with convicted burglars, van Zyl (2002:125) identified the cues that burglars tend to follow when targeting a property. Firstly, convicted burglars that participated in the research admitted to having prior knowledge of the area, either by carrying out legitimate work (for example, as a gardener) on the property (routine activities), or they gathered information from domestic workers or gardeners working at the burgled home. Secondly, burglars were reluctant to confront any occupants if anyone was at home. Rational choice was exercised to weigh-up the risk of someone being at home or whether there were any observing neighbours. Thirdly, the accessibility of a target property was considered in terms of whether the property was close to the main road or next to open or vacant property (land use) to allow easy access and escape. The fourth consideration is the design features of the target property (CPTED) such as concealed entrances and signs of affluence (rational choice of weighing up risk and rewards). The fifth consideration related to the security measures or target hardening devices present at the target property. Security measures ranged from alarms systems linked to armed response security, clear sight from neighbouring properties and barking dogs. During the interviews, it was emphasised that these security measures, or target hardening devices, would not deter burglars from carrying out a burglary at a target property, but only make them more cautious in doing so. The sixth and the least defining considerations were severe weather, such as lighting and thunder, and barking dogs which tend to draw attention to the activities of burglars (van Zyl, 2002:125).

It is evident from van Zyl (2002:125), that convicted residential burglars emphasised environmental risk factors such as house placement on the road, house location to nearby vacant property (land use) for easy access and escape, and house location to neighbouring houses. These risk factors are in line with Winchester and Jackson's (1982) index of burglary risk and vulnerability for the location of houses and environmental risk factors, Mundell and Ayres (2015) research, and research carried out by Olckers (2007).

Olckers (2007) conducted research on the impact of residential measures on the incidence of residential burglaries in two suburbs, namely Westcliff and Parkhurst in North Johannesburg (Gauteng), South Africa (Olckers, 2007: xi). Westcliff was described as an upper-income area with valuable heritage foundation and larger properties, and Parkhurst as an upmarket area consisting of a density of smaller properties (Olckers, 2007: xi). Olckers's research made use of residential burglary data from residential burglaries reported to the Parkview police station from 1 January 2001 to 31 December 2002 (one year) (Olckers, 2007: xi). Descriptive mapping and the Microsoft Excel software package were used to carry out statistical analysis (Olckers, 2007:45). Each grid block was equivalent to two residential blocks (Olckers, 2007:7).

Olckers focused on security measures and target hardening efforts for the prevention of residential burglaries while acknowledging the geographic location of the residential burglaries, and the location of other burgled properties, and environmental factors. Environmental factors included the distance of the burglarised property from places of entertainment, business properties, unoccupied properties, main access roads, location on the street and dead ends (cul-de-sacs or end nodes) (Olckers, 2007: 137-138, 140, 142).

Olckers' (2007:138) findings suggest the existence of near repeat residential burglary patterns in the Parkhurst and Westcliff during the period of investigation. In the case of repeat victimisation, burglars tend to return to the same homes to victimise, while near repeat patterns suggest general foraging behaviour of burglars who target houses in close proximity to previously burgled houses (Johnson et al, 2007:215). The burglar becomes aware of the different properties in the area that share the same access routes and other surroundings (Johnson et al, 2007:215).

Through descriptive mapping analysis, Olckers (2007:139) identified residential burglaries in relation to main access roads and found that 40% of the burglaries occurred in the same grid as a main access route; 24% within one grid distance of a main access route; 11% within a two grid distance of a main access route; 18% within a three grid distance, 6% within a four grid distance; and, 1% within a five grid distance of a main access route (Olckers, 2007:139). Residential burglaries in relation to dead-end or cul-de-sacs (end node) found that 33% of the burglaries occurred in the same grid as dead-ends, 41% within one grid distance, 14% within two grid distances, 8% within three grid distances and 4% within four grid distances. The quantification of residential burglaries on the street within a grid found that 41% of the properties burgled were close to a corner property, 37% were located in the middle of the street, and 22% were corner properties which made them least vulnerable (Olckers, 2007:141-142). It is evident from these findings that the number of residential burglaries decreased further away from the main access route, in a similar way that residential burglaries decreased further away from places of entertainment, business properties (commercial land use) and unoccupied land (vacant land). Main access routes, near the house on the street, contributed to residential burglary risk. Olckers' opined that descriptive mapping could be a useful tool to the SAPS and the CPF, by highlighting environmental factors that could contribute to the incidence of residential burglaries (Olckers, 2007:222). Olckers' (2007) research highlighted environmental risk factors linked to residential burglaries and suggested the potential clustering of residential burglaries close to one another in a South African context.

According to independent risk assessors (Alwinco) in South Africa, Mundell, and Ayres (2015:7) found that houses located in the middle of a street are at higher risk of being burgled compared to houses located on street corners. This difference in risk could be attributed to the line of visibility (Mundell & Ayres, 2015:7). An example is a view of passing traffic. The location of the house within the neighbourhood plays a prominent role in the environmental risk factors contributing to residential burglaries. Houses located close to woods or bushy areas, open spaces or open grounds, or parks and rivers are easily accessible, and a means of hiding and escape for burglars (Mundell & Ayres, 2015:7). According to Mundell and Ayres (2015:7), houses located in a cul-de-sac (dead-end or end node) are at higher risk of burglary victimisation because patrols carried out by the police, or security companies are less frequent compared to other roads.

This section concludes with consistent research findings (Mundell & Ayres, 2015; Olkers, 2007; van Zyl, 2002) regarding environmental factors linked to residential burglaries in a South African context and connects with earlier research by Winchester and Jackson (1982) relating to the UK. News articles pertaining to residential burglaries in the KZN will be discussed in the next part of this Chapter.

2.3.5 Relevant news articles on residential burglary in KwaZulu-Natal, South Africa

A news article by Erasmus and Radebe (2013:np), regarding the SAPS 2012/2013 crime statistics, highlighted that households are at a higher risk of residential burglary when located in middle to upper-income suburbs (formal settlements) and next to, or close to, an impoverished area (such as an informal settlement). In other words, crime rates (in this case burglary) are influenced by the location of an affluent area next to a poorer area, where people are more likely to carry out crimes such as residential burglary (Erasmus & Radebe, 2013: np).

Durban, (KZN) was used as an example, where residential burglary hotspots fall mostly in established suburbs (formal settlements). In KZN, households from Hillcrest to Berea are at a two to five times higher risk of been burgled compared to adjacent, less affluent neighbourhoods. Cato Manor (Near Berea), is made up of low-cost housing and is surrounded by middle-upper class income neighbourhoods, and thus experienced a low level of residential burglaries compared to the surrounding suburbs (Erasmus & Radebe, 2013: np). This news article highlighted the role that different land uses play in residential burglaries.

According to the 2012/2013 crime statistics, Prestonbury and Town Hill experienced the highest number of residential burglaries in Pietermaritzburg (PMB) in KZN. The Mountain Rise area which consists of the most substantial number of households has experienced a decline in residential burglaries between 2011 and 2012. Examples of residential burglary gangs operating in the PMB area are the 'Five Minute Gang' and the 'Morning Gang'. The Five-Minute Gang is believed to have been operating in the PMB area since 2007, and target Town Hill and Prestbury, in some cases using hired cars to carry out residential burglaries (Erasmus & Radebe, 2013: np).

The Five-Minute Gang got their name from their MO, as the burglars successfully carried out the residential burglary within five minutes; before the police and security companies could respond (Erasmus & Radebe, 2013: np). Some of the members of the Five-Minute Gang are believed to have been arrested in 2008. However, a number of years later the same MO continues in the area (Erasmus & Radebe, 2013: np).

Members of the Morning Gang were arrested in 2013, using the same MO as the Five-Minute Gang, with a deviation in terms of when they carried out their deeds to wit between 9 am and noon. It is believed that both these gangs travelled from a base in Durban to carry out residential burglaries in the PMB area (Erasmus & Radebe, 2013: np).

A recent residential burglary trend was identified in the Greenwood Park policing district in Durban, KZN, where burglars break and enter via the roof (North Glen News, 2016: np). Warrant Officer (WO) Audh of the Greenwood Park police (SAPS) advised residents to install latches and burglary alarm contact points on the trap doors to their ceilings. Another recent trend by residential burglars is to detach or remove the garage door to gain access. WO Audh urged residents to install burglar alarm contact points and to reinforce garage doors where possible (North Glen News, 2016: np). These examples of residential burglary trends in KZN highlight the different MOs used by burglars to carry out residential burglaries.

2.3.6 The link between national and international research

International research on residential burglary has identified near repeat patterns in a number of countries. These findings highlight the potential that identifying near repeat patterns can have for crime prevention and resource allocation by police. At the time of writing, there was no known research on near repeat residential burglary patterns, and the application of the NRC in South Africa.

The GIS, which originated in North America (Tomlinson, 1962; Tomlinson, 1963) quickly, gained popularity across the world because of its functionality and ease of interface (Chainey & Ratcliffe, 2015; Mukumbira, 2012; NIJ, 2018). The value of the GIS to policing in developing countries like Namibia (Mukumbira, 2012) and Nigeria (Balogun et al, 2014) has been highlighted. The initial research carried out in South Africa on the application and use of the GIS found useful but not yet fully valued and used by the SAPS, more specifically at station level. At the time of the qualitative interviews, the GIS was not utilised by the Hillcrest police (station level). Applying the GIS at station level to represent the Hillcrest policing area, and geo-coding residential burglary points, can promote the analysis of residential burglary locations, and environmental risk factors as outlined by early research conducted by Winchester and Jackson (1982), and more recent research by Moreto et al (2014); Mundell and Ayres (2015); Olckers, (2007); Piza and Carter (2018); Snyders (2016) and van Zyl (2002). The GIS can be used to visualise the spatial and temporal near repeat calculations, generated by the NRC for the Hillcrest policing area.

2.4 CONCLUSION

Morgan's (2000) research on repeat residential burglary victimisation was the first to identify repeat burglaries, subsequent to the spatial-temporal risk that was transferred to nearby houses following an initial incidence of burglary. His identification of near repeat burglary patterns in Australia, was a catalyst for further near repeat residential burglary research not only in Australia (Townsley et al, 2003), but also in the UK by Bowers and Johnson (2005), Fielding and Jones (2012), Johnson and Bowers (2004), Moreto et al (2014); and Piza and Carter (2018), in the USA; and in five different countries by Johnson et al (2007). In more recent years, near repeat burglary research were conducted by Chainey and da Silva (2016) in Brazil, Chen et al (2013), Wang et al (2017); and Wu et al (2015) who all identified near repeat burglary patterns in China. Even though near repeat burglary patterns of risk varied from country to country, the fundamental point is that near repeat patterns were identified across an array of countries and cities.

Wang and Lu (2017) highlighted the difference between near repeat patterns of crime and hotspots for crime. When crime clusters in space-time hotspots result, whereas near repeats suggest that the risk of crime is transferred to the surrounding area. In contrast, Moreto et al (2014) argued that risky environments, conducive to crime, exist before an initial burglary takes place. Bowers and Johnson (2005) concluded that crime prevention strategies and resource allocation should be tailor-made to address near repeat patterns and would be more efficient than using hotspotting techniques. Wang and Lui (2017) suggested that near repeat patterns of risk are a significant contribution to the formation of hotspots, with both hotspots and near repeat patterns enhancing one another. Fielding and Jones (2012) suggested that tools used for near repeat calculations of risk, and the creation of predictive maps, should be added to the tools used by police agencies and are not a sole replacement for current crime analysis tools. Research conducted by Chainey and da Silva (2016), Chen et al (2013), Fielding and Jones (2012), Moreto et al (2014), Piza and Carter (2018) and Wu et al (2015) applied Ratcliffe's NRC to identify the existence of near repeat residential burglary patterns in their studies. These near repeat patterns can be valuable to police agencies because they enable the planning and deployment of valuable resources to specific areas, at a specific time, in order to prevent near repeat residential burglaries from taking place. The NRC was a product of prior international research originating from the Knox Test. The NRC was applied in research by Chainey and da Silva (2016), Chen et al (2013), Fielding and Jones (2012), Moreto et al (2014), Piza and Carter (2018) and Wu et al (2015). The near repeat burglary research by Chainey and da Silva (2016), Chen et al (2013), Fielding and Jones (2012), Moreto et al (2014), Piza and Carter (2018), Wang and Lui (2017) and Wu et al (2015) relied on the GIS for geo-coding residential burglary points, spatial analysis and/or visualisation. The NRC and the GIS will be applied in this research in the same fashion as in international research.

The early development of the GIS in Canada during the 1960s by Tomlinson (1962, 1963) was instrumental for the international development and application of the GIS across the world (Aguirre, 2014). The GIS has proved to be an effective tool, used by police agencies throughout the world, due to its functionality and analysis capabilities (Chainey & Ratcliffe, 2005: np; NIJ, 2018: np). Research by Balogun et al (2014) in Nigeria and Mukumbrira (2012) in Namibia, concur that the GIS should be a fundamental tool used by police agencies to represent their policing areas, geocode crime, plan resource allocation and respond to crime, and to identify hotspots for certain crimes in specific areas. Schwabe and Schurink (1999) were among the first to investigate the application and capabilities of the GIS for the SAPS. Their initial research was followed shortly by research by Schmitz et al (2000). Cooper and Schmitz (2003) further promoted the use of the GIS by the SAPS. This early research lay the foundation for the application of the GIS for crime mapping and analysis by the SAPS. Eloff's (2006) research paved the way for further South African research by Breetzke (2016a), Olckers (2007) and Snyders (2016) utilising the GIS as visualisation and crime analysis tool.

The role that the environment plays in residential burglaries was identified in the UK by Winchester and Jackson (1984) who developed an index of environmental risk to house location. Different housing types have been identified as contributors to near repeat burglary patterns. Morgan's (2000) research focused on residential burglary patterns in Australia and acknowledged the role that housing types, proximity to alleyways, paths, and public transport; play in residential burglary victimisation. Townsley (2003) concluded that the link between housing types (homogenous and heterogeneous) and target vulnerability (risk) depends on the first incident of residential burglary. If housing in an area is similar, the risk will spread (like a disease) to nearby houses, while an area with diverse housing types will restrict the spread or risk of disease to nearby houses. Research by Bowers and Johnson (2005) concurred with Townsley's (2003) findings, as they identified the role that different housing types (homogenous and heterogeneous) contribute to the risk of near repeat residential burglaries. Areas with predominantly detached and semi-detached housing allowed near repeat patterns to spread, whereas areas that were predominantly terraced houses or flats experienced more repeat burglary victimisation (Bowers & Jonhson, 2005; Townsley, 2003). Moreto et al (2014) stated that risk factors in environments exist before an initial burglary (or crime) incident takes place.

Research by Eloff (2006) in South Africa, identified the relationship between specific land use and specific crimes. Olckers' (2007) research on residential burglary in Westcliff and Parkhurst, Johannesburg, South Africa identified the link between house location and environmental factors such as house location on the street or cul-de-sac, the proximity to entertainment places, business properties, unoccupied or vacant land, and main access roads. According to Olckers, the risk of residential burglary appeared to diminish if the houses were located further away from these environments. Research by Snyders (2016) in Pretoria, South Africa concurred with the research finding by Olckers (2007) and South African independent risk assessors, Alwinco (Mundell & Ayres, 2015). The location of the house in relation to certain environmental factors, such as main roads, railway lines, open spaces, as well as land use contributed significantly to residential burglary. The research conducted by Snyder's (2016) further highlighted hotspots for specific crime types in the vicinity of specific environments. Spatial analysis was conducted using the GIS to highlight the relationship between the environment and residential burglary points in his research study.

Fielding and Jones (2012) used the RAT and Foraging Theory to explain near repeat residential burglary patterns in Manchester, UK. The theory that burglars forage for potential properties to burgle concurs with research by Johnson et al (2007) and Wang and Lui (2017). Wang and Lui (2017) and Chen et al (2013) found that the RCT, RAT, and CPT explained repeat and near repeat residential burglary patterns in China. Piza and Carter (2018), Wang and Lu (2017) and Wu et al's (2015) research findings supported the FBT to explain the occurrence of repeat and near repeat burglary patterns. In contrast to the FBT, Morgan (2000) highlighted that the attractiveness and accessibility of the surrounding area or neighbourhood plays a more significant role than the characteristics of the home. Research conducted by Snyders (2016), in South Africa, highlighted the BWT, DSF, SCPT and the CPTED to reduce crime in the study area. Criminological and crime prevention theories pertaining to near repeat burglary patterns in the Hillcrest policing area, KZN, South Africa will be discussed in Chapter 3.

The NRC is applied in this research, for the first time, to identify near repeat residential burglary patterns in the Hillcrest policing area, KZN, SA. The GIS is used to represent the Hillcrest policing area, to geocode 12-months of residential burglary data or points, to visualise near repeat calculations of risk in the form of buffers, and to conduct spatial analysis. The success of crime prevention strategies, based on predictive risk maps of near repeat calculations in Trafford BCU, GMP, UK, as illustrated by Fielding and Jones (2012), and GIS spatial analysis in Villieria SAPS precinct in Pretoria, South Africa, by Snyders (2016) could likewise contribute to crime analysis and prevention in the Hillcrest policing area.

CHAPTER 3

CRIMINOLOGICAL CRIME PREVENTION THEORIES

This chapter discusses the Crime Pattern Theory (CPT) and the Flag and Boost Theory (FBT) to explain the occurrence of near repeat residential burglary patterns in the Hillcrest (KZN) policing area. In contrast, the Crime Prevention through Environmental Design (CPTED) and the Broken Windows Theory (BWT) are explained as a means to prevent initial residential burglaries and near repeat residential burglaries from occurring in the Hillcrest policing area (KZN). Hillcrest Park Neighbourhood Watch (HPNW) base their philosophy on the BWT and CPTED (Hillcrest Park Neighbourhood Watch, 2015: np) which has brought down opportunist crimes down (like residential burglary) by 80% in the Hillcrest Park suburb (Philip, 2014: np).

3.1 CRIME PATTERN THEORY (CPT)

Professor Kevin Lynch, of the faculty of Architecture and Urban Planning at the Massachusetts Institute of Technology (MIT) wrote, "*The image of a City*" (1960) and therein identified five elements of an image or cognitive map: paths, edges, districts, nodes and landmarks (Brantingham & Brantingham, 1984:359; Brantingham & Brantingham, 1993:15-22; Massachusetts Institute of Technology Press, [Sa]: np). Cognitive maps represent awareness spaces and are a process that individuals learn about, remember, and use regarding an area (Brantingham & Brantingham, 1984:358-359). The CPT was developed through the work of Canadian environmental criminologists Patricia and Paul Brantingham (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995) and intersects with the Rational Choice Theory (RCT), Routine Activities Theory (RAT) and environmental factors, to explain crime distribution (Eck & Weisburd, 2015:6; Hill & Paynich, 2014:46-47).

The RCT has its origins in the Classical School of Criminology and the work of the eighteenth and nineteenth-century philosophers Cesare Beccaria (1785) and Jeremy

Bentham (1823), who focused on the control of crime by punishment rather than the observation of criminals, or analysis of crime data (Winfree & Abadinsky, 2017:20-22). This early work was outlined in Beccaria's "*Essay of crime and punishment*" (1785) and Bentham's, "*An introduction to the principles of morals and legislation*" (1823) (Winfree & Abadinsky, 2017:20-22). The RCT suggests that criminals and potential criminals make choices about committing a crime based on the anticipated or perceived risks and rewards of committing the crime and getting away with it (Cornish & Clarke, 2014:6; Santos, 2017:43; Walklate, 2017:80-81). The RCT differs from other criminological theories which suggest that criminal behaviour is unavoidable (Santos, 2017:43) and can be distinguished from modern theories of crime causation because of their clear focus on crime prevention (Newman, Clarke & Shohom, 2016: np). The RCT is practical for crime analysis and police agencies because it helps to explain why individuals, or groups, commit certain types of crime, such as residential burglary (Santos, 2017:43). It is imperative for crime analysts and the police to be equipped with a solid understanding of behavioural patterns to better address and prevent crime (Santos, 2017:43).

The RAT originated from Amos Hawley's theory of human ecology (1950), which focused on the temporal aspects of human behaviour in communities (Cohen & Felson, 1979:590; Hawley, 1950:289). Before the 1970s, criminologists paid little attention to the role that opportunity plays in crime (Natarajan, 2016: xviii). Lawrence Cohen and Marcus Felson (1979), two North-American criminologists (Walklate, 2017:83), adapted Hawley's (1950) principles to explain crime, which formed the RAT as an ecological perspective to explain criminal behaviour. The RAT states that for a crime to take place, three elements are required: a motivated offender, a suitable target, and lack of guardianship (Natarajan, 2016: xviii; Walklate, 2017:83).

According to CPT, crime will most likely occur in places where the activity space of offenders or potential offenders' overlaps with the activity space of potential victims or targets. The CPT suggests that offenders commit crimes in places they are familiar with (Santos, 2017:44). Brantingham and Brantingham (1984:359) stated that cognitive maps, of residents from the same or similar area, could be a good indicator of criminals' awareness of space.

The place or location of the crime is vital to the CPT, which analyses the interaction of offenders, their environment and how they select targets or victims (Eck & Weisburd, 2015:6). The CPT explains crime patterns through the distribution of willing offenders, the potential victim, targets, and capable guardians within space and time (Eck & Weisburd, 2015:6). Most crime-types, like residential burglary, occur within a short distance of the offender's home. People interact with the environment or surroundings and other people near their home, rather than further away. This is known as 'distance decay' (Brantingham & Brantingham, 1984:344). The distance decay function has been established in residential burglary, robbery, and rape (Bruinsma & Weisburd, 2014:27).

The criminal has both activity spaces and awareness spaces (Hill & Paynich, 2014:46-47). The criminal's awareness space is made up of the areas that he or she is familiar with (Hill & Paynich, 2014:46-47; Brantingham & Brantingham, 1984:349). Individual awareness along a familiar path is limited, as the individual may not know what lies a block or two from the side of the familiar path (Brantingham & Brantingham, 1984:352).

The CPT suggests that for a crime to take place, criminals or potential criminals must have an opportunity to commit a crime in a location within their awareness space. Awareness space is shaped by a person's current routine activities (Bruinsma & Weisburd, 2014:697). Offenders are likely to commit a crime near their current residence and/or near their previous residence (Bruinsma & Weisburd, 2014:697). The routes individuals use to travel between nodes are called paths (Hill & Paynich, 2014:46-47). Crime patterns tend to occur around offender and victim nodes and along interconnecting paths (Brantingham & Brantingham, 1995:10). Burglars commit most of their burglaries within their awareness space along the nodes and paths intersecting with their routine activities (Brantingham & Brantingham, 1995:10). The CPT states that potential offenders usually search (or forage) for opportunities to commit crimes along the nodes and paths of their activity and awareness spaces. Edges are those areas on the border of spaces where most crimes are committed because the level of diversity encountered, limits the surveillance capabilities of potential guardians (Hill & Paynich, 2014:46-47). According to the CPT, potential targets are flagged and catch the attention of burglars during their routine activities along the nodes and paths of their activity space. Recent research by Chen et al (2013:2-4) and Wang and Liu (2017:2) applied the RCT, RAT and the CPT to explain the occurrence of residential burglaries and near repeat residential burglaries in China.

3.2 THE FLAG AND BOOST THEORY (FBT)

Ken Pease (1998) was the first to term the FBT (Bowers & Johnson, 2004:12), and to explain repeat residential burglary victimisation. The FBT developed through research studies on repeat victimisation of residential burglaries (Everson & Pease, 2001; Farrell & Pease, 1993; Forrester, Chatterton & Pease, 1988; Pease, 1998; Polvi, Looman, Humphries & Pease, 1991). Moreover, Morgan (2000) was researching repeat burglary victimisation in Australia when he first identified near repeat patterns. Morgan (2000) coined the term ‘near repeat’ to describe residential burglaries that clustered within time and space.

The risk of repeat burglary victimisation is at its greatest immediately after the first victimisation (Polvi et al, 1991). Polvi et al (1991) researched residential burglary in Saskatoon, Canada, and found that repeat victimisation made up a large number of total burglary victimisations. In addition, these researchers found that there was a 12-times greater risk of repeat victimisation within a month after the initial burglary (first victimisation) and that most repeat victimisation occurred within seven days of the initial event. According to Farell and Pease (1993:8), this heightened risk declines rapidly over time. Johnson et al (2007:206) concurred; following an initial crime (like residential burglary), a similar crime (burglary) may occur at the same place or location, shortly after the first or original crime, but this increased risk decays quickly over time.

Farrell and Pease (1993:13) suggest that risk decay could be the result of target-hardening carried out by the victimised resident installing a burglar alarm system, burglar bars, security gates or lighting which could take a few days to install or to complete. The burglars may take advantage of the brief period after the initial burglary because target-hardening measures may not have been carried out or installed yet. The burglars will be familiar with their burglary victims' properties regarding their layout and vulnerability (i.e. access and escape routes, level of target hardening, hiding places in an overgrown garden). The same burglar(s) may return to steal things that they forgot or did not steal the first time (Farrell & Pease, 1993:13). Housing heterogeneity refers to the diversity of the different housing types (Bowers & Johnson, 2005:71). The Flag Theory which focuses on risk heterogeneity suggests that certain properties are flagged, or brought to the attention of potential burglars, and future burglaries carried out at these properties are the result of the attractiveness of the targets and independent of burglars sharing information (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, (2015:178). The Boost Theory is event dependent, meaning when an initial burglary occurs, it increases (boosts) the likelihood of future burglary victimisation (Pease, 1998:8-9; Wu et al, 2015:178). According to Pease (1998: 8-9), offenders prefer to repeat victimise the same location rather than seek out a new property to victimise. Burglars may return to the same property to steal the remaining items that they could not carry the first time (Pease, 1998:8). The Boost Theory implies that burglars pass on information about items and valuables to other burglars, which motivates these burglars to carry out future burglaries at the same locations (Bowers & Johnson, 2004:12; Wang & Liu, 2017:2).

When victims implement target hardening after a burglary to reduce the attractiveness and vulnerability of the property (Safer Spaces, [Sa]: np; Snyders, 2016:26), burglars who are now familiar with the area will seek out nearby properties to victimise (Johnson et al, 2007:2015). This foraging behaviour takes place within the burglar's awareness space, along similar access routes and environments of previously victimised properties. Burglaries are committed in properties close to the first burglary victims within a brief period. This behaviour could be the result of changes in the environmental characteristics of an area (i.e. the clearing of vacant land, the clearing of overgrown gardens and verges) or target hardening of the properties and the neighbourhood. Over time, the burglar's memory of burgled properties and the surrounding area fades (Johnson et al, 2007:2015). The FBT continues to be used to explain the occurrence of both repeat and near repeat residential burglary patterns (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang

& Liu, 2017:2; Wu et al, 2015:178).

3.3 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN (CPTED)

Crime Prevention Through Environmental Design (CPTED) can be traced back to the early work of Jacobs (1961), Jeffery (1971), and Newman (1972) (Cozens & Love, 2017:2). In 1971 Clarence Ray Jeffrey wrote, "*Crime Prevention Through Environmental Design*", and began researching the relationship between crime and the environment (Nichols, 2012:4). CPTED refers to the design of the built environment (i.e. buildings, houses, or flats/apartments) to minimise crime opportunities which in turn promotes the well-being of residents and the public (Krehnke, [sa]: np). CPTED aims to change human behaviour by changing the environment, for example, by altering the physical landscape and surroundings like lighting, enhanced natural surveillance and the re-allocation of areas where people gather (Bernard et al, 2010:26).

In South Africa, the National Development Plan (2030) identified the significance of considering situational factors like environmental (spatial) design when developing community safety and crime prevention initiatives. The Integrated Urban Development Framework (IUDF) is responsible for planning, design, and management of safer living environments in South Africa (Safer Spaces, [Sa]: np).

In South Africa, spatial and socio-economic characteristics are largely the result of the Apartheid era (Safer Spaces, [Sa]: np). Often the poorest communities are located on the outskirts of urban areas, forcing residents to travel far distances to work or to make use of the commercial, social, recreational, and other facilities that the urban areas have to offer. These impoverished areas often lacked basic human necessities in the form of electricity, sanitation; facilities such as community halls, sports facilities, and safe public parks (Safer Spaces, [Sa]: np). These environmental factors, along with the lack of lighting in public spaces, streets without road names or house numbers, and informal taverns create a breeding ground for crime and a feeling of insecurity.

Such areas make it difficult for the police to patrol and respond to calls due to the poor condition of the streets (or in some cases, no road/vehicle access). Most South Africans cannot afford motor vehicles, and in most cases, roads do not accommodate the safe travel of cyclists and pedestrians (Safer Spaces, [Sa]: np). Poor communities have limited access to finances for security measures to safeguard themselves, their families, and properties; compared to affluent areas (like Hillcrest), that have the resources to implement security measures and target hardening, with gated communities growing in popularity in response to crime. Gated communities take the form of large security estates, smaller security complexes and enclosed neighbourhoods where roads have been closed or boomed off (Safer Spaces, [Sa]: np).

CPTED is a set of principles to design the physical environment so that it reduces crime opportunities (Santos, 2017:432). The physical or built environment can be considered the most crucial factor for determining whether a crime will likely take place in a location and can be a significant factor in perceptions of safety (Safer Spaces, [Sa]: np). CPTED consists of overlapping principles (Cozens & Love, 2017:3; Palmiotto, 2011:171). An example of overlapping principles includes perimeter fencing around a property, which is a form of target hardening but also sends a message of ownership or territoriality. Another example, well-kept gardens, and verges promote surveillance, visibility, image, and aesthetics. According to Safer Spaces ([Sa]: np) and Kruger, Lancaster, Landman, Lieberman, Louw, and Robertshaw (2016:36), there are five principles of CPTED in South Africa:

- Surveillance and visibility (e.g. a clear view or line of sight from the property to the street and neighbouring houses).
- Territoriality (e.g. perimeter fencing around the property).
- Access and escape routes (e.g. roads or pedestrian paths).
- Image and aesthetics (e.g. neatly trimmed verges and well-kept gardens).
- Target hardening (e.g. security gates and burglar alarm system).

These principles are explored below.

3.3.1 Surveillance and visibility

Surveillance and visibility refer to ensuring that public areas such as parks and roads and restricted areas, like properties/houses and gardens (passive surveillance) allow maximum observation of the routines of residents and law enforcement (active surveillance). Factors that enhance opportunities for observation: uninterrupted lines of sight, effective lighting, the window and door positioning on houses, the building layout, the distance between the buildings, the size of the public space and land usage (Safer Spaces, [Sa]: np). Passive surveillance is also known as the presence of ‘protective eyes’ or ‘eyes on the street’ (Kruger et al, 2016:36; Safer Spaces, [Sa]: np; Snyders, 2016:25).

Natural surveillance can increase opportunities for residents to notice or observe strangers in the neighbourhood. Increased surveillance of strangers sends criminals a message of increased risk of being caught if they commit a crime and instils a sense of safety for legitimate public users (Cozens & Love, 2017:2; Palmiotto, 2011:171). Palmiotto (2011:171) highlighted that surveillance includes police patrols, security patrols, and lighting. Design can provide opportunities to see and be seen, for example, opportunities to view adjacent properties, perimeter parking areas, walkways, and buildings. These features need to be supported by potential observers (residents) who will report suspicious behaviour to relevant authorities. Lighting improves the ability to identify individuals; windows allow both inside and outside viewing, and properly maintained trees, shrubs and gardens can obviate hiding. Furniture arrangements and interior design can support viewing, and the location of the building itself can restrict or create views (Zahm, 2007:8-9).

The clear line of sight from private properties like houses, and public areas such as the street or parks, can instil a sense of safety in residents and users. The zoning of areas (land usage) and the activities carried out at the properties and buildings determine if and when ‘protective eyes’ are present or not. Surveillance is enhanced providing there is good visibility in the form of effective lighting on dark streets and alleys, and the line of sight from windows and doorways are clear (Safer Spaces, [Sa]: np).

3.3.2 Territoriality

Access control and natural surveillance (i.e. well-kept gardens, cleared vegetation and trees) allow a clear line of sight to neighbouring properties and contribute to territoriality (Palmiotto, 2011:171). Territoriality sends a strong message of ownership of a property (Zahm, 2007:9; Kruger et al, 2016:36). Territoriality can instil a sense of ownership and responsibility for space. This sense of ownership and responsibility enhances the likelihood that passive observers will respond or assist in the case of a criminal event. Furthermore, the owners or users are more likely to maintain the space if they feel responsible for it. Thus, territoriality includes public, semi-public, and private space (Safer Spaces, [Sa]: np; Snyders, 2016:25).

3.3.3 Access and escape routes

Access and escape routes refer to limiting opportunities for burglars to access and utilise vacant land and enhancing escape routes for the public (potential victims) through clearly signposted streets, buildings and exit routes (Kruger et al, 2016:36; Safer Spaces, [Sa]:np; Snyders, 2016:25). Access control aims to reduce opportunities for crime by clearly defining public and private space. Gates, locks, or guards are used to control access to the property, increasing the perceived risk to criminals so that the risk outweighs the potential reward of committing the crime (Cozens & Love, 2017:2; Palmiotto, 2011:171). Access can be controlled through real and perceptual barriers to entry and movement while guiding legitimate public users through the environment with a sense of safety (Cozens & Love, 2017:2; Zahm, 2007:7-8).

The environment must suggest cues about who belongs there (i.e. parents and children) what they do and the duration of their stay (i.e. parents and children playing in a park for an afternoon or in the garden before dinner). Guardians or residents can control access by noting people and activities and reporting unwanted or suspicious behaviour to the relevant authorities (Zahm, 2007:7-8). For example, residents can report suspicious people or vehicles to the police, security companies or neighbourhood/street watch groups. Other examples of access control are fences, hedges, tree lines, gates and doors that restrict entry to a property or building (Zahm, 2007:7-8).

3.3.4 Image and aesthetics

Image and aesthetics refer to the physical appearance of an environment and whether it transmits a positive picture and instils a sense of safety among residents and the public (Kruger et al, 2016:36; Safer Spaces, [Sa]: np; Snyders, 2016:25). A sideroad with overgrown grass verges and vegetation, graffiti on walls and litter scattered all over may not send a sense of safety compared to a side road with well-kept grass verges and vegetation, fenced-off properties with a clear line of sight from the windows and doors; and which is litter free. The image of an environment or neighbourhood should be enhanced through the on-going upkeep and maintenance of the environment (Safer Spaces, [Sa]: np). Urban decay makes people reluctant to use areas that appear unsafe, and in turn, reduces the number of people (passive surveillance) that use that space, and therefore increases the risk of crime occurring within that environment. Superior design and effective management of public spaces are essential to prevent the environment from becoming a hotspot or perceived hotspot for crime (Safer Spaces, [Sa]: np).

3.3.5 Target Hardening

Target hardening refers to reducing the attractiveness and vulnerability of a property (Safer Spaces, [Sa]: np; Snyders, 2016:26). Kruger et al (2016:36) highlighted that target hardening should reduce the attractiveness and vulnerability of the potential target by elevating the risk or perceived risk and effort to would-be criminals. Snyders (2016:29-30) and Zinn (2010:155) strongly suggest that target hardening should consist of burglary alarm systems, electric fences, and garden beams linked to an armed response security company (in the event that they are activated), strong security fencing around the property, strong burglar bars on windows, solid security gates on all doorways to the building, and that dogs should be kept inside the house. Such target hardening efforts aim to deter potential criminals, or at least give an early warning that the property has been infiltrated. It must be noted that fences support and walls limit surveillance (Safer Spaces, [Sa]: np).

The criticism levelled against CPTED is that the interventions believed to be positive may have a drawback or negative effect (Cozens & Love, 2017:2). For example, more street lighting promotes surveillance and allows better visibility for pedestrians and on-lookers, however, it also allows offenders to catch sight of suitable victims or target properties. A potential victim wearing valuable jewellery or the affluence of a property may be illuminated by extra lighting which otherwise may not have been seen by offenders or burglars.

Target hardening efforts in the form of over-fortification of properties combined with efforts to discourage people, especially young people, from using public spaces (parks) can have an unintended negative impact for the social environment of the community or neighbourhood (Cozens & Love, 2017:2). For example, properties with high walls that block the view from the street and neighbouring properties, mean residents can no longer see their children playing in the park across the road or with the neighbour's children next door.

The principles of CPTED have been highlighted: if the environment is designed, managed, and effectively maintained, it can enhance the safety and well-being of the citizens of South Africa. The application of CPTED principles on a micro level can reduce crime in those areas and neighbourhoods. On a macro level intervention can target spatial characteristics of impoverished areas, where residents are forced to travel long distances to work which further exposes themselves to victimisation. Vacant land (buffer strips), used in the past to separate areas and people, now serve as breeding grounds for criminals (Safer Spaces, [Sa]: np). The same land use or zoning leaves some areas deserted at night or during the day thereby increasing opportunities for crime. The exclusion of many people residing in cities from basic amenities (e.g. running water and electricity) and lack of employment opportunities available in cities must be remedied. Conditions of poverty, unemployment, and a lack of basic needs, allow crime to manifest and make the people that live in these circumstances feel vulnerable (Safer Spaces, [Sa]: np). It is essential that CPTED is implemented on various levels consisting of planning, design, and management. The following levels are outlined:

- Planning: strategic urban planning is necessary to reduce vacant land, promote mixed land-use and to bring communities together (Safer Spaces, [Sa]: np; Snyders, 2016:26). An example implemented by the HPNW saw residents conducting clean-ups along the railway line that borders with the suburb, making it easy to patrol by bicycle, motorbike or on foot (Philp, 2014: np). Official state role-players are not maintaining the area along the railway line which provides an access route to the suburb, and HPNW have had to continue clean-ups, including brush cutting of grass that was more than two metres long, and where criminal elements could hide and manifest (Hitchcock, 2016: np).

- Design: detailed design of various urban elements ranging from transport systems, roads, public open spaces, buildings, and the environments in which these elements fall (Safer Spaces, [Sa]: np; Snyders, 2016:26). As an example, the residents of Hillcrest Park identified the taxi rank located across the railway line from the suburb, as a source of criminal activity that attracts crowds, beggars, hawkers, loiterers and drug dealers (Clark, 2014:27). Design elements could consider the relocation of such places as taxi-ranks in close proximity to suburbs.
- Management: the effective management of the entire urban system and precincts is essential. The infrastructure, on-going maintenance and effective enforcement of by-laws must be carried out, including the implementation of CPTED initiatives in communities (Safer Spaces, [Sa]: np; Snyders, 2016:26). A maintained environment can enhance community pride in the neighbourhood and encourage residents to take active responsibility for maintaining the standards of the environment. A fundamental and important ingredient for the success of CPTED intervention is community participation. A key objective of CPTED is to encourage residents' ownership of their neighbourhoods (Safer Spaces, [Sa]: np). Residents must be encouraged to get involved in their communities and neighbourhoods, to identify environment-related crime and develop a proactive approach to preventing crime in their communities and neighbourhoods (Safer Spaces, [Sa]: np). The effort of HPNW, in clearing and patrolling their neighbourhood, and taking ownership show that on-going management and maintenance is essential. HPNW have had to take on the responsibility of state role-players who are not meeting their obligations in this regard (Hitchcock, 2016: np).

3.4 THE BROKEN WINDOWS THEORY (BWT)

In 1969 a Stanford psychologist, Philip Zimbardo, placed two unoccupied cars in two different neighbourhoods. One car was in upmarket Palo Alto, California, one block away from the famous Stanford University, and the other in the Bronx, New York City, one block away from New York University, Bronx Campus (Zimbardo, 2007:304-305). The Bronx car was vandalised within minutes, and within 24 hours nothing of value remained inside. Passers-by continued to vandalise the car by ripping up the upholstery and breaking the windows. The car parked in Palo Alto remained untouched for almost a week. It was only after Zimbardo hit the car with a sledgehammer that people began to vandalise it. The car was destroyed within a few hours of Zimbardo's action. This experiment shows that when a 'no one cares' cue is sent out, crime can and will occur in any neighbourhood (Hill & Paynich, 2014:28; Kelling & Wilson, 1982: np; Miller, Hess & Orthmann, 2014:64).

James Q. Wilson and George L. Kelling (1982) based their BWT partly on Zimbardo's research. This theory proposes that if a neighbourhood or place suggests that 'no one cares'; disorder and crime will flourish. Broken windows and smashed cars are visible signs implying that people do not care about the community. Other signs include unmowed lawns, piles of accumulated rubbish, graffiti, rowdiness, drunkenness, fighting, prostitution, abandoned buildings, litter and broken windows - all of which can be referred to as 'incivilities' (Kelling & Wilson, 1982: np; Miller et al, 2014:64-65).

Police Chief William Bratton applied the BWT and contributed significantly to a decrease in crime in New York City in the 1990s. This policing strategy aimed to reduce crime by focusing on incivilities and keeping the physical environment clean and safe. The police focused on stamping out incivilities such as drinking in public, begging, and all crimes considered petty. The BWT was linked with a zero-tolerance approach to crime reduction (Isenberg, 2010:6; Kelling & Wilson, 1982: np).

The appearance of disorder in a neighbourhood signals to a potential offender that no one cares and that no one will call the police (Winfree & Abadinsky, 2017:10). When social control mechanisms are eroded, incivilities and social disorder occur.

Increased incivilities may heighten fear of crime and reduce the sense of safety. As a result, people may physically or psychologically withdraw from their neighbours. On the other hand, incivilities, and disorder in the form of crime could bring people together to 'take back the neighbourhood' (Miller et al, 2014:65).

The HPNW has been running since August 2012 because of crime in the area. The HPNW polices the Hillcrest Park area which is a formal urban settlement and they base their philosophy on the BWT and the CPTED (HPNW, 2015: np). The efforts and dedication of a few residents doing patrols and clean-ups have brought certain types of opportunist crimes (like residential burglary) down by 80%, but these efforts did not stop organised crime in the highway area (Philip, 2014: np).

Snyders (2016:28) highlighted that community participation is essential if residents want to take ownership and control of their neighbourhood. Participation should be in collaboration with local law enforcement to eradicate incivilities and maintain order (i.e. enforcement of by-laws).

3.5 CONCLUSION

This chapter applied the CPT and the FBT to explain initial residential burglaries and near repeat residential burglaries in the Hillcrest (KZN) policing area. The CPT is a combination of both the RCT and the RAT and highlights awareness space of burglars or would-be burglar along nodes and paths of the environment encountered during their routine activities.

The FBT states that certain properties attract or flag the attention of burglars or potential burglars, resulting in an initial burglary in the area. The Boost Theory refers to risk which is elevated or 'boosted' following the initial burglary, where burglars may return for goods they did not take the first time or share information about the property with other unsavoury elements. However, this elevated risk quickly deteriorates as time lapses, or when burglary victims have taken target hardening measures leaving the burglars to seek their next burglary target nearby.

The CPTED and BWT were used as a means of minimising initial residential burglaries, and near repeat burglaries from occurring in the study area. The CPTED is based on five principles namely: surveillance and visibility, territoriality, access and escape routes, image and aesthetics and target hardening. The BWT is largely based on maintaining the order of the environment or neighbourhood by ensuring gardens, and verges are well kept and not overgrown; streets and neighbourhood are litter free; graffiti is removed, and incivilities are not allowed to manifest or prosper. To be successful, both the CPTED and BWT need community involvement and collaboration with local law enforcement agencies.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

International research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Piza & Carter, 2018; Morgan, 2000; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015) on near repeat residential burglary patterns has highlighted the potential benefits of these patterns. The NRC is a tool that can identify near repeat residential burglary patterns (Ratcliffe, 2009:np, Tech Beat, 2008:np; Wu et al 2015:181) and assist police agencies, like Hillcrest (KZN) police station, with the decision-making process regarding resource allocation and crime prevention strategies in specific areas for a specific period of time, to prevent near repeat residential burglaries. This chapter outlines the research methods followed in the study. The researcher discusses the research approach; type of research; research design; aims and objectives of the research; sampling procedures; data collection methods; data analysis and interpretation; and ethical considerations applicable to this study.

4.2 RESEARCH APPROACH

This research follows a mixed methods research approach found to be popular in the areas of social, behavioural and health sciences (Porche & Spencer, 2017:3). The advantages of a mixed methods approach include the potential to answer questions that single approaches (exclusively qualitative or quantitative research) cannot answer, a deeper understanding of the research topic and more divergent research findings (Porche & Spencer, 2017:13). The disadvantages or challenges of mixed methods research is the time distribution needed to conduct both quantitative and qualitative research methods and integrate the data (dos Santos et al, 2017:7). Dos Santos et al (2017:8) highlighted the importance of a solid understanding of quantitative and qualitative research methods when conducting mixed methods research.

4.3 TYPE OF RESEARCH

Exploratory research is used to explore or gain a deeper understanding of a specific topic or area of interest (Babbie, 2016:92; Bachman & Schutt, 2018:9, Maxfield & Babbie, 2016:313). According to Babbie (2016:92), exploratory research is used to investigate the viability of further studies and to develop methods that can be used in future studies. However, the drawback of exploratory research is that it rarely concludes with clear or definite answers (Babbie, 2016:92). In this research, exploratory research was used to apply the NRC tool to identify near repeat burglary patterns in the Hillcrest (KZN) policing area for the first time.

4.4 RESEARCH DESIGN

Before scientific research can begin, the researcher must decide on the nature of the desired research and choose the proper research design to carry out the research (Babbie, 2016:89). A mixed methods research design makes use of quantitative and qualitative data, which is collected, analysed and merged to provide a deeper understanding of the research topic when compared to a single research approach (Bryman, 2016:692; Creswell, 2014:4, 215; Crowther-Dowey & Fussey, 2013: 207; dos Santos et al, 2017:3; Porche & Spencer, 2017:3).

An explanatory sequential mixed method approach is followed when the researcher carries out quantitative research, analyses the results and explains them in more detail using qualitative research (Bachman & Schutt, 2018:277; Creswell, 2014:13; DeCuir-Gunby & Schutz, 2017:86; dos Santos et al, 2017:4). The researcher selected an explanatory sequential mixed methods approach as it is best suited to exploratory research. The explanatory sequential method is popular in research that has a solid quantitative orientation (Creswell, 2014:14). The calculation of near repeat residential burglary risk is the basis of this research.

Firstly, the quantitative aspect of the research was conducted which required secondary data analysis of closed-case residential burglaries and the calculation of near repeat risk patterns, using the NRC. The near repeat results were illustrated using the GIS and then analysed. The quantitative research was followed by qualitative research in the form of structured interviews with five detectives, and electronic interviews with SMEs in the area of the topic.

4.5 AIMS AND OBJECTIVES

Research aims can be described as the broad aims or intentions of the research and what is to be achieved (eResearch Methods, [Sa]: np; Dudovskiy, 2017: np; Thomas & Hodges, 2010:38). Research objectives outline the specific processes used in order to meet the aim of the research (Dudovskiy, 2017: np; eResearch Methods, [Sa]: np; Thomas & Hodges, 2010:39). The aim of the research is to apply the NRC to identify near repeat residential burglary patterns in the Hillcrest policing area using 12-months of reported residential burglary cases at the Hillcrest police station. In order to test the ability of the NRC, the near repeat calculations are illustrated using the GIS for each of the 12 months, creating a predictive near repeat risk map for the following month. The findings are analysed and discussed.

This mixed methods research approach is applied to analyse the near repeat residential burglary patterns identified in the study area (Bachman & Schutt, 2018:315; Bryman, 2016:692; Creswell, 2014:4, 215; Crowther-Dowey & Fussey, 2013: 207). The secondary data analysis of residential burglary cases reported to the Hillcrest (KZN) police station, the geocoding of the burglary points and the visualisation of the near repeat residential burglary patterns identified by the NRC, make up the quantitative part of this research. Structured interviews with five detectives from Hillcrest police drew their views, attitudes, experience, and opinions of residential burglaries in the Hillcrest (KZN) police area. E-mail interviews with SMEs form the qualitative aspect of this research. Both the quantitative and qualitative findings are combined to form a concise account of the exploratory research.

In order to remain ethical and in line with the CRIMSA code of conduct, to uphold the agreement and to ensure anonymity of the voluntary participants, the researcher cannot include any names, ranks, ethnic groups or races of the five detectives (respondents) who participated in this research. The five detectives consisted of two females and three males ranging in rank from Constable to Captain, and ages from the mid-20s to mid-40s. Their experience of case investigation of residential burglaries ranged from dozens to several hundred cases.

Research questions that the researcher aimed to answer:

- Can the NRC identify near repeat residential burglary patterns in the Hillcrest (KZN) policing area?
- Can the NRC predict near repeat risk of residential burglaries in the Hillcrest policing area?
- Can the NRC be of value or use to the Hillcrest police for resource allocation, crime prevention strategies and investigations in the Hillcrest policing area?
- Can the GIS be a valuable visualisation and analytical tool at Hillcrest police station?

4.6 MOTIVATION FOR RESEARCH

The SAPS Annual Crime Statistics for the period April 2017 to March 2018 stated that there were 765 residential burglaries reported to Hillcrest police station (SAPS, 2018: np). This equates to at least two residential burglaries reported per day to Hillcrest police station. According to a news report (Mabena, 2017: np), the lack of essential police resources, such as vehicles and manpower, impacts negatively on the SAPS's ability to carry out their duties effectively. With a direct focus on Hillcrest SAPS, a local Councillor (Guy et al, 2016: np) stated that the high residential burglary rates in the Hillcrest policing area were the direct result of a lack of visible policing and inadequate resources. The crime waves experienced by communities in the Hillcrest policing area have made the local news, stressing the need for effective policing (Naicker, 2015: np; Nair, 2013a: np; Nair, 2013b: np). It is evident from these news reports and official SAPS crime statistics that Hillcrest SAPS lacks resources to meet the needs of the community it serves. The Hillcrest police need to streamline and effectively use the limited resources they have at their disposal.

Near repeat, patterns have become a major aspect in predicting crime and are further enhanced when integrated with other data such as land use or environment factors (Groff & Taniguchi, 2016: np). Extensive international research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Morgan, 2000; Piza &

Carter, 2018; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015) has identified near repeat residential burglary patterns, by highlighting the predictive value of near repeat patterns that could be applied by police agencies in resource allocation and crime prevention strategies.

The research study carried out by Fielding and Jones (2012) in Manchester, UK, applied the NRC and created predictive risk maps for residential burglaries to focus police deployment. This had a considerable influence on the decline of residential burglaries. Furthermore, research conducted by Snyders (2016) in Villieria, South Africa, highlighted the use of the GIS for the geocoding of reported crimes, spatial analysis, and resource allocation to specific areas by local law enforcement, and proved successful in crime prevention of certain crimes in certain areas.

International near repeat residential burglary research suggests that the identification of near repeat residential burglary patterns allow police agencies to deploy resources to specific areas at specific times, to prevent near repeat residential burglaries from taking place. However, to date, there is no known research on near repeat burglary patterns, or the application of the NRC, in a South African context, and more specifically in the Hillcrest policing area. The GIS is used to geocode residential burglary points and represents the Hillcrest policing area using eThekwini Municipal GIS data including roads, railway lines, suburbs, the various land uses.

A clearer picture of the nature and extent of residential burglaries is provided through closed-case analysis. This study included an analysis of 490 closed-case dockets of residential burglaries reported to Hillcrest Police Station between April 2012 and March 2013. The majority of these residential burglaries occurred in the formal urban settlements of the Hillcrest policing area. The findings of this research could be valuable to the SAPS, as the application of the NRC could prevent future incidents of residential burglary, more specifically near repeat residential burglaries.

Furthermore, the NRC can aid on-going investigations and resource allocation for crime prevention. The NRC can, for instance, indicate which areas (spatial) and for how long (temporal) they are at risk of near repeat burglaries so that crime prevention patrols can be more focused. Thus, the prediction of locations of house burglaries would assist the police in allocating patrols, reducing response times, and preventing further burglaries (Groff & Le Vigne, 2002:31).

Like the NRC, the Q-GIS is freely available software, and both the NRC and Q-GIS are valuable and cost-effective tools for the prevention and investigation of residential burglary, which can be utilised by the Hillcrest police at station level. The GIS was used to geocode residential burglary points, to illustrate the NRC results, highlight the various land uses in the area (like formal urban settlements, farmland, vacant land, informal settlements and so on) and environmental factors (such as main roads, railway lines, road nodes and end nodes or cul-de-sacs).

This research applied the NRC to identify near repeat residential burglary patterns in the Hillcrest policing area, and the GIS to visualise these results in the form of month-to-month predictive risk maps. This research is by no means a replacement for any processes used by Hillcrest police, but these tools are proposed as additional aids to identify near repeat residential burglary patterns.

4.7 RESEARCH POPULATION, SAMPLE AND SAMPLE METHOD

A population in research terms refers to all the elements of a context in which the research is focused. Examples of a population are towns, cities, countries, prisons, or universities (Bachman & Schutt, 2018:94). The Hillcrest SAPS policing area forms the research population in this study. A sample can be described as a subset of a population or elements of a larger group used in a research study (Bachman & Schutt, 2018:94; Schutt, 2016:44). Residential burglaries reported to Hillcrest SAPS, police station between April 2012 and March 2013 are the samples used in this research. Furthermore, only closed-case residential burglaries were included in the sample.

Both probability and non-probability sampling methods are applied in this research. In probability sampling, each element has a chance or opportunity of being selected or included in the research sample (Bachman & Schutt, 2018:100). Non-probability sampling methods are best suited for research where random sampling is not possible, or when the research needs a detailed analysis of a small group or population, or when the researcher is carrying out exploratory research (Bachman &

Schutt, 2018:106). Probability and non-probability sampling methods are followed.

4.7.1 Research unit

The research unit or unit of analysis refers to the area in which the research is focused (Bachman & Schutt, 2018:319). The research unit consisted of residential burglaries reported to Hillcrest SAPS police station between April 2012 and March 2013.

4.7.2 Sample

A probability sampling method was followed with the quantitative data sample process where prior knowledge on the residential burglaries reported to Hillcrest police was utilised to determine the sampling process. The elements of the residential burglaries differed in terms of essential data (i.e. fixed residential / street address) and formed the sampling strata (Bachman & Schutt, 2018:103).

A sample of 490 closed-case residential burglaries was drawn through secondary data analysis for this research. The researcher was only permitted access to closed residential burglary cases and made use of cases which had a fixed residential address, and which could be identified on the eThekwini Municipal GIS data. For example, residential burglary cases that had a vague address, such as ‘off Inanda Road’ or ‘near XYZ tuck-shop’ could not be included in the sample. All 490 residential burglary points were geocoded to the relevant street addresses, generating the required x and y coordinates necessary for near repeat calculations.

Purposive or judgement sampling was followed to carry out qualitative interviews with detectives at Hillcrest police station based on these participants unique positions with the SAPS. The researcher contacted the detectives privately and invited them to voluntarily participate in the research. Qualitative interviews with five detectives from Hillcrest police station were conducted to gain insight into their experiences, knowledge, attitudes, and views on residential burglaries in their policing area. Purposive or judgement sampling was also used to request electronic interviews with the SMEs who were known professionals in their areas of expertise. Several SMEs responded to the researcher’s request for electronic interviews to draw on their experience, expertise, and feedback.

4.7.3 Sample method (probability and non-probability)

There is a significant difference between probability and non-probability sampling methods. Probability sampling permits the researcher to identify in advance the likelihood of an element of a population that will be included in the sample, whereas in non-probability sampling methods, the probability of a selection of a population element is unknown (Bachman & Schutt, 201:99). Probability sampling methods are more desirable, because the elements included in the sample are determined by chance and can be generalised to a larger population (Bachman & Schutt, 201:100). Non-probability sampling methods are preferred for research where random sampling is not appropriate, when the research demands a detailed analysis or investigation on a small population or when the research underway is exploratory in nature (Bachman & Schutt, 2018:106).

The probability sampling method of stratified random sampling was applied during the quantitative data collection for this research. Stratified random sampling is a process where samples are selected because of a specific or relevant characteristic (Bachman & Schutt, 2018:103). A total of 490 closed-case residential burglaries were included in the probability sample. A non-probability sampling method was used for the qualitative data collection aspect of this research. Purposive or judgment sampling is when the researcher selects certain individuals for a specific purpose because of their experience or knowledge about the research topic (Bachman & Schutt, 2018:108). The research used a non-probability sample of five detectives from the Hillcrest police, and several SMEs for this research.

4.8 DATA COLLECTION METHODS

Since this is a mixed methods research, the researcher applied quantitative and qualitative data collection methods discussed separately below.

4.8.1 Quantitative data collection

The quantitative data in this research was collected through secondary data (Bachman & Schutt, 2016:18; Crowther-Dowey & Fussey, 2013: 81; Schutt, 2017:44; Withrow, 2014:273) in the form of a docket analysis of closed-case residential burglaries reported to Hillcrest police station during the period April 2012 to March 2013. The essential date and street address for each residential burglary was collected during the docket analysis. Van Graan and Van der Watt (2014:144) highlighted that docket analysis can support scientific research and supply a deeper understanding of the crime. To conduct near repeat calculations of risk, the data must be in the correct format. The NRC requires the x and y coordinates and the date of each residential burglary in comma separated values (.csv format) (Ratcliffe, 2007:5-6). The residential burglaries were geocoded using the Q-GIS to visualise the residential burglary locations and to provide x and y coordinates required for near repeat calculation of risk.

The researcher made provisions with the Hillcrest SAPS Station Commander, who introduced the researcher to the Detective Clerk in charge of the docket room. The researcher then made arrangements with the Detective Clerk to access the closed-case residential burglary dockets, for analysis at the Hillcrest police station, under supervision.

4.8.1.1 Setting

The researcher conducted secondary data analysis of closed-case dockets in the Docket Room, at Hillcrest police. The researcher was supervised and allowed access only to closed cases of residential burglaries.

4.8.1.2 Duration

The secondary data analysis of closed-cases was carried out between July 2014 and December 2014. The researcher made arrangements in advance with the Detective Clerk to access the docket room, and the researcher conducted the docket analysis at the convenience, and under the supervision of the Detective Clerk. Over a period of 19 days, the researcher completed the secondary data analysis (docket analysis) of all closed-case residential burglary cases available. A sample of 490 residential burglary cases was selected for this exploratory research, out of a total of the 1013 residential burglaries reported to Hillcrest police between April 2012 and March 2013 (SAPS, 2018: np).

All 490 residential burglary cases had street addresses which could be located on the GIS using eThekwini Municipality GIS data. Each residential burglary address was pinpointed and geocoded for the purpose of this research. Closed-case residential burglaries without a street address were excluded from the analysis, as a street address is required to geocode the residential burglary points essential for the near repeat calculation. Excluded residential burglaries without street addresses, that could not be identified from the eThekwini Municipal GIS data, were normally in informal residential and rural areas within the Hillcrest SAPS policing area.

4.8.2 Qualitative data collection

The researcher followed a structured interview schedule consisting of structured interviews using an open-ended questionnaire. An interview schedule refers to the structure of the interview which may consist of questions prepared in advance (Maxfield & Babbie, 2016: 315) and determines how detailed and interactive the interviewee or participant will be (Maxfield & Babbie, 2016: 315). According to Bachman & Schutt (2016:155), an interview schedule is made up of questions, which the interviewer will pose to the interviewee or research participant either face-to-face or on the phone. Structured interviews are considered a process of gathering specific information for a certain purpose (Maxfield & Babbie, 2016: 203). A disadvantage of structured interviews is that they could hamper in-depth responses, or the opportunity to probe deeper into unexpected responses from the interviewee or participant (Maxfield & Babbie, 2016: 203). Open-ended questions prompt the interviewee or participant for his or her own answers (Bachman & Schutt, 2016:74,158; Maxfield & Babbie, 2016: 316).

Qualitative data collection in the form of structured interviews was carried out with five detectives from the Hillcrest police. Structured interviews are a research instrument to ask questions and record the answers or feedback exactly as it is given (Bryman, 2016:21). It ensures each participant is asked exactly the same questions, verbatim to ensure no variation of questions which may result in a variation of answers (Bryman, 2016:207).

The researcher made an appointment with the Station Commander of Hillcrest SAPS, with regards to conducting interviews with five detectives for the research. The Station Commander introduced the researcher to the Branch Commander, Head of Detectives of Hillcrest SAPS. Following this introduction, the Head of Detectives at Hillcrest made an announcement about the research during a morning meeting with the detectives. The researcher was introduced and supplied all the detectives with a letter of introduction (Annexure 6) outlining the purpose of research while highlighting voluntary and confidential participation. The Head of Detectives further added during the same meeting, that the researcher would be contacting them individually to see if they would like to participate in the research. The researcher was provided with a list of names and contact numbers for the detectives by the Head of Detectives and contacted detectives to see if they would like to participate in the research. The researcher contacted detectives randomly from the list until he had five detectives who were willing to participate in the research. The interviews were set up at a convenient time for each detective and carried out in the privacy of the detective's office at Hillcrest police station.

A structured questionnaire with open-ended questions was prepared in advance, and the researcher read the questions to the participants whose feedback was recorded accurately. The interviews were carried out on a one-on-one basis at Hillcrest police station, where the researcher asked the detectives about their experience, opinions, attitudes and views of burglars, residential burglaries, predicting residential burglaries, and the application of the NRC and creation of predictive risk maps for residential burglaries in the Hillcrest policing area.

Several SMEs were contacted for their opinions, feedback and comments on the research methods used as follows:

- Dr Schmitz, a Principal Researcher at the Council for Scientific and Industrial Research (CSIR), South Africa. Schmitz has carried out extensive research in geospatial analysis, crime analysis, logistics and forensic geography in a South African context.
- Professor Greg Breetzke, of the Department of Geography, Geoinformatics and Meteorology, at the University of Pretoria, South Africa. Breetzke, holds a PhD in Geoinformatics, and has carried out a number of research studies, and promotes the use of the GIS for crime prevention by the SAPS.
- Dr Katrina Landman (previously a Principal researcher at CSIR, Built

Environment, South Africa), and who is currently a lecturer at the University of Pretoria.

- Professor Tinus Kruger, a Principal researcher at CSIR, South Africa, who is an expert in CPTED, crime science, situational crime prevention, architecture, housing, and community development.
- Professor Rudolph Zinn of the University of South Africa (UNISA), College of Law, School of Criminal Justice, Department of Police Practice, who specialises in intelligence-led policing, house robbery (home invasions), carjacking, violent crime, community safety networks and policing.

The valued SME feedback will be discussed in Chapter 5.

4.8.3 Sourcing the NRC and the Q-GIS

The Near Repeat Calculator (NRC) is freely available and was downloaded from the following link and applied in this research.

http://www.cla.temple.edu/center-for-security-and-crime-science/projects/

The Q-GIS is an open source GIS software programme which the researcher downloaded from the following link for use in this research.

http://www.qgis.org/en/site/forusers/download.html

4.8.4 Docket analysis

Data that has previously been collected but used by someone else for a different analysis is called secondary data (Bachman & Schutt, 2016:18; Crowther-Dowey & Fussey, 2013: 81; Schutt, 2017:44; Withrow, 2014:273). Docket analysis has the capacity to enhance the understanding of crime data and promote scientific research (Van Graan & Van der Watt, 2014:144). According to Van Graan and Van der Watt (2014:144), docket analysis allows a deeper understanding of the known circumstances and factors surrounding the crime incident. Dockets analysis should not be underrated or disregarded as an option, because it can assist crime investigators, crime analysts and crime researchers to narrow down or focus investigations; by highlighting dynamics and contributing factors; and assist in decision-making; enable specific crime incident analysis; and identify MO and case linkage (Van Graan & Van der Watt, 2014:144).

Docket analysis provides valuable information that cannot be obtained through any other method and allows an insight into the crime, how the investigation was carried out the outcomes and case closure. The contents of a docket normally include the nature and circumstances surrounding the crime, the victim and offender profiles, the relationship between the victim and offender, state any substance (drugs and alcohol) used by either the victim and/or offender, and ultimately an indication of whether the case will proceed to court (Mistry, Snyman & van Zyl, 2001:21-22).

The advantages of a docket analysis are: dockets are accessible (with permission) and consist of “source data”, rather than information through the police computer system, thereby eliminating secondary data capturing errors. As said above, dockets potentially hold a wealth of information on the crime incident, the victim, and the offender (if known). Dockets further outline the duration of the case investigation, the level of experience of the investigating officer and how the case was closed (Mistry, 2001:21-22; Van Graan & Van der Watt, 2014:150-151). The disadvantages of docket analysis include: dockets may have incomplete statements; the handwriting could be illegible or difficult to read due to poor language use. Further, docket analysis cannot determine the extent of the crime, the impact the crime has had on the life of the victim/s nor the reason or motivation of the offender/s to carry out the crime (Mistry, 2001:21-22; Van Graan & Van der Watt, 2014:150-151). The researcher relied on a docket analysis of secondary data in the form of closed-cases of residential burglaries reported to Hillcrest police between April 2012 and March 2013. A total of 490 close case dockets of residential burglary were analysed by the researcher.

4.8.5 Structured interviews

Participation was on a voluntary basis, and each participant (detective) was informed by the researcher of the purpose of the research interview. The interviews were arranged in advance at the convenience of the participant and conducted in the privacy of his or her office at the Hillcrest police station. All detectives had to give written and signed consent to the interview and give consent for the researcher to contact him or her at a later date regarding the research if necessary. The researcher followed a structured interview schedule, asked the questions exactly as they were worded and wrote down the feedback received. Only the researcher knew which detectives participated and only the researcher can link the feedback received to each participant.

4.9 RELIABILITY AND VALIDITY OF DATA COLLECTION INSTRUMENTS

There is a noteworthy difference between reliability and validity. Reliability can be met when a measurement procedure is consistent in scoring a phenomenon that is not changing. When a measure is considered reliable, it is less affected by random errors or variations compared to an unreliable measure (Bachman & Schutt, 2019:85-86). Measurement validity is achieved when a measure measures what it is intended to measure (Bachman & Schutt, 2019:83).

Reliability refers to the consistency and stability of a measure of a concept which can be repeated by different researchers and in different research projects (Bachman & Schutt, 2016:85; Creswell, 2014: np; Schutt, 2017:244). Reliability needs to be assessed before measurement validity can be tested (Bachman & Schutt, 2016:85). Validity refers to the extent that an indicator, used to measure a concept, is accurate (Bachman & Schutt, 2016:39; Bryman, 2016:275; Gray, 2014:150; Schutt, 2017:245). The validity and reliability of the NRC are tested by using and geo-coding 12-months of residential burglaries reported at Hillcrest police, illustrating near repeat calculations, creating month-to-month prediction risk maps and finally analysing the calculations for their predictive accuracy of the following month's near repeat residential burglaries.

4.9.1 Reliability

Reliability is essential for measurement validity (Bachman & Schutt, 2016:85). Twelve consecutive months of residential burglary data and near repeat calculations of risk were mapped, and the findings were analysed month-to-month to establish the consistency and reliability of the NRC to predict near repeat residential burglary patterns. The research findings are compared to previous research on the NRC in order to establish the reliability of the research findings. Internal reliability refers to the extent that the indicators of measurement are consistent (Bryman, 2016:692). The predictive value of the NRC in this research is limited to the Hillcrest policing area and is not representative of South Africa as a whole, as outlined by Dr Schmitz (2016: np). However, near repeat residential burglary patterns have been identified by international research. Even though the spatial and temporal patterns may vary from country to country, and place to place, the underlining point is that near repeat patterns can be identified and potentially hold crime prevention value for police agencies.

4.9.2 Validity

This research aims to ensure measurement validity, predictive validity, statistical validity, construct validity and external validity. Predictive validity refers to how well a test or instrument can forecast or predict (Bryman, 2016:694; Gray, 2014:153). Predictive validity is measured by analysing the NRC results and the month-to-month predictive risk maps for a period of 12 months. Starting with residential burglaries in April 2012, which were geocoded, near repeat risk calculations are illustrated in the form of risk buffers, creating a predictive risk map for May 2012. In another layer, the May 2012 residential burglaries are represented on the same predictive risk map, showing the number of burglaries that occurred within the predicted risk buffers using spatial analysis. This process was repeated for each month. The predictive map for each month is compared and analysed with the following month's map showing where the residential burglaries occurred in order to determine how accurate the near repeat calculations of risk were for predicting near repeat residential burglaries during the following month.

Measurement validity is achieved when a measure, measures what it says it measures (Bachman & Schutt, 2016:83). Measurement validity will be achieved by comparing the month-to-month predictive maps, and the location of the month-to-month residential burglaries to determine whether the NRC was able to predict or forecast near repeat resident burglaries.

Statistical validity is the extent to which research has utilised appropriate design and statistical methods that allow it to detect the effects that are present (Gray, 2014:153). The x and y coordinates and dates are entered in the required format into the NRC and calculated using the settings outlined in section 4.10 (data analysis and interpretation). Drawing from the concluding process for predictive validity (above), the number of residential burglaries that occurred within the predicted risk buffer or area is calculated to represent a statistic to indicate the accuracy of the NRC and the predictive risk map. This process was carried out for each month.

Construct validity refers to the quality of conceptualisation or operationalisation of the relevant concepts, and to the extent which the research findings test or investigate what it claims to have found (Gray, 2014:279). According to Bryman (2016:69), construct validity is a measurement of validity which tests a hypothesis that is relevant to the fundamental concept. Construct validity has been established when a measure is similar to, or like other measures as stated in a theory (Bachman & Schutt, 2016:85; Schutt (2017:240). Depending on the findings supporting predictive validity and statistical validity, construct validity can be established on the basis of the NRC ability to identify near repeat residential burglaries in the Hillcrest policing area.

External validity refers to the degree to which the research findings can be generalised beyond the research study itself (Bryman, 2016:691; Crowther-Dowey & Fussey, 2013:109; Gray, 2014:280). As already discussed, near repeat burglary patterns have been identified through international research in a number of countries. The NRC itself is externally valid, and international research on near repeat residential burglaries has been conducted using various measures. As noted by Dr Schmitz (2016: np), research findings on the application of the NRC in the Hillcrest policing area, cannot be generalised to South Africa as a whole. This would require further research studies using different policing areas, for example, rural and city policing areas in South Africa (Schmitz, 2016: np). This research is only valid within the sample area of Hillcrest policing area, KZN, South Africa, thus making it internally valid in nature. Internal validity is the extent to which a finding integrates a relationship or link between two or more variables (Bryman, 2016:692).

What can be generalised beyond the study area is the identification of near repeat residential burglary patterns similar to international research findings (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen, Yuan & Li, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Morgan, 2000; Piza & Carter, 2018; Townsley et al, 2003; Wang & Liu, 2017; Wu, Xu et al, 2015).

4.9.3 Trustworthiness

Trustworthiness consists of credibility, transferability, dependability, and conformity (Devault, 2017: np). Credibility can be assured when the same research participants are asked the same questions consistently and when the researcher has referred to various sources (Devault, 2017: np). Transferability refers to whether the research findings can be generalised and applied to other situations and/or contexts beyond the research (Devault, 2017: np). Dependability is established if the research findings are consistent and can be repeated by other researchers using the same data (Anon, [sa]:np). Conformity refers to whether an individual's behaviour has been influenced by others (Cherry, 2018:np).

All five participants (detectives) were asked the same questions in the form of a structured, one-on-one interview, in the privacy of his or her office. All participation was voluntary, and the participants have no reason to blur the truth or facts. Only the researcher knows who the participants are, and their identity remains private, confidential and anonymous. No personal details of residential burglary victims are revealed. The research findings are only applicable to the research area. All SMEs are well known in their fields of expertise.

4.10 DATA ANALYSIS AND INTERPRETATION

Twelve consecutive months of residential burglary data and NRC results are geocoded using the GIS. The geocoded residential burglary points (x and y coordinates) and dates of the burglaries for each month were captured into Microsoft Excel columns with x-coordinates, y-coordinates, and the date. The number of burglaries varied each month from 33 to 76. Each entry or row was termed "iterations". The Excel worksheet was converted into .csv (Comma Deliminated) format and entered into the NRC. The NRC has various settings. Temporal bandwidths of 30, 14, 10 and 7-days were tested, as were spatial bandwidths of 500m, 400m, and 300m. Temporal bands for seven days was selected, as it was the only temporal setting that would identify or produce near repeat calculations of risk.

Different statistical settings of p= 0.05 (by chance once in 20 times) is the standard minimum threshold for statistical significance. P=0.01 (one in 100) produces results that are statistically valid and universally acceptable. Statistically, p=0.001 (one in 1000) would be ideal. The more iterations, the more reliable the results (Ratcliffe, 2009:8). The NRC was set for Manhattan Measure with temporal bandwidths of 7-days with 30 bands, and 400m spatial bands with 13 spatial bands using p=0.01. P=0.01 was selected because it produces statistics that are universally accepted. This process was repeated month-to-month.

Dr Schmitz (2016: np), an SME, agreed with testing the NRC using bandwidths up to 500m, which is equivalent to two street blocks. Schmitz (2016: np) further emphasized that the aim of the NRC was to identify repeat or near repeat residential burglary patterns of risk close (spatial) to where the initial burglary occurred within a specific period (temporal), allowing the police time to set up a crime prevention operation. There are two separate ways for measuring the distance between two points - Manhattan and Euclidean. Briefly, the Euclidean method measures the distance between two points 'as the crow flies.' Euclidean measures tend to underestimate the distances of routes. The Manhattan Method is better suited for those urban environments where it is impossible to calculate the actual routes taken between points. Research suggests, that the Manhattan Method is more accurate than the Euclidean Method (Ratcliffe, 2009:8-9). The Manhattan measure was used for this research because the majority, being 449 out of 490 (91.6%) residential burglaries occurred in formal urban settlements in the Hillcrest policing area.

The near repeat calculations, in the form of temporal and spatial calculations, were illustrated using the GIS and represented by risk buffers or bandwidths in relation to each geocoded residential burglary point. Apart from being a visualisation tool, the GIS was used to carry out month-to-month analysis to measure the accuracy of the near repeat calculations, and the number of the following month's residential burglaries which occurred within the predicted near repeat residential burglary risk buffers (or bandwidths).

The GIS was used to conduct spatial query analysis for all 490 residential burglary cases to highlight the residential burglary locations from environmental factors like neighbouring land uses, railway lines, road nodes and cul-de-sacs. Through case analysis, the housing type for each burglary was recorded either as a stand-alone house or inside a gated community.

The qualitative feedback from five interviews with detectives is analysed for their valued opinions, views, experiences, and attitudes on residential burglaries in the Hillcrest policing area, and insight into crime mapping tools and/or predictive tools that may be of use at station level. The valued feedback and opinions from SMEs ensured that the methodology used was appropriate and any pitfalls that may exist were brought to light in this exploratory research.

4.11 ETHICAL ASPECTS

The researcher followed the CRIMSA code of conduct. The CRIMSA code of conduct states that the researcher will remain professional, ethical, competent, and be aware of his or her limitations and expertise (CRIMSA, 2012: np). All people will be valued and respected by the researcher, who will ensure informed consent is granted before carrying out any research or interview. The personal details of research participants remain confidential. However, the researcher has the right to share research findings providing it will not harm anyone, or any organisation, or breach any prior agreements. All aspects of the research will be carried out to a high standard and reported accurately, truthfully and within the agreed timeframe (CRIMSA, 2012: np).

The fundamental ethical principles and guidelines from the Belmont Report, 1979 were applied to this research i.e. respect for persons, beneficence, and justice (Bachman & Schutt, 2018:50; the Belmont Report, 1979: np).

The researcher must respect the independence and views of individuals and provide protection in the form of assistance, safety and security to persons in need. Beneficence is ensured, by causing no harm to others, maximising the probable benefits of the research while simultaneously ensuring risk or harm is kept to a minimum. Justice refers to fairness to the participants in the research (the Belmont Report, 1979:np; Bachman & Schutt, 2018:50-51). No street numbers or the personal details of residents or victims of residential burglaries are mentioned in this research to ensure confidentiality and privacy, thus contributing to this research being categorised as low-risk. The data was stored and password-protected electronically, and the researcher was the only one with access to the data. All participation was voluntarily in the structured one-on-one interviews, and all five participants were informed beforehand of the purpose of the research. The participants were provided with a letter of introduction, containing the researcher's name and contacts details, and were required to sign the consent form before commencing with the interview.

Email communication interviews were conducted with SMEs. The researcher included a brief outline of the research aims and objectives, research questions and methodology. A structured questionnaire, comprised of questions related to the aforementioned areas, was included in the emails. The responding SMEs granted permission to include their feedback and opinions in the study.

4.11.1 Ethical approval for research: UNISA and SAPS

This research was approved by the University of South Africa (UNISA), College of Law Research and Ethics Committee (Ref: CLAW 2015 ST 11, see Annexure 3). The researcher sent a request to the SAPS (see Annexure 4) which was approved by the SAPS's Head of Strategic Management; the Divisional Commissioner of the Detective Service; and the Provincial Commissioner. This approval was granted in terms of SAPS Research Policy (National Instruction 1/2006 - see Annexure 5) which stipulates that the findings of this research may only be published with permission from the SAPS. All conditions were adhered to in the research, namely the research was conducted at the exclusive cost of the researcher, arrangements were made in advance to access the closed-case dockets, the research did not disrupt the duties of any SAPS members, interviews were conducted on a voluntary basis and all information was treated in confidence. To ensure the ethical requirements of the UNISA College of Law Research and Ethics Committee were fulfilled, a letter of permission from Professor Ratcliffe, to use the NRC was included (see Annexure 2).

4.11.2 Level of risk

The researcher only had permission and access to analyse closed-case residential burglary cases. There is no risk of any open cases being jeopardised because of the secondary data analysis carried out by the researcher. No names or street numbers of victims of residential burglaries, or names of detectives who participated are mentioned in this research Only the researcher has access to personal details of the samples drawn, and interviews conducted, making the level of risk low.

The researcher followed all ethical considerations of CRIMSA, UNISA, College of Law Research and Ethics Committee and the SAPS, while under the supervision of UNISA, thus making the level of risk low.

4.11.3 Informed consent

All five participants (detectives) were provided with a letter of introduction, to read before agreeing to continue with the interview. The participants had to give signed consent before beginning the interviews. There were two consent forms, one to consent before the start of the interview (Annexure 7) and the other for consent for the interviewer to contact the detective at a later stage if necessary (Annexure 8). If the participant still wished to continue, the consent form had to be read, agreed to, and signed before the start of the interview. The signed consent forms were kept by the researcher for safe keeping. The NRC is freely available for download and use for research purposes, however, a permission letter from Professor Ratcliffe was obtained (Annexure 2). The SMEs were contacted by electronic communication (email), and consent to use their feedback was granted via electronic communication (email).

4.11.4 Anonymity, confidentiality, and privacy

No sensitive, private, or confidential information about any individuals or residential properties that were burgled are mentioned in this research dissertation. No names of individuals, nor house or property numbers are mentioned in this dissertation. There is no mention of the names and ranks of detectives who participated in the qualitative interviews. These measures have been taken to ensure the privacy and confidentiality of residential burglary victims in the Hillcrest policing area and the identity of detectives who voluntarily participated. SMEs names, opinions and views are mentioned in this dissertation with their permission.

4.11.5 Conflict of interest

There is no conflict of interests identified in this research, as the research was firstly approved by the UNISA, College of Law Research and Ethics Committee (Ref: CLAW 2015 ST 11 – see Annexure 3). A detailed request was sent to the SAPS and was approved by the Head of Strategic Management; the Divisional Commissioner of the Detective Service; and the Provincial Commissioner. This approval was granted in terms of SAPS Research Policy (National Instruction 1/2006 – see Annexure 5) which stipulates that the findings of this research may only be published with permission from the SAPS. All conditions were adhered to in the research, namely the research was conducted at the exclusive cost of the researcher, arrangements were made in advance to access the closed-case dockets, the research did not disrupt the duties of any SAPS members, interviews were conducted on a voluntary basis, and all information treated confidentially. The Provincial Commissioner: KwaZulu-Natal and the Divisional Commissioner: Detective Service, will read the final draft of this research dissertation to ensure research ethics have been followed before publication of the research dissertation is permitted. The research was conducted following the CRIMSA code of conduct which states that the researcher will remain professional, ethical, competent, and be aware of his or her limitations and expertise (CRIMSA, 2012: np).

4.11.6 Deception of respondents

All five participants volunteered and were informed from the start of the purpose of the research and the researcher had no reason to distort the truth. All detectives (participants) gave signed consent to take part. The SMEs are known experts in their areas of expertise and have no reason to distort the truth in any way, and their opinions, experience and expertise are valued.

The researcher was truthful and transparent in conducting the data collection, and all participants were informed of the purpose of the research. Detectives were supplied with a “Letter of introduction” (Annexure 6), and the SMEs were contacted via electronic mail which outlined the research underway. The researcher, the five detectives who participated and the SMEs have no reason to be dishonest or distort the truth as this research may be beneficial to all parties.

4.11.7 Benefits of research

The application of the NRC as a tool to identify near repeat residential burglary patterns in the Hillcrest policing area can assist the police in resource allocation and crime preventions strategies in certain areas, to prevent near repeat burglaries from occurring. Using the GIS in the Hillcrest policing area NRC results can be visualised and used to produce month-to-month predictive near repeat residential burglary maps based on the results. The NRC and the GIS are valuable tools which the Hillcrest police could use in their crime prevention toolbox. Through reducing crime, like residential burglaries, the police may be considered more productive by the community while reducing the fear of crime like residential burglaries. The fear of residential burglary victimisation in the community could also be reduced (VOC, 2015:2)

4.11.8 Safekeeping and storage of data

The data collected was entered and stored on a computer hard drive, backed up and is password protected. The original signed consent forms are stored in a safe place, and only the researcher can identify which completed interview schedule belongs to which participant (detective).

4.11.9 Sharing of research findings and publication of data

No confidential or personal data used in this research will be shared. Only once the dissertation has passed the UNISA examination, will the Provincial Commissioner KwaZulu-Natal and the Divisional Commissioner: Detective Service test the final draft of this research dissertation to ensure research ethics have been followed before publication is permitted.

4.12 CONCLUSION

The research was exploratory in nature and applied the NRC to identify near repeat residential burglary patterns in the Hillcrest policing area in a South African context for the first time. The NRC could assist in specific crime prevention strategies and resource allocation to certain areas for a certain period of time. The GIS was used to represent the Hillcrest policing area, geocode residential burglary points, to illustrate the near repeat calculations of risk and carry out spatial analysis.

The explanatory sequential mixed method approach was found to be the best suited for this research because it has a solid quantitative basis. In an explanatory mixed method approach, the quantitative aspect of the research is completed, the results are analysed and further explained through the qualitative data collection. The quantitative research entailed secondary data analysis of 490 closed-case residential burglaries reported to Hillcrest police between April 2012 and March 2013. The residential burglaries for each month were geocoded using the GIS, and the required data was entered into the NRC and calculated. The near repeat calculations of risk were illustrated using the GIS and analysed for each of the 12-months. The qualitative research consisted of five structured interviews with detectives from Hillcrest police and electronic communication with several SMEs on the research topic. Both quantitative and qualitative data is merged to ensure detailed and concise research findings.

CHAPTER 5

ANALYSIS AND FINDINGS

5.1 INTRODUCTION

This chapter focuses on the research findings and analysis of the application of the NRC. The first section begins with the time of day that the residential burglaries occurred, followed by the spatial analysis of 490 residential burglaries in relation to their location and proximity to environmental factors. These environmental factors were neighbouring or boarding land use, railway lines, main arterial roads, road nodes or intersections and cul-de-sacs or end-nodes. The spatial analysis highlights the environments in which these residential burglaries occurred and suggests the role that environmental factors may play in residential burglary risk (Breetzke, 2016a:np; Clark, 2014; Moreto et al, 2014; Morgan, 2000; Mundell & Ayres, 2015; Olckers, 2007; Piza & Carter, 2018; Schmitz, 2016:np; Snyders, 2016; VanZyl, 2002; Winchester & Jackson, 1982; Zinn, 2017:np). The month-to-month near repeat residential burglary risk calculations are illustrated using the GIS (Q-GIS) and are analysed and compared to actual reported cases of residential burglary for that month, hence allowing one to determine the accuracy of the risk calculation. The GIS was used to conduct month-to-month spatial analysis of residential burglaries in relation to the locations of the previous months residential burglaries, to determine if there was a crime prevention value to focusing crime prevention strategies on previous residential burglary victims (Farrell & Pease, 1993:22; Forrester et al,1988:3; Pease, 1998:v).

This chapter consists of feedback and opinions from SMEs regarding the research methodology and the application of the NRC in a South African context. The third section is composed of feedback from qualitative interviews with detectives from the Hillcrest police station. The detectives shared their experiences, opinions, and attitudes and provided valuable insight into the mapping and predictive tools used for the investigation and prevention of residential burglaries at the Hillcrest policing area at that time.

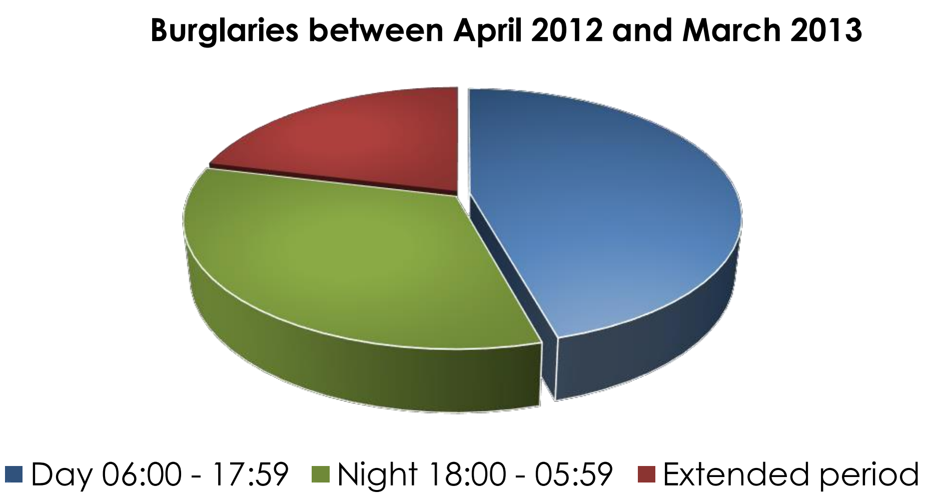
5.2 FINDINGS OF THE SPATIAL ANALYSIS

The findings of a spatial analysis of the residential burglary locations in relation to environmental factors are discussed below. These environmental factors ranged from the location of residential burglary victims to various neighbouring land usages, such as undeveloped land, urban settlements informal, peri-urban settlement informal, other farming and sugarcane land. Other environmental factors were railway lines, main arterial roads, road nodes or intersections and cul-de-sacs or end-nodes.

5.2.1 Time of day

Vis-à-vis this research, 224 (45.7%) of the 490 residential burglaries between April 2012 and March 2013 were carried out during the day (between 06:00 and 17:59), 162 (33.1%) occurred at night (between 18:00 and 05:59), and 104 (21.2%) over an extended period of more than 12 hours. Snyders (2016: np) showed similar findings in the Villieria Police Precinct (Kilner Park and Queenswood) in Pretoria, in that most residential burglaries occurred during the day (06:00-18:00). However, research findings by van Zyl (2002) differed between the two areas in Garsfontein and Pretoria West, Pretoria.

DIAGRAM 1:

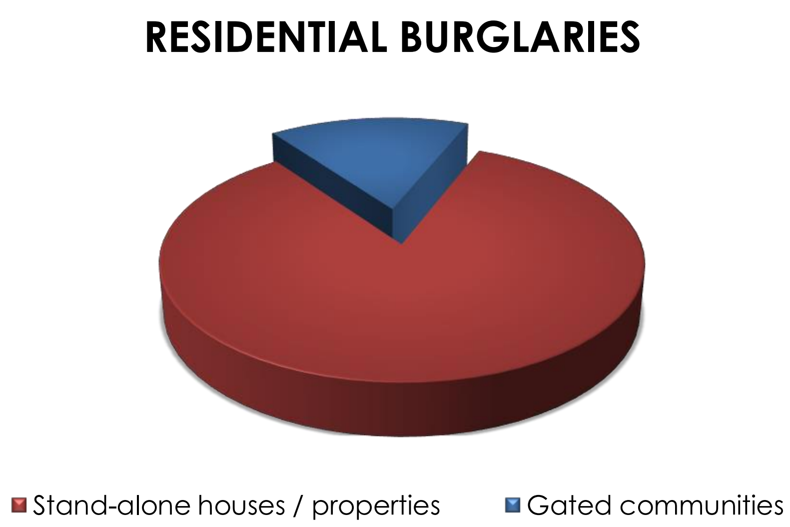


Research by Snyders (2016: np) found that residential burglary rates were higher during the day (06:00-18:00) making up 47% of all property crime, whereas residential burglaries at night (18:00-06:00) made up 24% of all property crimes. Research conducted by van Zyl (2002:129) established that 66.6% of residential burglaries (in Garsfontein and Pretoria West) occurred when no one was home. However, 33.3% took place when the residents were at home. Van Zyl (2002:130-131) identified that 42% of residential burglaries in Garsfontein occurred between 24:00-06:00, and 33% between 06:00-12:00. The majority (84%) of residential burglaries in Pretoria West occurred between 24:00 and 06:00.

5.2.2 Environmental factors

Secondary data analysis of the 490 residential burglary cases found that 411 (83.9%) residential burglaries occurred at stand-alone houses or properties, while only 79 (16.1%) happened within gated communities between April 2012 and March 2013. Townsley et al's (2003:630) research in Australia identified the relationship between the various housing types and target vulnerability in the initial residential burglary. Townsley et al (2003:630) further stated that if housing was similar in the area, the risk of burglary victimisation spreads like a virus to nearby houses, but diverse housing types hamper the spread of risk to nearby houses in the area.

DIAGRAM 2



Using the GIS (Q-GIS), a spatial analysis of the 490 residential burglary cases in relation to environmental factors, like the various neighbouring land uses, railways lines, main roads, road nodes, and cul-de-sacs, is outlined showing the environmental context in which these burglaries occurred. Moreto et al (2014:1120-1121) argued that environmental risk factors exist before an initial residential burglary takes place. These researchers highlighted that specific environments or locations are riskier than others and are therefore more conducive to crime like residential burglary (Moreto et al, 2014:1120-1121). The month-to-month spatial relationships of the residential burglaries have been included for each month, following the analysis of the near repeat calculations of risk. In this regard, see Table 2: Month-to-month near repeat calculations (April 2012 to March 2013).

5.2.3 Neighbouring land usage

The following statistics are based on the spatial analysis of this study using the GIS (Q-GIS) for the location of the 490 residential burglaries from the neighbouring or bordering land usages in the Hillcrest (KZN) policing area. It was established that out of 490 cases, 449 (91.6%) occurred within the urban formal settlements, whereas only 38 (7.8%) occurred within other farming lands.

5.2.4 Undeveloped land

The spatial analysis of this study found that the following residential burglaries occurred on/near undeveloped land: 144 (29.3%) residential burglaries bordered with undeveloped land within 100m, 240 (48.9%) within 200m, 327 (66.7%) within 300m, 390 (79.6%) occurred within 400m, and a staggering 425 (86.7%) within 500m of undeveloped land. These findings square with research by Clark (2014), Mundell and Ayes (2015), Olkers (2007), Snyders (2016), Winchester and Jackson (1982) and van Zyl (2002) regarding the high risk of residential burglary victimisation for houses located close to undeveloped land. Residents of Hillcrest Park identified Springside Nature Reserve (undeveloped land) as a hiding place for criminal elements and stolen goods (Clark, 2014:27). Mundell and Ayres (2015:7) stated that houses located in the vicinity to bushy areas, open space, open grounds or parks provide hiding places and escape routes for burglars. Olkers (2007:137) established that 50% of residential burglaries occurred within one grid reference (equivalent to two residential blocks) of open or unoccupied properties and decreased further away from open or unoccupied land. Snyders (2016:74) analysed crime in the Villieria

SAPS Precinct in Pretoria and identified that 29% of all crime occurred within 150m of parks and open spaces. According to Winchester and Jackson's (1982:39) environmental risk index, houses located adjacent to open space or open land pose a risk for residential burglary victimisation. These spatial findings concur with Winchester and Jackson (1982), particularly that 144 (29.3%) of residential burglaries in the Hillcrest policing area occurred within 100m of undeveloped land. Van Zyl (2002:125) received feedback from convicted residential burglars, confirming that the location of the target properties in relation to their proximity to vacant land facilitated easy access and escape.

5.2.5 Urban settlement informal

From the 490 residential burglaries studied in this research, only two cases (0.4%) occurred within 100m, 16 (3.3%), within 200m, 22 (4.5%) within 300m, 41(8.4%) within 400m, and 46 (9.4%) within 500m, of a neighbouring urban informal settlement. Urban formal residential areas that bordered with urban informal settlements did not seem to be significantly affected by residential burglaries within 500m (9.4%) when compared to boarding with undeveloped land within 500m (86.7%).

5.2.6 Peri-urban settlement informal

Based on the location of the 490 residential burglaries analysed in this research, the spatial analysis found that none (0%) occurred between 100m and 300m of a peri-urban informal settlement, and three (0.6%) within 400m, and 11 (2.3%) within 500m of a peri-urban settlement. The spatial analysis furthermore revealed that urban formal residential areas, that border with informal peri-urban settlements, do not appear to pose significant environmental risk factors in comparison to boarding with undeveloped land. A total of 2.3% of residential burglaries occurred within 500m of the peri-urban settlements' informal border, in comparison to undeveloped land within 500m (86.7%).

5.2.7 Other farming

The spatial analysis identified that 51 (10.4%) of residential burglaries occurred within 100m, 64 (13%) within 200m, 84 (17.2%) within 300m, 107 (21.9%) within

400m, and 134 (27.4%) within 500m, of other farming lands. More than a quarter of residential burglaries occurred within 500m of farming land. The spatial findings correspond to findings by Mundell and Ayres (2015:7), that houses in proximity to woods, bushy areas or opens spaces, which are easily accessible facilitate cover for burglars to hide and escape. Winchester and Jackson (1982:39) stated that houses located in a rural area or opposite to open land are at higher risk of experiencing a residential burglary.

5.2.8 Sugarcane fields

Concerning this research, no residential burglaries occurred (0%) within 100m of sugarcane fields, while seven (1.4%) happened within 200m, 13 (2.6%) within 300m, 21 (4.3%) within 400m, and 23 (4.7%) within 500m of such land use. The spatial analysis established that 4.7% of the houses located within 500m of sugarcane were burgled. Even though sugarcane fields can be described as open or bushy spaces in which residential burglars could hide and escape (Mundell & Ayres, 2015:7; Winchester & Jackson, 1982:39), this statistic appears to be low which could be attributed to the small land use designated for sugarcane in the area under investigation.

5.2.9 Railway lines

The spatial analysis revealed that out of the 490 residential burglaries, 43 (8.7%) occurred within 100m of a railway line, 88 (17.9%) within 200m, 124 (25.3 %) within 300m, 157 (32%) within 400m and, 186 (37.9%) within 500m from a railway line. Research by Clark (2014), Piza and Carter (2018) and Snyders (2016) correlates with these findings. Residents of Hillcrest Park identified the railway line as access and escape route to the neighbourhood, which is used by the general public as a footpath and by criminals who target Hillcrest Park (Clark, 2014:27). These findings concur with the research (spatial analysis) by Piza and Carter (2018:12) and Snyders (2016:74). Piza and Carter’s (2018:2) research in Indianapolis, the USA, identified that 12.21% residential burglaries occurred within two blocks of railroad tracks or a railway. Snyders (2016:74), through spatial analysis (using the GIS), identified the vicinity of railway lines as a hotspot and revealed that 46% of all crime occurred within 500m of a railway line.

5.2.10 Main arterial roads

Apropos to this study, a spatial analysis of residential burglaries to main arterial roads (Inanda Road and Old Man Road) was conducted. The Old Main Road runs through Hillcrest up to Botha's Hill and beyond, and Inanda Road runs from Hillcrest through Waterfall to Molweni.

Concerning Old Main Road, 32 (6.5%) out of 490 residential burglaries happened within 100m, 63 (12.8%) ensued within 200m, 107 (21.8%) within 300m, 140 (28.5%) within 400m, and 161 (32.8%) transpired within 500m of Old Main Road. In the vicinity of Inanda Road, the following residential burglaries took place: 16 (3.2%) within 100m, 42 (8.5%) within 200m, 55 (11.2%), within 300m, 81 (16.5%) within 400m, and 116 (23.6%) within 500m of Inanda Road. These spatial statistics correspond to research findings by Olckers (2007), Snyders (2016) and Winchester and Jackson (1982). Olckers (2007:7,139) established that 40% of residential burglaries occurred in the same grid block (equivalent to two residential blocks) as the main access route (main road). Winchester and Jackson's (1982:39) risk and vulnerability for burglary check-list stipulate that houses on a major town road, or on or near a major road, are at risk of burglary. Research by Snyders (2016:74), identified the vicinity of main roads as a hotspot, with 60% of all crimes occurring within 250m of the main road in the research area.

5.2.11 Road nodes or intersections

In the proximity of road nodes or intersections, the spatial analysis of this study identified that out of the 490 residential burglaries, 44 (8.9%) occurred within 50m of a road node, 188 (38%) within 100m of a road node, 306 (62.4%) within 150m of a road node, and 393 (80.2%) within 200m of a road node. These findings suggest that a large majority of burgled homes were situated close to a road node or intersection. These spatial statistics correspond to Olckers' (2007), research which found that house placement on a street can play a role in residential burglary risk. Olckers' (2007:141-142) research correlates with this study's findings, in terms of one grid block where 41% of residential burglaries happened close to a corner property, 37% residential burglaries occurred on the middle of the street, and 22% of residential burglaries took place at houses located on corners, thus making corner properties the least vulnerable to burglary.

5.2.12 Cul-de-sacs or end nodes

Out of the 490 residential burglaries that were analysed in this study, the spatial analysis found that the following burglaries occurred within the vicinity of cul-de-sacs or end nodes: 20 (4%) occurred within 50m, 65 (13.2%) within 100m, 123 (25.1%) within 150m and 176 (35.9%) within 200m of a cul-de-sac or end node. These findings suggest that there are fewer burglaries in a cul-de-sac and that burglary incidents increase further away from a cul-de-sac.

Statistics from this research concur with research by Olckers (2007:140) who highlighted that 33% of residential burglaries occurred within the same grid block as a dead end or cul-de-sac, 41% of residential burglaries occurred within one grid distance and deteriorated (risk decay) by 15% within two grid distances, 8% within three grid references and 4% within four grids.

5.3 ANALYSIS AND INTERPRETATION OF DATA

The data for 490 residential burglaries reported to Hillcrest police station (April 2012 to March 2013) was used in the application of the NRC. Dr Schmitz (2016: np), an SME, agreed that the sample of 490 residential burglary cases would be sufficient to test the NRC's ability to identify near repeat residential burglary patterns in the Hillcrest policing area.

Based on the residential burglary data, the NRC identified diverse types of risk patterns, such as repeat victimisation, near repeat and statistical risk. The statistical significance for risk calculations were p= 0.05 (by chance once in 20 times), when p=0.01 (one in 100) and, p=0.001 (one in 1000) (Ratcliffe, 2009:8). These risk calculations were illustrated and analysed to demonstrate the application of the NRC to identify near repeat patterns of risk using the Hillcrest police station's residential burglary data.

The following month-to-month near repeat calculations and analysis support the near repeat residential burglary theory, which cautions that every burglary heightens the risk of further residential burglary to surrounding properties for a period (Morgan, 2000, Groff &Taniguichi, 2016: np; Wang & Liu, 2017:1; Wu et al, 2015:178). The identification of the near repeat patterns of risk can give the police the opportunity to set up crime prevention strategies, in the form of patrols, and manpower allocation to specific areas for a specific period.

The research findings on the application of the NRC, can be explained by the CPT (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Chen et al, 2013; Wang & Liu, 2017) where burglars seek out suitable targets along paths and nodes during their routine activities, and the FBT (Bowers & Johnson, 2004; Pease, 1998; Wang & Lui, 2017; Wu et al, 2015), where a property initially catches the attention, or flags the attention, of burglars, and boosts the risk of repeat or near repeat residential burglaries, close to the initial burglary victim.

The researcher's identification of near repeat residential burglary patterns took place for the first time in the Hillcrest policing area, and within a South African context. The findings of this research concur with international research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Piza & Carter, 2018; Morgan, 2000; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015) on near repeat residential burglary.

In some instances (as with the near repeat risk calculations in this study for May 2012 and July 2012 that projected 4001m - 4400m distances), the near repeat calculations of risk projected further distances in comparison to international research findings and projected beyond the Hillcrest policing area, in some calculations. An explanation for this could be that burglars use motor vehicles to carry out residential burglaries (Erasmus & Radebe, 2013: np; Respondent 4, 2015). The use of motor vehicles by burglars suggest that they can cover a wider area to commit residential burglaries. In support of this, Respondent 3 (2015: np), commented that burglars travel up to three to five kilometres to carry out residential burglaries.

It is evident from the following month-to-month near repeat calculations of risk that residential burglaries in this study tended to cluster in space and time. The spatial analysis highlighted the predictive accuracy of the NRC over a 12-month period. These results can be explained by the CPT (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Chen et al, 2013; Wang & Liu, 2017), where burglars travel along paths (roads and paths) between nodes (work and home) where suitable targets (houses) catch or flag their attention. The FBT (Bowers & Johnson, 2004; Pease, 1998; Wang & Lui, 2017; Wu et al, 2015) suggests these houses catch the attention of burglars who carry out the burglary. The burglars may return to revictimise the property or share the information about the burgled premises. The burglars were familiar with the access and escape routes to the neighbourhood and the surrounding properties and targeted the nearby houses. In addition, the Near Repeat Burglary Theory (NRBT) (Bernasco, 2008:414; Wang & Liu, 2017:1; Wu et al, 2015:178) explains that burglars seek out suitable targets in the vicinity of houses that they have already burgled.

Pertaining to this study, the month-to-month spatial analysis of the residential burglaries in relation to one another is explained by the CPT (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Chen et al, 2013; Wang & Liu, 2017), the FBT (Bowers & Johnson, 2004; Pease, 1998; Wang & Lui, 2017; Wu et al, 2015) and the NRBT (Bernasco, 2008:414; Wang & Liu, 2017:1; Wu et al, 2015:178). Previous research (Farrell & Pease, 1993:22; Forrester et al, 1988:3; Pease, 1998: v) suggested that by channelling crime prevention resources spatially and temporally, towards the prevention of repeat residential burglary victimisation, was found to be an effective use of valuable crime prevention resources.

In this regard, see Table 2: Month-to-month near repeat calculations on the following page. See also Residential Burglaries (April 2012 to March 2013) Annexure 9 and Annexures 10-44 for the month-to-month risk maps

TABLE 3: Month-to-month Near Repeat Calculations

MONTH	CASES	0-7 DAYS	8-14 DAYS	15-21 DAYS	22-28 DAYS	29-35 DAYS	PREDICTIVE ACCURACY FOR THE FOLLOWING MONTH
April 2012	42			158%> 4001-4400m p=0.01			Twenty-eight (70%) of the 40 residential burglary cases in May 2012 occurred within the 158% increased risk bandwidth of 4001m - 4400m of April 2012 residential burglaries.
May 2012	40	70%> Near Repeat 2401-2800m					Twenty-nine (87.9%) out of 33 residential burglaries in June 2012 occurred within the 70% near repeat risk bandwidth of 2401m - 2800m of May 2012 residential burglaries.
June 2012	33		165%> 801-1200m p=0.05 79%> 4001-4400m p=0.05				Twenty-four (72.7%) out of 33 residential burglaries in July 2012 occurred within the 165% greater risk bandwidth of 801m - 1200m for June 2012 residential burglaries. Fifteen (45.5%) out of 33 residential burglary cases in July 2012 occurred within the 79% greater risk bandwidth of 4001m - 4400m of June 2012 residential burglaries.

July 2012	33	81%> Near Repeat 401-800m p=0.05	164%> 4001-4400m p=0.05	318%> 1-400m p=0.01	Fifteen (40.6%) out of 37 residential burglaries in August 2012 occurred within the 81% near repeat risk bandwidth of 401m to 800m of July 2012 residential burglaries. Twenty-two (59.5%) out of 37 residential burglary cases in August 2012 occurred within the 164% greater risk bandwidth of 4001m - 4400m of July 2012 residential burglaries. Eleven (29.7%) out of 37 residential burglary cases in August 2012 occurred within the 318% greater risk bandwidth of 1m - 400m of July 2012 residential burglaries.
August 2012	37		67%> 3601-4000m p=0.05		Twenty-eight (75.7%) out of 37 residential burglaries in September 2012 occurred within the 67% greater risk bandwidth of 3601m - 4000m of August 2012 residential burglaries.

September 2012	37	49%> Near Repeat 1201-1600m p=0.05	223%> 4401-4800m p=0.01		Fifty-seven (75%) out of 76 residential burglaries in October 2012 occurred within the 49% near repeat risk bandwidth of 1201m - 1600m of September 2012 residential burglaries. Thirty-five (46%) out of 76 residential burglaries in October 2012 occurred within the 223% greater risk bandwidth of 4401m - 4800m of September 2012 residential burglaries.

October 2012	76	28%> Near Repeat 401-800m		50%> 801-1200m p=0.05 65%> 1201-1600m p=0.05	191%> 2001-2400m p=0.05	Twenty-eight (75.6%) out of 37 residential burglary cases in November 2012 occurred within the 28% near repeat risk bandwidth of 401m - 800m of October 2012 residential burglaries. Thirty-four (91.9%) out of 37 residential burglary cases in November 2012 occurred within the 50% greater risk bandwidth of 801m - 1200m of October 2012 residential burglaries. Thirty-three (89.2%) out of 37 residential burglary cases in November 2012 occurred within the 65% greater risk bandwidth of 1201m - 1600m of October 2012 residential burglaries. Thirty-six (97.3%) out of 37 residential burglary cases in November 2012 occurred within the 191% greater risk bandwidth of 2001m - 2400m of October 2012 residential burglaries.
November 2012	37	40%> Near Repeat 2801-3200m				Thirty-one (86.1%) out of 36 residential burglaries in December 2012 occurred within the 40% near repeat risk bandwidth of 2801m - 3200m of November 2012 residential burglaries.

December 2012	36	65%> Near Repeat 2801-3200m p=0.05		Thirty-two (78%) out of 41 residential burglary cases in January 2013 occurred within the 65% near repeat risk bandwidth of 2801m - 3200m of December 2012 residential burglaries.
January 2013	41		169%> 3601-4000m p=0.05 146%> 4001-4400m p=0.05	Twenty-six (72.2%) out of 36 residential burglaries in February 2013 occurred within the 169% greater risk bandwidth of 3601m - 4000m of January 2013 residential burglaries. Thirty-one (86.1%) out of 36 residential burglaries in February 2013 occurred within the 146% greater risk bandwidth of 4000m – 4400m of January 2013 residential burglaries.

February 2013	36	57%> Near Repeat 4001-4400m	111%> 1601-2000m p=0.05 156%> 2401-2800m p=0.05	Thirty-four (81%) out of 42 residential burglaries in March 2013 occurred within the 57% near repeat risk bandwidth of 4001m - 4400m of February 2013 residential burglaries. Twenty-nine (69%) out of 42 residential burglary cases in March 2013 occurred within the 111% greater risk bandwidth of 1601m - 2000m of February 2013 residential burglaries. Thirty (71.4%) out of 42 residential burglary cases in March 2013 occurred within the 156% greater risk bandwidth of 2401m - 2800m of February 2013 residential burglaries.
March 2013	42	140%> Repeat at the same property. 39%> Near Repeat 1601-2000m	95%> 401-800m p=0.05	No data for April 2013. This research covered the period from April 2012-March 2013.

5.3.1 April 2012

For April (2012), data from 42 residential burglary cases were entered into the NRC. According to the results, the NRC predicted that in May (2012) there will be an elevated risk of 158% (p=0.01) for residential burglaries throughout 15 to 21-days and within the area of 4001m and 4400m of the burglaries that occurred in April (2012). The chances of a residential burglary occurring in May (2012) within the specific area (4001m – 4400m) from burglaries that occurred in April (2012), and specific time (15 to 21 days) as predicted, were at least one in 20 chance of taking place as predicted. The elevated risk was forecasted to project beyond the Hillcrest policing area (see Annexures 10 and 11).

5.3.2 May 2012

The NRC forecasted the locations of 28 (70%) out of the 40 residential burglaries in May 2012. These burglaries occurred within the elevated risk of 158% bandwidth of 4001m – 4400m over the period of 15 to 21-days of the April 2012 residential burglaries (see Annexure 12).

Based on the residential burglary data of May (2012), the NRC identified a near repeat residential burglary pattern in June (2012) with 70% risk over a period of zero to seven days, likely to occur in the space of 2401m and 2800m (see Annexures 13 and 14).

In May (2012), three burglaries (7.5%) occurred within 100m, 10 (25%) within 200m, 14 (35%) within 300m, 18 (45%) within 400m, and 21 (52.5%) within 500m of the previous month's residential burglaries (April 2012). If the police had this foresight, crime prevention strategies focused in the vicinity of 500m of April's residential burglaries could have prevented up to 52.5% of the residential burglaries that took place during this period. However, if crime prevention strategies were focused on the near repeat calculations of risk for May, the police may have prevented up to 70% of the residential burglaries.

5.3.3 June 2012

In June (2012), 29 (87.9%) out of 33 residential burglaries occurred within the 70% near repeat risk bandwidth of 2401m – 2800m. The burglary data for June (2012) was entered into the NRC and calculated to identify near repeat risk for residential burglaries for July (2012) (see Annexure 15).

The NRC identified two instances of statistical risk that forecast for July (2012). Firstly, the risk was predicted to be at 165% elevation (at least p=0.05 or better) than normal for the period of eight to 14-days, and between the area of 801m –1200m.

Secondly, the NRC predicted a 79% greater risk than normal (p=0.05 or more) for the period of eight to 14-days and in 4001m – 4400m. In this instance, the 79% risk projected beyond the Hillcrest police area (see Annexures 16 and 17).

From the 33 residential burglaries experienced in June 2012, the spatial analysis identified that none (0%), occurred within 100m, five (15%) within 200m, nine (27.3%) within 300m, 10 (30.3%) within 400m, and 16 (48.5%) transpired within 500m of the previous month's residential burglaries (May 2012). According to the spatial analysis, had police resources been allocated to the 500m surrounding areas of the residential burglaries that occurred in May, they could have prevented up to 48.5% of the residential burglaries. Conversely, if the police resources were allocated based on the near repeat calculations for June, the police could have prevented up to 87.9% of the residential burglaries that took place during this period.

5.3.4 July 2012

A considerable number of residential burglaries in July (2012) occurred within the areas of elevated risk identified by the NRC. A total of 24 (72.7%) out of 33 residential burglaries occurred within the 165% greater risk bandwidth of 801m – 1200m, and 15 (45.5%) out of 33 residential burglary cases in July 2012, occurred within the 79% greater risk bandwidth of 4001m – 4400m. The NRC forecasted the location of residential burglaries in July (2012) with an accuracy ranging between 45.5% and 72.7% (see Annexure 18).

The residential burglary data for July (2012) was calculated for August (2012) and identified three spatial-temporal areas of risk: firstly, the NRC identified a near repeat pattern of risk, which was 81% greater (p=0.05) than normal over the period of zero to seven days and ranging between the area of 401m – 800m. Secondly, the NRC predicted that the risk was 318% greater (p=0.01) for residential burglaries to occur, throughout 15-21-days and within 1m – 400m from the burglary locations in July (2012). Thirdly, the NRC identified elevated risk of 164% (at least p=0.05 or better) for residential burglaries to occur, over the period of eight to 14-days and 4001m – 4400m from the previous months (July 2012) burglary locations (see Annexures 19 and 20).

The spatial analysis of the 33 residential burglaries in July (2012) identified that five (15.1%) residential burglaries occurred within 100m, eight (24.2%) within 200m, 11 (33.3%) within 300m, 13 (39.4%) within 400m, and 16 (48.5%) happened within 500m of the previous month's residential burglaries (June 2012). With this foresight, if police resources had focused on the 500m radius of residential burglaries that occurred in June 48.5% of the residential burglaries in July could have been prevented. However, the near repeat calculations of risk were significantly higher, which could have facilitated the prevention of up to 72.7% of burglaries.

5.3.5 August 2012

Out of 37 residential burglaries in August (2012), 15 (40.6%) occurred within the 81% near repeat risk bandwidth of 401m to 800, a further 11 (29.7%) happened within the 318% greater risk bandwidth of 1m - 400m, and 22 (59.5%) transpired inside the 164% greater risk bandwidth of 4001m - 4400m (see Annexure 21). The accuracy of the NRC forecast in August (2012) ranged from 29.7% up to 59.5%.

The NRC calculated August's (2012) burglary data to project the likely locations of residential burglaries in September (2012). The NRC anticipated the heightened risk (at least p=0.05 or better) to be 67% greater for residential burglaries to occur than normal for the period of eight to 14-days and 3601m – 4000m (see Annexures 22 and 23).

Out of the 37 residential burglaries that happened in August 2012, four (10.8%) occurred within 100m, six (16.2%) within 200m, 11 (29.7%) within 300m, 11 (29.7%) within 400m, and 13 (35.1%) within 500m of the previous month's residential burglaries (July 2012). Police resources that focused on the 500m of the residential burglaries in July may have prevented up to 35.1% of the residential burglaries from taking place. In parallel, if the resources had been channelled based on the near repeat calculations of risk, up to 59.5% of the burglaries in August may have been prevented.

5.3.6 September 2012

The analysis identified that 28 (75.7%) out of 37 residential burglaries in September (2012) occurred within the 67% greater risk bandwidth of 3601m - 4000m. This near repeat calculation based on August's (2012) residential burglary data was 75.7% accurate (see Annexure 24).

Based on the September 2012 burglary data, the NRC calculated the following for October 2012: firstly, the NRC identified a near repeat residential burglary pattern in October (2012), which was 49% greater (p=0.05 or better) for zero to seven days and between the area of 1201m – 1600m. Secondly, the elevated risk of residential burglary was expected to be 223% (p=0.01) greater than normal, over the period of 15-21-days and between 4401m – 4800 (see Annexures 25 and 26).

The spatial analysis highlighted that from the 37 residential burglaries, three (8.1%) happened within 100m, eight (21.6%) within 200m, nine (24.3%) within 300m, 16 (43.2%) within 400m, and 22 (59.4%) within 500m of the previous month's residential burglaries (August 2012).

If crime prevention strategies had focused on the 500m surrounding area of the residential burglaries that occurred in August; up to 59.4% (more than half) of the burglaries in September could have been prevented. If the same prevention strategies focused on the area of the near repeat calculations, up to 75.7% (three quarters) of residential burglaries could have been prevented.

5.3.7 October 2012

The analysis of residential burglaries that occurred in October (2012), concluded that 57 (75%) out of 76 residential burglaries occurred within the 49% near repeat risk bandwidth of 1201m - 1600m. 35 (46%) out of 76 residential burglaries occurred within the forecasted 223% greater risk bandwidth of 4401m – 4800m. These findings highlighted that the NRC predicted with accuracy (46% – 75%) the location of residential burglaries in October (2012) (see Annexures 27).

The NRC calculated the residential burglary data for October (2012) and identified the following four risk calculations for November (2012): firstly, a near repeat residential burglary pattern was identified, the likeliness of near repeat residential burglaries were 28% greater for zero to seven days, between the areas of 401m – 800m. Secondly, the risk of burglary was elevated by 50% (p=0.05) compared to normal, for the period of 22-28-days and between 801m – 1200m. Thirdly, the risk of residential burglary was heightened by 65% (at least p=0.05 or better), than normal for the period of 22-28-days and between the area of 1201m – 1600m. Lastly, the predicted risk escalated to 191% (p=0.05 or better) for a residential burglary to occur over the period of 29 to 35-days and 2001m – 2400m (see Annexures 28 and 29).

Based on the location of the 76 residential burglaries in October 2012, the spatial analysis found that five (6.5%) occurred within 100m, 15 (19.7%) within 200m, 24 (31.5%) within 300m, 35 (46%) within 400m, and 40 (52.6%) within 500m of the previous month's residential burglaries (September 2012). For October, if police resources had focused on the 500m surrounding area of Septembers residential burglary locations, they could have prevented half (52.6%) of the residential burglaries from happening in October. If police resources had been focused on the NRC forecast for October, up to 75% (three quarters) of the burglaries could have been prevented.

5.3.8 November 2012

The NRC forecast for November (2012) was incredibly accurate compared to previous months, which could be attributed to October (2012) experiencing the most burglaries, with 76 residential burglaries (geocoded) in this research. The analysis confirmed that 28 (75.6%) out of 37 residential burglaries occurred within the 28% near repeat risk bandwidth of 401m - 800m, 34 (91.9%) out of 37 residential burglaries occurred within the 50% greater risk bandwidth of 801m-1200m, 33 (89.2%) out of 37 residential burglaries occurred within the 65% greater risk bandwidth of 1201m - 1600m, and finally 36 (97.3%) out of 37 residential burglary cases in November 2012 occurred within the 191% greater risk bandwidth of 2001m-2400m. The accuracy of the NRC's location prediction of residential burglaries for November (2012) was exceptionally high, with the precision ranging from 89.2% to 97.3% (see Annexure 30).

Using the November (2012) residential burglary data, the NRC recognised a near repeat residential burglary pattern, with 40% greater risk over the space of 2801m – 3200m from the previous month's burglaries (see Annexures 31 and 32).

The spatial analysis established that out of the 37 residential burglaries that happened in November (2012), three (8.1%) occurred within 100m, eight (21.6%) within 200m, 18 (48.6%) within 300m, 21 (56.7%) within 400m, and 25 (67.5%) within 500m of the previous month's residential burglaries (October 2012). With reference to November, if the police had insight into this spatial analysis, they may have prevented up to 67.5% of the residential burglaries that occurred in November, by allocating resources to the 500m radius of the residential burglaries that occurred in October. However, if the resources had been focused on the near repeat calculations, a staggering 97.3% of residential burglaries may not have occurred.

5.3.9 December 2012

The NRC was accurate in its projection for December 2012, as 31 (86.1%) out of 36 residential burglaries were committed within the 40% near repeat risk bandwidth of 2801m – 3200m (see Annexure 33).

Based on the December (2012) burglary data, the NRC identified a near repeat residential burglary pattern for January 2013. This near repeat risk was 65% greater (p=0.05 or better) for zero to seven days and between 2801m–3200m (see Annexures 34 and 35).

Based on the location of the 36 residential burglaries that took place in December 2012, one (2.8%) occurred within 100m, four (11.1%) within 200m, eight (22.2%) within 300m, 15 (41.6%) within 400m, and 23 (63%) within 500m of the previous month's residential burglaries (November 2012). In December, if resources had been channelled to the vicinity of 500 metres of the residential burglary locations in November 63% of the burglaries could have been prevented. However, the near repeat calculations were more accurate, which may have facilitated the prevention of up to 97.3% of the residential burglaries in December.

5.3.10 January 2013

As anticipated by the NRC, 32 (78%) out of 41 residential burglaries occurred within the 65% near repeat risk bandwidth of 2801m - 3200m (see Annexure 36).

Based on the residential burglary data for January (2013), the NRC forecasted the following for February (2013): firstly, the risk was 169% greater (at least p=0.05 or better) than normal for residential burglaries to occur during the period of 22 to 28-days, and between 3 601m–4 000m. Secondly, the risk was elevated to 146% (at least p=0.05 or better) greater than normal, for 22 to 28-days, and between 4001m – 4400m (see Annexures 37 and 38).

Based on the location of the 41 residential burglaries in January 2013, two (4.8%) occurred within 100m, six (14.6%) within 200m, 11 (26.8%) within 300m, 19 (46.3%) within 400m, and 26 (63.4%) within 500m of the previous month's residential burglaries (December 2012). If crime prevention resources were deployed to the 500m radius of the residential burglary locations in December, the SAPS may have prevented up to 63.4% of the residential burglaries that took place in January. If the resources focused on the near repeat calculations of risk, up to 78% of the burglaries may not have occurred.

5.3.11 February 2013

In February (2013), it was established that 26 (72.2%) out of 36 residential burglaries occurred within the 169% greater risk bandwidth of 3601m – 4000m and 31 (86.1%) out of 36 residential burglaries in February (2013) occurred within the 146% greater risk bandwidth of 4001m – 4400m of (January 2013) burglary risk calculations. The precision of the NRC forecast ranged from 72.2% to 86.1% (see Annexure 39).

The NRC applied the residential burglary data for February (2013) and projected the following risk: firstly, the near repeat risk was 57% greater for zero to seven days and between 4001m – 4400m. Secondly, the NRC identified an increase of risk of 111% (at least p=0.05 or better) greater than normal, for 15 to 21-days, and between 1 601m – 2000m. Thirdly, it was projected that risk was 156% (at least p=0.05 or better) greater than normal for 15 to 21-days, and between 2401m – 2800m (see Annexures 40 and 41).

The spatial analysis revealed that out of the 36 residential burglaries in February 2013, three (8.3%) occurred within 100m, seven (19.4%) within 200m, 13 (36.1%) within 300m, 16 (44.4%) within 400m, and 25 (69.4%) within 500m of the previous month's residential burglaries (January 2013). In February 69.4% of the residential burglaries may have been prevented if crime prevention resources had been allocated to the area of a 500m radius of the residential burglary locations of January. Moreover, if the resources had focused on the near repeat calculations of risk, up to 86.1% of the burglaries could have been prevented.

5.3.12 March 2013

The analysis identified 34 (81%) out of 42 residential burglaries occurred in March (2013), within the 57% near repeat risk bandwidth of 4001m – 4400m, 29 (69%) out of 42 residential burglaries occurred within the 111% greater risk bandwidth of 1 601m – 2000m and a further 30 (71.4%) out of 42 residential burglaries occurred within the 156% greater risk bandwidth of 2401m – 2800m. The NRC's accuracy ranged from 69% to 81% (see Annexure 42).

The NRC identified significant repeat and near repeat residential burglary risk for April (2013). The repeat victimisation to the same property was at 140% greater risk for zero to seven days, and the near repeat risk was also 39% greater for zero to seven days, between 1601m – 2000m. Furthermore, the NRC projected elevated risk (at least p=0.05 or better) of 95% greater for 15 to 21-days, and between 401m - 800m. The researcher was unable to provide an analysis of the results or accuracy for the NRC calculations for March 2013, as this research does not include April 2013 (see Annexures 43 and 44).

For March (2013), the spatial analysis established that out of the 42 residential burglaries three (7.1%) occurred within 100m, six (14.2%) within 200m, eight (19%) within 300m, 11 (26.1%) within 400m, and 14 (33.3%) within 500m of the previous month's residential burglaries (February 2013). If the police had focused resources on the surrounding area of 500m of the residential burglary locations in February, then they may have prevented up to 33.3% (one third) of the residential burglaries that occurred. If, however, the resources had focused on the near repeat calculations, up to 81% of the burglaries could have been prevented.

5.3.13 Interpretation of near repeat calculations

The NRC identified repeat, near repeat and elevated statistical risk patterns over the 12-month period under examination. June 2012 and July 2012 experienced the least amount of residential burglaries, both with 33 cases, while October 2012 experienced the most, with 76 cases. The NRC was able to predict residential burglary locations (spatial) from 29.7% for August (2012) up to 97.3% in November (2012). The average accuracy of the near repeat calculations was 64.3% over a 12-month period. The NRC identified near repeat burglary patterns scattered over and beyond the Hillcrest policing area. It is evident that the near repeat risk calculations projected a greater distance compared to prior international research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen, et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Morgan, 2000; Piza & Carter, 2018; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015) and for some months, the risk calculations projected beyond the study area.

An explanation for projection of risk calculations over a greater area could be attributed to the size, and the layout of the various land uses within the Hillcrest policing area. Another reason could be that burglars used vehicles (Erasmus & Radebe, 2013: np; Respondent 4, 2015) and they were able to cover a larger area than if they were on foot. To add, Respondent 3 (2015: np), believed burglars travel up to three to five km to carry out burglaries, which explains the spread of risk over greater distances in this research.

Based on the application of the NRC and the analysis of the month-to-month calculations, the findings suggest that the near repeat risk calculations of risk hold a crime prevention value that can assist in resource allocations to intercept and prevent near repeat residential burglaries from occurring; in a similar way to the GMP area (Fielding & Jones, 2012). Further research on the NRC calculator using present data from current residential burglary reports is required to enhance and build on this exploratory research.

5.4 SUBJECT MATTER EXPERTS

The Subject Matter Experts (SMEs) who provided valuable feedback in this research included: Dr Schmitz, a Principal Researcher at the Council for Scientific and Industrial Research (CSIR), Built Environment (South Africa) and Professor Breetzke of the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria (South Africa). These experts were the first SMEs approached by the researcher. Another expert was Dr Landman (previously a Principal researcher at CSIR, Built Environment, South Africa), and currently a lecturer at the University of Pretoria. Dr Landman referred the researcher to Professor Kruger, a Principal Researcher at CSIR, Built Environment, South Africa and to Professor Breetzke (who the researcher had already consulted with). Professor Kruger suggested to the researcher to contact Professor Zinn of the University of South Africa (UNISA), College of Law, School of Criminal Justice, Department of Police Practice.

Dr Schmitz and Professor Breetzke were presented with questions relating to the study's focus and broad goal, the background of the NRC, the study aims, objectives and sample method used to obtain an example of near repeat calculations, including an outline of the possible benefits of the NRC to the SAPS. However, Schmitz provided elaborated answers to all the questions posed to him while Breetzke did not answer all the questions, due to his workload and time constraints. He provided short answers. Hence, Breetzke's answers are only included in the questions he answered.

The following questions were posed to Dr Schmitz and Professor Breetzke:

- What are your comments and opinion on the research focus areas and the goal of this research?
- What are your comments and opinion on the study aims, objectives and sample of this research?
- What are your comments and opinion on the data collection and application of the NRC related to this study?
- What are your comments and opinion on the background of the NRC?
- What are your comments and opinion on the possible benefits of the NRC in South Africa?
- Can environmental factors, such as the location of the residence to main roads, end nodes (cul-de-sacs), various land usages, and railway lines be related to the risk of residential burglary victimisation?

5.4.1 What are your opinion and comments on the research focus areas and the goal of this research?

Schmitz (2016: np) commented that 490 residential burglary cases should be sufficient to test the NRC, but he cautioned that the research findings would be applicable only to Hillcrest police station and could not be extrapolated to South Africa. In line, Breetzke (2016: np) agreed that the sample of 490 residential burglaries would be sufficient to test the NRC.

5.4.2 What are your comments and opinion on the background of the NRC related to this study?

Schmitz (2016: np) commented that the NRC is a handy tool to use and to be applied in a South African context, but he questioned whether police stations (SAPS) have the capability to conduct near repeat calculations and analysis on a regular basis (as required). He further proclaimed that the NRC and Q-GIS are freely available software tools which can run on a standalone computer, but that financial cost is not the issue; rather the skills to carry out the analysis remain a challenge (Schmitz (2016: np). Schmitz' statement is in line with news articles (Guy et al, 2016: np; Mabena, 2017: np) referring to the police being under-resourced. Schmitz (2016: np), accentuated that the NRC has been applied by various law enforcement agencies around the world, and it has been valuable in crime prevention, but he cautioned that these law enforcement agencies are better resourced, both in equipment and staff in comparison to the SAPS. Breetzke did not answer this question.

5.4.3 What are your comments and opinion on the study aims, objectives and sample of this research?

Schmitz (2016: np) concurred with the aims, objectives and sample to test the NRC for this research. He commented that further research on the application of the NRC should include various types of police stations, for example, a rural police station (dense rural such as certain areas in KZN, sparse rural with a small town such as the Free State or the Northern Cape), and other residential areas similar to Hillcrest, and downtown areas such as Durban Central.

According to Breetzke (2016:np), the application of the NRC to examine burglary patterns in a South African context would provide interesting research findings. Breetzke (2016:np) suggested that there is no reason the NRC would not be accurate in a South African context. However, Breetzke (2016: np) cautioned that the usefulness of the NRC may vary depending on the urban area under investigation.

5.4.4 What are your comments and opinion on the data collection and application of the NRC related to this study?

Schmitz (2016: np) agreed that the sample of 490 residential burglaries over a 12-month period would be sufficient to test the application of the NRC. Schmitz (2016: np) proclaimed that the NRC aims to identify repeat and near repeat burglary patterns as close as possible to the initial burglaries, within a certain period so that the police can develop crime prevention strategies. Schmitz (2016: np) also agreed that using a spatial bandwidth up to 500m (which equates to about two street blocks) may be sufficient for urban areas (formal and informal) but stressed that this may not be appropriate for rural areas. Schmitz (2016: np) further emphasised that research findings would only apply to the Hillcrest policing area and not to South Africa as a whole. In addition, Breetzke (2016) commented that Hillcrest (KZN) is a relatively affluent area and comprises of a well-established road network with accurate cadastral boundaries (eThekwini Municipal GIS Data), however, this may not be the case for the informal areas.

5.4.5 What are your comments and opinion on the possible benefits of the NRC in South Africa?

Schmitz (2016: np) replied that this research holds possibilities, but he highlighted that the sample size should include different police stations in different policing areas to ascertain accuracy. Breetzke (2016:np) answered that using a crime analysis tool, (like the NRC) in a South African context is innovative and original because little spatially based crime research has been carried out. He further noted that the probable cause of this research gap is the lack of crime data from the SAPS. Beetzke (2016: np) commented that there is no reason the NRC should not be an accurate tool in a South African context, depending on the area that is focused on.

5.4.6 Can environmental factors, such as the location of the residence to main roads, end nodes (cul-de-sacs), various land usages, and railway lines be related to the risk of residential burglary victimisation?

Schmitz (2016: np), stated: “Literature and experience indicate that certain areas are crime attractors, and these can be addressed through Crime Prevention Through Environmental Design (CPTED) principles.” These CPTED principles are discussed in Chapter 3. Professor Kruger and Dr Landman are experts in the field of CPTED. Breetzke (2016:np) confirmed “That is one of the most important theoretical underpinnings of environmental criminology. That the 'environmental backcloth' of an area creates or reduces the opportunities for crime.” This statement by Breetzke (2016:np) concurs with the CPT regarding the backcloth or environment, and the CPTED which can reduce opportunities for crime.

Dr Landman’s responses are discussed hereunder.

5.4.7 Are you aware of any past or present research on the NRC or near repeat residential burglary patterns in South Africa?

Dr Landman (2017: np) responded that she was not aware of any research on the NRC in South Africa.

5.4.8 To what extent is the GIS used by the SAPS at the station, provincial and national levels?

Landman indicated that she was not aware of any other research on the GIS at station, provincial and national levels, apart from one of her earlier master’s student’s (Snyders, 2016) who completed a Master’s Degree in Town and Regional Planning. The student made use of crime statistics and the GIS at a station level of one precinct in Pretoria.

5.4.9 Are you aware of any past or present research on the use of the GIS at the SAPS station level?

Again, Dr Landman referred the researcher the work of her previous master’s student (Snyders, 2016) who completed a Master’s Degree in Town and Regional Planning.

The research by Snyders (2016) has been included in this research.

On this matter, Kruger's responses to the above two questions are reflected below. Professor Kruger (2017: np) was asked the following questions:

- Are you aware of any past or present research on the NRC or near repeat residential burglary in South Africa?
- To what extent is the GIS used by the SAPS at the station, provincial and national levels?

5.4.10 Are you aware of any past or present research on the NRC or near repeat residential burglary in South Africa?

Kruger (2017: np) was not aware of any research on the NRC or near repeat residential burglary in South Africa. He suggested that the lack of accurate (geocoded) data identifying locations could be a contributing factor. Kruger further added that he has some reservations about the application of models or tools in countries like South Africa, but he was interested in this research on the application of the NRC in a South African context.

5.4.11 To what extent is the GIS used by the SAPS at the station, provincial and national levels?

Kruger (2017: np) answered that the use of the GIS varies considerably between police stations, as does the understanding of how the GIS can be applied.

Professor Zinn (2017: np) was asked the following questions:

- To what extent are the Crime Pattern Analysis (CPA) and the Crime Threat Analysis (CTA) tools used by the SAPS?
- How effective are the CPA and the CTA tools in predicting residential burglary patterns?
- Are you aware of any past or present research on the Near Repeat Calculator (NRC) or near repeat residential burglary in South Africa?
- Do you think the NRC could be a valuable tool for the SAPS at station level to predict near repeat residential burglary patterns?
- What are the advantages and disadvantages of the SAPS using the GIS?

- If the NRC results are used in conjunction with the GIS to create predictive near repeat residential burglary maps, do you think the SAPS will be better informed to allocate resources such as crime prevention patrols in areas with increased risk for residential burglaries?
- At station level, do you think the SAPS has the ability, skills, and resources to run the NRC and the GIS software on a standalone computer, and create up-to-date month-to-month near repeat residential burglary risk maps?
- Can the location of a neighbourhood or houses in relation to the environmental factors, like main roads, road nodes, end nodes (cul-de-sacs), railway lines and land use play a role in the risk of residential burglaries?
- Under which circumstances could a residential burglary in progress escalate to become a house robbery?

5.4.12 To what extent are the Crime Pattern Analysis (CPA) and the Crime Threat Analysis (CTA) tools used by the SAPS?

Zinn (2017: np) was not aware of research data to indicate to what extent the CPA and CTA are used at station level. However, he highlighted that the SAPS do have the capacity at station level and confirmed that the CPA and the CTA tools are used at the cluster and provincial levels. Zinn further added that a problem that researchers come across in their research, or with regards to assistance to police students, is that some individuals do not use the available tools effectively.

5.4.13 How effective are the CPA and the CTA tools in predicting residential burglary patterns?

Zinn (2017: np) proclaimed that the effectiveness of predictive tools (like the CPA and the CTA) is a highly contentious issue. All these models come under scrutiny at international conferences resulting in critical debates on the accuracy of these tools/instruments. Zinn revealed that if a tool is currently accurate in any predictions (or forecasting), it may change overnight as a result of a change in some of the elements that caused the problem in the first place. The researcher submits that these elements could range from target hardening initiatives in a neighbourhood, such as the clearing of overgrown vacant land which harbours criminal activity, community patrols following a newly established neighbourhood watch, or extra police patrols in the area due to crime.

5.4.14 Are you aware of any past or present research on the Near Repeat Calculator (NRC) or near repeat residential burglary in South Africa?

Zinn (2017: np) was not aware of any NRC or near repeat residential burglary research in South Africa.

5.4.15 Do you think the NRC could be a valuable tool for the SAPS at station level to predict near repeat residential burglary patterns?

Zinn (2017: np) commented that the NRC could be a valuable tool to be utilised at the station level, but he emphasised that current residential burglary data must be used in the calculation of near repeat risk.

5.4.16 What are the advantages and disadvantages of the SAPS using the GIS?

Zinn (2017: np) could not answer this on behalf of the SAPS.

5.4.17 If the NRC results are used in conjunction with the GIS to create predictive near repeat residential burglary maps, do you think the SAPS will be better informed to allocate resources such as crime prevention patrols in areas with increased risk for residential burglaries?

Zinn (2017: np) supported the idea that if the NRC results (risk calculations) are used, in conjunction with the GIS to create predictive near repeat burglary maps, that the SAPS will be better informed to allocate resources such as crime prevention patrols in areas with increased risk for residential burglaries. According to Zinn (2017: np), “The best type of crime intelligence, including proactive crime intelligence, should be based on a variety of tools and resources. The more analysis and tools the more accurate the crime intelligence becomes."

5.4.18 At station level, do you think the SAPS has the ability, skills, and resources to run the NRC and the GIS software on a standalone computer, and create up-to-date month-to-month near repeat residential burglary risk maps?

Professor Zinn (2017: np) was not in a position to answer this question and therefore did not provide an answer.

5.4.19 Can the location of a neighbourhood or houses in relation to the environmental factors, like main roads, road nodes, end nodes (cul-de-sacs), railway lines and land use, play a role in the risk of residential burglaries?

Zinn (2017: np) rejoined, "Yes, there is a definite correlation between the environmental factors and burglaries". He added that the link between environmental factors and residential burglaries is supported by international literature, the analysis performed by the ISS (Institute of Security Studies) crime hub on SAPS statistics, and in his own experience as a police officer

This statement by Zinn (2017:np) correlates with the CPT where offenders (burglars) seek out targets to victimise along the paths (roads) and nodes (home or place of work) during their routine activities (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995).

A property may 'flag' the attention of such offenders and which supports the FBT.

5.4.20 Under which circumstances could a residential burglary in progress escalate to become a house robbery?

Circumstances, where a residential burglary may escalate to a residential robbery, would likely include if the burglars unexpectedly encountered someone inside the yard or house (Zinn, 2017: np).

5.5 QUALITATIVE INTERVIEWS WITH DETECTIVES

This section discusses the feedback gathered from the one-on-one qualitative interviews with five detectives from Hillcrest police station. The detectives were asked open-ended structured questions to give the researcher insight into their experiences, expertise, knowledge, and opinions on residential burglaries that have taken place in the Hillcrest policing area. All five detectives participated voluntarily, and they consisted of a mixture of males and females holding various ranks. However, all five detectives had been involved in a number of investigations on residential burglaries, ranging from dozens to several hundred cases. The detectives are referred to as respondents, and each given a number between one and five in order to maintain their privacy, and to keep their identity anonymous which was a condition for their voluntary participation.

5.5.1 Do you map the crimes that you investigate?

Respondent 1 answered that she sometimes maps the crime that she is investigating on a (paper) map. Respondents 2, 3 and 4 stated that they did not map residential burglaries that they were investigating. Respondent 5 noted he used “Street Maps” (a map website) on a computer to map burglaries under investigation. Based on these responses, crime mapping, or the use of the GIS was absent and does not appear to be the norm for residential burglary investigations at Hillcrest. At the time of the interviews, this highlighted the importance and the benefits that the GIS tool could bring to residential burglary investigations (and crime investigations) if utilised at Hillcrest.

According to the CPT, it is believed that offenders (burglars) seek out suitable targets to victimise along the paths (roads and pedestrian walkways) and nodes (home or place of work) during their routine activities (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995). Using the GIS to illustrate the Hillcrest policing area, related environmental factors such as roads; and to map the residential burglary points, may highlight patterns or routines that burglars (offenders) travel along between destinations.

5.5.2 How well planned are residential burglaries?

Respondent 1 was unsure of the distinct types of burglary. Respondent 2 was of the opinion that some burglaries were well planned, and others were committed by drug addicts from nearby informal settlements. According to Respondent 3, burglaries were not planned. Burglars took chances with dogs and fences and had no idea whether anyone was at home or not. Respondent 4 and 5 stated that there were two types of residential burglary: planned and unplanned. Some residential burglaries were planned, using inside information from domestic staff, while unplanned residential burglaries were often motivated by drugs (like Whoonga).

Whoonga is a street drug which was first reported in Durban (KZN) but has spread to other parts of South Africa (Africa Health Placements, 2015: np). It is an addictive combination of detergent powder, rat poison and (sometimes) crushed antiretroviral drugs (ARVs) (Shembe 2013:5). The ARVs are crushed in combination with other drugs like marijuana, and drug dealers also mix or cut the product with soap powder and rat poison to stretch their profits. Whoonga is a cream coloured powder which costs about R20 a smoke (Bryson, 2010: np). Another form of Whoonga is brown heroin mixed with rat poison, ammonia, and another street drug called 'tik' (Chapman, 2013: np). Tik is the street name for crystal methamphetamine (United Nations Office on Drugs and Crime, 2015: np).

The CPT (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Chen et al, 2013; Wang & Liu, 2017) and the FBT (Bowers & Johnson, 2004; Pease, 1998; Wang & Lui, 2017; Wu et al, 2015) can explain planned and unplanned residential burglaries in the Hillcrest policing area. Burglars, or would be burglars, travel along paths and nodes (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995) during their routine activities to search for suitable targets to burgle. A suitable target or house catches the attention or flags the attention of the burglar. The burglar may take the opportunity immediately or plan to return later to carry out the burglary.

5.5.3 In general, how far away do the burglars live and work from the crime scene or burgled property?

Respondent 1 suggested that burglars commit burglaries outside of their own area. Respondent 2, used the following example: burglars travel from Molweni (peri-urban settlement) to commit burglaries in Waterfall (formal urban settlement), from Embo (urban settlement informal and peri-urban settlement formal) to commit burglaries in Hillcrest (formal urban settlement), and from Kwanyuswa (kwasondela area, peri-urban settlement) to commit burglaries in Botha's Hill (consisting of undeveloped and farming land, retail and urban settlement formal). According to Respondent 3, the estimated distance travelled by burglars was three to five kilometres. Respondent 4 said the distance burglars travelled to residential burglary targets could vary. Burglars, however, tended to target nearby properties or areas close to where they lived. Respondent 5 answered, that unplanned burglars were usually local and that burglars stayed in the area of the target properties or houses. Planned burglaries were committed by burglars from outside the area of targeted properties or houses, and they often used motor vehicles to travel. Based on this feedback, burglars appear to travel from peri-urban settlements and informal urban settlements to burgle properties which are mostly formal urban settlements.

The feedback from detectives strongly suggests that burglars travel along paths and nodes to carry out residential burglaries. This fits in with the CPT (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Chen et al, 2013; Wang & Liu, 2017) whereby until suitable property catches a burglar's attention. The burglar either commits the residential burglary at short notice or returns later to carry out the burglary as promulgated in the FBT (Bowers & Johnson, 2004; Pease, 1998; Wang & Lui, 2017; Wu et al, 2015).

5.5.4 What attracts burglars to target a specific house or houses in an area?

Respondent 1 did not have an opinion or suggestion as to what attracts burglars to target a specific property. According to Respondent 2, houses surrounded by trees and vegetation provided cover for burglars. Respondent 2's comment is in line with the CPTED (Cozens & Love, 2017:2; Palmiotto, 2011:171) and the BWT (Kelling &

Wilson, 1982:np; Miller et al, 2014:64-65). Trees, vegetation, and overgrown gardens can hamper natural surveillance. CPTED, with regards to natural surveillance, highlights whether residents can notice strangers in the neighbourhood (Cozens & Love, 2017:2; Palmiotto, 2011:171).

Furthermore, the BWT suggests that unmowed lawns and overgrown gardens can signal disorder and a ‘no one cares’ vibe, allowing incivilities and crime to manifest (Kelling & Wilson, 1982: np; Miller et al, 2014:64-65). Respondent 3 said burglars took chances and targeted all houses, not just “fancy” (affluent) houses. According to Respondent 4, high-class and affluent areas were targeted by organised burglars who usually travelled in vehicles. The use of motor vehicles by burglars can explain the risk calculations over large distances, identified by the NRC. These burglars were usually in and out of a house within two to three minutes, setting-off burglar alarm systems and fleeing before armed response security arrived. In the case of targets that appeared to be easier, with more relaxed security, the burglars would carry the items away on foot. Lastly, Respondent 5 claimed that burglars were attracted by wealth (affluent characteristics). The views of Respondents 4 and 5 (2015:np) are in line with the Flag Theory which states that the attractiveness or perceived wealth of a property draws the attention of would-be burglars (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178).

5.5.5 What factors do burglars take into consideration before committing these crimes?

According to Respondent 1, burglars considered whether the property has Closed Circuit Television (CCTV). Respondent 2 noted that burglars considered the cover of trees and vegetation where they can hide. This is in line with CPTED (Cozens & Love, 2017:2; Palmiotto, 2011:171) as burglars are concerned with being seen and apprehended. Overgrown shrubbery and un-kept gardens provide hiding places by blocking natural surveillance of occupants, neighbours and people passing by. The BWT (Kelling & Wilson, 1982:np; Miller et al, 2014:64-65) also applies, for example, un-kept gardens and a littered street send a ‘don’t care’ attitude to burglars and convey a message that it is unlikely that anyone would be bothered to report anything suspicious to the police.

Respondent 3 posited that burglars often did not know whether someone was in the house when they burgled, which could lead to a confrontation escalating to a residential robbery (house robbery). Respondent 4 felt that burglars monitored the routines of the residents, considered the security of the premises - security gates, fences, walls, dogs - and then decided whether the house was an easy or hard target. Respondent 5 maintains that burglars assess the security of the property. The security of the property can encompass burglar alarms systems linked to an armed response security company, dogs, security gates, burglar bars, CCTV, walls, and fences. The RCT and the RAT form part of the CPT and can be applied to this feedback. Burglars weigh up the pros and cons (risk and rewards) of committing the burglary beforehand, suggesting rational thinking and rational choice by weighing up the security measures of the property (RCT) (Santos, 2017:43; Walklate, 2017:80-81). A motivated burglar, a suitable target, and lack of guardianship form the base of Cohen and Felson (1979) RAT. The RAT applies as Respondent 4 suggested, burglars will monitor the routine activities (coming and going) of the occupants before carrying out the burglary and assess the risks and rewards (target hardening measures versus property to steal) (Natarajan, 2016: xviii; Walklate, 2017:83).

5.5.6 How many burglars are usually involved in residential burglaries?

Respondent 1 expressed that it could be a single burglar or a group of burglars committing residential burglaries. She noted that it could vary, depending on the number of goods taken. Respondent 2 said that there were usually two to three burglars in a group, while Respondent 3 specified two to four burglars in a group. According to Respondent 4, the number of burglars could vary from two to four burglars in an organised group. Respondent 5 commented that drug-dependent burglars burgled alone and that planned burglaries usually consisted of two to four burglars in the group.

5.5.7 What time of day and day of the week do the burglaries mostly occur?

Respondent 1 said burglary times varied and Respondent 2 said burglary times were always changing. Respondent 3 believed most burglaries occurred over weekends when residents went out and left the home unoccupied. Respondent 4 remarked that in the past operations were planned according to the CPA, and the CTA. The CPA and CTA are tools used at station level (Hillcrest police station) to identify hotspots; for operational planning, resource allocation and crime prevention strategies (Krause, 2007:3-4, 35; NRC, 2017:16-17). Respondent 5 cited that planned burglaries were generally between 11 am and 5 pm and unplanned burglaries occurred in the early hours of the morning between 2 am and 4 am. These responses suggested that the time of burglaries varied. Planned burglaries generally occurred between 11 am, and 5 pm and unplanned burglaries between 2 am, and 4 am. From analysing closed-cases in this research, most of the residential burglaries occurred during the day when houses were unoccupied.

This feedback suggests, the RCT and RAT apply to planned and unplanned residential burglaries. The RCT refers to a burglar that weighs up the advantages or disadvantages of committing the burglary, and when to commit the burglary (Santos, 2017:43; Walklate, 2017:80-81). The RAT applies as the feedback suggests that burglars carry out burglaries at certain times, for example during the day when most people are likely to be at work (Cohen & Felson, 1979; Natarajan, 2016: xviii; Walklate, 2017:83). Both the RCT and RAT form part of the CPT.

5.5.8 Do criminals that commit residential burglary escalate to commit robberies at residential premises?

Respondents 1 and 2 believed residential burglars progress to become residential robbers. These respondents explained that when burglars burgle a house, they do not know if anyone is home and the burglary can escalate to residential robbery when the burglar is confronted by a resident (or an occupant). Respondents 1 and 2's statement correlates with Zinn (2017: np), where he noted that burglars are startled by occupants which increases the risk of confrontation, and escalation to residential robbery. Respondents 1 and 2, further added that burglars become more confident and gain experience whenever they burgle a house, which encourages progression from residential burglary to residential robbery. Respondent 3 was unsure whether residential burglars progressed to become residential robbers. According to Respondent 4, drugs could make burglars more confident, leading to escalation from residential burglary to residential robbery, and drugs could also increase the level of violence used by burglars in a confrontation. Respondent 5 answered that criminals can progress their criminal career from residential burglary to residential robbery. Respondent 5 gave an example when the burglars burgle a house, the residents might be out or believed to be out, leaving the house unoccupied. The burglars gained entry only to be startled or surprised by a resident that is home (or a domestic worker); the burglars' panic and either flee the house or retaliate by threatening or attacking the occupant. It is then no longer a residential burglary but has progressed into a residential robbery. Respondent 5 further claimed that the burglars may tie up the occupants and make off with the desired goods.

Based on these answers, residential burglary can progress to residential robbery, and residential burglars can advance their criminal careers by becoming residential robbers. Whoonga and other drugs contribute to this progression which can involve assault, rape, or murder. The RCT (Santos, 2017:43; Walklate, 2017:80-81) applies to these circumstances in that burglars can choose to flee the property when confronted, or to rise to the confrontation and carry out the burglary or robbery. However, if burglars are under the influence, they may not be thinking rationally.

5.5.9 In your investigations, can you identify patterns for a series of crimes?

According to Respondents 1 and 2, when the same burglar, or group of burglars, were operating in an area, it was possible for burglary patterns to be identified. Respondent 3 was unsure whether burglary patterns could be identified. Respondent 4 replied that if a residential burglary took place in a specific area, he checked whether a certain burglar was still in prison. For example, one burglar operating in the Hillcrest policing area was responsible for eight residential burglaries. Respondent 4, believed burglars that have previously been arrested and have served their prison sentence, often return to the same area to continue to commit burglaries. Respondent 5 responded that a burglary pattern could be identified where doors and gates were left open at houses, resulting in burglary opportunities and unplanned burglaries, in the case where wealthy houses were targeted.

The CPT states that offenders (burglars) travel along paths (roads) and nodes (destinations like home or work) during their everyday activities looking for suitable properties to burgle (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Chen et al, 2013; Wang & Liu, 2017). The FBT can explain when a property catches the attention of a burglar (Bowers & Johnson, 2004; Pease, 1998; Wang & Lui, 2017; Wu et al, 2015). The NRBT (Bernasco, 2008:414; Wang & Liu, 2017:1; Wu et al, 2015:178) suggests that nearby properties are at elevated risk for residential burglary following an initial burglary in the area.

5.5.10 Can you predict, based on previous cases, where the next residential burglary is most likely to occur?

Respondents 1 and 3 felt that residential burglary could not be predicted. Respondent 2 reported that when an area is burgled, nearby areas are also at risk of being burgled. Respondent 4 pronounced that it was possible to predict residential burglary by working according to the CPA and CTA. Respondent 5 postulated that it was possible to predict where residential burglary could occur next, for example, when houses in two streets were burgled, and there were access routes to the same roads. Respondent 5 added that burglars target houses with escape routes.

Respondent 2 and 5's comments correspond with the NRBT that an initial burglary transmits a risk of burglary to nearby properties (Bernasco, 2008:414; Wang & Liu, 2017:1; Wu et al, 2015:178). Respondent 5's comment can be ascribed in the CPT where burglars travel along paths and nodes seeking suitable properties to target. The FBT describes the risk that is 'boosted' to surrounding properties following an initial residential burglary (Bowers & Johnson, 2004; Pease, 1998; Wang & Lui, 2017; Wu et al, 2015).

Respondent 4 appears to be confident in predictive tools like the CPA and CTA. Respondent 5's comment concurs with the NRBT and the CPT with regards to access routes (paths) that burglars travel along.

An understanding of the NRBT and the application of the NRC could empower the Hillcrest police to identify near repeat residential burglary patterns which could assist in the allocation of resources to specific areas, for a certain period, to prevent further burglaries from occurring. Based on this research, the NRC can be applied to identify near repeat residential burglary patterns in the Hillcrest policing area.

5.5.11 Would you use the NRC?

Respondents 1, 2 and 3, were unfamiliar with the NRBT or the NRC. Respondent 4 had not heard of the theory or the NRC but had a sound understanding of the CTA and the CPA. Respondent 5 was familiar with the NRBT. The respondents were informed about the NRBT and the NRC, and thereafter all five respondents said they would be willing to use the NRC if it assisted in and added value to their investigations.

From the feedback received from the respondents, it is evident that they are valuable sources with a wealth of experience in the investigation of residential burglaries. Feedback suggests that the GIS was not used by detectives (or at station level) to map the location of residential burglaries or to represent the area they police. It was stated, that affluence or perceived affluence is believed to attract burglars which draws parallels with the FBT (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178). According to the Flag Theory, the attractiveness or perceived wealth of a property draws the attention of would-be burglars (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178). Two types of residential burglaries were identified, namely planned and unplanned. In the case of planned burglaries, offenders may have used motor vehicles, and they travelled further distances to carry out their crimes that occurred mostly during the day.

In contrast, unplanned burglaries took place mostly at night, and the burglars most likely travelled shorter distances on foot. The CTA and the CPA are tools that are currently used at station level to forecast/predict future residential burglary risk and for the planning of operations. Residential burglars generally work in groups but can also work in isolation. Certain circumstances can progress the criminal career from residential burglary to residential robbery: as a burglar’s confidence grows with experience and/or drug use, they can progress their criminal careers from residential burglary to residential robbery; encountering a resident or occupant at home when the home was believed to be unoccupied, causing the confrontation to escalate into a robbery. The CPA and CPT were used to forecast or predict residential burglary patterns in the Hillcrest policing area. When a burglary occurred in a neighbourhood, detectives could gauge that nearby houses may also be at risk of burglary, as the same access routes into the street or neighbourhood, could be used by burglars operating in the area. The statements by the Respondents 2, "…when an area is burgled, nearby areas are also at risk of being burgled" and 5 "…it was possible to predict where residential burglary could occur next, for example, when houses in two streets were burgled, and there were access routes to the same road" on the prediction of residential burglaries support the Flag Theory (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178), and the Boost Theory (Pease, 1998:8-9; Wu et al, 2015:178) and the NRBT (Bernasco, 2008:414; Wang & Liu, 2017:1; Wu et al, 2015:178). The Flag Theory refers to the attractiveness, or perceived wealth, of a property which draws the attention of would-be burglars (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178). The Boost Theory comes into play when a house is burgled for the first time, the risk of another burglary occurring at the same place is boosted, as a result of previous burglary victimisation (Pease, 1998:8-9; Wu et al, 2015:178). All five respondents (detectives) highlighted that they would be willing to apply the NRC if it brought value to and enhanced their residential burglary investigations.

5. 6 CONCLUSIONS

The NRC identified near repeat residential burglary patterns by using 12 months of residential burglary data (April 2012 to March 2013) from the Hillcrest (KZN) police station. A total of 411 (83.9%) residential burglaries ensued at stand-alone houses or properties, and 79 (16.1%) happened within gated communities.

The majority (45.7%) of these residential burglaries occurred during the day, while 33.1% happened at night, and 21.2% took place over a period of longer than 12 hours.

For each month, the burglary data was entered into the NRC, which identified any patterns of risk. The NRC was able to project the location of near repeat residential burglaries from 29.7% to 97.3% accuracy. The purpose of the NRC is not to replace any other tools, but to work in conjunction with the CPT and CPA. As highlighted by Zinn (2017: np), the best type of crime intelligence should include a variety of tools and resources. In addition, Fielding and Jones (2012), noted that tools used for near repeat calculations of risk, and for creating predictive maps should be added to the tools used by police agencies, and not as a sole replacement for current crime analysis tools.

The precision of the NRC over the 12 month period demonstrated predictive value, and it was accurate to 70% in May (2012), 87.9% in June (2012), 45.5% to 72.7% in July (2012), 29.7% to 59.5% in August (2012), 75.7% in September (2012), 46% to 75% in October (2012), 75.6% to 97.3% in November (2012), 86.1% in December (2012), 78% in January (2013), 72.2% to 86.1% in February (2013) and 69% to 81% in March (2013).

Month-to-month spatial analysis of residential burglaries in relation to the previous month's burglary locations suggested a crime prevention value in focusing crime prevention resources to risk areas. Based on this, the allocation of crime prevention strategies may have prevented a significant amount of residential burglaries from as high as 69.4% in February 2013, and as low as 33.3% in March 2013. However, the analysis concluded that had crime prevention resources been allocated, based on the near repeat calculations of risk, that potentially more residential burglaries would have been prevented due to the predictive accuracy of the time-space clustering of near repeat residential burglaries, using the NRC. These findings can be supported by the CPT where burglars, and potential burglars, travel along paths (roads) and nodes (from work or home) until a suitable target flag their attention. The FBT is event-dependent, which means that property flags, or catches the attention of a burglar, who carries out a residential burglary at the property. The initial residential burglary 'boosts' the risk of future burglary victimisation at the same location or nearby properties. The NRBT explains these NRC findings and postulates that an initial burglary elevates the risk of burglary to the surrounding properties (Bernasco, 2008:414; Wang & Liu, 2017:1; Wu et al, 2015:178).

It was established that the CPT and the CPA are tools that are used to predict or forecast the space and time of residential burglaries (Krause, 2007:3,34-35; NRC, 2017:20; National Instruction 3/2011, 2011:5). Respondents 4 and 5 stated that the CPT and CPA are analysis tools used by Hillcrest police station to forecast or gauge the areas at increased risk of residential burglaries. The NRC differs to the CPT and the CPA because the NRC is a tool that focuses specifically on identifying near repeat residential burglary patterns (Chainey & da Silva, 2016; Chen et al, 2013; Piza & Carter, 2018; Schmitz, 2016: np; Wu et al, 2015).

This research consisted of 490 closed-case residential burglaries, out of a total 1013 residential burglary cases reported to Hillcrest Police Station between April 2012 and March 2013. Schmitz (2016: np) and Breetzke (2016: np) agreed that the sample should be adequate to test the application of the NRC in this exploratory research. The SMEs (Breetzke, 2016: np; Kruger, 2017: np; Landman, 2017: np; Schmitz, 2016: np; Zinn, 2017: np) provided valuable feedback and supported the research on the NRC in a South African context. However, Kruger (2017: np) was cautious of models or tools developed for Western countries being applied in South Africa. Schmitz (2016: np) cautioned that this research would only apply to the Hillcrest policing area, and not South Africa as a whole. Breetzke (2016: np) suggested that a lack of essential data from the SAPS hampers spatial-temporal research in South Africa. Zinn (2017: np) stated that predictive tools need to be monitored, as a tool may be accurate at present but may quickly change overnight. Zinn (2017: np) was furthermore in support of using the NRC, in conjunction with the GIS, to create predictive visual maps, which can be used for resource allocation to areas at elevated risk. Schmitz (2016: np) was uncertain if station level staff had the skills to carry out NRC analysis, which would be required on an on-going basis if it was to be effective.

Feedback from the SMEs (Breetzke, 2016:np; Schmitz, 2016:np; Zinn, 2017:np) correlates with research by Clark, (2014:24,27); Moreto et al (2014:1120-1121); Morgan (2000:87, 94); Mundell and Ayres, (2015:7); Olckers (2007:137-138, 140, 142, 222); Snyders, (2016:75); van Zyl (2002:70-71, 125); Winchester and Jackson, (1982: 9,14-15, 39), that proved that environmental factors contribute to the level of risk. Moreto et al (2014:1120-1121) argued that this risk is present before an initial residential burglary is committed, which in turn elevates the near repeat risk of burglary to nearby houses.

The Q-GIS was used to a conduct spatial analysis of residential burglary locations, in relation to environmental factors and found that houses within 500m of undeveloped land experienced most of the residential burglaries (86.7%). Undeveloped land posed the highest risk of burglary to houses in its vicinity. This was followed by 27.4% of residential burglaries occurring within 500m of other farming land and, 9.4% within 500m of urban settlement informal, 2.3% within 500m of peri-urban settlements, and 4.7% within 500m of sugarcane. A considerable number of residential burglaries (37.9%) took place within 500m of railway lines. Many residential burglaries took place along main arterial routes, like Inanda Road and Old Main Road. A total of 32% of residential burglaries occurred within 500m of Old Main Road, and 23.6% within 500m of Inanda Road. A staggering 80.2% of the residential burglaries happened within 200m of a road node, or road intersection and 35.9% within 200m of a cul-de-sac or end node.

From the feedback received from the respondents (detectives) on residential burglaries, it is evident that the GIS is not widely used (if at all) at the station level, for the mapping and investigation of residential burglaries. Burglars are attracted to target houses which are affluent (or perceived to be affluent), which is in line with the Flag Theory (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178), because a suitable target property 'flags' or attracts the attention of the burglars.

Two types of residential burglaries were identified, namely, planned, and unplanned. Planned burglaries were believed to be committed by burglars from out of the area, while unplanned burglaries were carried out by local offenders who stay or live in the area. It was estimated that burglars travel up to three to five kilometres to burgle a house. Burglars considered the security at the property before carrying out a burglary. Planned burglaries were usually committed between 11:00 and 17:00, while unplanned burglaries were said to be committed between 02:00 and 04:00. Snyders (2016: np) had similar findings in Villieria, Pretoria where most of the residential burglaries took place during the day (06:00-18:00). Van Zyl (2002:129) found that 66.6% of burglaries in his study area, occurred when no one was home, meaning that 33.3% occurred while the residents were home. In such circumstances, as highlighted by Zinn (2017: np) and Respondents 1, 2, 4 and 5 (2015: np), if burglars are confronted, the burglary may progress into a residential robbery. According to the RAT burglars carry out burglaries at certain times, for example during the day when the property is unoccupied (Cohen & Felson, 1979; Natarajan, 2016: xviii; Walklate, 2017:83). The RCT suggests that burglars weigh-up the risks and rewards of committing the burglary, and when to commit the burglary (Santos, 2017:43; Walklate, 2017:80-81). Both the RCT and RAT form part of the CPT.

Target hardening devices, such as burglar alarms, do not deter burglars, as planned burglaries are carried out within two to three minutes, and the burglars flee (by motor vehicle) before security can respond. Burglars may progress their criminal career to residential robbery as their confidence grows, with the use of drugs, and/or when the burglars are startled or confronted by an occupant when the house was believed to be empty. The CPA and the CPT are analytical and predictive tools used at station level by the SAPS, to predict the time and location of future burglaries. The NRBT was not widely known by the detectives (respondents), but all five detectives were willing to apply the NRC to their investigations if it added value.

CHAPTER 6

RECOMMENDATIONS AND CONCLUSION

6.1 INTRODUCTION

This chapter commences with the findings and adherence to the research design. The second part of this chapter provides recommendations for future research on the application of the NRC. The recommendations support the inclusion of SMEs views in research, the capturing of the x and y coordinates of residential burglaries by the police, and the essential training of police members to conduct routine near repeat calculations and generate predictive risk maps. Residential burglary statistics, from non-police sources like security companies and neighbourhood watch groups, should ideally be included in near repeat calculations. The police can enhance community participation through local neighbourhood watches or street watches and practice the concepts of the CPTED and the BWT, as the success of these crime prevention strategies relies on community participation. Further research on the role that environmental factors play in residential burglaries is suggested. Lastly, the chapter concludes with an outline of the chapters.

6.2 FINDINGS AND ADHERENCE TO THE RESEARCH DESIGN

The researcher followed the explanatory sequential mixed methods research design for this exploratory research, which made use of both quantitative and qualitative data. The quantitative data, followed by qualitative data was collected during the research and merged together to provide an in-depth understanding of the research problem (Bryman, 2016:692; Creswell, 2014:4, 215; Crowther-Dowey & Fussey, 2013: 207; dos Santo et al, 2017:3; Porche & Spencer, 2017:3). This research is based largely on a quantitative orientation, which made the explanatory sequential mixed methods ideal for this exploratory research (Creswell, 2014:14).

This research focused on the application of the NRC using 490 geocoded residential burglary cases over a 12-month period (April 2012 – March 2013). The NRC was set for the Manhattan Distance Measure with temporal bandwidths of seven days with 30 bands, and 400m spatial bands with 13 spatial bands using p=0.01. The Manhattan Measure was used as the majority of the residential burglaries occurred in urban settlements (91.6%) within the Hillcrest policing area. All 12-months were calculated to these settings. Schmitz (2016: np) agreed with testing the NRC by using bandwidths up to 500m; as 500m is equal to two street blocks. The month-to-month near repeat calculations were performed, and the calculations for each month visualised using the Q-GIS. The quantitative aspect of the research, in the form of secondary data analysis, and risk calculations were conducted and followed by one-on-one qualitative interviews with detectives of Hillcrest police station, and electronic communications with SMEs. All ethical considerations and CRIMSA (2012: np) code of conduct, as well as the principles of the Belmont Report 1979, were adhered to during the research.

The secondary data collection and analysis of all closed-case residential burglaries between April 2012 and March 2013 provided a sample of 490 residential burglary cases. All the residential burglaries in the sample had known street addresses which could be identified using eThekwini Municipal GIS data (cadastral). Breetzke (2016: np) advised that Hillcrest (KZN) has a well-constructed road network and will have accurate cadastral boundaries but cautioned this may not be the case for informal areas (which fall within the Hillcrest policing area). All the residential burglaries were geocoded providing a visual representation of the location of the residential burglaries and x and y coordinates (and dates) necessary for near repeat calculations. Qualitative interviews were conducted with detectives who volunteered to participate, providing that anonymity was ensured. These interviews were conducted at the convenience of the detectives in the privacy of their offices, at Hillcrest police station. All participants were provided with a letter of introduction outlining the purpose of the research, and consent forms which were signed before the start of the interview. The secondary data collection, qualitative data collection (in form of one-on-one interviews with detectives from Hillcrest police station), and electronic communications with SMEs were successful (and valuable to the research) as far as the NRC was recognised as a valuable tool in predicting near repeat residential burglaries.

Reliability was achieved as the application of the NRC identified that near repeat residential burglary patterns were consistent, in terms of the NRCs ability to identify them, in the same way as international research on near repeat residential burglary prediction (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Piza & Carter, 2018; Morgan, 2000; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015). As highlighted by Bachman and Schutt, (2016:85); Creswell (2014: np) and Schutt (2017:244), reliability can be confirmed if the consistency and stability of a measure of a concept can be repeated by a different researcher and in different research projects. Furthermore, this research met the criteria of internal reliability as the indicators of measurement (near repeat residential burglary patterns identified in Hillcrest) are consistent (Bryman, 2016:692). Breetzke (2016: np) held the opinion that there was no reason the NRC would not be accurate in a South African context but warned that this may vary depending on the urban area.

As highlighted by Dr Schmitz (2016: np), these research findings only represent the Hillcrest policing area and not South Africa as a whole. However, the NRC identified the existence of near repeat residential patterns in the Hillcrest policing area within a South African context for the first time. Even though these near repeat residential burglary patterns may differ in space and time, to previous international research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Piza & Carter, 2018; Morgan, 2000; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015), the underlying point is that near repeat patterns exist in the study area, and according to these research findings, the NRC holds a crime prevention value for the Hillcrest police.

The NRC can identify near repeat residential burglary patterns, (as is the case with international research), but the near repeat patterns identified in Hillcrest cannot hold true for South Africa as a whole. The near repeat residential burglary patterns identified in the Hillcrest policing area are similar in nature to international research findings, but cannot be generalised beyond the study area (Bowers & Johnson, 2005;

Chainey & da Silva, 2016; Chen, Yuan & Li, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Morgan, 2000; Piza & Carter, 2018;Townsley et al, 2003; Wang & Liu, 2017; Wu, Xu et al, 2015).

Predictive validity was achieved through the NRC's ability to accurately identify near repeat residential burglary patterns for the following month over a 12-month period (Bryman, 2016:694; Gray, 2014:153). These near repeat calculations of risk were used to create month-to-month predictive risk maps over a 12-month period. For each month, these calculations were compared to the actual location of residential burglaries, to determine the predictive accuracy of the NRC. The NRC was found to be accurate in predicting the space and time locations of near repeat residential burglaries ranging from as low as 29.7% for August 2012, and up to 97.3% in November 2012. Construct validity was met, as the NRC identified near repeat residential burglary patterns which were found to be accurate through month-to-month analysis, confirming its crime prevention value for the Hillcrest police (Bachman & Schutt, 2016:85; Bryman, 2016:69; Gray, 2014:279; Schutt; 2017:240). The geocoded residential burglary points (x and y coordinates) and date were entered in the required format for the NRC and systematically calculated for each month other a 12-month period. The near repeat residential burglary patterns and risk calculations were visualised using the Q-GIS. The statistical validity was met by following this design and a statistical method (Gray, 2014:153). The NRC itself is externally valid, and external validity was achieved in this research as the research findings in terms of identifying the existence of near repeat residential burglary patterns in the Hillcrest policing area, have been identified worldwide by international research (Bryman, 2016:691; Crowther-Dowey & Fussey, 2013: 109; Gray, 2014:280

The existence of near repeat residential burglary patterns has been proven by international research (Bowers & Johnson, 2005; Chainey & da Silva, 2016; Chen et al, 2013; Fielding & Jones, 2012; Johnson et al, 2007; Johnson & Bowers, 2004; Moreto et al, 2014; Piza & Carter, 2018; Morgan, 2000; Townsley et al, 2003; Wang & Liu, 2017; Wu et al, 2015) using the NRC and related different measures. However, the research findings presented here are only applicable to the Hillcrest policing area and not South Africa as a whole (Schmitz (2016: np), making these findings internally valid. As stated by Bryman (2016:692), internal validity refers to the extent to which findings integrate a relationship or link between two or more variables. The geocoded and dated month-to-month residential burglary points entered into the NRC, identified near repeat residential burglary patterns in the Hillcrest policing area.

The NRC calculations over the 12-month period were visualised using the Q-GIS and analysed month-to-month. The month-to-month near repeat residential burglary pattern and risk calculations were analysed against actual reported residential burglaries reported to the Hillcrest police station (April 2012 - March 2013), to give an insight into the predictive accuracy of the NRC. The data that was gathered through one-on-one qualitative interviews with five detectives of Hillcrest police, and the feedback and opinions of SMEs, was combined with the analysis of near repeat calculations of risk to supply a deeper understanding of near repeat residential burglary patterns in the Hillcrest policing area. This exploratory research succeeded in following an explanatory sequential mixed method approach and therein merging the quantitative and qualitative data, to provide a detailed account of the research findings.

The research aimed to apply the NRC to identify near repeat residential burglary patterns in the Hillcrest policing area using 12-months of residential burglary cases reported at the Hillcrest police station. To test the NRCs predictive ability, the near repeat calculations were illustrated using the GIS for each of the 12 months, creating a predictive near repeat risk map for the following month. The findings were analysed and discussed.

The interpretation of the findings suggests that the NRC can be a valuable tool to the Hillcrest police station. The NRC identified near repeat residential burglary patterns in the Hillcrest policing area, which were found to be accurate through comparison with actual reported residential burglaries. The identification of near repeat residential burglary patterns holds a crime prevention value for the Hillcrest police.

The researcher thus successfully answered the research questions namely:

6.2.1 Can the NRC identify near repeat residential burglary patterns in the Hillcrest (KZN) policing area?

The NRC was able to identify near repeat residential burglary patterns in the Hillcrest policing area over a 12-month period.

6.2.2 Can the NRC predict near repeat risk of residential burglaries in the Hillcrest policing area?

It is evident from the findings as discussed above that the NRC can accurately predict near repeat residential burglaries in the Hillcrest policing area. NRC accuracy ranged from 29.7%% to 97.3%, when month-to-month near repeat calculations were compared to actual reported residential burglaries, between April 2012 and March 2013.

6.2.3 Can the NRC be of any value or use to the Hillcrest police for resource allocation, crime prevention strategies and investigations in the Hillcrest (KZN) policing area?

The NRC identified near repeat residential burglaries in the Hillcrest policing area. The NRC can predict or forecast the spatial-temporal locations of near repeat residential burglaries. This holds a crime prevention value for Hillcrest police. With this insight, valuable resources in the form of patrols and workforce deployment can be assigned to certain areas of elevated risk for a certain period.

Schmitz (2016: np) highlighted that the aim of the NRC was to identify repeat and near repeat residential burglary patterns, close to where the first burglary occurred and within a certain period so that the police can prevent further residential burglaries from occurring.

6.2.4 Can the GIS be a valuable visualisation and analytical tool at Hillcrest (KZN) police station?

The research findings strongly support that the GIS as visualisation and analytical tool should be utilised at the Hillcrest police station. The GIS (Q-GIS) was used to map the Hillcrest policing area, and the sample of 490 residential burglaries was pinpointed or geocoded for each month over 12 months. The NRC results were visualised using the GIS, and spatial analysis was conducted to determine the month-to-month risk calculations, against actual reported residential burglaries, to determine the accuracy of the predictive risk maps.

6.3 RECOMMENDATIONS

SMEs should be included at the early stages of future research endeavours. In this research, SMEs like Dr Schmitz, Professor Kruger, Professor Breetzke, Dr Landman and Professor Zinn, brought value to this research by confirming the value and need of the NRC, to identify near repeat residential burglary patterns in the Hillcrest (KZN) policing area for the first time.

This research consisted of 490 closed-case residential burglaries out of a total of 1013 reported Hillcrest Police station between April 2012 and March 2013. The cases displayed street addresses that could be identified using eThekwini Municipal GIS data (cadastral). It is recommended that future studies of the NRC should make use of current residential burglary statistics and include all the reported cases of residential burglary; not only closed cases. Access to closed-cases of residential burglaries was permitted for this exploratory research. As highlighted by Schmitz (2016:np), future research on near repeat residential burglaries, and the application of the NRC, should include a broader sample of police stations, such as a police station in a dense rural populated area in KZN, a police station in sparse rural areas with small towns in the Free State or Northern Cape, and downtown Durban Central police station (urban area).

For future research purposes, all residential burglaries reported to the SAPS should include the x and y coordinates for the address or location of the burgled home. The reason for this is to ensure that all residential burglary occurrences, even if there is no known or fixed street address, can be geocoded or mapped using the GIS. The same applies to units within complexes or gated communities. The detective who visits the crime scene and investigates the burglary can do this using a GPS. The same can apply for all residential burglaries reported to other establishments, like the neighbourhood and street watches, and armed response security companies. Recording of the x and y coordinates is essential for the NRC.

Additional research in the application of the NRC would result in more detailed near repeat calculations of risk for residential burglaries. Thus, further research should be carried out. Once the application of the NRC in the Hillcrest policing area has been streamlined, then the near repeat calculations of risk can be included in support systems, or decision-making regarding the CPA and CTA, for resource allocation to specific areas at specific times. Zinn (2017: np) emphasised that the best type of intelligence consists of proactive crime intelligence based on a variety of tools and resources. He further proclaimed that the more analyses and tools applied, the more accurate the crime intelligence will be (Zinn, 2017: np). In addition, Kruger (2017: np), suggested that the lack of research in this area could be attributed to a lack of accurate (geocoded) data for some locations. Regarding this matter, Breetzke (2016: np), believed there is no reason the application of the NRC in a South African context would be inaccurate, but he noted that accuracy may depend on the urban area. Kruger (2017: np) expressed his reservations about predictive tools from developed countries being applied in the South African context. However, future research on the NRC can either prove or discredit it as a tool applied in the South African context.

Likewise, the GIS and NRC tools should be implemented at the station level, and members should be trained to conduct near repeat calculations and visualise data using the GIS to create predictive risk maps, based on near repeat calculations of risk. These maps should be updated on a weekly or monthly basis. However, Schmitz (2016: np) cautioned that even though the Q-GIS and the NRC are freely available, the skills necessary to carry out this analysis may be lacking in SAPS staff. The effective training of SAPS members at station level in the use and application of the GIS (Q-GS) and the NRC, would be an advantage.

Zinn (2017: np), supported the idea of the application of the NRC and the GIS to create predictive risks maps and confirmed that the application of these tools would be of advantage to the SAPS for resource allocation, for the prevention of residential burglaries. Zinn (2017: np) however cautioned that if tools such the NRC, the CPA and CPT are currently accurate in predictions (or forecasting), they may change, and should thus be subject to on-going reviews.

The lack of crime statistics from the SAPS remains a challenge and this could be the reason for the dearth in research of this nature (Breetzke, 2016: np). Since only half of the residential burglaries are reported to the police (Statistics South Africa, 2012:3; Lehohla, 2014:59, Lehohla, 2017a:1; Lehohla, 2017b:65), residents may report residential burglaries to other establishments like armed response security companies, and neighbourhood and street watches, instead of reporting it to a police station. Concerning this research, if the Hillcrest police included the aforementioned sources of crime statistics and if they allowed for and included the residential burglary incidents, then the data could have been captured by the CPA and the CTA, which are currently used by the SAPS for resource allocation. The residential burglary statistics provided by armed response security companies, and neighbourhood and street watch groups, will enhance the application of the NRC to identify near repeat residential burglary patterns, in the Hillcrest policing area. The NRC differs to the CPT and the CPA because the NRC is a tool that focuses specifically on identifying near repeat residential burglary patterns (Chainey & da Silva, 2016; Chen et al, 2013; Piza & Carter, 2018; Schmitz, 2016: np; Wu et al, 2015).

The Hillcrest police should promote community participation and educate the public on the importance of reporting crimes like residential burglaries. The public should be encouraged to establish, or join existing neighbourhood or street watch groups, and should be educated on community-minded crime prevention theories like the CPTED (Safer Spaces, [Sa]: np) and the BWT (Snyders, 2016:28) which rely on community participation. The HPNW is a good example of a community that empowered themselves and took ownership of their neighbourhood through community participation, and the application of crime prevention theories like the BWT and the CPTED.

With regards to environmental factors, such as location of the residence to main roads, end nodes (cul-de-sacs); various land usages; and railway lines as factors relating to the risk of residential burglary victimisation, Schmitz (2016:np), stated, “Literature and experience indicate that certain areas are crime attractors and these can be addressed through Crime Prevention Through Environmental Design (CPTED) principles.” Schmitz’s (2016: np) statement corresponds with the research of Moreto et al (2014:1120) who highlighted, using the RTM and NRC, that specific environments or locations are at higher risk for initial residential burglaries than others.

Breetzke (2016:np) confirmed that environmental factors are one of the most important theoretical underpinnings of environmental criminology and that the 'environmental backcloth' of an area creates or reduces opportunities for crime. Zinn (2017: np), also confirmed that there is a definite correlation between environmental factors and burglaries. Statements on environmental factors by Schmitz (2016:np) and Breetzke (2016:np) concur with the CPT in terms of the backcloth or the environment in which offenders travel along paths (roads) and nodes (work or home) during their routine activities, where a suitable target property 'flags' their attention (FBT). In contrast to the CPT and FBT; the CPTED theory aims to reduce opportunities for crime by enhancing surveillance, increasing visibility, encouraging territoriality, managing access and escape routes, improving image and aesthetics and target hardening. The BWT concurs with the CPTED, which promotes ownership of the environment.

More research into the role that environmental risk may play in residential burglary victimisation in the Hillcrest policing area, will be beneficial as it will help to prevent the initial residential burglary from occurring, which elevates the residential burglary risk to surrounding properties. This statement is supported by Moreto et al (2014:1120-1121) who stated that risk is present before an initial residential burglary has taken place, which escalates the (near repeat) risk of burglary to nearby houses. Prior research by Clark, (2014:24,27), Moreto et al (2014:1120-1121), Morgan (2000:87, 94), Mundell and Ayres, (2015:7), Olckers (2007:137-138, 140, 142, 222), Snyders, (2016:75), van Zyl (2002:70-71, 125), and Winchester and Jackson, (1982: 9,14-15, 39) identified environmental factors that contribute to the risk of residential burglary victimisation.

6.4 CONCLUSION

Chapter 1 commenced by recognising international research on near repeat residential burglary patterns. The NRC was introduced, as well as the CPA and CPT analysis tools currently used by the SAPS.

The aims and objectives of the research were presented, and the research questions were highlighted. The following basic key concepts were defined for the reader: environmental criminology, the GIS, crime mapping, the Q-GIS, crime analysis, near repeat burglary, the NRC, DSS, residential burglary, and robbery at residential premises. Furthermore, the research methodology was outlined, namely the mixed-methods approach, unit of analysis, data collection methods, reliability and validity and ethics followed, which were discussed in further detail in Chapter 4.

Chapter 2 introduced the work of Morgan in Australia, who was the first to identify near repeat residential burglary patterns which opened the doorway to international research on the near repeat residential burglary patterns in Australia (Johnson et al, 2007; Morgan, 2000; Townsley et al, 2003), Brazil (Chainey & da Silva, 2016), China (Chen et al, 2013; Wang & Liu, 2017; Wu et al, 2015), New Zealand (Johnson et al, 2007), the Netherlands (Johnson et al, 2007), the UK (Bowers & Johnson, 2005; Fielding & Jones, 2012; Johnson & Bowers, 2004; Johnson et al, 2007) and the USA (Johnson et al, 2007; Moreto et al, 2014; Piza and Carter, 2018).

Early developments of the GIS was outlined by Tomlinson in Canada in the 1960s and the research highlighted the international development and popularity of the GIS as a spatial analysis tool. The GIS provided a platform for the development of crime mapping and crime analyses by law enforcement agencies around the world. The application of the GIS in an African context was considered. In South Africa, the development of the GIS by the SAPS began in the 1990s, but the extent to which it is currently used by the SAPS is unclear. Environmental factors and the link to residential burglaries were highlighted by international research findings. Different housing types had been identified that could spread the near repeat risk (or contagion) to surrounding properties, following an initial residential burglary. However, it was reported that environmental factors can increase the risk of the first initially residential burglary in an area.

Chapter 3 highlighted criminological theories to wit CPT and the FBT to explain initial residential burglaries, and near repeat residential burglary patterns in the Hillcrest (KZN) policing area. The CPT borrows from the RCT and the RAT, which state that burglars' awareness space is along the nodes and paths of the environment in which they go about their routine activities until a suitable target catches or flags their attention. The FBT states that certain properties catch or flag the attention of burglars and potential burglars, which might result in a burglary in the area. The FBT suggests that risk is elevated or ‘boosted’ following the initial burglary, where burglars may return for goods not taken during the initial burglary or share information about the property within their criminal network. The heightened risk is short-lived and diminishes quickly following target hardening measures taken by the residents or burglary victims.

The HPNW applies the CPTED and the BWT to assist in the prevention of residential burglaries (initial and near repeat) in the Hillcrest policing area. Both the CPTED and BWT require community participation and working with local law enforcement to successfully prevent residential burglaries (and other crimes) in their area. The CPTED consists of five principles namely: surveillance and visibility, territoriality, access and escape routes, image and aesthetics and target hardening. The BWT is largely based on order maintenance of the environment or neighbourhood, which sends a clear message of ownership by ensuring the neighbourhood is well maintained and litter and graffiti free.

In Chapter 4, the methodological outlay of this exploratory research was outlined in detail. The value of this research regarding the application of the NRC to identify near repeat residential burglary patterns in the Hillcrest (KZN) policing area; and to assist with the deployment of valuable police resources to specific areas, or for a specific period to prevent further residential burglaries, was discussed. The GIS (Q-GIS) was used to visualise the Hillcrest policing area, residential burglary locations and the near repeat calculations of residential burglary risk. The objective of the research was to test the predictive accuracy of the NRC on month-to-month near repeat calculations of risk over 12 months. The GIS was used to conduct spatial analysis of the residential burglary locations, and environmental factors such as neighbouring land usage, railway lines, main roads, road nodes or intersections and cul-de-sacs or end nodes. Month-to-month spatial analysis of residential burglaries, in relation to the previous month’s burglaries, was analysed to prove whether the NRC has a crime prevention value. Both the NRC and the Q-GIS are free downloads.

An exploratory research design was followed because of limited research on this topic in South Africa. The unit of analysis consisted of docket analysis (secondary data collection) of 490 residential burglary cases reported to the Hillcrest (KZN) police station between April 2012 and March 2013. The researcher was only granted permission to access closed-cases. A sequential mixed methods approach was found to be the most appropriate data collection method for this exploratory research, as it allowed the merging of quantitative and qualitative data for a deeper understanding of the research topic. The quantitative aspect of this research consisted of secondary data collected through docket analysis, the geocoding of residential burglary points, and the near repeat calculations of risk. The qualitative aspect of this research entailed confidential qualitative interviews with five detectives from the Hillcrest (KZN) police station. The qualitative aspects also consisted of electronic communications with SMEs - Dr Schmitz, a Principal Researcher at the Council for Scientific and Industrial Research (CSIR), Built Environment (South Africa); Professor Breetzke of the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria (South Africa); Dr Landman (previously a Principal researcher at CSIR, Built Environment, South Africa), and currently a lecturer at the University of Pretoria; Professor Kruger, a Principal Researcher at CSIR, Built Environment, South Africa; and Professor Zinn of the UNISA, College of Law, School of Criminal Justice, Department of Police Practice.

The researcher described how validity (predictive, statistical, construct and external) and reliability was met through the research methodology followed. Permission for this research was demonstrated by following the ethics outlined by UNISA, College of Law Research and Ethics Committee (Ref: CLAW 2015 ST 11, see Annexure 3), and the permission and guidelines from the SAPS's Head of Strategic Management; the Division Commissioner of the Detective Service; and the Provincial Commissioner. The researcher respected the CRIMSA code of conduct, and the ethical principles and guidelines described in the Belmont Report,1979.

In Chapter 5, the near repeat calculations of risk were applied to 12 months of Hillcrest police residential burglary data (April 2012 – March 2013). The NRC identified a significant amount of near repeat residential burglary patterns. Through docket analysis, the researcher established that a total of 411 (83.9%) residential burglaries happened at stand-alone houses or properties, and 79 (16.1%) occurred within gated communities.

For each month, other the 12-month period, the burglary data was calculated using the NRC, with the aim of identifying any near repeat residential burglary patterns in the Hillcrest policing area. It was established that the NRC was able to forecast the locations of near repeat residential burglaries with accuracy ranging from 29.7% to 97.3%. The researcher stated that the purpose of the NRC was not to replace any current analysis tools used by the SAPS such as the CPA and CTA, but rather presented a valuable tool to specifically identify near repeat residential burglary patterns. As emphasised by Zinn (2017: np), the best type of crime intelligence should include a variety of tools and resources. In addition, Fielding and Jones (2012) promoted the application of the NRC, and the creation of predictive risks maps using the GIS, as additional tools to be utilised by police agencies to prevent near repeat residential burglaries, and not as a replacement for any crime analysis tools currently used.

The NRC proved its ability to accurately predict near repeat residential burglary locations over a 12-month period. This precision was highlighted by the accurate prediction of 97.3% of the residential burglary locations in November (2012). The month-to-month spatial analysis of residential burglaries that occurred within 500m of the previous months' burglaries topped off at 69.4% in February 2013. However, the analysis concluded, that had crime prevention resources been allocated based on the near repeat calculations of risk; potentially more residential burglaries would have been prevented based on the NRCs accuracy for predicting the locations of near repeat residential burglaries in the study area.

The CPT was confirmed in this study's findings and further explained that burglars and potential burglars travel along paths (roads) and nodes (work or home) until a suitable target 'flags' their attention (Brantingham & Brantingham, 1984; Brantingham & Brantingham, 1993; Brantingham & Brantingham, 1995; Chen et al, 2013; Wang & Liu, 2017). The FBT promulgates that a suitable target catches the attention of the burglars and that 'boost is event dependent', which means that property flags or catches the attention of a burglar who carries out a residential burglary at the property. The initial residential burglaries ‘boost’ the risk of repeat residential burglary victimisation at the same location, or nearby properties. The NRBT, which elaborates that an initial burglary heightens and transmits the risk of burglary to surrounding properties, which boosts the risk of future burglary victimisation either at the same location or nearby properties; was also applicable to the research (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178). The NRBT explains these NRC findings and proves that an initial burglary elevates the risk of burglary to the surrounding properties (Bernasco, 2008:414; Wang & Liu, 2017:1; Wu et al, 2015:178).

It was established that the CPT and CPA are analysis tools used by the SAPS to predict or forecast the space-time clustering of crimes, like residential burglary (Krause, 2007:3,34-35; NRC, 2017:20; National Instruction 3/2011, 2011:5). In addition, Respondents 4 and 5 stated that the CPT and the CPA are analysis tools used by Hillcrest police station to forecast, or gauge, the areas that are at higher risk of residential burglaries. It must be emphasised that NRC is different from the CPT and the CPA, because the NRC is designed specifically to identify near repeat residential burglary patterns (Chainey & da Silva, 2016; Chen et al, 2013; Piza & Carter, 2018; Schmitz, 2016:np; Wu et al, 2015).

Regarding the sample, Schmitz (2016: np) and Breetzke (2016: np) agreed that the sample should be adequate to test the application of the NRC in this exploratory research. The SMEs (Breetzke, 2016: np; Kruger, 2017: np; Landman, 2017: np; Schmitz, 2016: np; Zinn, 2017: np) supported the research on the NRC in a South African context and provided valuable feedback, which was discussed in detail.

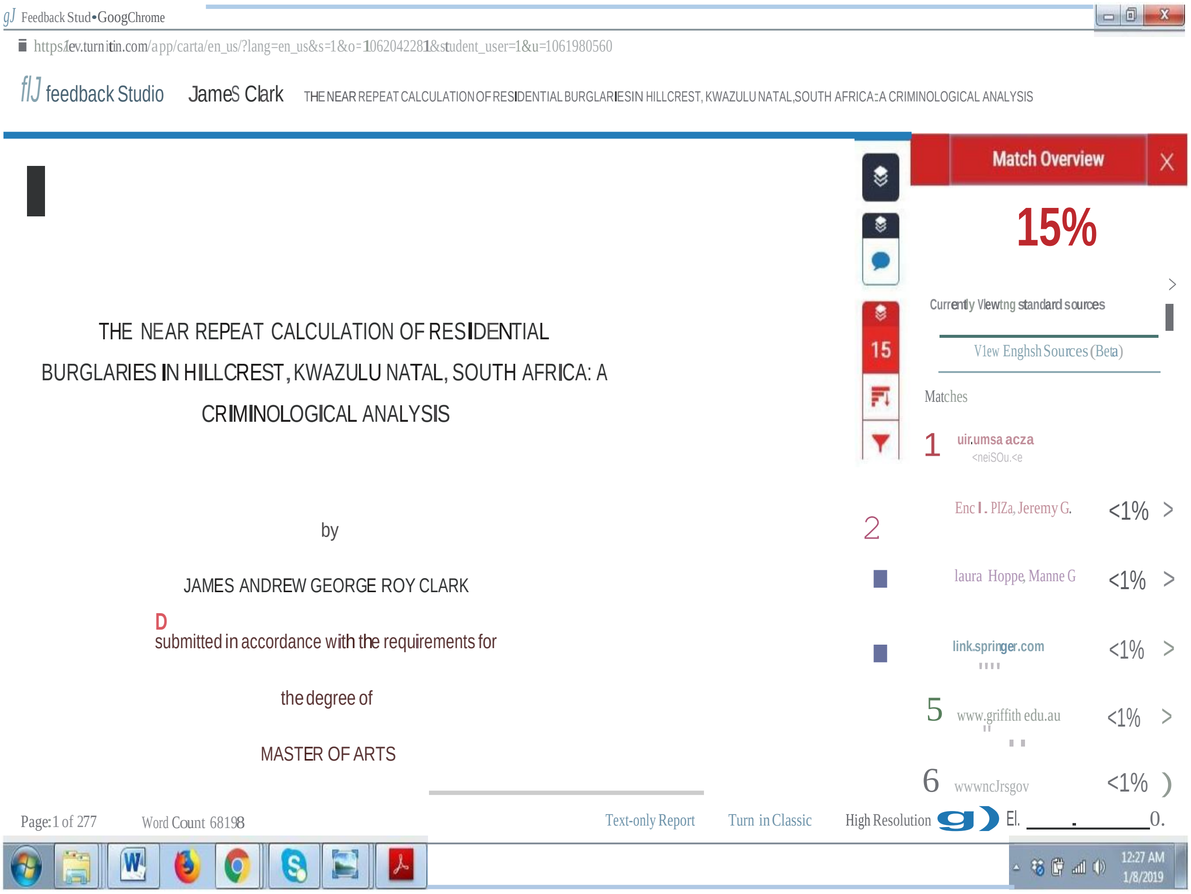
Feedback from the SMEs (Breetzke, 2016:np; Schmitz, 2016:np; Zinn, 2017:np) correlates with research conducted by Clark (2014:24,27); Moreto et al (2014:1120-1121); Morgan (2000:87, 94); Mundell and Ayres (2015:7); Olckers (2007:137-138, 140, 142, 222); Snyders (2016:75); van Zyl (2002:70-71, 125); and Winchester and Jackson (1982: 9,14-15, 39), that environmental factors contribute to the level of risk. In this regard, Moreto et al (2014:1120-1121) argued that the risk is present before an initial residential burglary is committed, which in turn elevates the (near repeat) risk of burglary to nearby houses.

The Q-GIS was used to conduct spatial analysis of residential burglary locations in relation to environmental factors. Houses within 500m of undeveloped land experienced the majority of the residential burglaries (86.7%), followed by other farming lands at 27.4%. Undeveloped land posed the highest risk of burglary to houses in its vicinity. Other neighbouring land uses (urban settlement formal, peri-urban settlement, and sugarcane fields) were found to pose significantly less risk in comparison to undeveloped land. Many residential burglaries (37.9%) took place within 500m of railway lines. A large number of residential burglaries took place along main arterial routes, like Inanda Road and Old Main Road. A total of 32% of residential burglaries occurred within 500m of Old Main Road and 23.6% within 500m of Inanda Road. A staggering 80.2% of the residential burglaries happened within 200m of a road node or road intersection, and 35.9% ensued within 200m of a cul-de-sac or end node.

Through interviews with the respondents (detectives), it was concluded that the GIS is not widely utilised at station level for the mapping and investigating residential burglaries. Burglars are attracted to target houses which are affluent (or perceived to be affluent), which is in line with the FBT (Bowers & Johnson, 2004:12; Pease, 1998:8-9; Wang & Liu, 2017:2; Wu et al, 2015:178), because a suitable target 'flags' or attracts the attention of the burglars.

From the feedback, it was established that residential burglaries in the study area could be one of two types of burglaries: planned and unplanned. It was proposed that planned burglaries were the work of burglars from other areas, and unplanned residential burglaries were normally the work of burglars living in the area. It was established that burglars travel up to three to five kilometres to carry out a residential burglary. Burglars consider the security of the property, and the routine of the residents when deciding wherever to burglarise a property or not. Target hardening in the form of burglar alarms linked to a security company did not deter burglars, because often the burglars had fled, with the desired goods, within two to three minutes before anyone could respond. If burglars are on drugs (like Whoonga) while carrying out a burglary and were confronted by a resident at home, the incident may escalate from burglary to a robbery at residential premises. Both the RCT and the RAT form part of the CPT. The CPA and the CPT are crime analysis tools used by Hillcrest police station and the SAPS. The NRBT was not widely known by the detectives (respondents), but all five detectives were willing to apply the NRC to their investigations if it added value. Finally, recommendations were made about future research on the application of the NRC.

APPENDIX A - TURNITIN REPORT



APPENDIX B - EDITOR'S LETTER

DR MG KARELS

Email: korelsmg@outlookcom

PO Box 17589
Bredell
Benoni
1501

CONFIRMATION OF ENGLISH *EDITING*

To whom it may concern

This is to certify that the thesis with the title "THE NEAR REPEAT RISK CALCULATION OF RESIDENTIAL BURGLARIES IN HILLCREST, KWAZULU NATAL, SOUTH AFRICA: A CRIMINOLOGICAL ANALYSIS", to be submitted for examination by JAMES ANDREW GEORGE ROY CLARK, has been edited for language under my hand. Neither the research content nor the researcher's intentions were altered in anyway during the editing process.

I applied standard United Kingdo11 English language conventions during the editing process. I stand by the quality of the English language in this document, provided my amendments hove been accepted and further changes mode to the document hove been submitted to me for review.

Or MG Karels

karell smg@outlook.eom

ANNEXURE 1: CHANGE OF TITLE AND SUPERVISION

30/10/2018 Gmail - FW:HD meeting feedback

From:Schoeman, Marelize
Sent:29 May 2017 11:26 AM
To:Hesselink, Ann-Mari <Hesselae@unisa.ac.za>;Dastile, Nontyatyambo <Dastinp@unisa.ac.za>
Subject:HD meeting feedback

Dear Colleagues,

Herewith feedback from the HD committee:

(a) Clark, J – MA in Criminology (4346-739-3) Approved

Amendment of title and change of supervisor:

Amended title: The near repeat risk calculation of residential burglaries in Hillcrest, Kwazulu Natal, South Africa: a criminological analysis

Previous title: The application of the near repeat calculator as an investigative tool in the prevention of burglary in Kwazulu Natal, South Africa: a criminological analysis

Supervisor: Prof AE Hesselink

Co-supervisor: Prof NP Dastile

Previous supervisor: Prof BW Haefele

Kind regards,

Marelize

Prof M Schoeman
Department of Criminology and Security Science
College of law
Tel: 012 433 9491
Email: schoemi@unisa.ac.za

httpsJ/mail.google.com/maiVu/O?ik=eaae0ab056&view=pt&search=all&permthid=thread-f%3A1568723568889136126&simpl=msg-f%3A15687235688... 213

ANNEXURE 2: TEMPLE UNIVERSITY PERMISSION LETTER

TEMPLE UNIVERSITY®

Ocputf!lo:nt or C1imi'' ''JV$ri<:e
111.) i>olctt Wlt
.)0-Fl. G leltU l-leU
Phi lecltfpnie, £>l, 19122

fMti-, 11S-104-791.S
fGJI 21)-2CK-1812
, ..www.tcmplc.cclu/cj

July 28, 2016

James Clark

UNISA MA Criminology student

Student number: 43467393

Please use this letter as permissi on to use the Near Repeat calculator software for your project and dissertat on. Please also advise the University of South Africa powers-that-be that the software is in the public domain and the freeware license agreement is available online for their perusal. Perhaps this might helP' them avoid forcing their students to indulge in such irrelevant and unnecessary requests in the future.

Regards

Jerry Ratcliffe
Professor
Department of Criminal Just ce

ANNEXURE 3: COLLEGE OF LAW RESEARCH ETHICS REVIEW COMMITTEE (CLAW) APPROVED

UNISA university of south africa

Ref:ClAW 2015 ST11
Applicant: J ClARK

COLLEGE OF lAW RESEARCH ETHICS REVIEW COMMITTEE

2015/02/10

Dear J Clark

ETHICAL CLEARANCE APPLICATION: THE APPLICATION OF THE NEAR REPEAT CALCULATOR AS AN INVESTIGATIVE TOOL IN THE PREVENTION OF BURGLARY IN HILLCREST,KWAZULU-NATAL, SOUTH AFRICA.A CRIMINOLOGICAL ANALYSIS

Thank you for the application for research ethics clearance by the College of law Research Ethics Review Committee for the above mentioned research project. The ethicalclearance application for the above mentioned research project has been approved.

The proposed research may now commence with the proviso that:

1) *The reseorcher/s will ensure that the research project adheres to the values and principles expressed in the UN/SA Poliey on Research Ethics, which con be found at the following website: http://www.uniso.oc.za/cmsys/stoff/contents/deportments/res_policiesjdocs/Poliey_ Reseorch%20Ethics_rev%20app!i620Counci/_22.06.2012.pdf*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the Chair of the College of Law's Research Ethics Review Committee. An amended application could be requested if there ore substantial changes from the elCisting proposal, especially if those changes affect any of the study-related risks for the research participants.*
3) *The researcher will ensure that the research project adheres to any applicable notional legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.*

Yours Faithfully,

Chairperson Research Ethics Review Committee
College of Law

Prof R Songca
Executive Dean
College of Law

Vnr..c.-r i:y ofOuih A!.'lea
Freller Sv ;et f.-1.d:lenev<. C·,-o:"Ts.h :cre
PO Box 392 UNISA 0003 South Afnca
lek;'A10"¥- -o2i 124293i11 Fanirmle •27124294iSO
www.unisa.ac.za

Open Rubric

ANNEXURE 4: RESEARCH REQUEST AND SAPS APPROVAL

SOUTH AFRICAN POLICE

IlltATii!IGiiC – A – NT COIITTTNI!NT

INI:ETOfi:IA

Reference No	[illegible]
Navrae / Enquiries	[illegible]
Telefoon / Telephone	[illegible]
Faksnommer / Fax number	[illegible]

A. The Divisional Commissioner
DETECTIVE SERVICE

Col Van Der Linde

KWAZULU-NATAL

ARCH REQUEST: THE APPLICATION OF NEAR RISK CALCULATION AS AN ATIVE TOOL IN THE PREVENTION OF BURGLARY IN HILLCREST, KWAZULU ESEARCHER: MR JAMES CLARK

The research request of Mr James Clark, pertaining to the above mentioned topic, refers. Mr Clark is currently a MA Criminology student at UNISA.

The aim of the research is to establish whether the near risk calculation can be a valuable investigative tool for the police, in order to predict the risk of residential burglaries and other crimes such as robbery with aggravating circumstances. (see proposal attached)

The researcher requests permission for the following:

access to dockets on house breakings and robberies with aggravat circumstances in Hillcrest.

interviewing detectives investigating the above mentioned crimes in

detailed crime statistics for house breakings and robberies with aggravatin circumstances reported to the Hillcrest SAPS between July 2012 and June 2013.

With regard to par 3.1, this office is recommending that access should be limited to closed dockets only.

With regard to par 3.3, the researcher should use the crime statistics as displayed on the SAPS website.

The proposal was perused according to National Instruction 1 of 2006 by this

RE: RESEARCH REQUEST: THE APPLICATION OF NEAR RISK CALCULATION AS AN INVESTIGATIVE TOOL IN THE PREVENTION OF BURGLARY IN HILLCREST, KWAZULU-NATAL RESEARCHER: MR JAMES CLARK

office and it is recommended that permission be granted for the research subject to the final approval and further arrangements by the office of the Provincial Commissioner: KwaZulu-Natal and the Divisional Commissioner: Detective Service and that the undertaking be obtained from the researcher prior to the commenceme of the research that –

the research will be at his [redacted]

he will conduct the research without any disruption of the duties of members of the Service and where it is necessary for the research goals, research procedure or research instruments to disrupt the duties of a member, prior arrangements must be made in good time with the commander of such member;

the researcher should bear in mind that participation in the interviews must be on a voluntary basis;

[redacted] will at all times be treated as strictly confidentia

if information pertains to the investigation of crime or a criminal case, the researcher must acknowledge that he, by publication thereof, may also be guilty of defeating or obstructing the course of justice or contempt of court;

the final draft document will be tested with the Provincial Commissioner: KwaZulu-Natal and the Divisional Commissioner: Detective Service to confirm whether the research ethics have been adhered to, prior to the publication of the research article/report, and [redacted]

he will donate an annotated copy of the research work to the

[redacted]

With kind

MAJOR GENERAL
HEAD: STRATEGIC MANAGEMENT
M MENZIWA

Date: 2014

ANNEXURE 5: SAPS RESEARCH APPROVAL

South African Police Service

Suid-Afrikaanse Polisiediens

Umbutho Wamaphoyisa Aseningizimu-Afrika

Our Refllrence / U Veowyslng / I<*omba Y-'<ho		THE PROVINCIAL COMMISSIONER
My Refwence / My Yeowysing /Inl<ambe Yeml	211171121213(271)	IWJAZULU-NATAI..
Enq - - Navr./ Buzlo	Colonel A.D.111111 clar l.ble / CN:.R. Moodley	POBOX1965
Telephone / Tellofocn II.Jango	031–3264841 /8118	DURBAN
Fax No / Fek• No	031–3258022	4000

Mr James Clark
P.O. Box 1995
LINK HILLS
3652

RE: RESEARCH STUDY: THE APPLICAnoN OF NEAR RISK CALCULAnoN AS AN INVESTIGATIVE TOOL IN THE PREVENTION OF BURGLARY IN HILLCREST,KWAZULU-NATAL: RESEARCHER: MRJAMESCLARK

Attached, please find Head Office minute 313412 dated 2014-06-06 from the office of Major GeneralMenziwa regarding permission to conduct the above-mentioned research.

Recommendation to conduct the said research has been granted in terms of SAPS Research Policy (National Instruction 112006).

Approval from the office of the Divisional Commissioner: Detective Service as 'N911 as the Provincial Commissioner ls hereby granted to oonduct the research on oondltlon that the contents stipulated in paragraphs 4,5 and 6 af Head Office minute 3134/2 dated 2014-06-<>6 are adhered to prior to the commencement of the research study.

P8ge 1of2

RE: RESEARCH STUDY: THE APPLICATION OF NEAR RISK CALCULATION AS AN INVESTIGATIVE TOOL IN THE PREVENTION OF BURGLARY IN HILLCREST, KWAZULU-NATAL: RESEARCHER: MR JAMES CLARK

Kindly be advised that all statistics accessed must be officially released statistics (up to the end of March 2013).

For any queries, please contact Colonel A.D. van der Linde on the following numbers:

Office: 031 325 4841
Cell: 082 496 1142

Thank you.

....MAJOR GENERAL
DEPUTY PROVINCIAL COMMISSIONER: OPERATIONS OFFICER: KWAZULU-NATAL
P E. RADEBE

DATE: ....1............Ob-. :l.Z>........

ANNEXURE 6: LETTER OF INTRODUCTION

LETTER OF INTRODUCTION

Hello, I am James Clark. I am currently studying towards my Master's in Criminology through University of South Africa (UNISA). My research topic is,

"The application of the Near Risk Calculator as an investigative tool in the prevention of burglary in Hillcrest, KwaZulu-Natal, South Africa. A criminological analysis".

My research has been approved by Major General Menziwa of Head Strategic Management, The Divisional Commissioner: Detective Services and the KZN Provincial Commissioner.

I have analysed crime data for closed cases of house breaking and robberies at residential premises reported to Hillcrest Police, KZN between April 2012 to March 2013. All crimes have been mapped using Arc GIS (Geographic Information System). The Near repeat (NRC) results have been calculated, and the results have been mapped on the same maps, creating 'risk maps'.

I would like to ask you some questions which relate to closed cases of house breaking and robberies at residential premises. There are no right or wrong answers to these questions. Please understand your participation is voluntary and you are not being forced to participate in this research. The choice to participate is your choice alone. However, I would really like you to share your knowledge and experiences with me. If you choose not to participate in this research, you will not be affected in any way. If you agree to participate, you may stop the interview at any time, and refuse to answer any question you are uncomfortable with. I will not be recording your name anywhere on the questionnaire, and no one, apart from myself will be able to link you to the answers you give. All individual information will remain confidential.

The interview will last about 40 minutes. I will be asking you a few questions, and I request that you be open and honest in answering these questions. Some questions may be of a personal or sensitive nature, which you may refuse to answer these questions. I may be asking questions that you have not thought of before, and which may involve you thinking about the past or future.

Your participation and input would be greatly appreciated.

If you have any questions about this study, you may contact my supervisor Dr Häefele , at UNISA, School of Law, Criminology Department on email: haefebw@unisa.ac.za .

My contact details are: 0768715137, and my email is, jamesclark137@gmail.com , if you have any queries at a later date relating to this research.

Thank you for your time.

James Clark

Master's in Criminology student at UNISA

ANNEXURE 7: CONSENT FORM 1

CONSENT FORM 1

Consent form for participation in research questionnaire

I, ____ hereby agree to participate in James Clark's research on:

"The application of the Near Repeat Calculator as an investigative tool in the prevention of burglary in Hillcrest, KwaZulu-Natal, South Africa. A criminological analysis."

I understand that I am participating freely of my own will. I also understand that I can terminate the interview at any point should I not want to continue and that my decision will not prejudice me in any way.

The purpose of the study has been explained to me and I understand what is expected of me. I understand that this research project may not benefit me personally.

I have received the details of a person to contact should I wish to speak about any issues regarding the research or interview. I understand that my name and details will not be written anywhere on the questionnaire, and no one will be able to link me to the answers I give. I understand that all my personal information will remain confidential and only James Clark will have access to it. I understand that, if James Clark is permitted to, I shall receive feedback of the research findings.

Name and signature of participant: __________________________

Date: ___________________

Place: ___________________

ANNEXURE 8: CONSENT FORM 2

<u>CONSENT FORM 2</u>

Permission to contact participant at a later date

I hereby consent to James Clark contacting me at a later date about his on-going (or future) research on the topic:

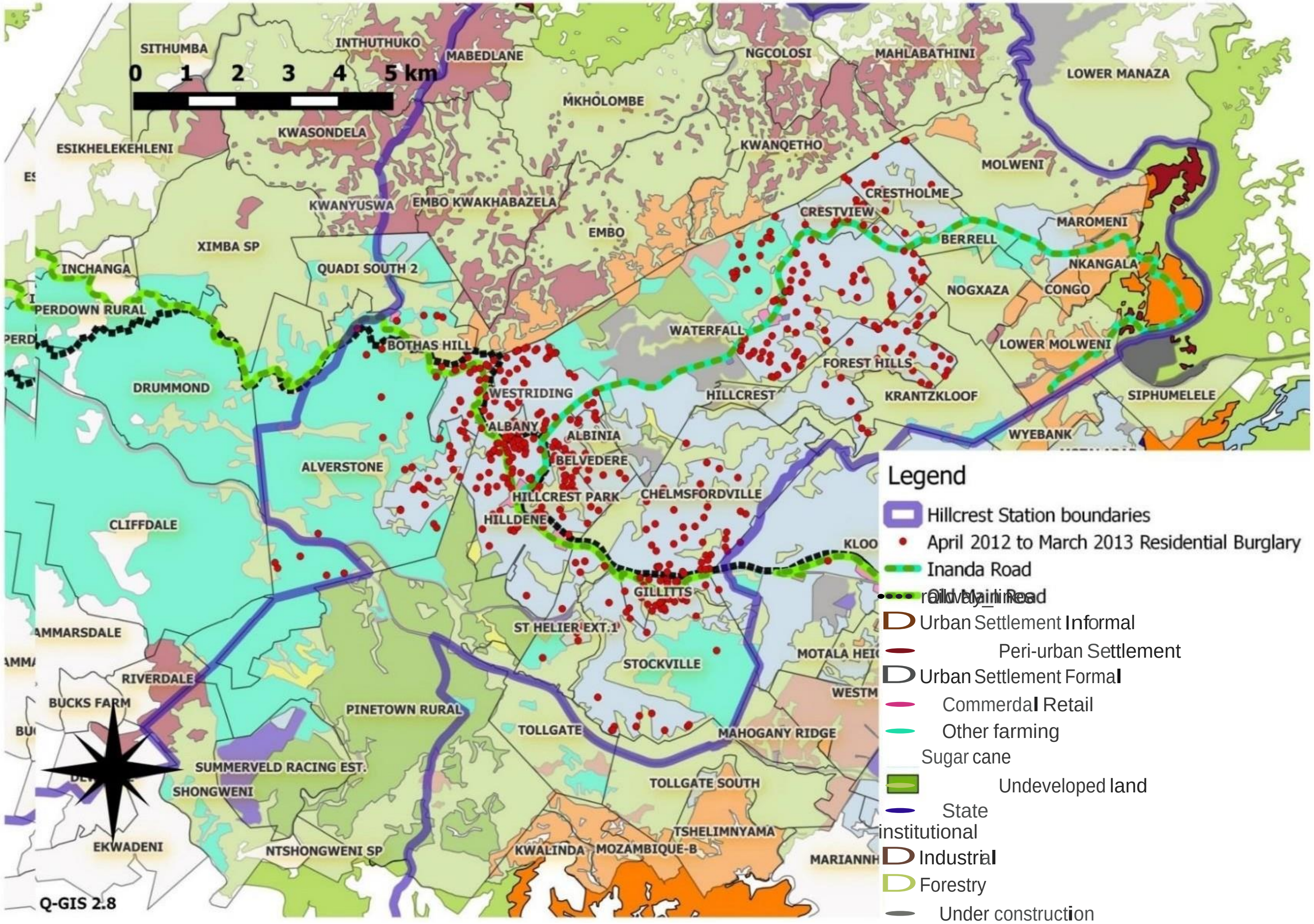
"The application of the Near Repeat Calculator as an investigative tool in the prevention of burglary in Hillcrest, KwaZulu-Natal, South Africa. A criminological analysis."

Name and signature of participant: ________________________

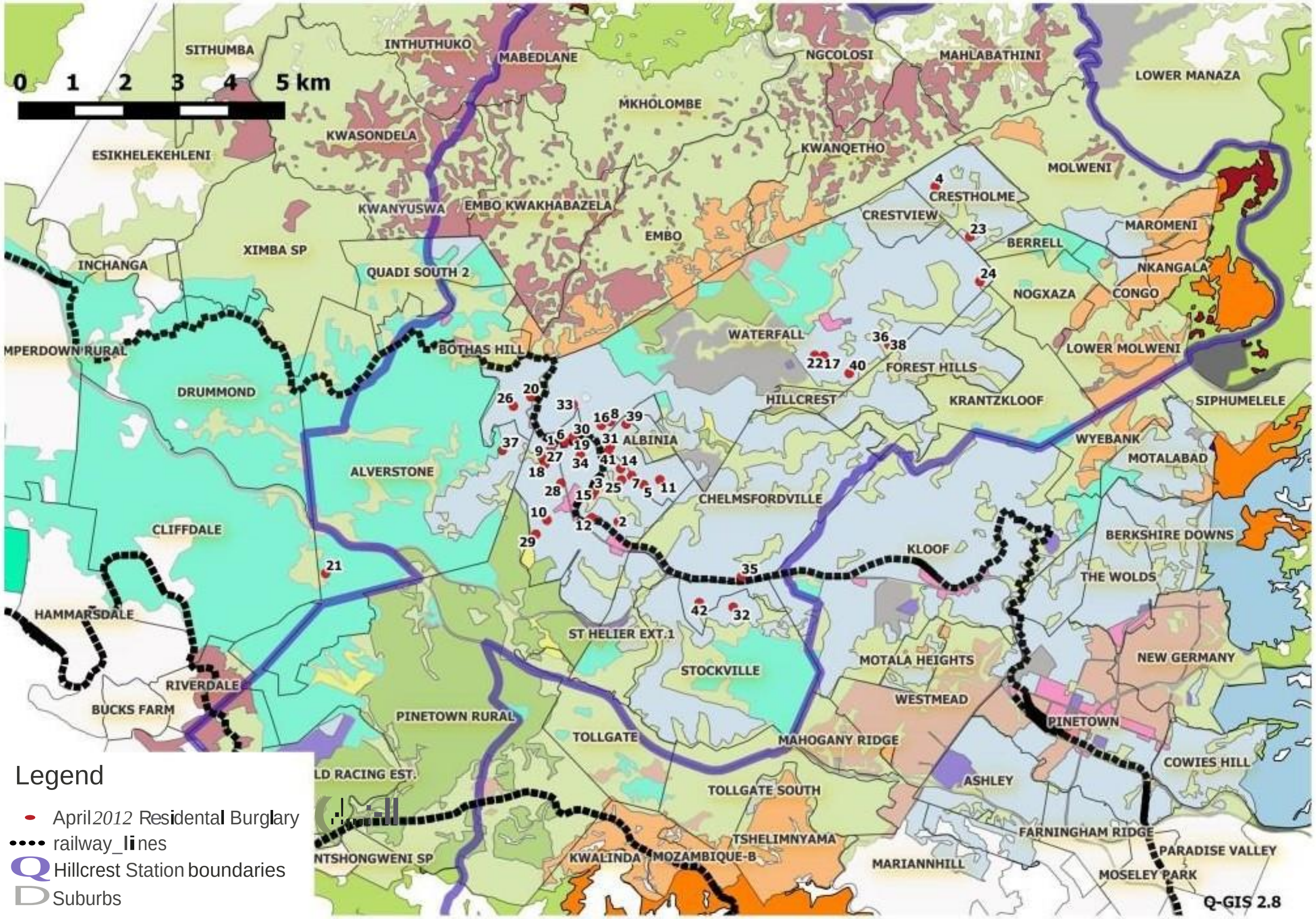
Date: _____________________

Place: ____________________

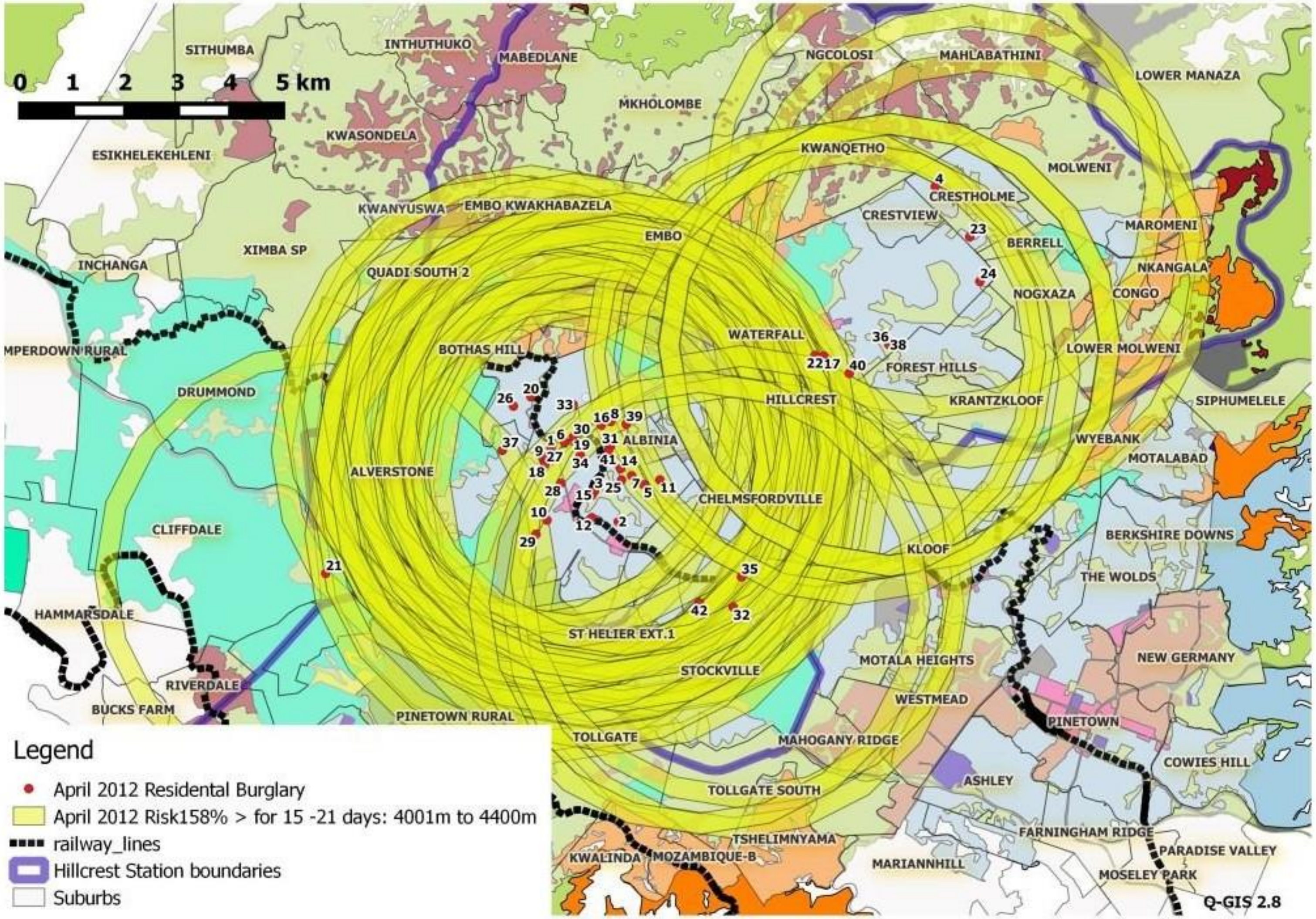
ANNEXURE 9: RESIDENTIAL BURGLARIES (APRIL 2012 TO MARCH 2013)



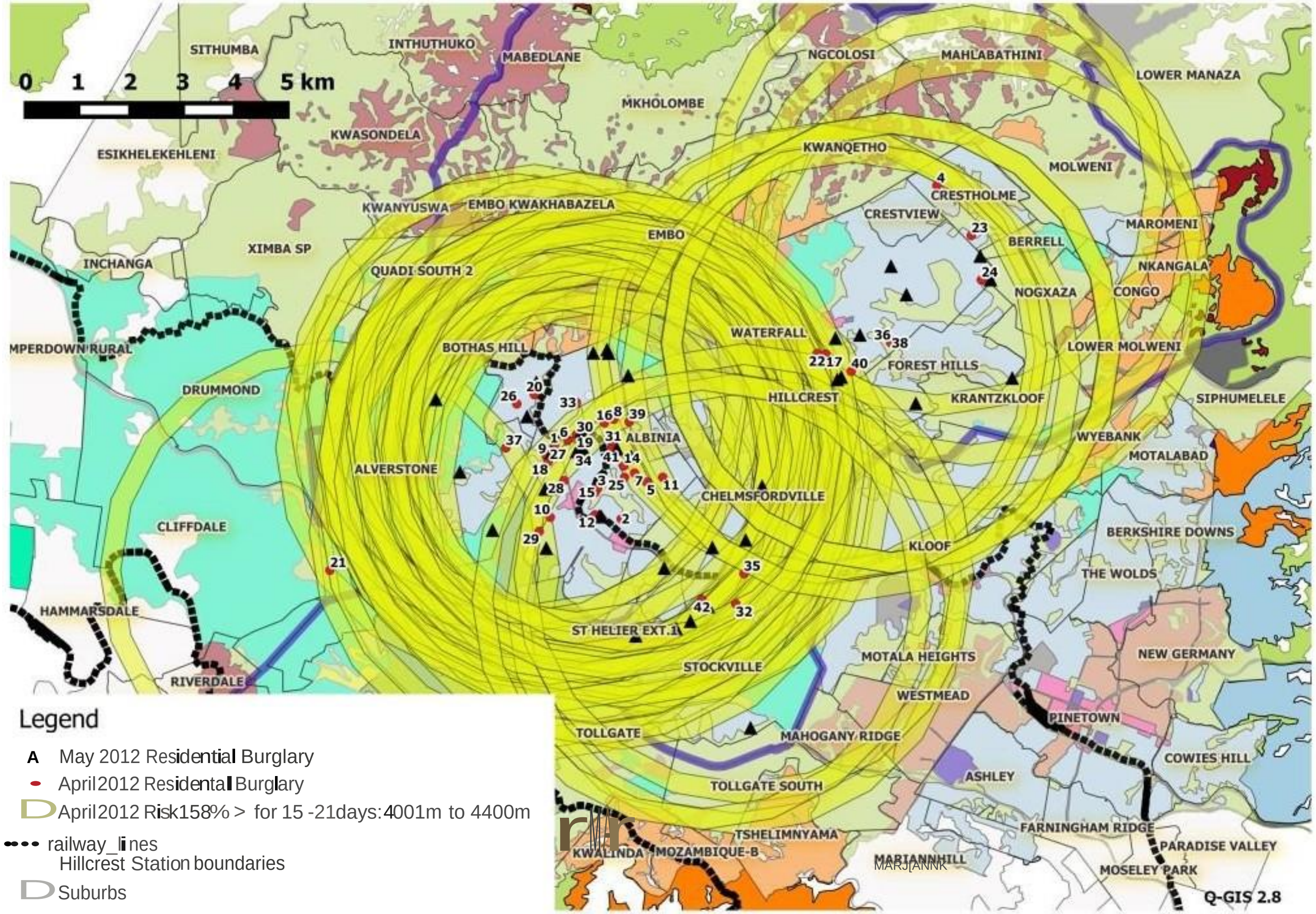
ANNEXURE 10: APRIL 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



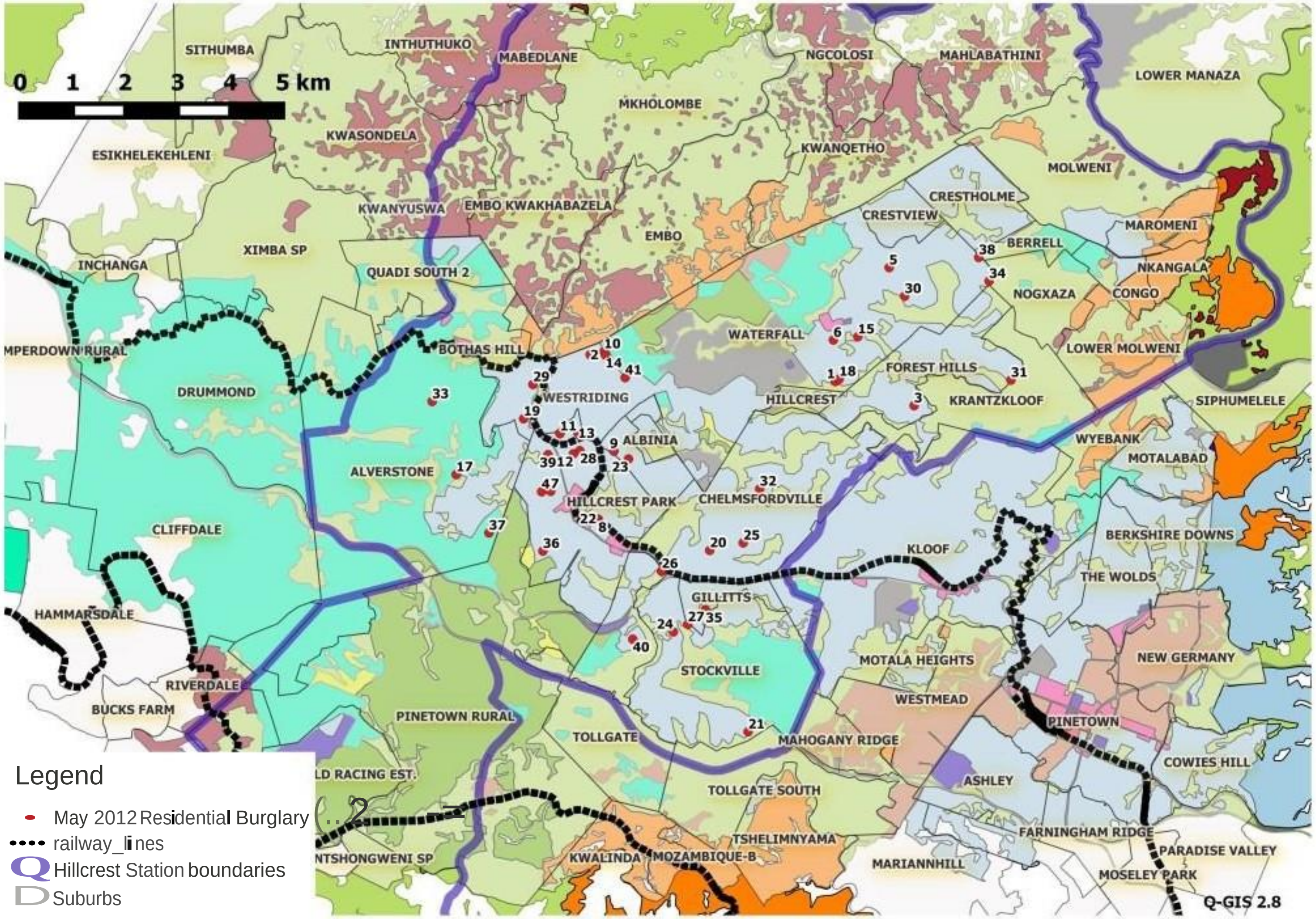
ANNEXURE 11: APRIL 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



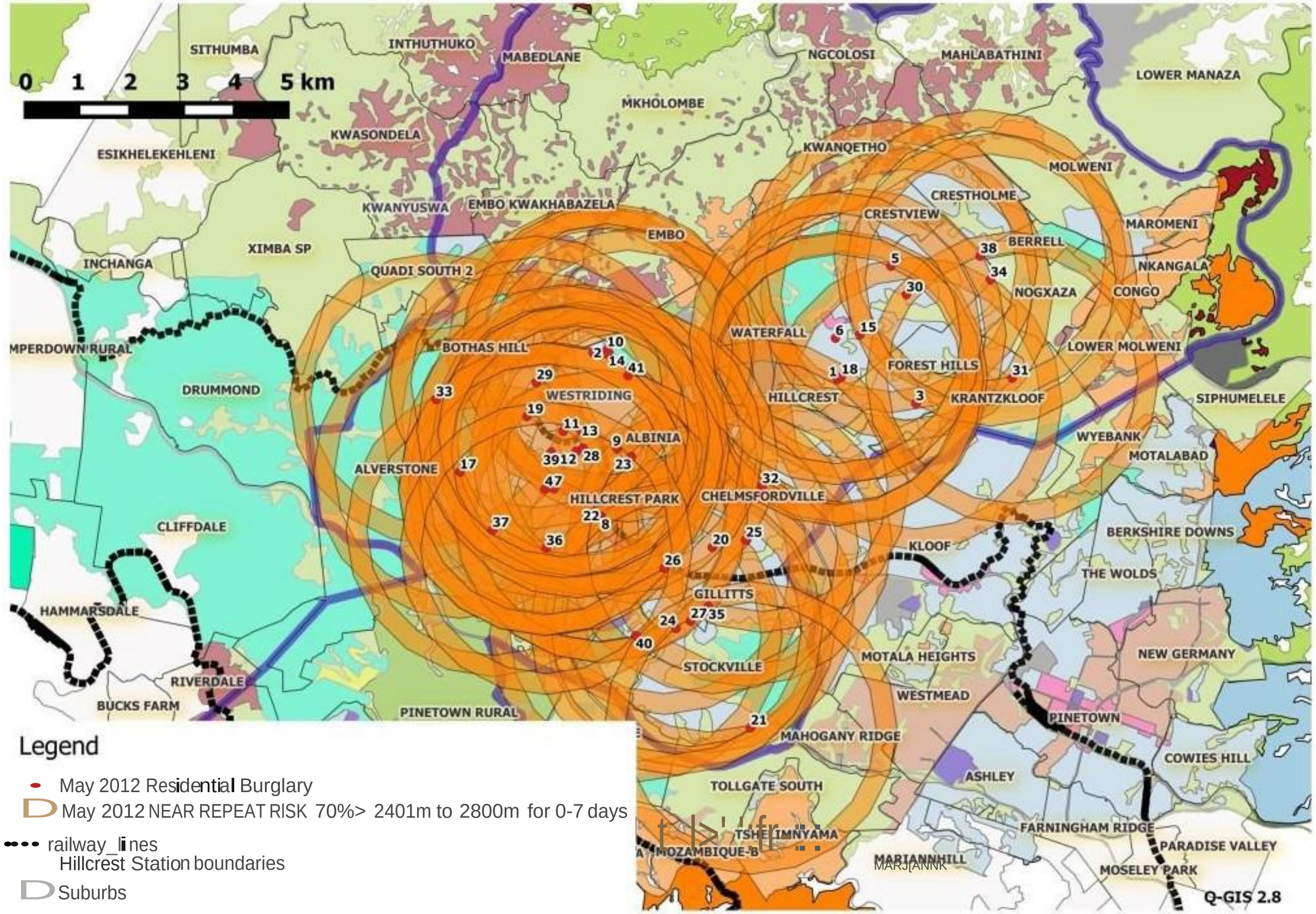
ANNEXURE 12: APRIL 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



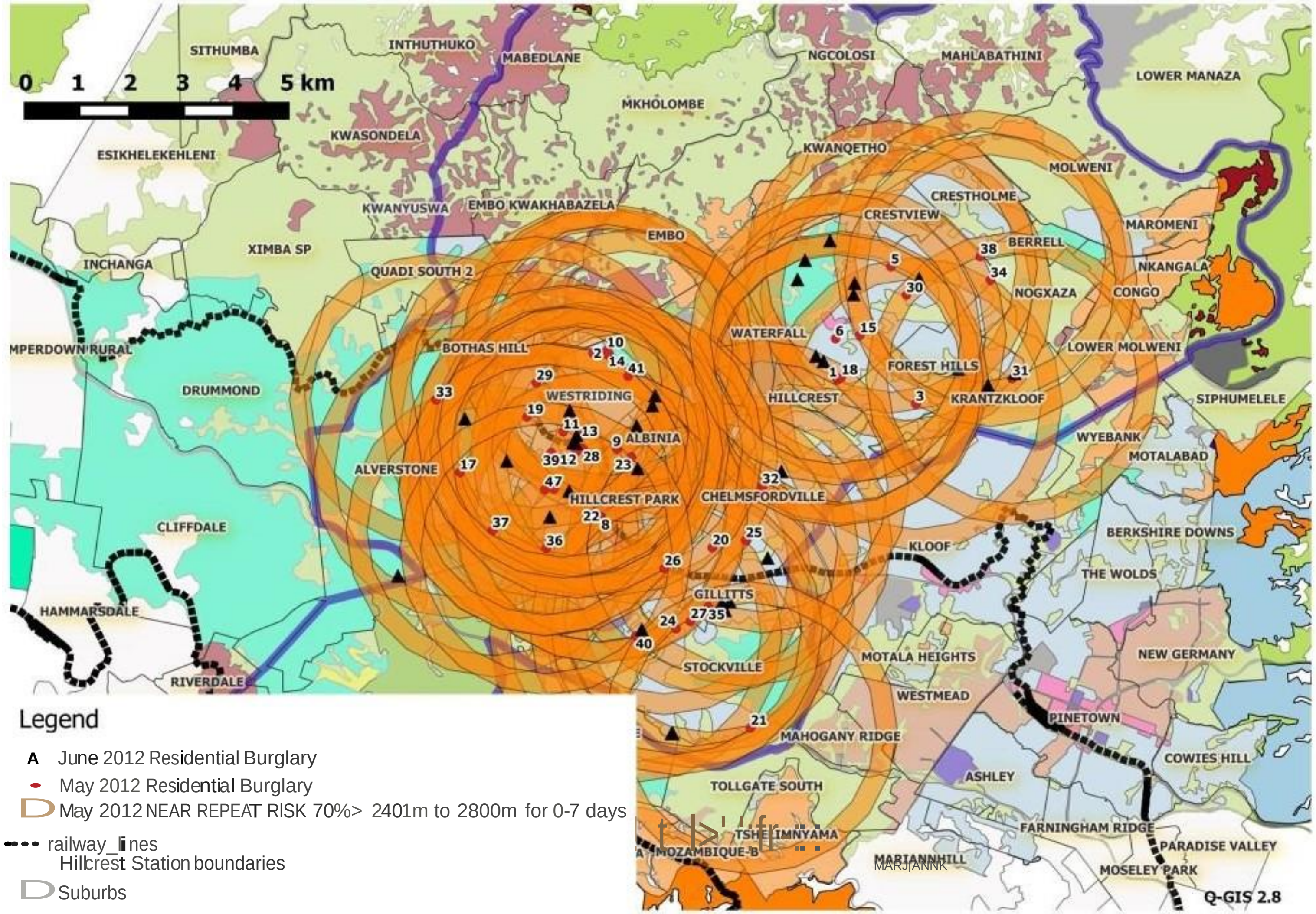
ANNEXURE 13: MAY 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



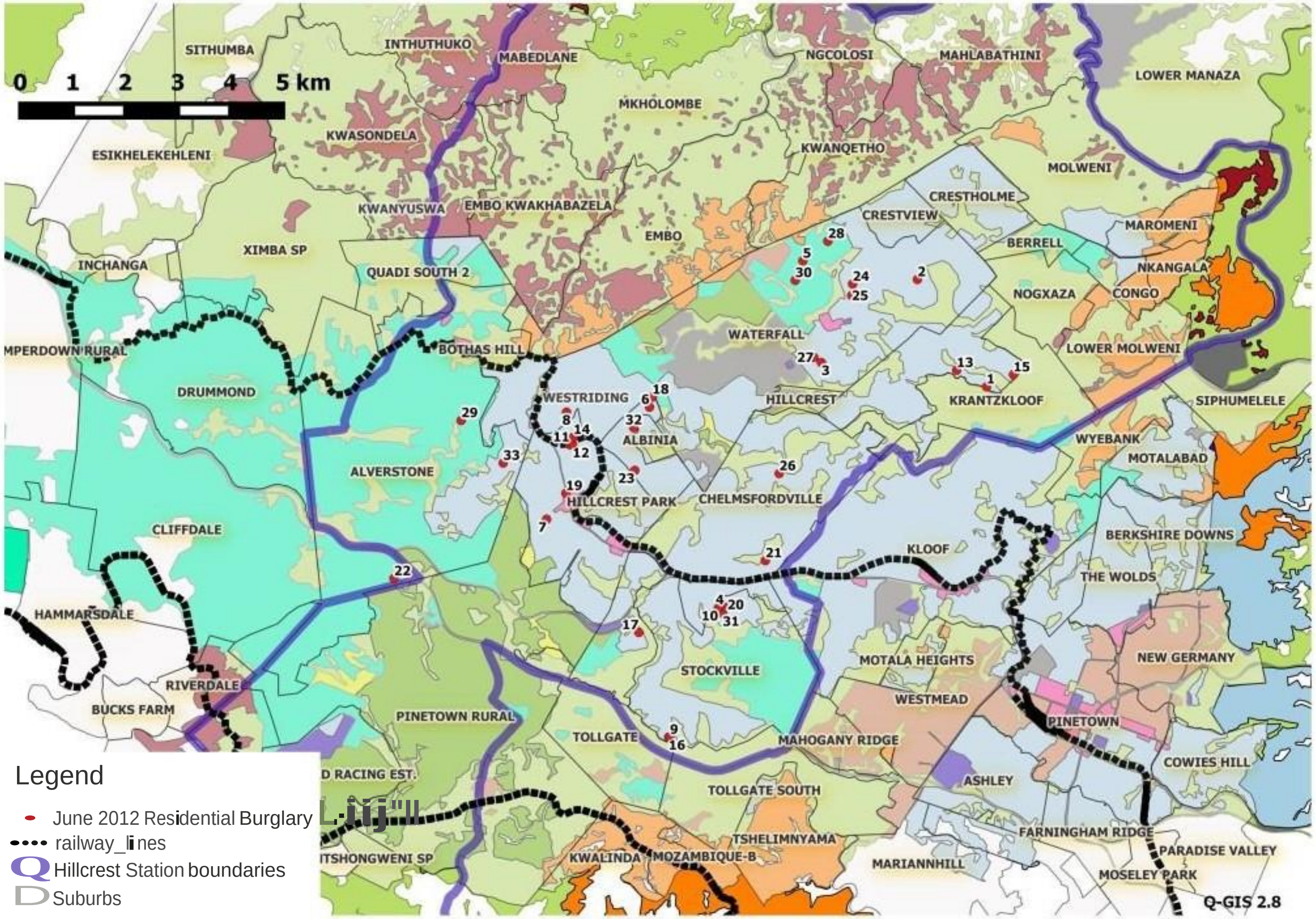
ANNEXURE 14: MAY 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



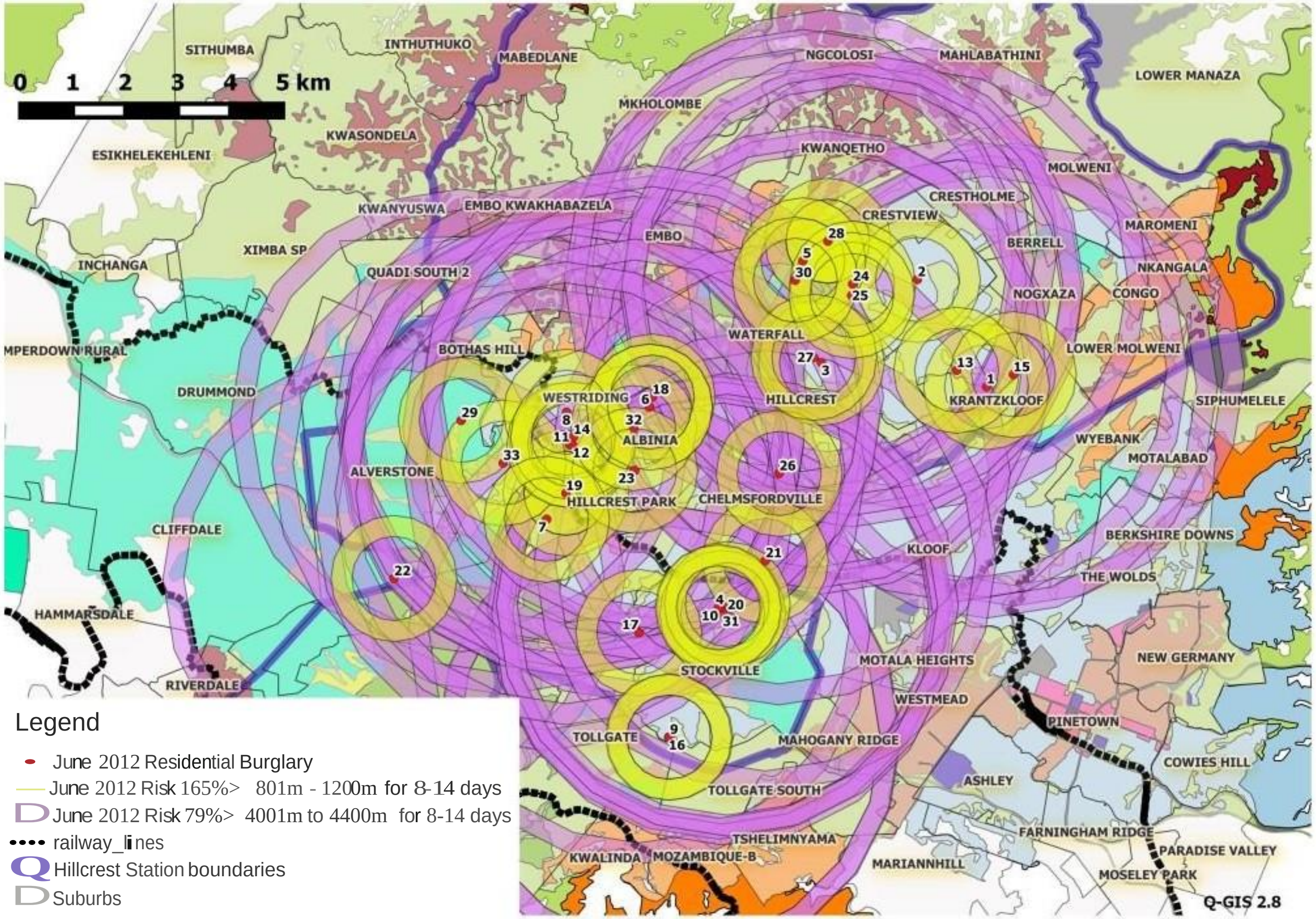
ANNEXURE 15: MAY 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



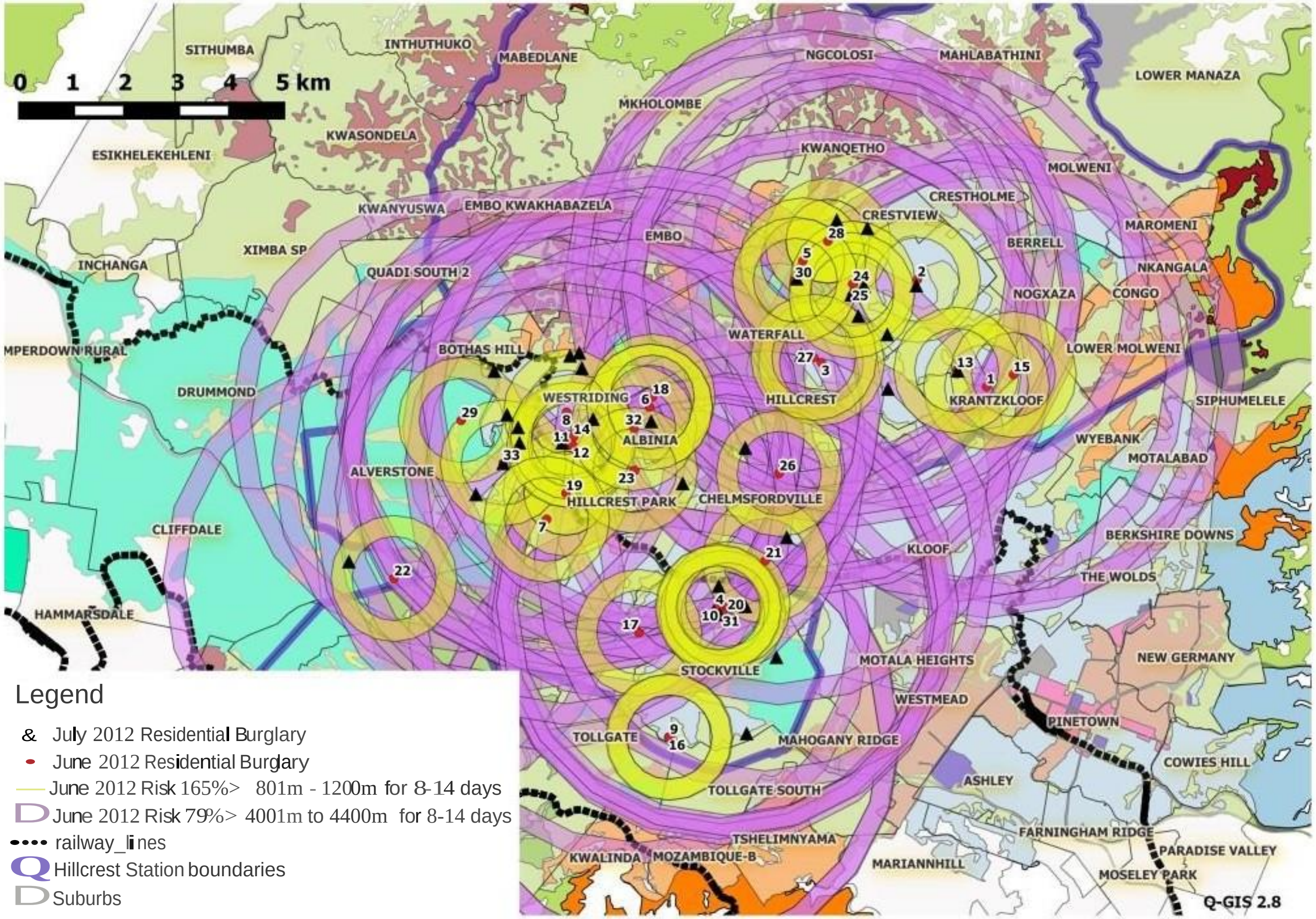
ANNEXURE 16: JUNE 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



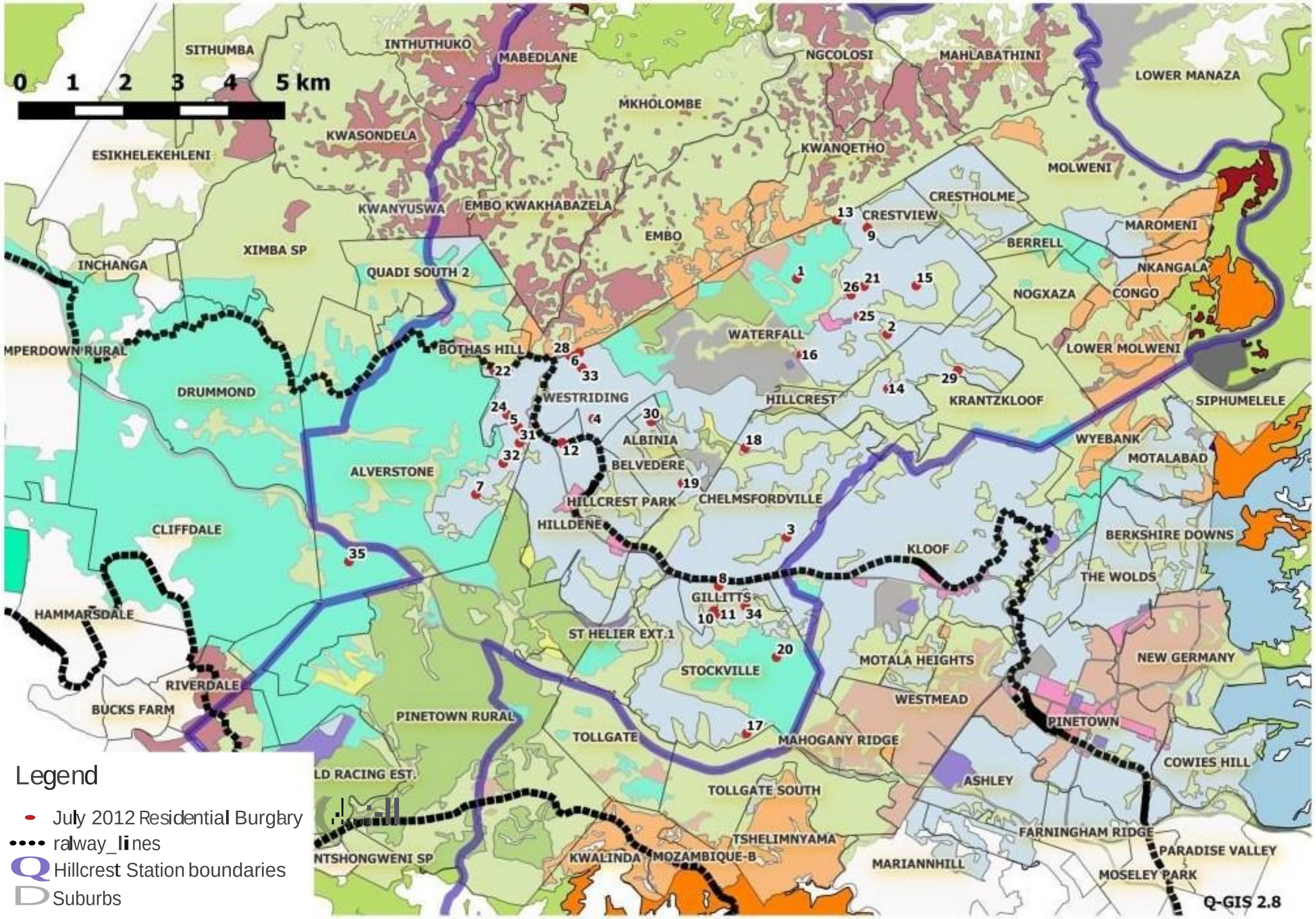
ANNEXURE 17: JUNE 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



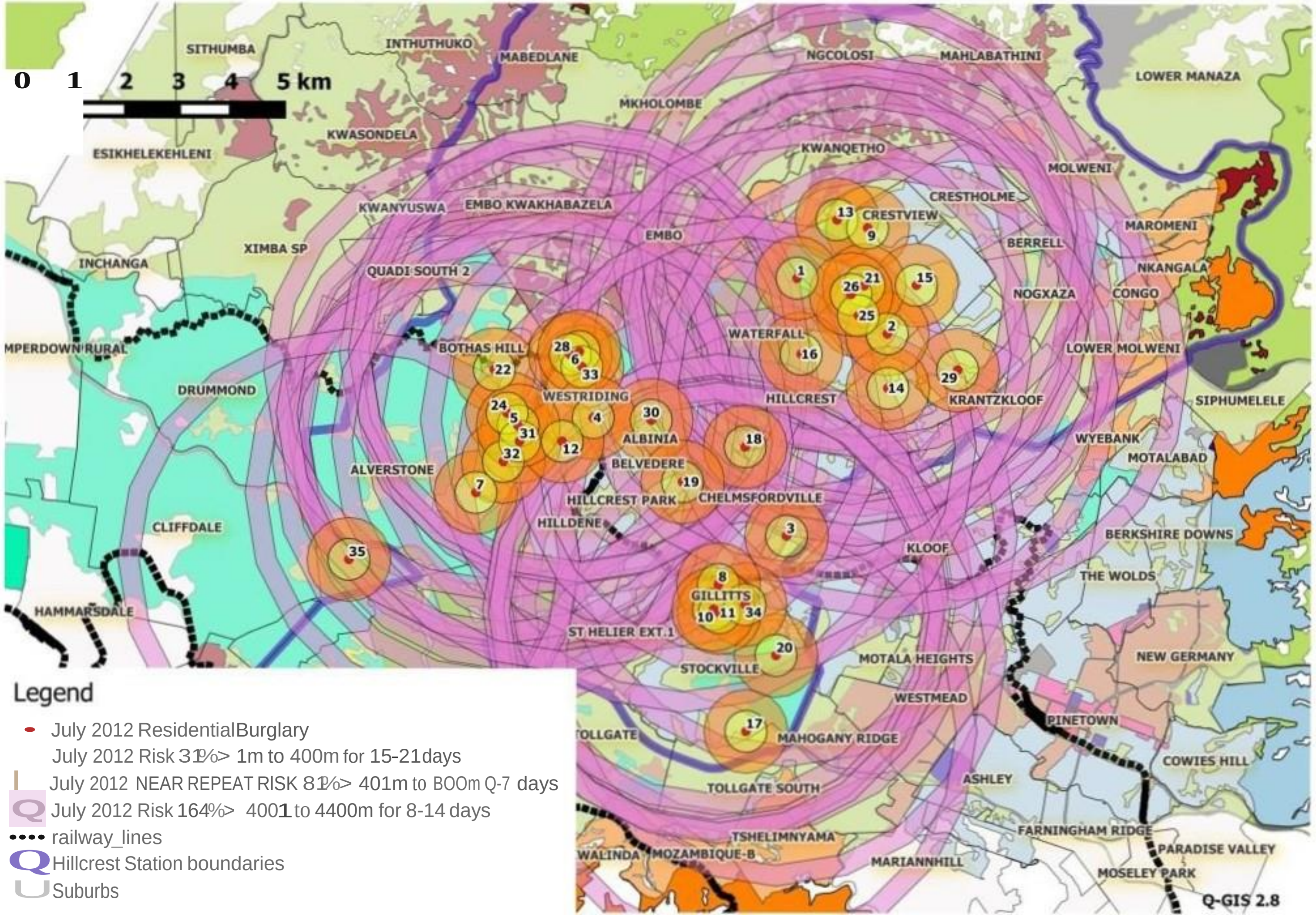
ANNEXURE 18: JUNE 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



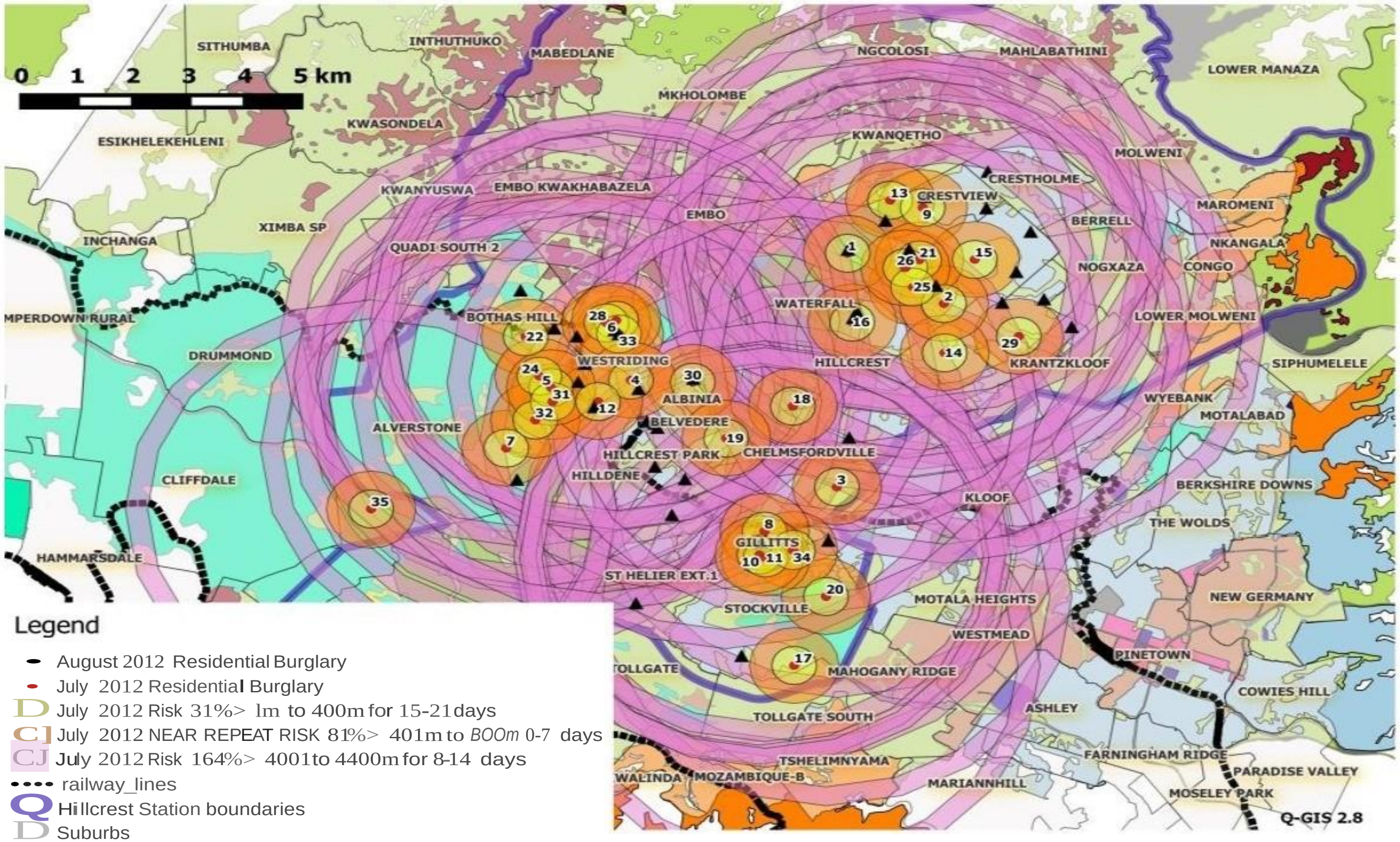
ANNEXURE 19: JULY 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



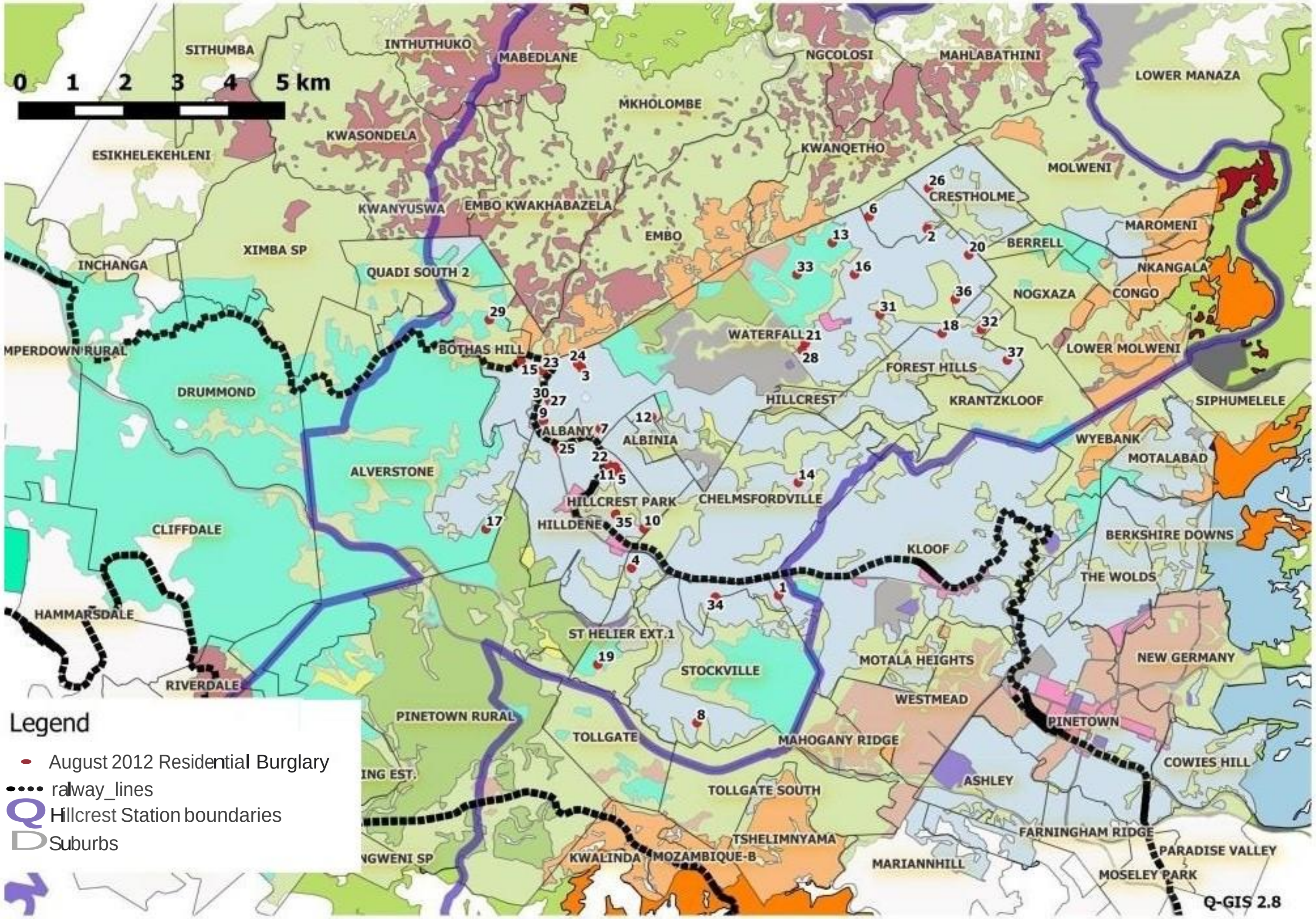
ANNEXURE 20: JULY 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



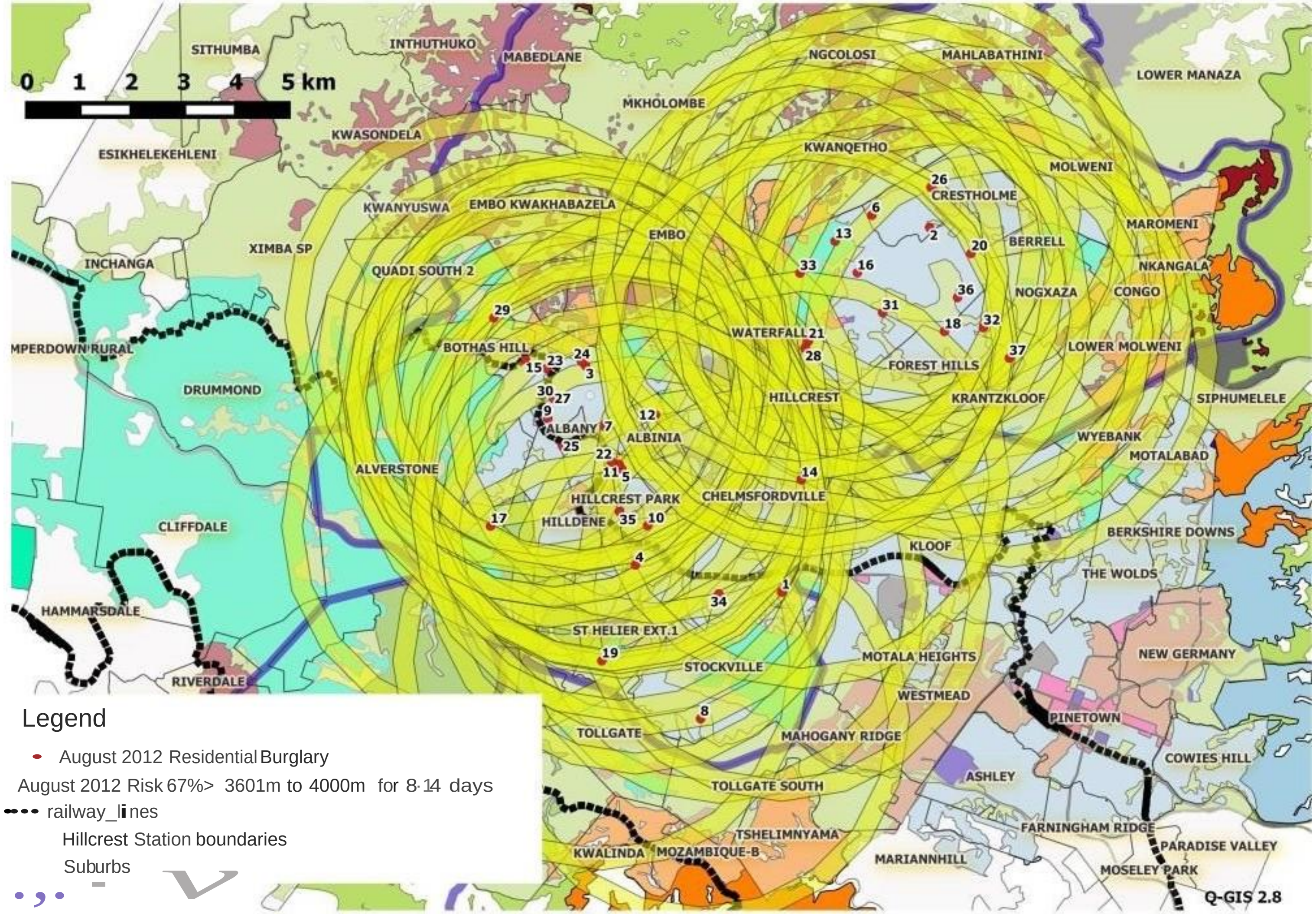
ANNEXURE 21: JULY 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



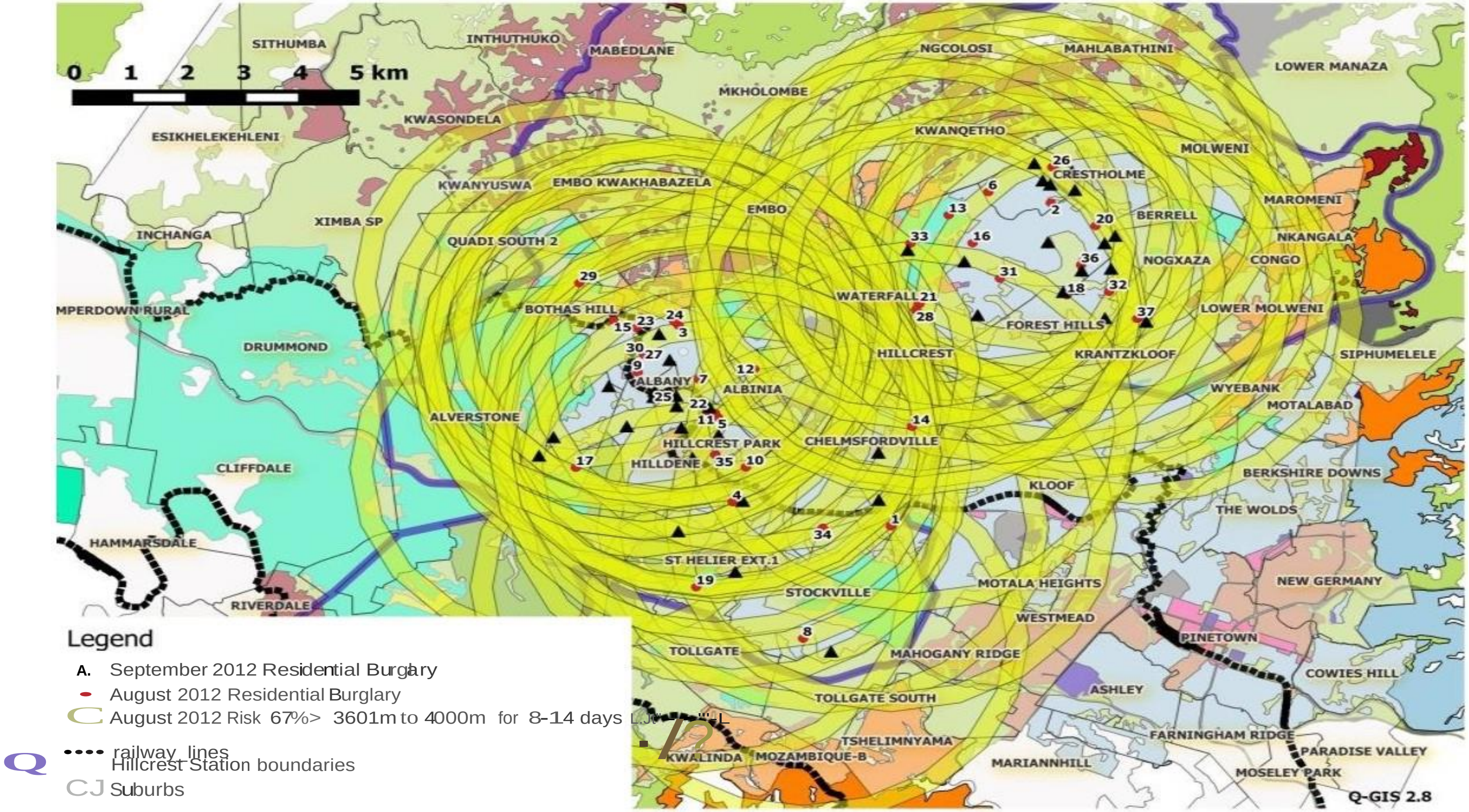
ANNEXURE 22: AUGUST 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



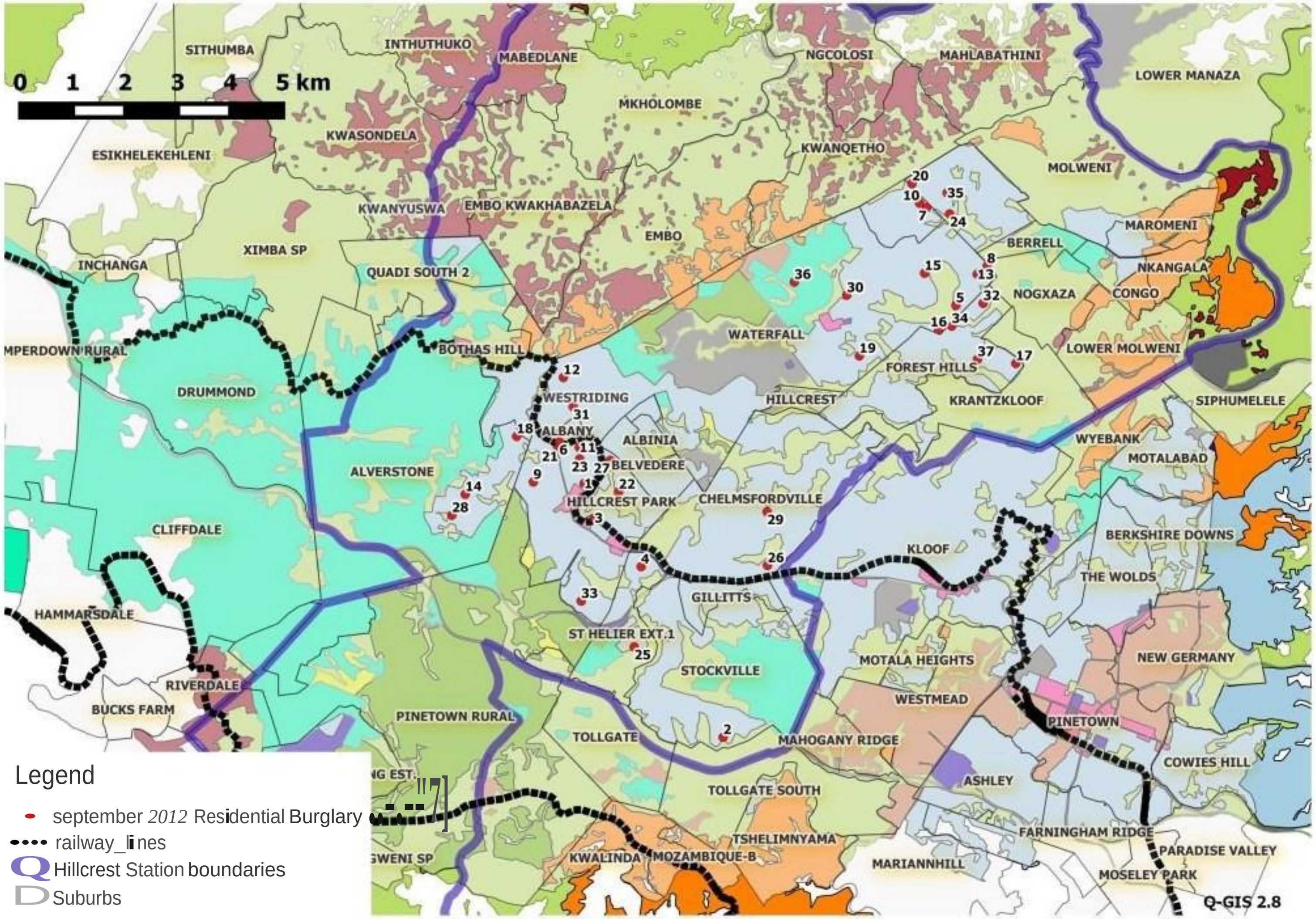
ANNEXURE 23: AUGUST 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



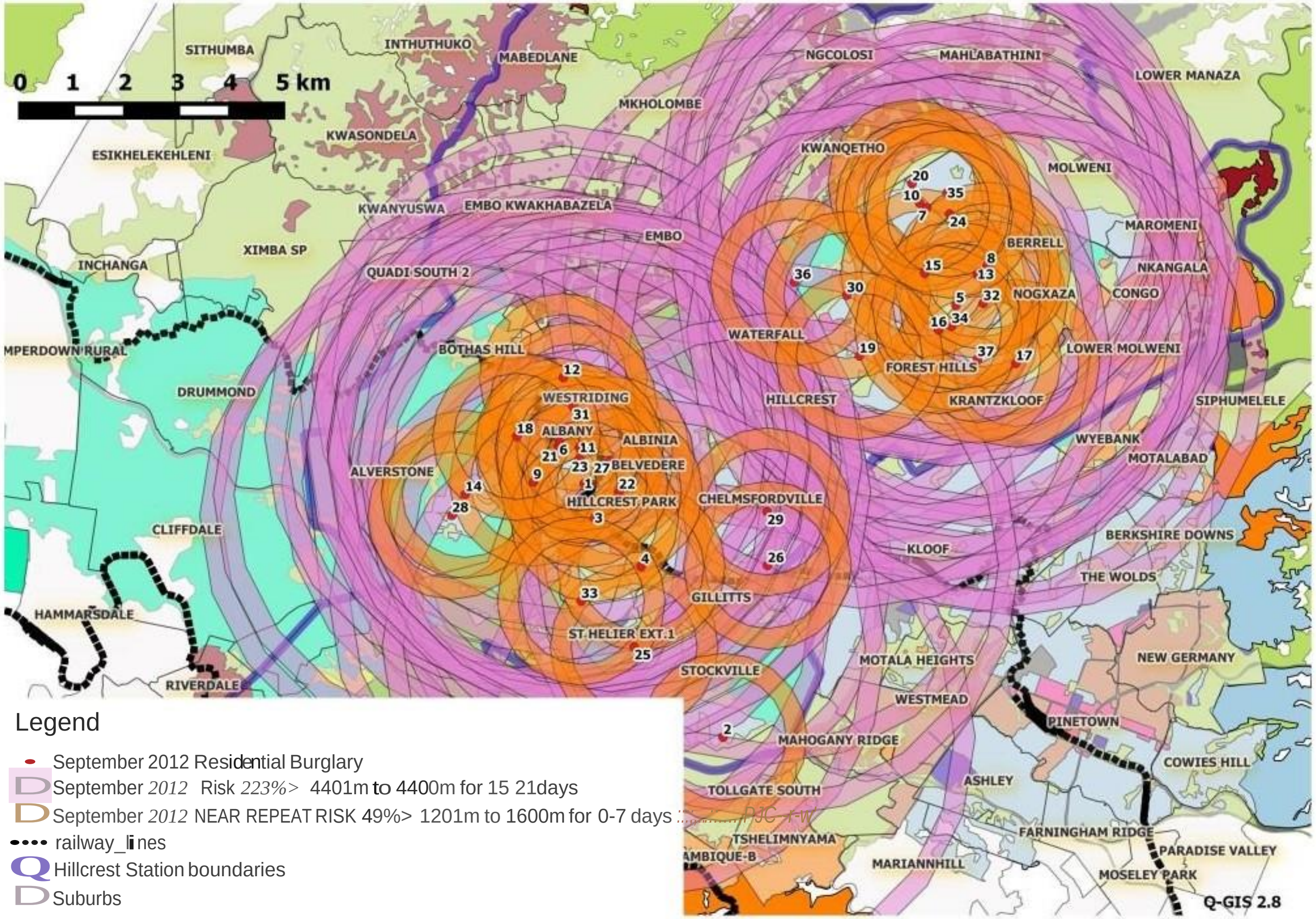
ANNEXURE 24: AUGUST 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



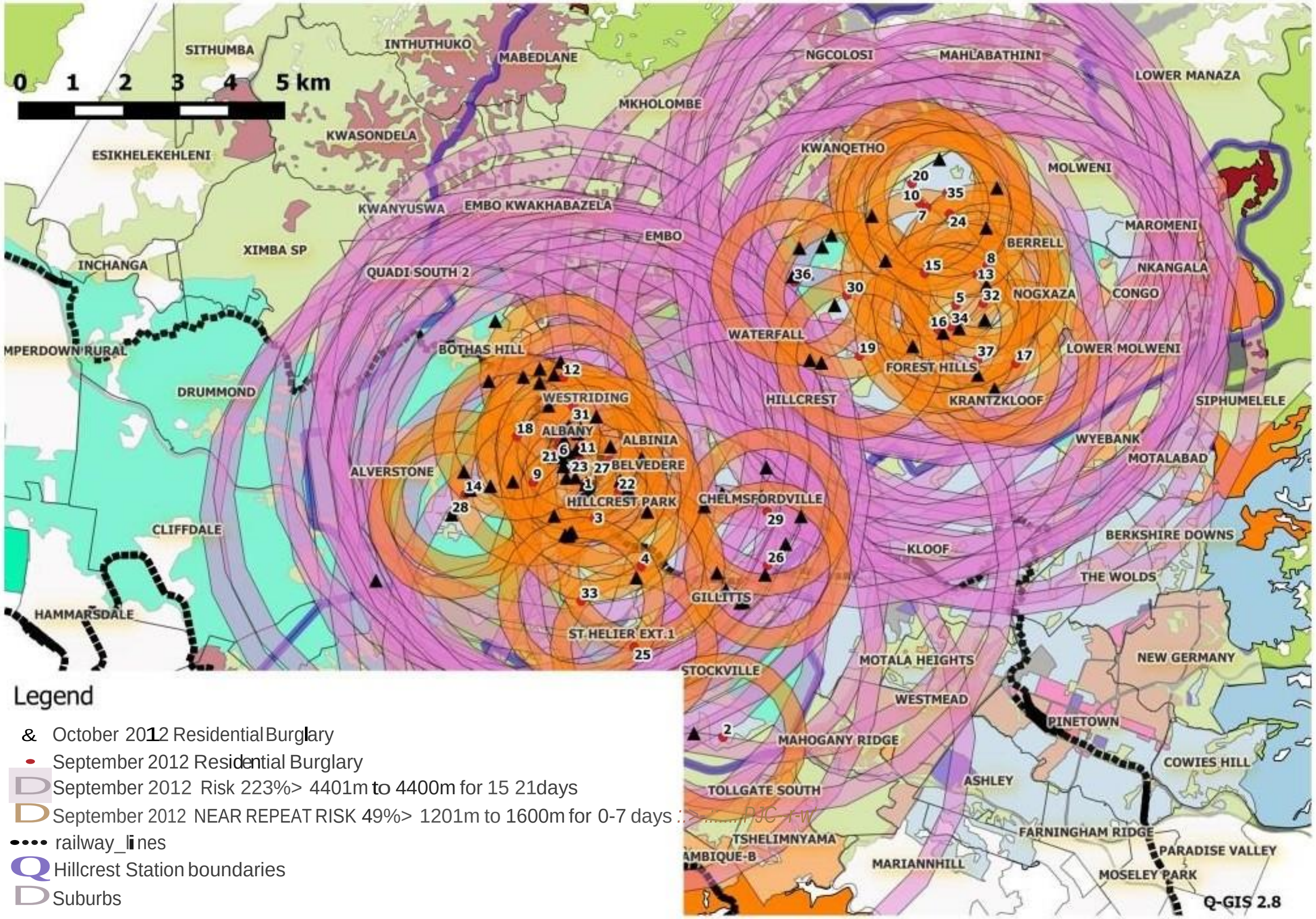
ANNEXURE 25: SEPTEMBER 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



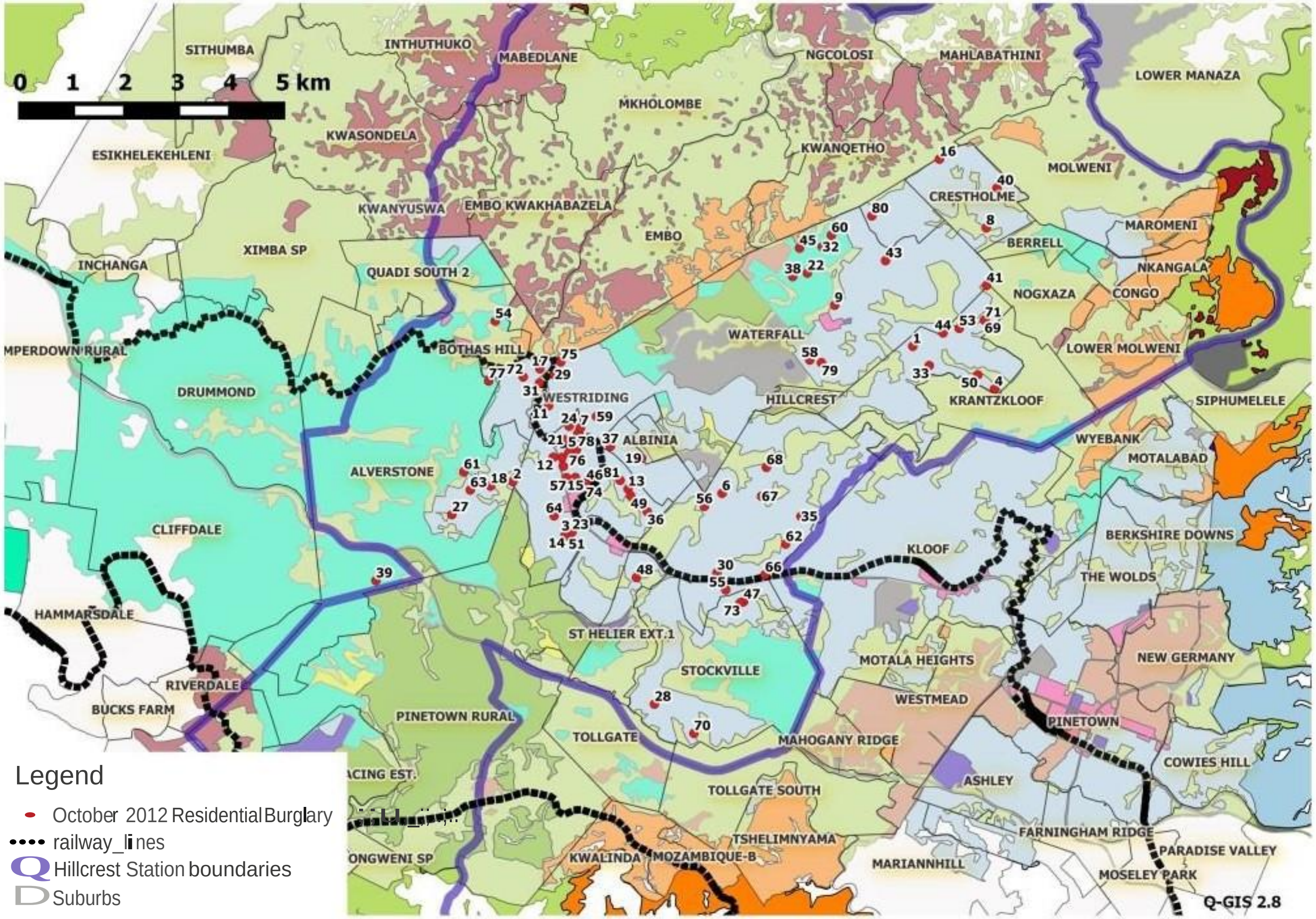
ANNEXURE 26: SEPTEMBER 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



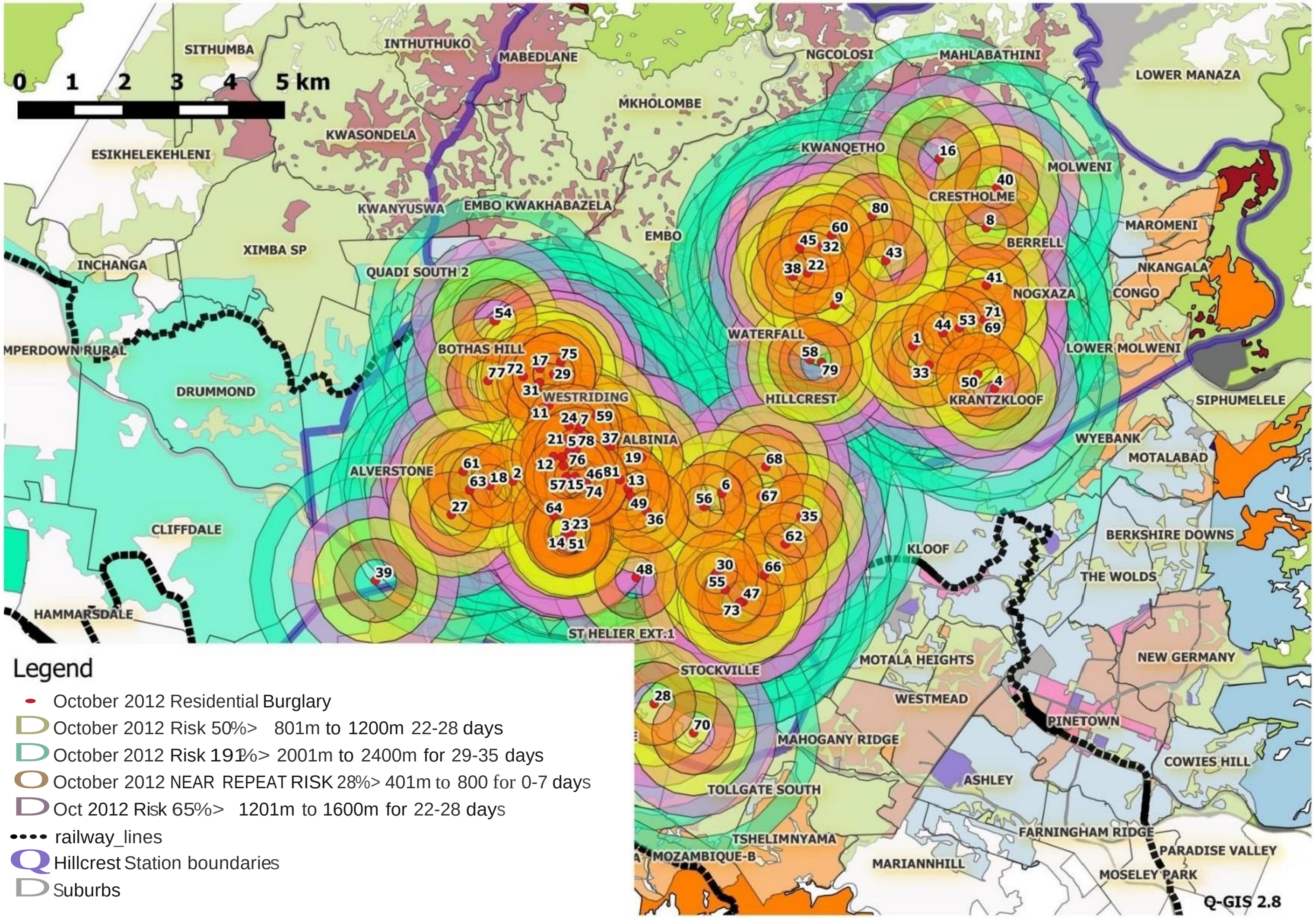
ANNEXURE 27: SEPTEMBER 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



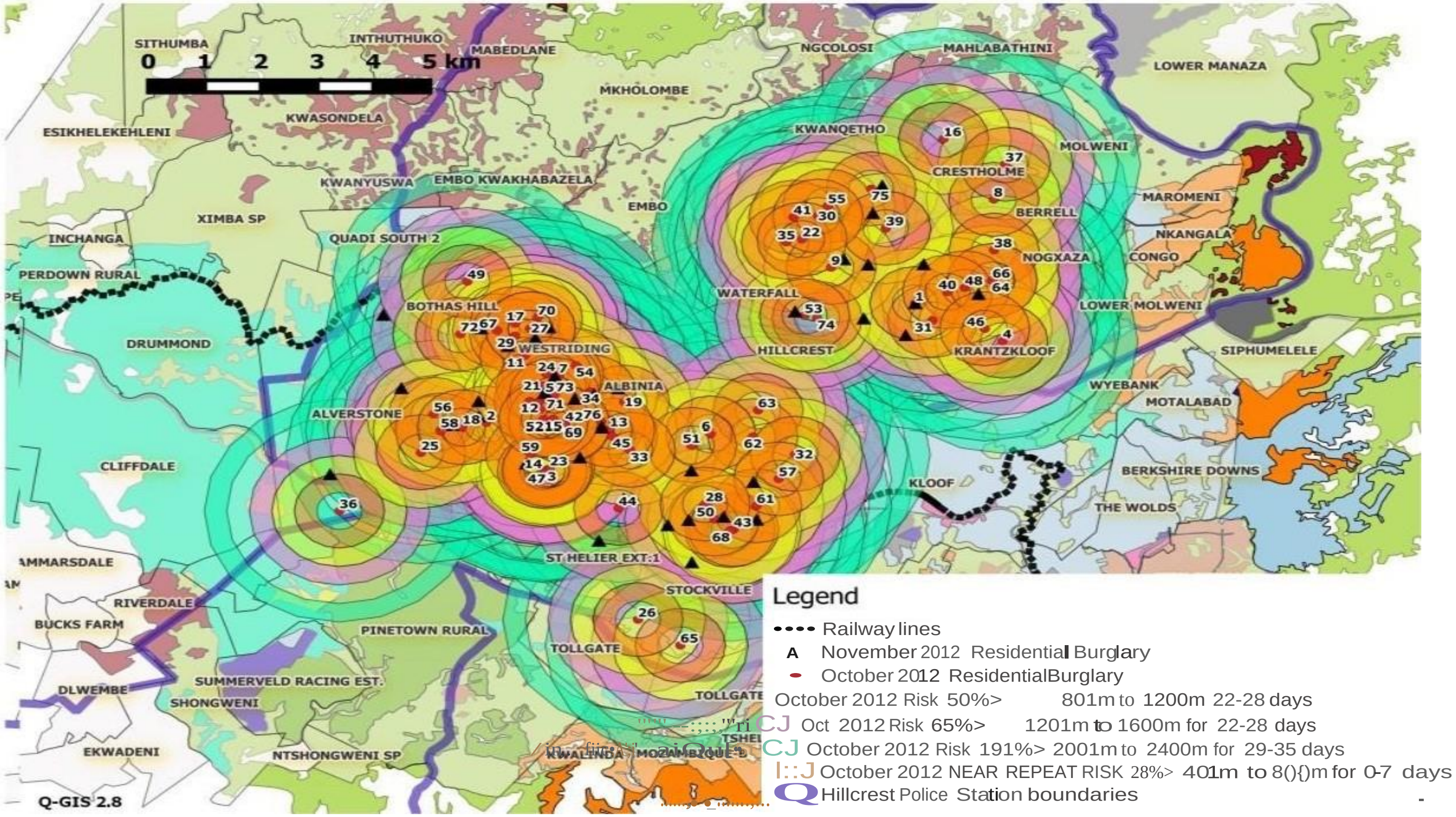
ANNEXURE 28: OCTOBER 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



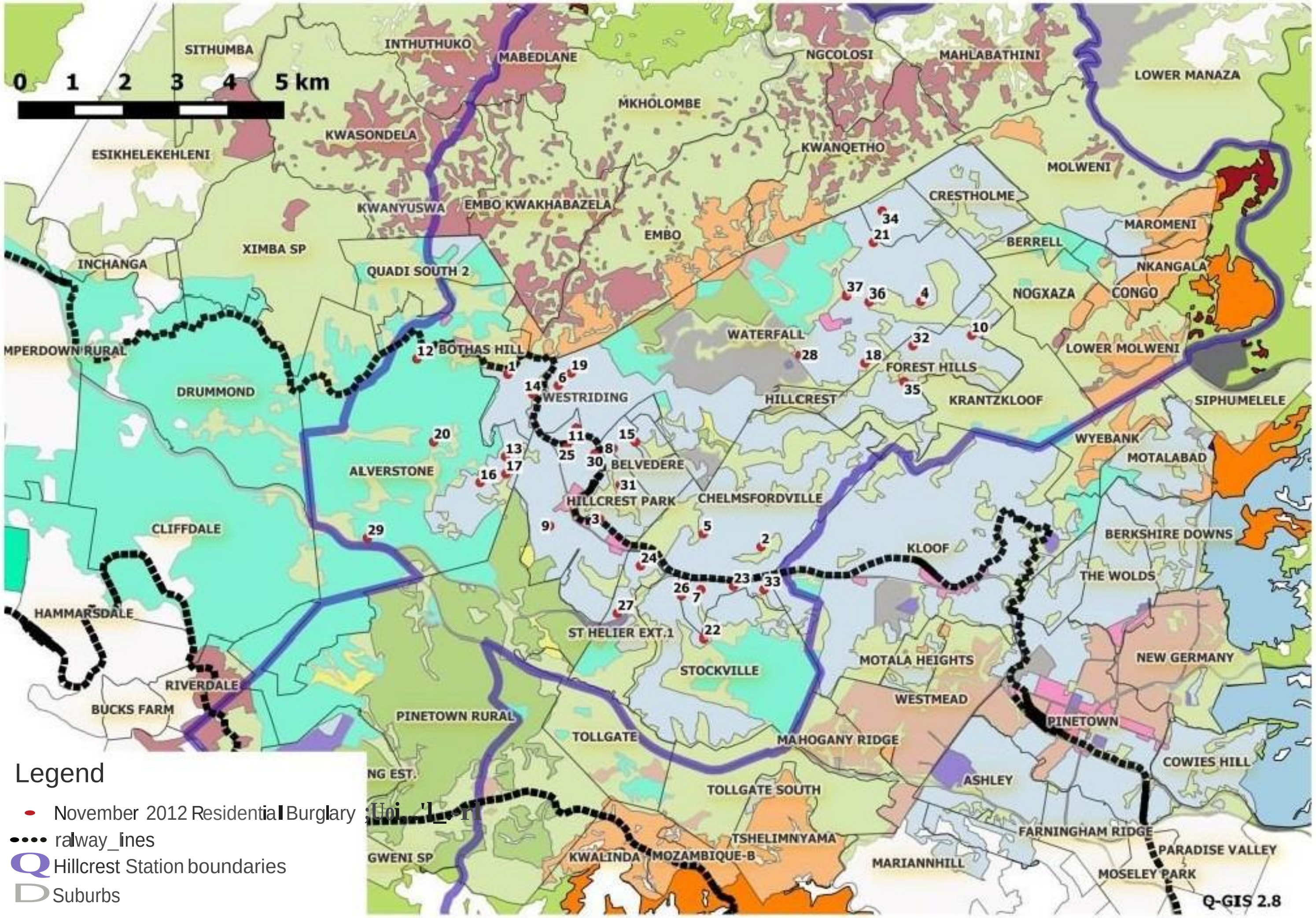
ANNEXURE 29: OCTOBER 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



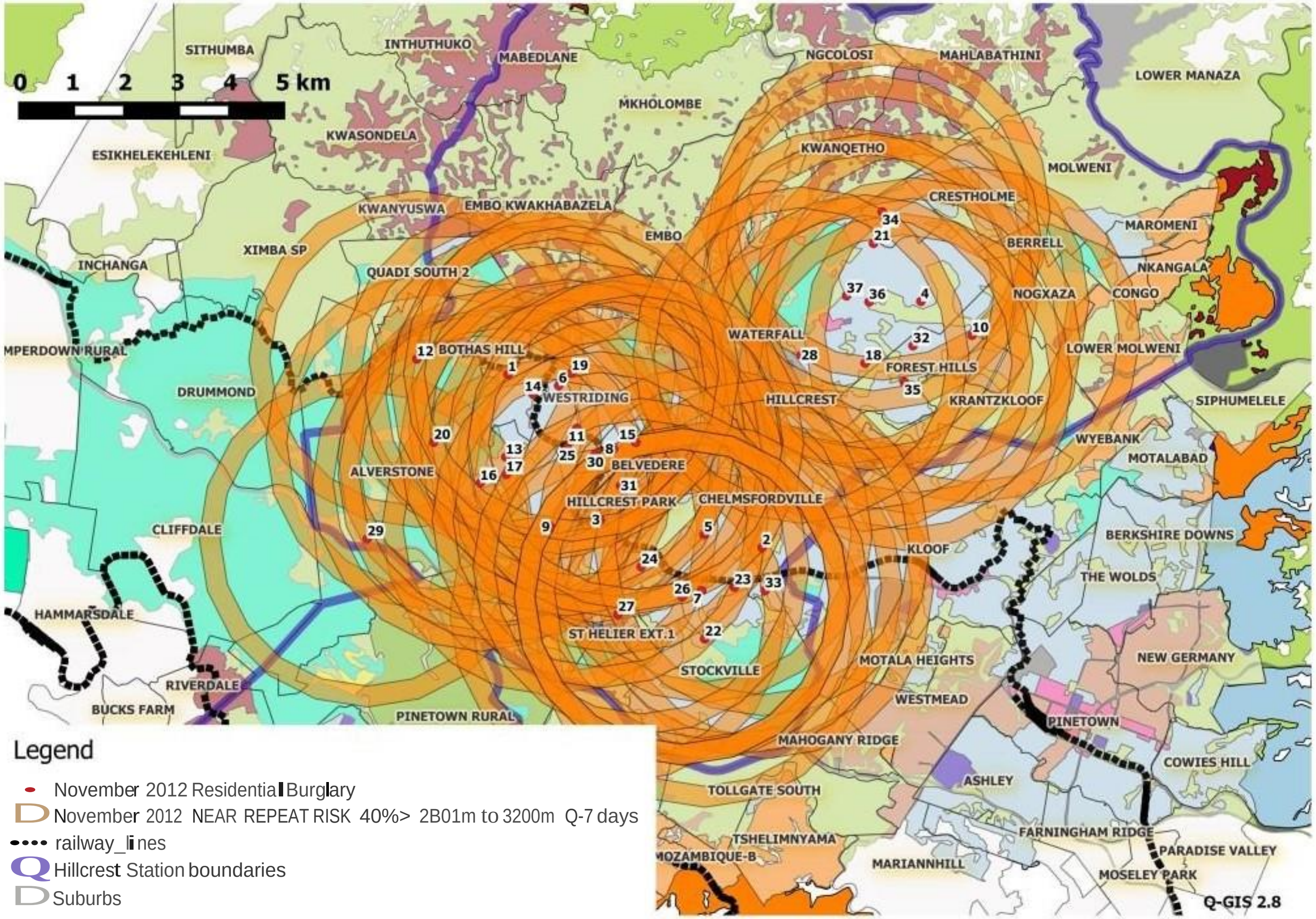
ANNEXURE 30: OCTOBER 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



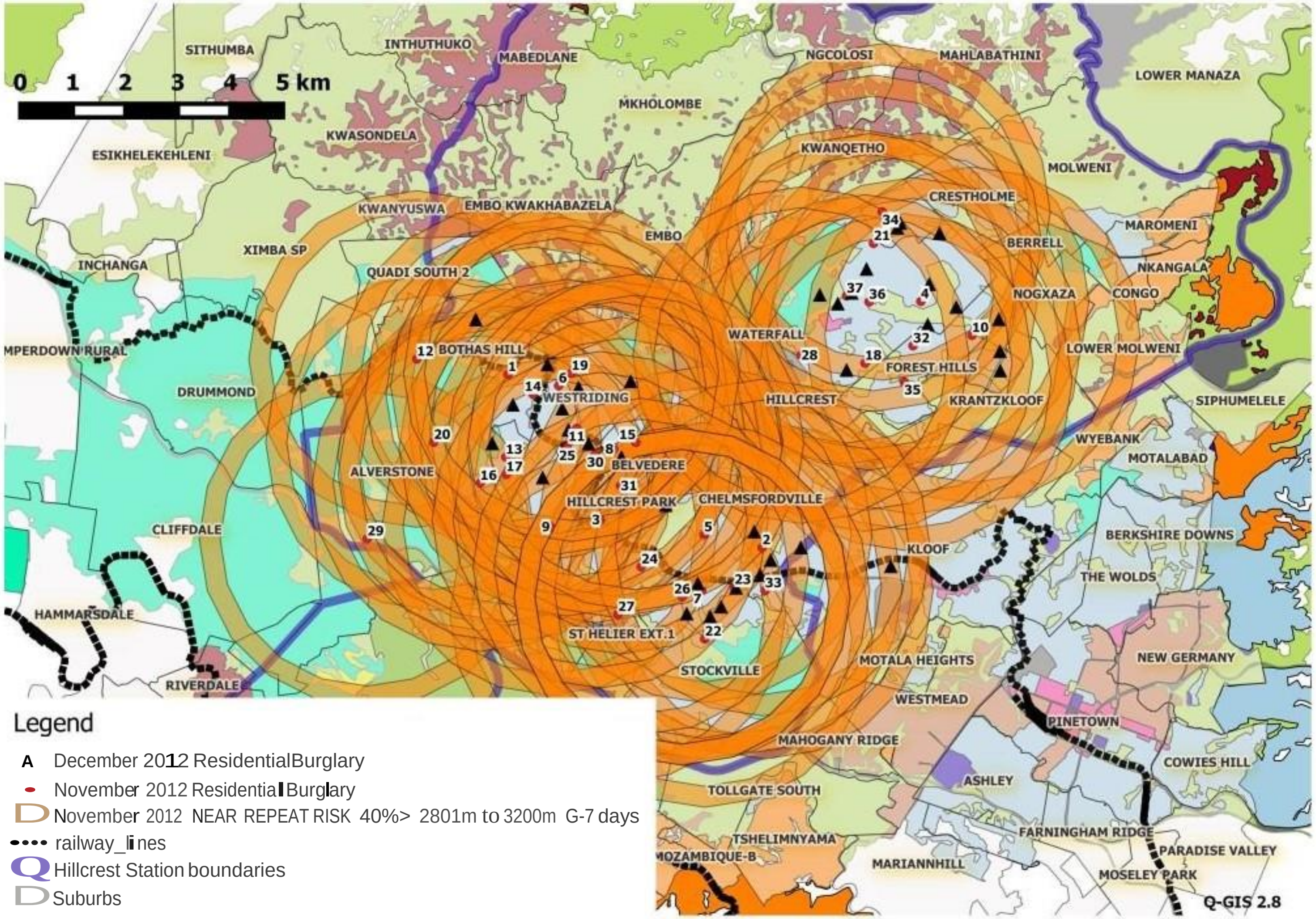
ANNEXURE 31: NOVEMBER 2012- RESIDENIIAL BURGLARIES (MAP 1 OF 3)



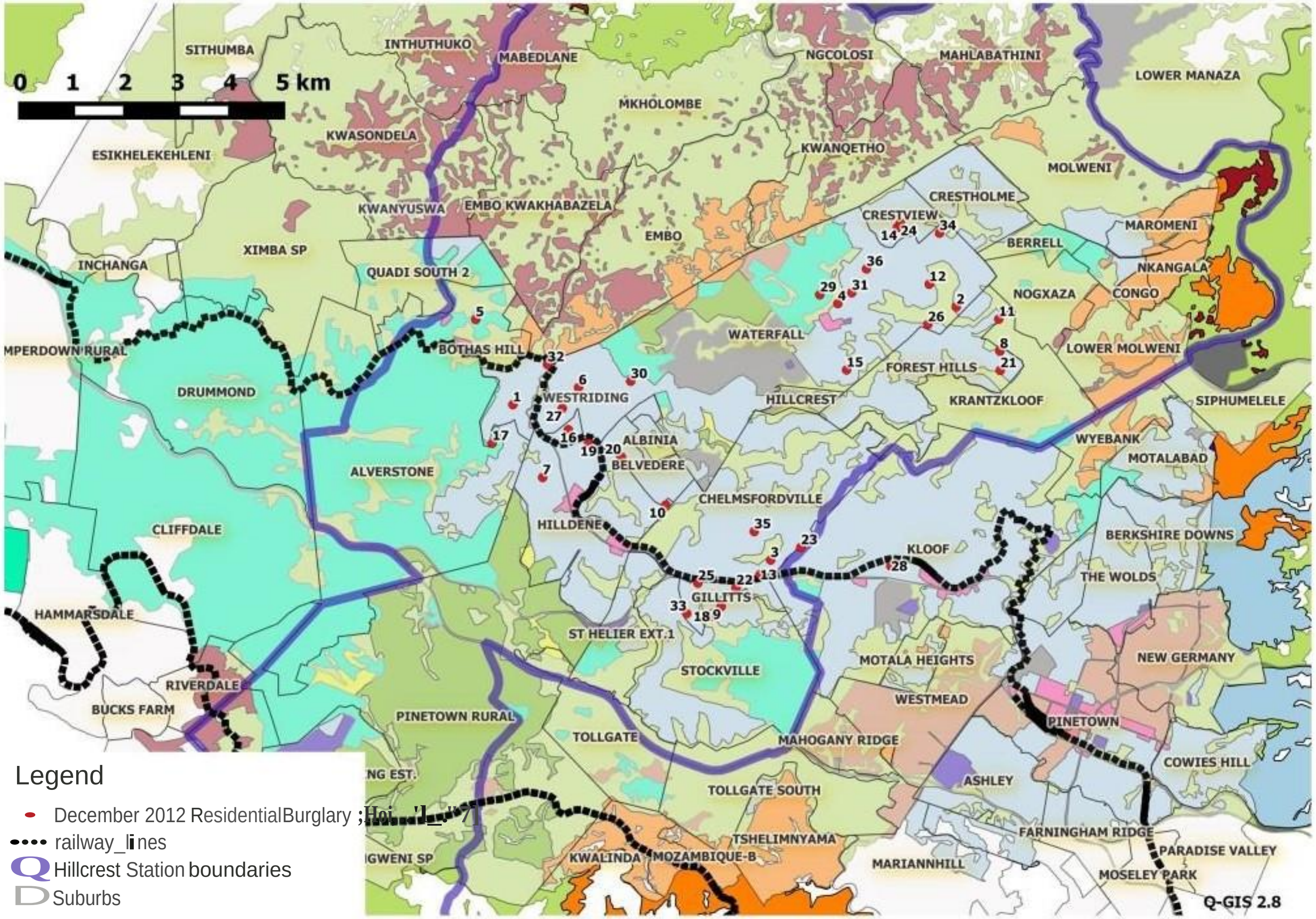
ANNEXURE 32: NOVEMBER 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



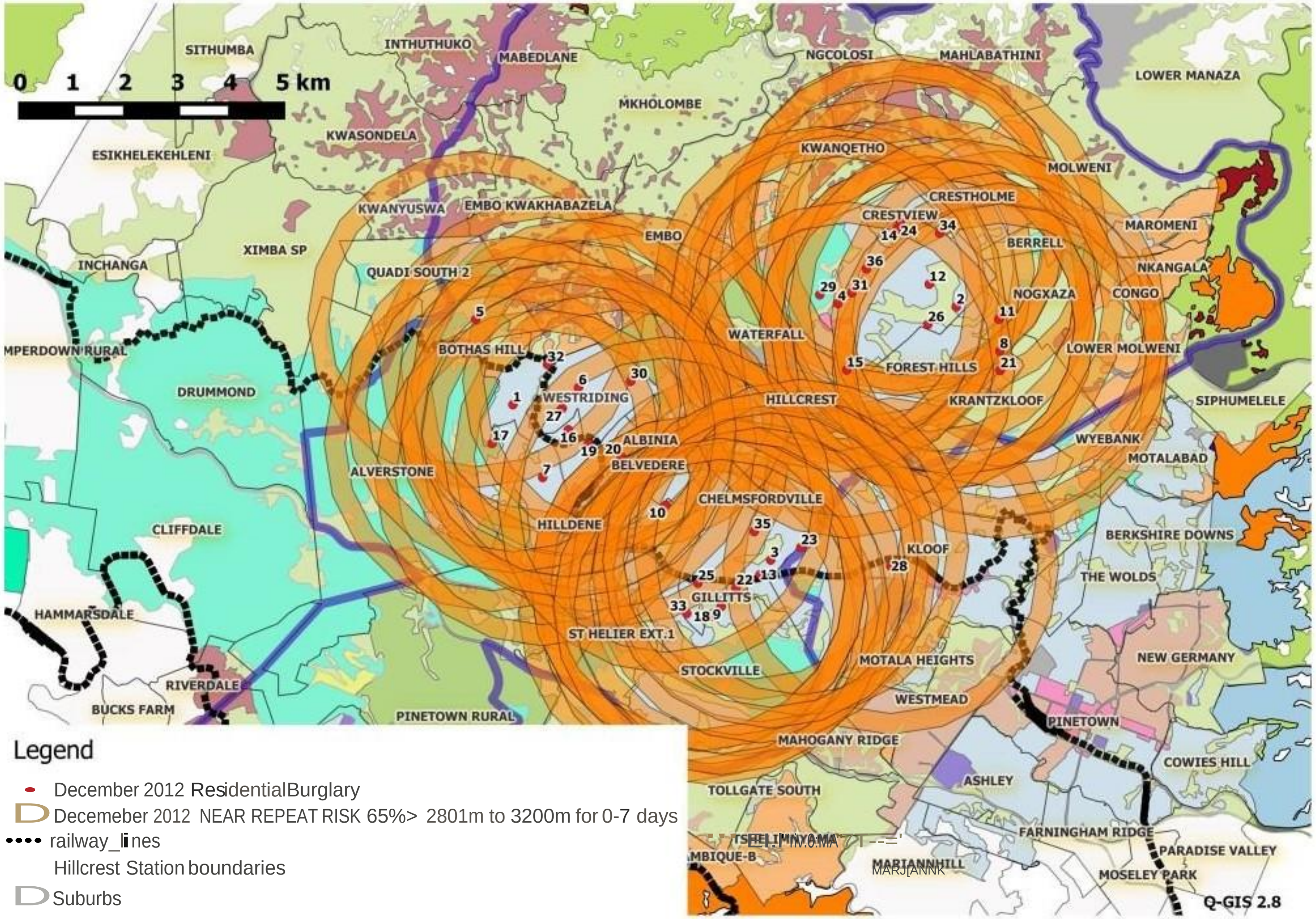
ANNEXURE 33: NOVEMBER 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



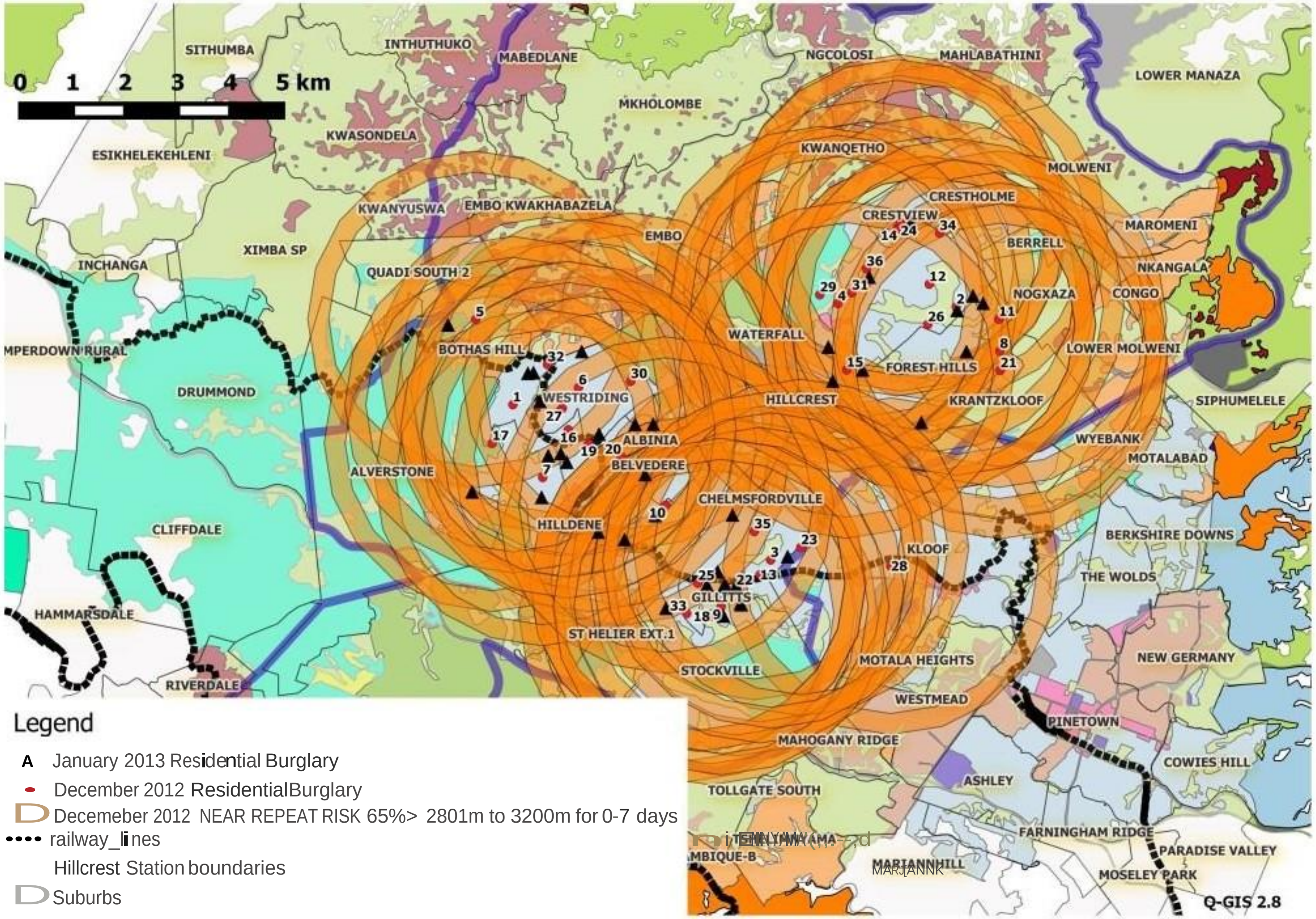
ANNEXURE 34: DECEMBER 2012- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



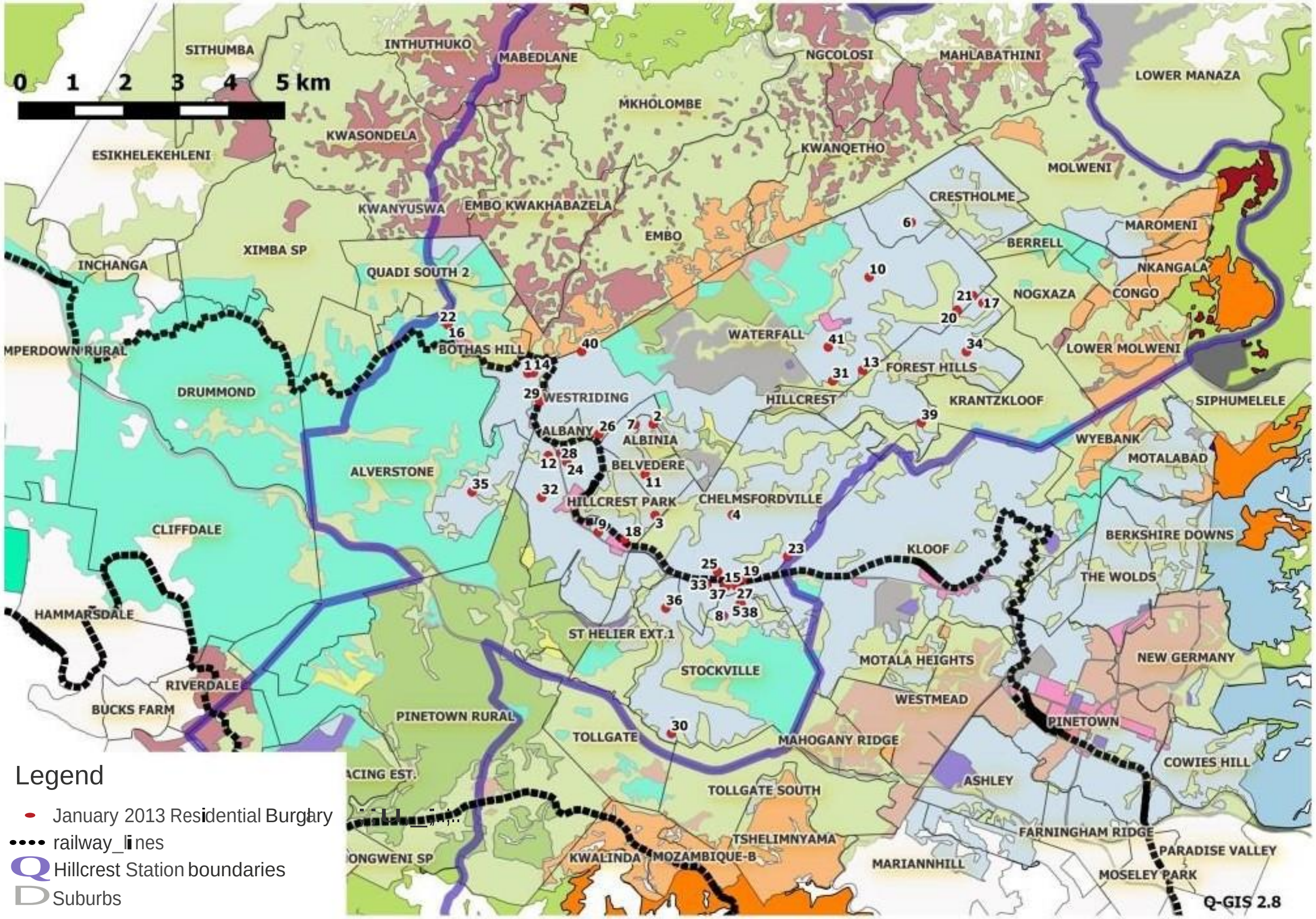
ANNEXURE 35: DECEMBER 2012- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



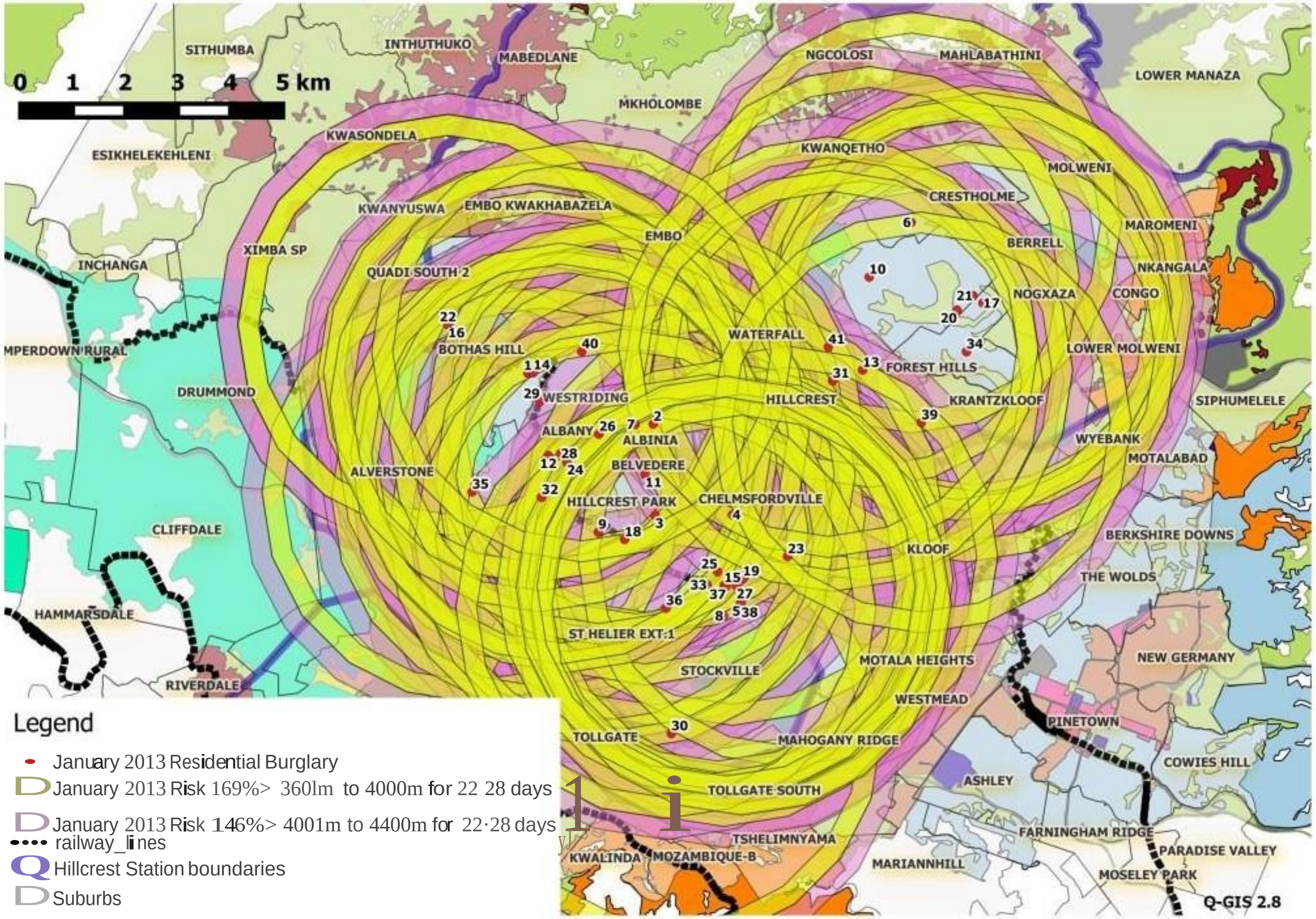
ANNEXURE 36: DECEMBER 2012- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



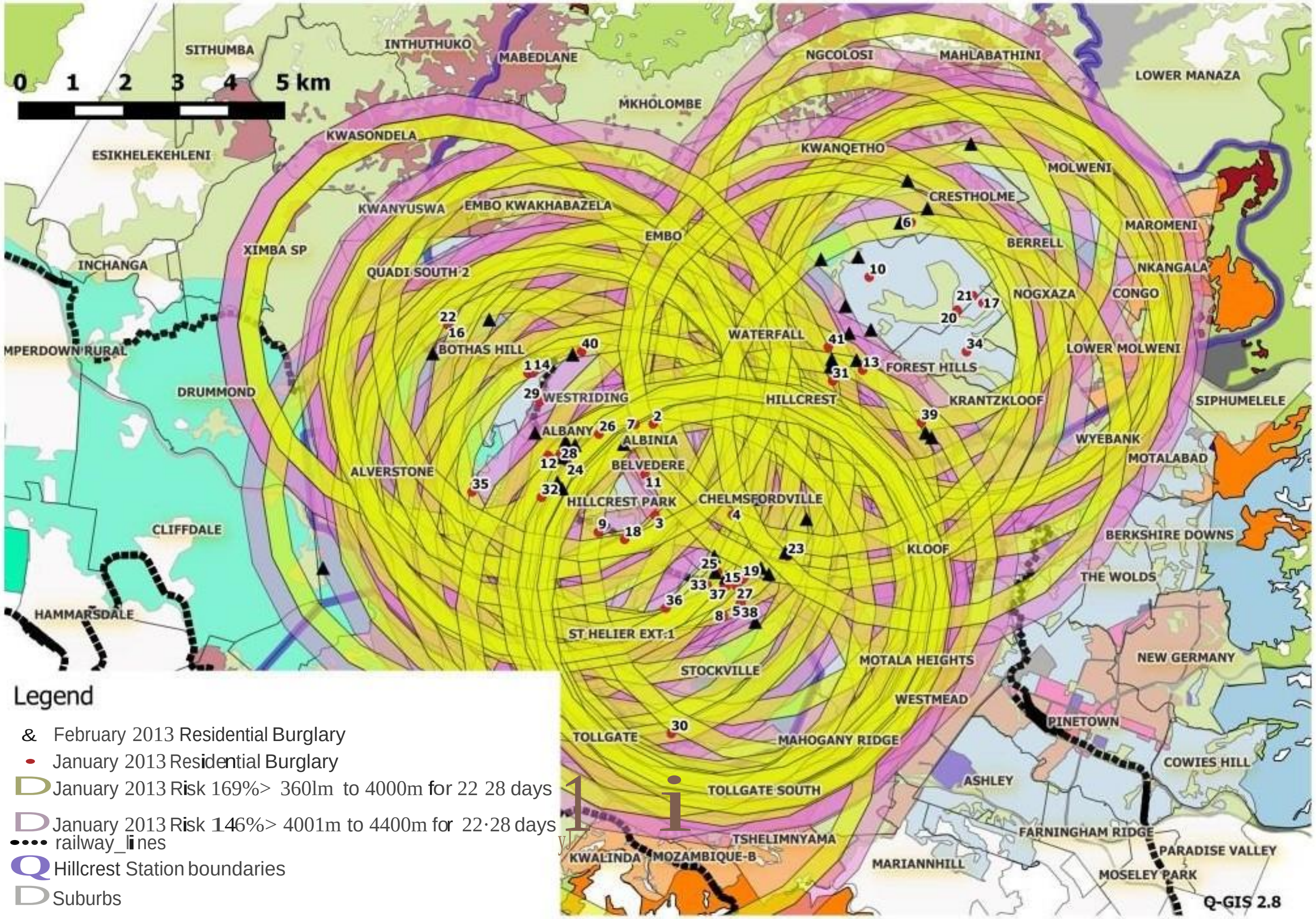
ANNEXURE 37: JANUARY 2013- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



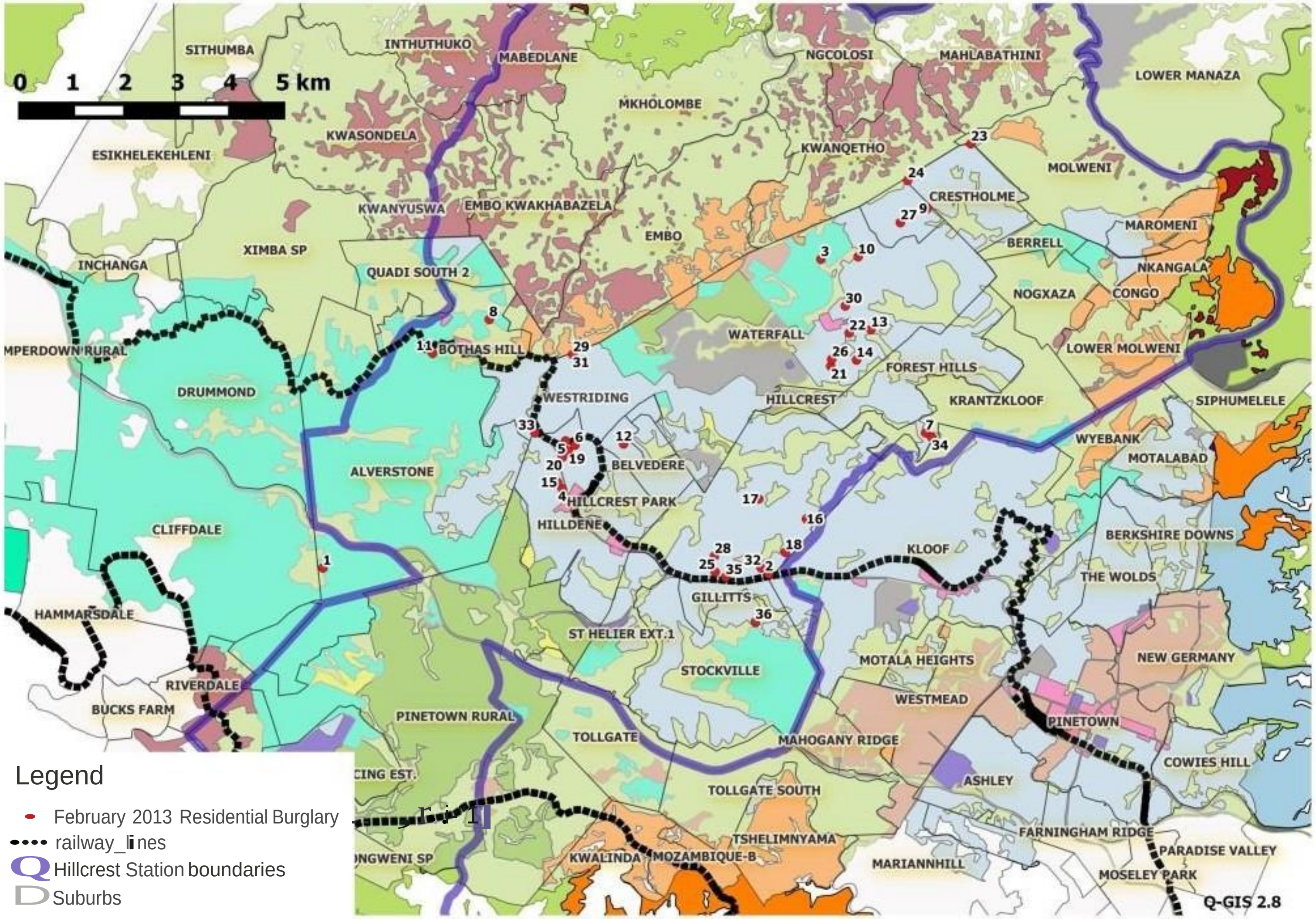
ANNEXURE 38: JANUARY 2013- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



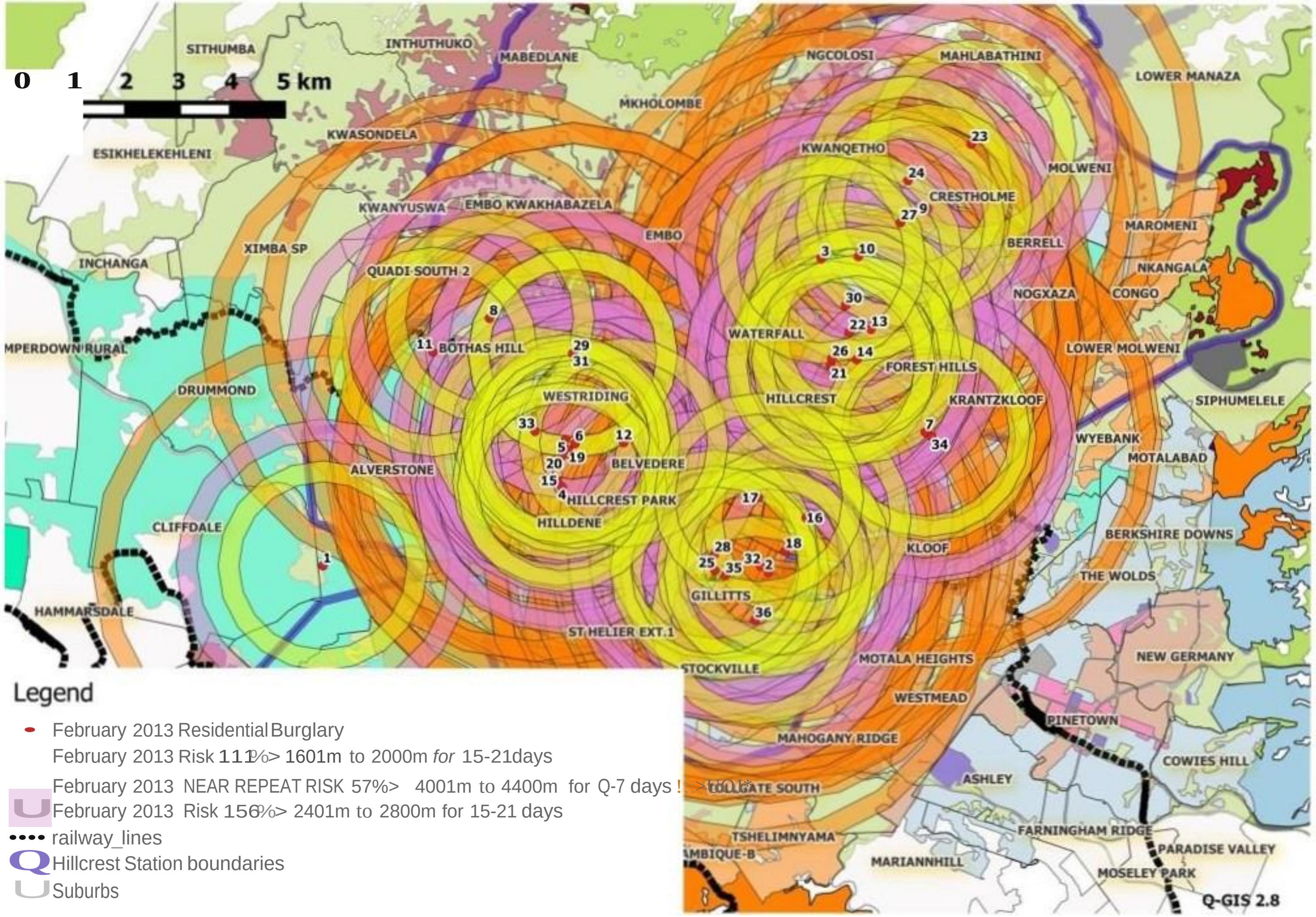
ANNEXURE 39: JANUARY 2013- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



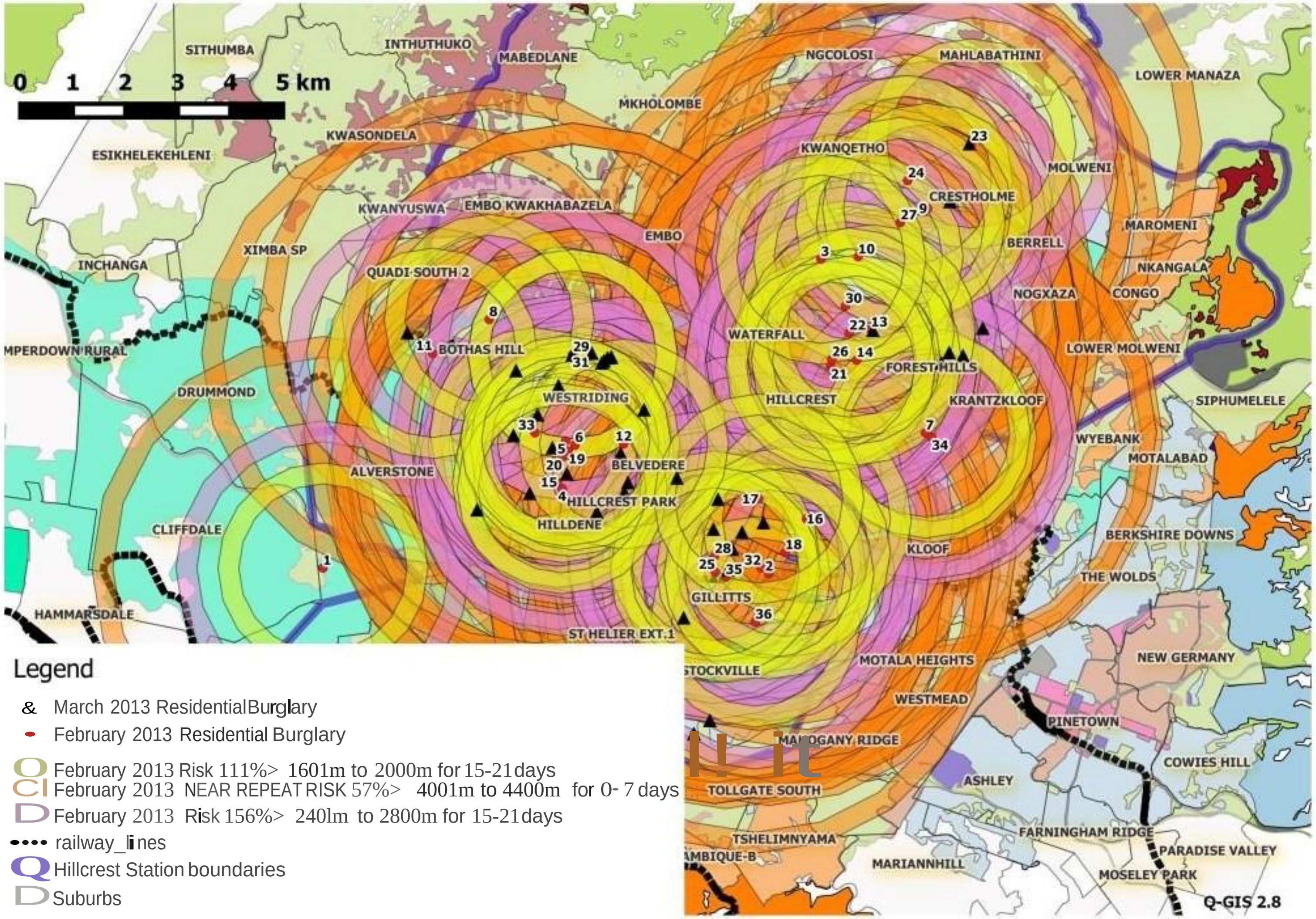
ANNEXURE 40: FEBRUARY 2013- RESIDENTIAL BURGLARIES (MAP 1 OF 3)



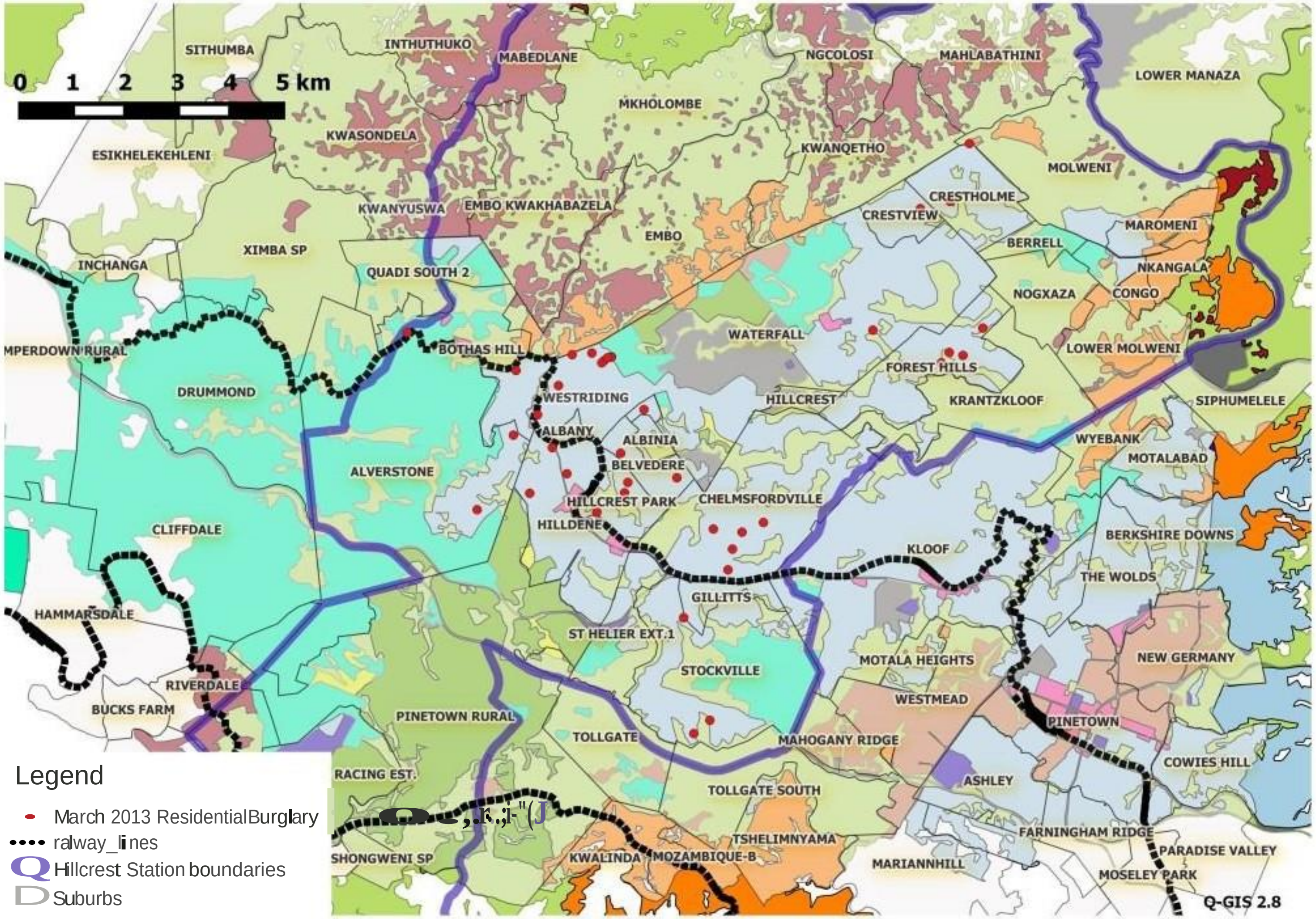
ANNEXURE 41: FEBRUARY 2013- RESIDENTIAL BURGLARIES (MAP 2 OF 3)



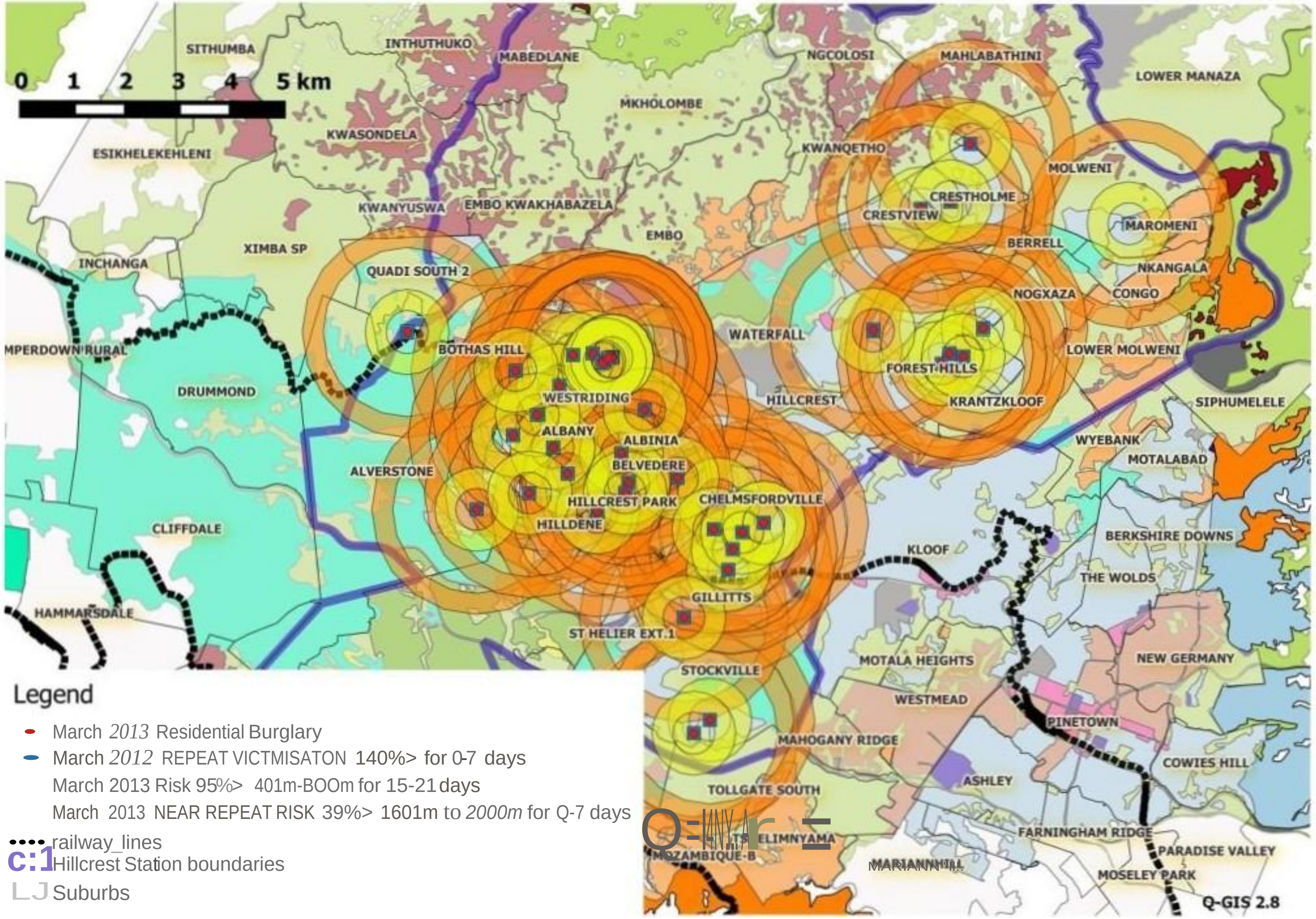
ANNEXURE 42: FEBRUARY 2013- RESIDENTIAL BURGLARIES (MAP 3 OF 3)



ANNEXURE 43: MARCH 2013- RESIDENTIAL BURGLARIES (MAP 1 OF 2)



ANNEXURE 44: MARCH 2013- RESIDENTIAL BURGLARIES (MAP 2 OF 2)



REFERENCES

A

Africa Health Placements. 2015. Whoonga, the cruellest drug. Available at: http://www.ahp.org.za/news-detail/87/whoonga-the-cruellest-drug
(accessed on: 4/11/2015).

Aguirre, J.C. 2014. The Unlikely History of the Origins of Modern Maps. Available at: http://www.smithsonianmag.com/history/unlikely-history-origins-modern-maps-180951617/
(accessed on: 21/01/2017).

Andresen, M.A., Brantingham, P.J. & Kinnery, J.B. 2010. Classics in Environmental Criminology. Canada: Simon Fraser University. Available at: https://books.google.co.uk/books?hl=en&lr=&id=iTDNBQAAQBAJ&oi=fnd&pg=PP1&dq=environmental+criminology&ots=sHw_J9Q7rK&sig=gMtGzYkiPiBMcqjBwsGbnnUpFls#v=onepage&q=environmental%20criminology&f=false
(accessed on: 6/01/2017).

Anon. [Sa]. What is dependability in qualitative research and how do we establish it? https://www.statisticssolutions.com/what-is-dependability-in-qualitative-research-and-how-do-we-establish-it/
(accessed on: 22/11/2018).

B

Babbie, E. (2016). *The basics of social research.* 7th edition. Boston: Cengage. Available at: https://books.google.co.uk/books?id=croaCgAAQBAJ&pg=PA92&dq=Exploratory+research+methods+social+sciences&hl=en&sa=X&ved=0ahUKEwjbxI7GnNfTAhWKL8AKHeBIBeg4ChDoAQgrMAI#v=onepage&q=Exploratory%20research%20methods%20social%20sciences&f=false
(accessed on: 4/05/2017).

Bachman, R. & Schutt, R.K. (2016). *The practice of research in criminology and justice. 6th edition.* California: SAGE.
https://books.google.co.uk/books?id=thwzCwAAQBAJ&pg=PT62&lpg=PT62&dq=Exploratory+research+criminology&source=bl&ots=giz7dLcUwB&sig=1JEn8ulxzlvfl2_JIUKjpqy3Xfc&hl=en&sa=X&ved=0ahUKEwjQlq63mprQAhWoA8AKHQcpCW0Q6AEIQDAG#v=onepage&q=Exploratory%20research%20criminology&f=false
(accessed on 16/01/2017)

Bachman, R.D. & Schutt, R.K. (2018). *Fundamentals of research in criminology and criminal justice.* Los Angeles: SAGE.

Balogun, T.F., Okeke, H. & Chukwukere, C.I. (2014). "Crime Mapping in Nigeria Using GIS". *Journal of Geographic Information System* 6(5): 453-466.
http://dx.doi.org/10.4236/jgis.2014.65039
(accessed on: 21/11/2018).

Beccaria, C. (1785). *Beccaria's essay of crime and punishment.* Translated from the Italian: With a Commentary, Attributed to Mons. de Voltaire. Translated from the French. 4th edition. London: Newbery. Available at:
https://books.google.co.uk/books?hl=en&lr=&id=j9RCAQAAMAAJ&oi=fnd&pg=PA1&dq=Beccaria++On+crimes+and+punishments+&ots=1apQHpSKMZ&sig=WNseeurwnM1Fcrds-Yd
_EZ1UlI#v=onepage&q=Beccaria%20%20On%20crimes%20and%20punishments&f=false
(accessed on: 22/11/2018).

Bentham, J. (1823). *An introduction to the principles of morals and legislation.* London: Macmillan & Co. Available at:
https://books.google.co.uk/books?id=xqkSAQAAMAAJ&printsec=frontcover&dq=jeremy+bentham&hl=en&sa=X&redir_esc=y#v=onepage&q=jeremy%20bentham&f=false
(accessed on 22/11/2018).

Bernard, T.J., Snipes, J.B. & Gerould, A.L. (2010). *Vold's theoretical criminology.* 6th edition. New York: Oxford University.

Bernasco, W. (2006). "Co-offending and the Choice of Target Areas in Burglary". *Journal of Investigative Psychology and Offender Profiling*, 3: 139-155. Available at: http://www.wimbernasco.nl/Manuscripts/English/Bernasco2006.pdf (accessed on: 20/01/2016).

Bishop, L. & Kuula-Luumi, A. (2017). "Revisiting Qualitative Data Reuse: A Decade On. Special Issue: Reusing Qualitative Data". *SAGE Open,* 7(1) January – March*:* 1-15.

Bowers, K.J. & Johnson, S.D. (2004). "Who commits near repeats? A test of the boost explanation". *Western Criminology Review,* 5(3): 12-24*.* Available at: http://westerncriminology.org/documents/WCR/v05n3/article_pds/bowers.pdf (accessed on: 22/11/2018).

Bowers, K.J. & Johnson, S.D. (2005). "Domestic burglary repeats and space-time clusters: the dimensions of risk." *European Journal of Criminology,* 2:67–92.

Brantingham, P.J. & P.L. Brantingham. (1984). *Patterns in crime*. USA: Macmillan.

Brantingham, P.L. & Brantingham, P.J. (1993). "Nodes, Paths and Edges: Considerations on the Complexity of Crime and the Physical Environment." *Journal of Environmental Psychology,* 13(1): 3-28.

Brantingham, P.L. & Brantingham, P.J. (1995). "Criminality of Place: Crime Generators and Crime Attractors." *European Journal on Criminal Policy and Research,* 13(3) January: 5-26.

Breetzke, G.D. (2007). "Geographic Information Systems (GIS) and policing in South Africa: A review." *Policing: An International Journal of Police Strategies & Management,* 29 (4): 723-724. https://doi.org/10.1108/13639510610711628

Breetzke, G.D. 2016a. GIS and its role in crime prevention in South Africa. Available at: http://www.ee.co.za/article/gis-role-crime-prevention-south-africa.html (accessed on: 22/11/2018)

Bruinsma, G. & Weisburd, D. (2014). *Encyclopaedia of criminology and criminal justice.* New York: Springer.

Bryman, A. (2016). *Social Research Methods*. 5th edition. New York: Oxford. Available at: https://books.google.co.uk/books?hl=en&lr=&id=N2zQCgAAQBAJ&oi=fnd&pg=PP1&dq=Research+method+bryman&ots=dnQuEWK5vc&sig=9ojVtp7h5sB55nJBENMJ6jtR6ec#v=onepage&q=Research%20method%20bryman&f=false (accessed on: 01/01/2017).

Bryson, D. 2010. AIDS drugs stolen in South Africa for 'whoonga'. Available at: http://www.sfgate.com/health/article/AIDS-drugs-stolen-in-South-Africa-for-whoonga-3164946.php# (accessed on: 05/05/2015).

C

Canter, D. & Youngs, D. (2008). *Principles of geographic profiling*. Oxon: Ashgate.

Chainey, S. & Ratcliffe, J. (2005). *GIS and crime mapping*. West Sussex: Wiley. Available at: https://books.google.co.uk/books?hl=en&lr=&id=FUEh9TUVNagC&oi=fnd&pg=PT11&dq=gis+for+crime+mapping+residential+burglary+history&ots=jJGC5W66UD&sig=eCsKXia6zJOHB44Z3fl_kqSakDs#v=onepage&q&f=false (accessed on: 18/01/2017).

Chainey, S.P. & da Silva, B.F.A. (2016). “Examining the extent of repeat and near repeat victimisation of domestic burglaries in Belo Horizonte, Brazil.” *Crime Science Journal,* 5(1): 1-10. Available at: https://crimesciencejournal.springeropen.com/articles/10.1186/s40163-016-0049-6 (accessed on: 26/0/2016).

Chapman, S. 2013. Best of 2013: Rat poison and heroin. Available at: http://www.mahala.co.za/reality/rat-poison-and-heroin/ (accessed on: 05/07/2018).

Chen, P., Yuan, H. & Li, D. (2013). “Space-time analysis of burglary in Beijing.” *Security Journal,* 26(1) 1-15.

Cherry, K. 2018. The Asch Conformity Experiments. Asch's seminal experiments demonstrated the power of conformity. Very Well Mind. Available at: https://www.verywellmind.com/the-asch-conformity-experiments-2794996 (accessed on: 22/11/2018).

Clark, J.A.G.R. 2014. *An exploratory study of the resident’s perception of security companies and the police in reducing crime in Hillcrest Park, KwaZulu-Natal.* Unpublished BA Honours (Criminology) research article. Department of Criminology and Security Science, the University of South Africa (available from the author at: jamesclark137@gmail.com).

Cohen, L.E. & Felson, M. (1979). “Social change and crime rate trends: a routine activities approach”. *American Sociological Review,* 44 (August): 588-608. Available at: http://www.personal.psu.edu/exs44/597b-Comm%26Crime/Cohen_FelsonRoutine-Activities.pdf (accessed on: 22/05/2017).

Cooper, A.K. & Schmitz, P.M.U. (2003). “Tactical crime mapping in South Africa.” *Networks and Communication Studies*,17, 3-4, 269-279. Available at: http://www.netcom-journal.com/volumes/articlesV173/Netcom269-279.pdf (accessed on: 30/10/2016).

Cooperative Governance Traditional Affairs. 2018. The Integrated Urban Development Framework (IUDF). Available at: http://www.cogta.gov.za/?programmes=the-integrated-urban-development-framework-iudf (accessed on: 04/01/2018).

Coppock, J.T. & Rhind, D.W., 1991, "The History of GIS". In Maguire, D.J., Goodchild M.F. & Rhind D.W. (editors) *Geographical Information Systems: Principles and Applications* 1: 21-43.

Cornish, D.B. & Clarke, R.V. (1986). *The reasoning criminal. Rational choice perspectives on offending*. New York: Springer-Verlag.

Cornish, D.B. & Clarke, R.V. (2014). *The reasoning criminal: rational choice perspective on offending*. London L Transaction. Available at: https://books.google.co.uk/books?hl=en&lr=&id=MPmmAgAAQBAJ&oi=fnd&pg=PP1&dq=critics+of+criminology+rational+choice+theory&ots=FBq4QlXiNO&sig=yCODzCFlSC8ZbMwNOvpNR24oYDM#v=onepage&q=critics%20of%20criminology%20rational%20choice%20theory&f=false (accessed on: 16/07/2017).

Cozens, P. & Love, T. (2017). *The Dark Side of Crime Prevention Through Environmental Design (CPTED).* Oxford Research Encyclopedias. Criminology and Criminal Justice. March. Available at: http://criminology.oxfordre.com/view/10.1093/acrefore/9780190264079.001.0001/acrefore-9780190264079-e-2 (accessed on: 26/11/2018).

Creswell, J.W. (2014). *Research design: qualitative, quantitative, and mixed methods approaches*. 4th edition. Croydon: SAGE.

CRIMSA. 2012. Constitution of the Criminological and Victimological Society of Southern Africa (CRIMSA). Available at: http://www.crimsa.ac.za/constitution.html (accessed on: 21/11/2018).

Crowther-Dowey, C. & Fussey, P. (2013). *Researching crime: approaches, methods, and application*. Hampshire: Palgrave Macmillan.

D

DeCuir-Gunby, J.T. & Schutz, P.A. (2017). *Developing mixed method proposals. A practical guide for beginning researchers*. California: SAGE.

Dempsey, C. 2012. History of GIS. Available at: https://www.gislounge.com/history-of-gis/
(accessed on: 21/01/2017).

Devault, G. 2017. Establishing Trustworthiness in Qualitative Research: What Are Qualitative Research Processes? The balance of small business. Available at: https://www.thebalance.com/establishing-trustworthiness-in-qualitative-research-2297042
(accessed on: 04/03/2018).

dos Santos, J.L.G., Erdmann, A.L., Meirelles, B.H.S., Lanzoni, G.M.D., da Cunha. V.P. & Ross, R. (2017). "Mixed Methods Approach in Research: Using an Example Focused on Gender and Race." *Texto Contexto Enferm*; 26(3): e1590016. Available at:http://www.scielo.br/pdf/tce/v26n3/en_0104-0707-tce-26-03-e1590016.pdf
(accessed on: 28/01/2018).

Dudovskiy, J. [Sa]. Exploratory Research. Available at: http://research-methodology.net/research-methodology/research-design/exploratory-research/ (accessed on:22/11/2018).

E

Eck, J.E. & Weisburd, D. (2015). "Crime places in crime theory." *Crime and Place: Crime Prevention Studies,* 4: 1-33*.* Hebrew University of Jerusalem Legal Research Paper. Available at: https://www.researchgate.net/profile/John_Eck2/publication/245815360_Crime_Places_in_Crime_Theory/links/0046353bbe4810d646000000.pdf (accessed on: 22/11/2018).

Eloff, C. 2006. Spatial Technology as a tool to analyse and combat crime. Available at: https://core.ac.uk/download/pdf/43164668.pdf (accessed on 21/11/2018).

Eloff, C. 2013. Integration of spatial technologies and methods to understand and combat crime in South Africa. Institute of Security Studies Seminar. 28 March. Available at: https://issafrica.s3.amazonaws.com/site/uploads/CorneEloff-Presentation-SpatialCrime.pdf (accessed on: 21/05/2017).

Erasmus, J. & Radebe, M. 2013. Prestbury and Town Hill have most burglaries in PMB. Available at: http://www.news24.com/Archives/Witness/Prestbury-and-Town-Hill-have-most-burglaries-in-PMB-20150430-2 (accessed on: 29/04/2017).

eResearch Methods. [Sa]. The University of Southampton. eResearch Methods. Aims and objectives. Available at:http://www.erm.ecs.soton.ac.uk/theme4/aims_and_objectives.html
(accessed on: 22/11/2018).

Everson, S. & Pease, K. (2001). "Crime against the same person and place: Detection opportunity and offender targeting." *Crime Prevention Studies,* 12:199-220.Available at:
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.491.3081&rep=rep1&type=pdf
(accessed on: 22/11/2018).

F

Farrell, G. & Pease, K. 1993. Once bitten, twice bitten: repeat victimisation and its implications for crime prevention. *Police Research Group, Crime prevention unit series paper no. 46 London: Home Office Police Department*. Available at: http://core.ac.uk/download/pdf/67259.pdf
(accessed on: 22/11/2018).

Fielding, M. & Jones, V. (2012). "Disrupting the Optimal Forager: Predictive Risk Mapping and Domestic Burglary Reduction in Trafford, Greater Manchester." *International Journal of Police Science and Management,* 14(1*)* March: 30-41. DOI: 10.1350/ijps.2012.14.1.260

Ford, C. 2016. The University of Virginia Library. Research Data Services and Sciences. Getting started with Negative Binomial Regression Modeling. Available at: https://data.library.virginia.edu/getting-started-with-negative-binomial-regression-modeling/
(accessed on: 02/11/2018).

Forrester, D., Chatterton, M., Pease, K. & Brown R. (1988). The Kirkholt Burglary Prevention Project, Rochdale. *Crime Prevention Unit: Paper 13*. London: Home Office.

G

GIS Geography. 2016. GIS Spatial Data Types: Vector vs Raster. Available at: http://gisgeography.com/spatial-data-types-vector-raster/
(accessed on: 2/01/2017).

Glasner, P. & Leitner, M. (2017). "Evaluating the Impact the Weekday Has on Near-Repeat Victimization: A Spatio-Temporal Analysis of Street Robberies in the City of Vienna, Austria". *International Journal of Geo-Information,* 6(1),3. Available at: doi:10.3390/ijgi6010003
(accessed on: 31/12/2018).

Gorr, W.L. & Kurland, K.S. (2012). *GIS tutorial for crime analysis.* California: ESRI Press.

Gray, D.E. (2014). *Doing research in the real world*. 3rd edition. London: SAGE.
Groff, E. & Taniguchi, T. (2016). "Employing Near-Repeat Patterns for Community-Driven Crime Prevention". *The Police Chief 83 (August): 54–60.*

Groff, E.R. & La Vigne N.G. 2002. Forecasting the future of crime mapping.
Available at:
http://www.popcenter.org/library/crimeprevention/volume_13/03-groff.pdf
(accessed on: 8/07/2015).

Grubb, J.A. & Nobles, M.R. (2016). "A Spatiotemporal Analysis of Arson". *Journal of Research in Crime and Delinquency* 53(1): 66-92.

Guy, D., Waterworth, T & Gopi, A. Stats reveal new crime patterns. Available at: https://www.iol.co.za/ios/news/stats-reveal-new-crime-patterns-2064140
(accessed on: 21/11/2018).

H

Haberman, C.P. & Ratcliffe, J.H. (2012). "The Predictive Policing Challenges of Near Repeat Armed Street Robberies". *Policing: A Journal of Policy and Practice,* 6(2), 1 June: 151–166. Available at: doi:10.1093/police/pas012 (accessed on: 31/12/2017)

Hägerstrand, T. (1970). "What about people in regional science?" *Papers of the Regional Science Association.* 24 (1): 6–21. Available at: http://courses.washington.edu/cee500/What%20about%20people%20in%20regional%20science.pdf
(accessed on: 22/11/2018).

Hawley, A. (1950). *Human ecology: a theory of community structure*. New York: Ronald.

Herbig, F.J.W. (2016). "Conservation Crime Research: Taking a step back to move forward". *Act Criminologica: South African Journal of Criminology,* 29(2).

Hill, B. & Paynich, R. (2014). *Fundamentals of crime mapping.* 2nd edition. Massachusetts: Jones & Bartlett.

Hillcrest Park Neighbourhood Watch. 2015. Hillcrest Park Neighbourhood Watch. Available at: http://www.hpnw.co.za
(accessed on: 31/01/2016).

Hitchcock, L. 2016. It's our community. Hillcrest Fever. Available at: https://www.news24.com/SouthAfrica/Local/Hillcrest-Fever/its-our-community-20160404
(accessed on: 01/12/2018).

I

Institute of Security Studies. Sa. The Definitions of Crimes used to compile the crime statistics. Available at:
https://www.issafrica.org/crimehub/topics/crime-statistics/the-definitions-of-crimes-used-to-compile-the-crime-statistics
(accessed on: 9/11/2016).

Isenberg, J. 2010. Police Leadership in a Democracy: Conversations with America's Police Chiefs. Available at:
http://books.google.co.za/books?id=G72r2ZSrZYYC&pg=PA6&lpg=PA6&dq=new+york+city+broken+windows+bratton+atlantic&source=bl&ots=ulNnN_xQh&sig=RCmt7dZHiiu1H6ags25LOEAJu8E&hl=en&sa=X&ei=YVyUU4vTOIu7PZj4gNgI&ved=0CCAQ6AEwCDgK#v=onepage&q=new%20york%20city%20broken%20windows%20bratton%20atlantic&f=false
(accessed on: 2/04/2015).

J

Jacobs, J. (1961). *The death and life of great American cities*. London: Jonathon Cope. Available at:
http://www.petkovstudio.com/bg/wp-content/uploads/2017/03/The-Death-and-Life-of-Great-American-Cities_Jane-Jacobs-Complete-book.pdf
(accessed on: 27/08/2018).

Jeffery, C. (1971). *Crime prevention through environmental design*. Beverly Hills California: SAGE.

Johnson, S.D. & Bowers, K.J. (2004). “The burglary as clue to the future: the beginnings of prospective hotspotting.” *European Journal of Criminology,* 1(2):237–255.

Johnson, S.D., Bernasco, W., Bowers, K.J., Elffers, H., Ratcliffe, J., Rengert, G. & Townsley, M. (2007). “Space-Time Patterns of Risk: A Cross National Assessment of Residential Burglary Victimisation”. *Journal of Quantitative Criminology*, 23: 201-219. Available at:
http://0eds.b.ebscohost.com.oasis.unisa.ac.za/eds/pdfviewer/pdfviewer?vid=2&sid=87efddfa-468a-4f41-9175-73d0c0bef33a%40sessionmgr101&hid=121
(accessed on: 22/01/2017).

K

Kelling, G.L. & Wilson, J.Q. 1982. Broken Windows: The police and neighbourhood safety. The Atlantic. Available at:
https://www.theatlantic.com/magazine/archive/1982/03/broken-windows/304465/
(accessed on: 22/11/2018).

Knox, G. (1963). “Detection of low-intensity epidemicity application to cleft lip and palate”. *Brit. J. prev. soc. Med*, 17, 121-127. Available at:
http://pubmedcentralcanada.ca/pmcc/articles/PMC1058905/pdf/brjprevsmed00071-0011.pdf
(accessed on: 11/02/2017).

Knox, G. (1964). “Epidemiology of childhood leukaemia in Northumberland and Durham”. *British Journal of Preventive & Social Medicine,* 18:17-24. Available at:
http://jech.bmj.com/content/18/1/17.full.pdf
(accessed on: 2/02/2017).

Krause, A. 2007. *The Crime Threat Analysis Process – An assessment*. Unpublished Magister Technologiae, University of South Africa. Available at:
http://uir.unisa.ac.za/bitstream/handle/10500/1727/dissertation.pdf
(accessed on 5/11/2016).

Krehnke. M. [Sa]. Crime Prevention through Environmental Design. Information Security Systems. Available at: http://www.infosectoday.com/Articles/CPTED.htm (accessed on: 22/11/2018).

Kruger, T., Lancaster, L., Landman, K, Liebermann, A., Louw, A. & Robertshaw, R. 2016. Making South Africa Safe: A manual for community-based Crime Prevention. Available at: https://www.csir.co.za/sites/default/files/Documents/Making%20South%20Africa%20Safe.pdf (accessed on: 27/08/2018).

L

Lehohla, P. 2014. Crime Statistics Series Volume 1: Exploration of the extent and circumstances surrounding housebreaking/burglary and home robbery 2010-2011. In-depth analysis of the Victims of Crime Survey data. Available at: http://beta2.statssa.gov.za/publications/Report-03-40-02/Report-03-40-022011.pdf (accessed on: 29/04/2015).

Lehohla, P. 2017a. Victims of Crime Survey 2016/2017. Statistics South Africa. Statistical release P0341. Available at: https://www.statssa.gov.za/publications/P0341/P03412016.pdf (accessed on: 2/12/2018).

Lehola, P. 2017b. Victims of Crime Survey 2015/2016. Statistical release P0341. Available at: https://www.statssa.gov.za/publications/P0341/P03412015.pdf (accessed on: 22/11/2018).

Lynch, K. (1960). *The image of the city.* Cambridge, Mass: MIT Press. Available at: http://www.miguelangelmartinez.net/IMG/pdf/1960_Kevin_Lynch_The_Image_of_The_City_book.pdf (accessed on: 22/11/2018).

M

Mabena, S. 2017. Lack of resources is crippling effective policing, study finds. Available at: https://www.businesslive.co.za/bd/national/2017-03-23-lack-of-resources-is-crippling-effective-policing-study-finds/ (accessed on: 21/11/2018).

Mantel, N. 1967. The Detection of Disease Clustering and a Generalized Regression Approach. Cancer Research 27 Part 1, 209-220, February. Available at: http://cancerres.aacrjournals.org/content/27/2_Part_1/209.full-text.pdf (accessed on: 5/02/2017).

Massachusetts Institute of Technology. [Sa]. Contributors: Kevin Lynch. Available at: https://mitpress.mit.edu/contributors/kevin-lynch (accessed on: 22/11/2018).

Maxfield, M.G. & Babbie, E.R. (2016). *Basic of research methods for criminal justice and criminology.* 4th edition. Boston: Centage. Available at: https://books.google.com/books?id=sDd-BAAAQBAJ&printsec=frontcover&dq=Basic+of+research+methods+for+criminal+justice+and+criminology.+4th+edition.+Cengage:+USA&hl=en&sa=X&ved=0ahUKEwippeTP_eXeAhXOneAKHeeZBJwQ6AEIKDAA#v=onepage&q=Basic%20of%20research%20methods%20for%20criminal%20justice%20and%20criminology.%204th%20edition.%20Cengage%3A%20USA&f=false (accessed on: 11/05/2017).

Miller, L.S, Hess, K.M. & Orthmann, C.H. (2014). *Community policing partnerships for problem-solving*. 7th edition. New York: Delmar Cengage.

Mistry, D., Snyman, R. & van Zyl, M. (2001). "Social fabric crime in the Northern Cape". Florida (SA): Institute for Human Rights and Criminal Justice Studies. Technikon SA.

Moreto, W.D., Piza, E.L. & Caplan, J.M. (2014). “A Plague on both Your Houses? Risks, Repeats and Reconsiderations of Urban Residential Burglary”. *Justice* Quarterly, 31 (6): 1102-1126. DOI: 10.1080/07418825.2012.754921 Available at: https://www.researchgate.net/profile/William_Moreto/publication/265390124_A_Plague_on_both_Your_Houses_Risks_Repeats_and_Reconsiderations_of_Urban_Residential_Burglary/links/5669d82f08ae430ab4f746a4.pdf (Accessed on: 12/03/2017).

Morgan, F. 2000. Repeat burglary in a Perth suburb: indicator of short-term or long-term risk. In: Farrell, G. & Pease K. (eds) *Repeat victimization: Crime Prevention Studies* 12: 83-118. Monsey, New York: Criminal Justice Press.

Mukumbira, S. 2012. Development of a Crime Mapping, Analysis and Prediction Tool for Windhoek. Polytechnic of Namibia. School of Information Technology Department of Software Engineering. Available at: http://ir.nust.na/bitstream/handle/10628/385/Mukumbira.%20MIT.%20Dev%20of%20a%20crime%20mapping%2C%20analysis%20and%20prediction%20tool%20for%20Windhoek.pdf?sequence=1&isAllowed=y (accessed on: 22/11/2018).

Mundell, A. & Ayres, D.2015. Alwinco: Taking security to a New Level in 2015 & into the future. Available at: http://www.camprosa.co.za/documents/Burglary_Armed_Robbery.pdf (accessed on: 25/04/2017).

Mysiak, J., Giupponi, C. & Rosato, P. 2005. Towards the development of a decision support system for water resource management. Environmental Modelling & Software 20, 203-214. Available at: https://www.researchgate.net/profile/Carlo_Giupponi2/publication/222580958_Towards_the_Development_of_a_Decision_Support_System_for_Water_Resource_Management/links/02e7e51bd77997e71a000000.pdf (accessed on: 04/01/2017).

N

Naicker, K. 2015. Crime wave hits Waterfall. Hillcrest Fever. 24 April. Available at: https://issuu.com/hillcrestfever/docs/hillcrest_fever_21- (accessed on: 21/11/2018).

Nair, Y. 2013a. Under Siege. Available at: http://www.iol.co.za/dailynews/news/under-siege-1.1489300 (accessed on: 21/11/2018).

Nair, Y. 2013b. Police move on Hillcrest. Available at: https://www.iol.co.za/dailynews/news/police-move-on-hillcrest-1498324 (accessed on 21/11/2018).

Natarajan, M. (2016). *Crime opportunity theories: routine activity, rational choice and their variants.* New York: Routledge. Available at: https://books.google.co.uk/books?hl=en&lr=&id=BTErDwAAQBAJ&oi=fnd&pg=PA157&dq=purpose+of+criminological+theories&ots=Sy7lkgkzh&sig=wBmaQeHhDSr4wLtjH8mjzOcDyPk#v=onepage&q=purpose%20of%20criminological%20theories&f=false (accessed on: 23/07/2017).

National Crime Registrar. 2017. Assessment: Functionality of crime information management and analysis centre at station level. Available at: https://www.saps.gov.za/resource_centre/publications/brig_manamela_assessment_functionality_of_CIMAC_at_station_level.pdf (accessed: on 21/11/2018).

National Institute of Justice. 2014. Translating “Near Repeat” Theory into a Geospatial Police Strategy. Available at: https://www.nij.gov/topics/law-enforcement/strategies/predictive-policing/Pages/near-repeat-theory.aspx

(accessed on: 21/11/2018).

National Institute of Justice. 2018. Mapping and Analysis for Public Safety. Available at: http://www.nij.gov/topics/technology/maps/pages/welcome.aspx
(accessed on: 11/22/2018).

National Planning Commission. 2012. National Development Plan 2030: Our future – make it work. Available at:
https://www.gov.za/sites/default/files/gcis_document/201409/ndp-2030-our-future-make-it-workr.pdf
(accessed on: 04/01/2018).

Newman, G., Clarke, R.V. & Shoham, S. (2016). *Rational choice and situational Crime prevention: theoretical foundations.* New York: Routledge. Available at:
https://books.google.co.uk/books?hl=en&lr=&id=ziSoDQAAQBAJ&oi=fnd&pg=PT6&dq=Rational+choice+and+situational+crime+prevention+&ots=AIkRHIsUuD&sig=yRUpyCyyEbPdLDHHp9Oizo5tVVI#v=onepage&q=Rational%20choice%20and%20situational%20crime%20prevention&f=false
(accessed: 20/06/2017).

Newman, O. (1972). *Defensible space: Crime prevention through urban design.* New York: Macmillan.

Nichols, J. 2012. Crime Prevention Through Environmental Design (CPTED). Oshkosh Police Department. Crime Prevention Unit. Available at:
http://www.oshkoshpd.com/assets/pdf/CRIME_PREVENTION_THROUGH_ENVIRONMENTAL_DESIGN_HANDBOOK.pdf
(accessed on: 30/01/2016).

North Glen News. 2016. Criminals are breaking into homes via the roof. Available at:
http://northglennews.co.za/94463/police-warn-of-latest-house-break-in-trends/
(accessed on: 29/04/2017).

O

Olckers, C. 2007. *An examination of the impact of residential security measures on the incidence of residential burglary in two selected northern suburbs of Johannesburg: A security risk management approach*. Unpublished MT Research Report. The University of South Africa. Available at: http://uir.unisa.ac.za/bitstream/handle/10500/1276/dissertation.pdf?sequence=1&isAllowed=y (accessed on: 22/11/2018).

Overall, C., Singh, S. & Gcina, B. (2008). "Crime mapping and analysis: filling the gaps". *Position IT, May/June*: 37-40. Available at: http://www.ee.co.za/wp-content/uploads/legacy/GisT-Crime%20mapping.pdf (accessed on: 04/01/2017).

P

Palisade. Sa. Monte Carlo Simulation. Available at: http://www.palisade.com/risk/monte_carlo_simulation.asp (accessed on: 02/11/2018).

Palmiotto, M.J. (2011). *Community policing: a police-citizen partnership.* New York: Routledge.

Pease, K. 1998. Repeat Victimisation: Taking Stock. Crime Detection and Prevention Series. Paper 90. Home Office Police Research.

Philip, R. 2014. Cleaning up grime to tackle criminals. The Witness. 16 January 2014. Available at: http://www.witness.co.za/index.php?showcontent&global[_id]=112953 (accessed on: 6/06/2014).

Piza, E.L. & Carter, J.G. (2018). "Predicting Initiator and Near Repeat Events in Spatiotemporal Crime Patterns: An Analysis of Residential Burglary and Motor Vehicle Theft". *Justice Quarterly*, 35(5): 842-870.

Polvi, N., Looman, T., Humphries, C. & Pease, K. (1990). “Repeat Break-And Enter Victimisation: Time Course and Crime Prevention Opportunity”. *Journal of Police Science and Administration,* 17(1): 8-11.

Porche, M. & Spencer, R. Mixed Methods Approach in Research: Using an Example Focused on Gender and Race. Massachusetts Institute for College and Career Readiness. Available at:
http://sites.bu.edu/miccr/files/2017/03/02.10.2017-SRF-Forum-Mixed-Method-Slides.pdf
(accessed on 28/01/2018).

Q

Q-GIS. [Sa]. QGIS - The Leading Open Source Desktop GIS. Available at: https://www.qgis.org/en/site/about/index.html
(accessed on: 21/11/2018).

Q-GIS. 2015. Q-GIS 2.8.3 programme download. Available at:
http://qgis.org/downloads/QGIS-OSGeo4W-2.8.3-1-Setup-x86.exe
(accessed on: 29/09/2015).

R

Ratcilffe, J.H. (2002). “Aoristic Signatures and the Spatio-Temporal Analysis of High-Volume Crime Patterns.” *Journal of Quantitative Criminology*, 18(1) March: 23-43.

Ratcliffe, J. [Sa]. Policing, criminal intelligence, and crime science. Near Repeat Calculator. Available at: http://www.jratcliffe.net/software/
(accessed on: 21/011/2016).

Ratcliffe, J.H. 2009. Near Repeat Calculator (version 1.3). Temple University, Philadelphia, PA, and the National Institute of Justice. Washington DC. August 2009. Available at:
http://www.cla.temple.edu/center-for-security-and-crime-science/projects/
(accessed on: 21/11/2018).

Riddick, A.T. Kessler, H. Giles, J. R. A. (eds.) (2017) *Integrated environmental modelling to solve real world problems: methods, vision, and challenges.* London, UK, Geological Society of London, NP-NP, 274pp. (Geological Society Special Publications, 408). Available at:
https://books.google.com/books?id=ljb2DQAAQBAJ&printsec=frontcover&dq=Riddick,+A.T.+Kessler,+H.+Giles,+J.R.A.,+eds.+2017+Integrated+environmental+modelling+to+solve+real+world+problems:+methods,+vision+and+challenges.+London,+UK,+Geological+Society+of+London,+NP-NP,+274pp.+(Geological+Society+Special+Publications,+408)&hl=en&sa=X&ved=0ahUKEwiVvqii8ufeAhXBmOAKHVbZClkQ6AEIMDAB#v=onepage&q&f=false
(accessed on: 22/11/2018).

S

Safer Spaces. [Sa]. Crime Prevention through Environmental Design (CPTED). Available at:
https://www.saferspaces.org.za/understand/entry/crime-prevention-through-environmental-design-cpted
(accessed on: 27/08/2018).

Santos, R.B. (2017). *Crime analysis with crime mapping.* 4th edition. California: SAGE.

Schmitz, P.M.U., Potgieter, M., Du Plessis, P., Cooper, A.K. & Schwabe, C.A. 2000. Crime analysis and decision support in the South African Police Service: enhancing capability with the aim of preventing and solving crime: Part 1: theoretical aspects of GIS and geocoding. Available at: http://hdl.handle.net/20.500.11910/8410 (accessed on: 11/04/2017).

Schutt, R.K. 2017. *Understanding the social world. Research methods for the 21st century.* California: SAGE.

Schwabe, C.A. & Schurink, W.J. 1999. GIS: the foundation of crime prevention in South Africa. In: Geographical Information Management Services User Conference. Midrand, South Africa) (Unpublished). Available at: http://hdl.handle.net/20.500.11910/8291 (accessed on: 11/04/2017).

Short, M.B., D'Orsogna, M.R., Brantingham, P.J. & Tita, G.E. (2009). "Measuring and Modelling Repeat and Near-Repeat Burglary Effects". *Journal Quantitative Criminology.* Available at: http://www.math.ucla.edu/~mbshort/papers/crime2.pdf (accessed on: 07/07/2015).

Snyders, E. 2016. *Crime perceptions of crime and the built environment: A case study of Kilner Park and Queenswood (Pretoria).* Unpublished dissertation. M Town and Planning. The University of Pretoria. Available at: http://repository.up.ac.za/handle/2263/57504 (accessed on: 7/05/2017).

South African National Space Agency. [Sa]. The First Remote Sensing Atlas to be launched in SA. Available at: https://www.sansa.org.za/2015/12/17/the-first-remote-sensing-atlas-to-be-launched-in-sa/ (accessed on: 22/11/2018).

South African Police Service. 2006. National Instruction 1/2006: Research in the Service. Unpublished document. Pretoria: SAPS.

South African Police Service. 2011. National Instruction 3/2011: The registration of case dockets on the crime administrative systems (CAS). The Division: Detective Service. Available at:
https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjpgr3forzWAhWPLFAKHe9SCnQQFggmMAA&url=http%3A%2F%2Fwww.khayelitshacommission.org.za%2Fbundles%2Fbundle-twelve%2Fcategory%2F266-1-expert-reports.html%3Fdownload%3D2585%3A6j.%2520MVE%2520Nt%2520instruction%25203%2520of%25202011%2520annex%2520J%26start%3D40&usg=AFQjCNEnL_Behl4IHb-_2HlM4E5RPsf_Aw
(accessed on: 23/09/2017).

South African Police Service. 2015a. Strategic Plan 2014-2019. South African Police Service. Available at:
https://www.saps.gov.za/about/stratframework/strategic_plan/2015_2019/strategic_plan_%202015.pdf
(accessed on: 21/11/2018).

South African Police Service. 2015b. 2015/2016 Annual Performance Plan for the South African Police Service. Available at:
http://www.saps.gov.za/about/stratframework/strategic_plan/2015_2016/APP_2015-16.pdf
(accessed on: 21/11/2018).

South African Police Service. 2018. South African Police Service. SAPS Crimestats. Available at:
https://www.saps.gov.za/services/crimestats.php
(accessed on 21/11/2018).

Statistics South Africa. 2012. Victims of Crime Survey 2012: Reference period January to December 2011. Statistical release P0341. Available at: http://www.statssa.gov.za/publications/P0341/P03412012.pdf (accessed on: 02/12/2018).

Statistics South Africa. 2015. Victims of Crime Survey 2014/2015. Statistical release P0341. Available at: https://www.statssa.gov.za/publications/P0341/P03412014.pdf (accessed on: 13/01/2019).

Statistics South Africa. 2018. Victims of Crime Survey 2017/2018. Media Released. 11 October 2018. Available at: http://www.statssa.gov.za/?p=11632 (accessed on: 02/12/2018).

T

Tech Beat. 2008. Calculate repeat crime. Available at: https://www.policeone.com/police-products/false-alarm-management/articles/1806302--Calculate-repeat-crime/ (accessed on: 10/11/2016).

Thakur, D. [Sa]. What is DSS? What is the purpose of Decision Support System in MIS? Available at: http://ecomputernotes.com/mis/structure-and-classification/what-is-dss-what-is-the-purpose-of-decision-support-system-in-mis (accessed on: 21/11/2018).

The Belmont Report. 1979. Office for Human Research Protections. Available at: https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html (accessed on: 21/11/2018).

Thomas, D. R. & Hodges, I. D. (2010). *Designing and managing your research project: Core knowledge for social and health researchers.* London: Sage.

Tobler, W.R. (1970). "A Computer Movie Simulating Urban Growth in the Detroit Region Economic Geography. Supplement: Proceedings. International Geographical Union". Commission on Quantitative Methods (46) June: 234-240.Available at: https://pdfs.semanticscholar.org/eaa5/eefedd4fa34b7de7448c0c8e0822e9fdf956.pdf
(accessed on: 22/11/201).

Tomlinson, R. F. 1962. Computer Mapping: An Introduction to the Use of Electronic Computers in the Storage, Compilation and Assessment of Natural and Economic Data for the Evaluation of Marginal Lands. Report presented to the National Land Capability Inventory Seminar held under the direction of the Agricultural Rehabilitation and Development Administration of the Canada Department of Agriculture, Ottawa, November 29th and 30th. Available at: https://gisandscience.files.wordpress.com/2012/08/4-computermapping.pdf
(accessed on: 21/11/2018).

Tomlinson, R.F. 1963. Feasibility Report of Computer Mapping System, Agricultural Rehabilitation and Development Administration, Department of Agriculture, Government of Canada. August. Available at: https://gisandscience.files.wordpress.com/2012/08/5-feasibility-report.pdf
(accessed on: 21/11/2018).

Townsley, M., Homel, R. & Chaseling, J. (2003). "Infectious Burglaries: A Test of the Near Repeat Hypothesis". *British Journal of Criminology,* 43(3), 615-633. Available at: http://www.researchgate.net/publication/29457289_Infectious_Burglaries_A_Test_of_the_Near_Repeat_Hypothesis/file/60b7d51eb901bb1af7.pdf
(accessed on: 27/06/2014).

Townsley, M., Johnson, S.D. & Ratcliffe, J.H. (2008). "Space Time Dynamics of Insurgent Activity in Iraq". *Security Journal,* 21: 139-146.

Turner, J. 2013. Juvenile Criminality and Environmental Criminology. Available at: https://www.academia.edu/4302108/Juvenile_Criminality_and_Environmental_Criminology
(accessed on: 6/01/2017).

U

United Nations Office on Drugs and Crime. 2015. "Tik" Crystal meth in Cape Town. Available at: https://www.unodc.org/unodc/en/frontpage/tik-meth-in-cape-town.html (accessed on: 4/11/2015).

V

Van Graan, J. & Van der Watt, M. (2014). "Case docket analysis: An effective crime information product for criminal investigators, crime analysts and crime researchers". *Acta Criminologica: Southern African Journal of Criminology,* 27(1): 144-159.

van Zyl, G.S. 2002. *Residential burglary in South Africa: A geographical perspective.* Unpublished D.Phil Dissertation. Department of Geography, Geoinformatics and Meteorology. The University of Pretoria. Available at:
http://repository.up.ac.za/handle/2263/28842
(accessed on: 30/01/2016).

W

Waldheim, C. & Irving, J.E. 2011. The Invention of GIS. The Harvard Gazette. Available at:
https://news.harvard.edu/gazette/story/2011/10/the-invention-of-gis/
(accessed on: 03/11/2018).

Walklate, S. (2017). *Criminology the basics*. 3rd edition. New York: Routledge.

Wang, Z. & Liu, X. (2017). “Analysis of Burglary Hotspots and Near-Repeat Victimization in a Large Chinese City”. *ISPRS International Journal of Geo-Information,* 6(5):148.

Winchester, S., & Jackson, H. 1982. Residential Burglary: the limits of prevention. A Home Office Research and Planning Unit Report. London: Home Office Research Study No. 74. Available at:
https://pdfs.semanticscholar.org/4bea/e772748235a3802cbc4f4f793b55416ee5b5.pdf
(accessed on: 21/11/2018).

Winfree, L.T. & Abadinsky, H. (2017). *Essentials of criminological theory*. 4th edition. Illinois: Waveland. Available at:
https://books.google.co.uk/books?id=A5yqDAAAQBAJ&printsec=frontcover&dq=criminological+theories+2016+role+of+criminological+theories&hl=en&sa=X&ved=0ahUKEwi2sMjz6a7UAhWEbRQKHfHvAKcQ6AEIIjAA#v=onepage&q=criminological%20theories%202016%20role%20of%20criminological%20theories&f=false
(accessed on: 21/11/2018).

Withrow, B.L. (2014). *Research methods in crime and justice*. New York: Routledge.
Wortley, R. & Mazerolle, L. (2011). *Environmental Criminology and Crime Analysis.* Routledge: New York. Available at:
https://books.google.co.uk/books?hl=en&lr=&id=bjKo1sjd4mIC&oi=fnd&pg=PR3&dq=WHat+is+environmental+criminology&ots=0PLBP_E6R1&sig=yIWweDvtdgfgo4y4_8rB1dqCkgE#v=onepage&q=WHat%20is%20environmental%20criminology&f=false
(accessed on: 12/11/2016).

Wu, L., Xu, X., Ye, X. & Zhu, X. (2015). “Repeat and near-repeat burglaries and offender involvement in a large Chinese city”. *Cartography and Geographic Information Science,* 42(2): 178-189.

Y

Youstin, T.J., Nobles, M.R., Ward, J.T. & Cook, C.L. (2011). "Assessing the Generalizability of the Near Repeat Phenomenon". *Criminal Justice and Behaviour,* 38(10) September: 1042-1063.

Z

Zahm, D. 2007. Using Crime Prevention Through Environmental Design in Problem-Solving. U.S. Department of Justice Office of Community Oriented Policing Services. Problem-Oriented Guides for Police Problem-Solving Tools Series No. 8. Available at:
https://ric-zai-inc.com/Publications/cops-p132-pub.pdf
(accessed on: 22/11/2018).

Zimbardo, P. 2007. *The Lucifer Effect: How Good People Turn Evil.* New York: Random House. Available at:
https://archive.org/details/TheLuciferEffectUnderstandingHowGoodPeopleTurnEvilISBN9781400064113/page/n313
(accessed on 22/11/2018).

Zinn, R. (2010). *Home invasion: Robbers disclose what you should know*. Cape. Tafelberg.

Personal communications:

Breetzke, G. Professor. Department of Geography, Geoinformatics and Meteorology, at the University of Pretoria, South Africa. 2016. 2, 19, 20 October. Personal communication by email.

Hillcrest Community Policing Forum. 2015. Personal communication via email. 24 August.

Interview No 1. Detective. South African Police Services, Hillcrest. 2015. 7 May.

Interview No 2. Detective. South African Police Services, Hillcrest. 2015. 8 May.

Interview No 3. Detective. South African Police Services, Hillcrest. 2015.19 May.

Interview No 4. Detective. South African Police Services, Hillcrest. 2015. 20 May.

Interview No 5. Detective. South African Police Services, Hillcrest. 2015.15 June.

Kruger, T. Professor. Principal researcher at the Council for Scientific and Industrial Research (CSIR). 2017. 2017. 4, 6, 9, 13 July. Personal communication by email.

Landman, K. Dr. Previously a Principal researcher at CSIR, Built Environment, South Africa, and currently a lecturer at the University of Pretoria. 2017. 2, 3 July. Personal communication by email.

Schmitz, P. Dr. A Principal Researcher at the Council for Scientific and Industrial Research (CSIR), South Africa. 2016. 2, 3 and 4 October. Personal communication by email.

Zinn, R. Professor. University of South Africa (UNISA), College of Law, School of Criminal Justice, Department of Police Practice. 2017. 14, 15 September. Personal communication by email.