

**UNDERSTANDING RAILWAY TRESPASSING  
IN A  
SOUTH AFRICAN CITY:  
THE CASE OF CAPE TOWN**

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WLLFAI003**



Submitted in partial fulfilment of the requirements for the degree of  
Master of Science in Engineering

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2020

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## **Keywords**

Countermeasures, fatalities, pedestrian, railway, safety, security, trespass.

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# Abstract

Trespassing behaviour is a problem for railway operations and manifests itself through train-pedestrian collisions, incidents of theft and vandalism to rail infrastructure, as well as encroachment on railway property. The study has consisted of a quantitative and a qualitative part. The quantitative part analyses demographic, temporal and spatial data on train-pedestrian fatalities and injuries, as well as data on occurrences of theft and malicious damage to rail infrastructure in the Cape Town Functional Region between 2015 and 2018. The qualitative part presents the perspective from a diverse group of subject matter experts, having explored opinions on trespassing behaviours and preventative measures. Additionally, the trespassing behaviour at several sites was investigated and a case study evaluation of the efficacy of a pilot Rail Enforcement Unit was carried out. There were 456 railway-related deaths during the study period with 330 of this being train-pedestrian collisions. There were 4715 occurrences of theft and malicious damage to railway assets over the period. Several hot-spot areas were identified via the data and interviews with experts and several sites chosen for further verification. Site visits confirmed widespread trespassing behaviours with the two worst locations recording an average of over 300 persons in a 15-minute period. The case study reviewing the effectiveness of the security and enforcement countermeasure revealed that occurrences of train-pedestrian incidents, as well as security occurrences have increased by 1.4% and 7.5% respectively. Evidence of geographical displacement of crime is evident, suggesting that enforcement countermeasures are temporarily effective and need to be considered in combination with other measures to ensure its durability. In conclusion, this research presents a detailed analysis of railway trespassing and its main effects in order to understand the problem locally. Different approaches are required to combat the various guises of railway trespassing. Certain countermeasures may well be within the rail operator's remit, but essentially, the nature of problems experienced by the rail operator is beyond a rail problem, and requires a systems approach involving multiple authorities.

# Statement of Original Authorship

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# Acknowledgements

This dissertation is written in the Faculty of Engineering & the Built Environment, Department of Civil Engineering's, Centre for Transport Studies and concludes my Master's Degree.

Several persons and organisations have been involved in this project with advice, guidance, professional knowledge, experience and motivation.

I am very grateful for the belief and support from my supervisor, Professor Marianne Vanderschuren. Thank you very much for your professional guidance and motivation.

To Metrorail and the Railway Safety Regulator: Thank you for your advice and support and making the required data available for my research.

To the Forensic Pathology Services: Thank you for providing access to the required data for my research.

To Teuns Kok, City of Cape Town: Thank you very much for your assistance and valuable time spent to give constructive criticism and advice.

To my work colleagues at the Department of Transport and Public Works, Transport Operations, thank you for your assistance and time.

I am thankful to the Department of Transport and Public Works for providing me with the financial support to enable me to complete my studies.

Finally, to my wife, Shameemah Williams: Thank you very much for all your support, help, patience, motivation and guidance through my period of study.

Cape Town, August 10, 2020

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Faizel Williams

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# List of Abbreviations

CCTV	Closed-circuit Television
E-a	Occurrence where a member of public is struck by rolling stock on a running line
FPS	Forensic Pathology Services
PAIE	Prevention of Illegal Eviction from and Unlawful Occupation of Land Act
PRASA	Passenger Rail Agency of South Africa
PT	Public Transport
RAP	Resettlement Action Plan
RESTRAIL	Reduction of Suicides and Trespasses on Railway Property
REU	Rail Enforcement Unit
RRPU	Rapid Rail Police Unit
RSR	Railway Safety Regulator
RSSB	Rail Safety and Standards Board
SANS	South African National Standards
SAPS	South African Police Services
TFR	Transnet Freight Rail

# Chapter 1: Introduction

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South Africa's, Railway Safety Regulator (RSR) in its State of Safety Report for 2017/18, revealed that "people struck by trains on running lines contributes the most to the overall number of fatalities caused by rail operations". The report continues to confirm that "the public accounted for 98.8% of the total fatalities and 98.4% of the total injuries reported in 2017/18" (RSR, 2018). For the occurrence category *People struck by trains during movement of rolling stock*, 588 occurrences were recorded, of which 343 were fatal (RSR, 2018). Unfortunately, as far as railway trespassing is concerned, this only describes a fraction of the problem.

Theft of railway assets and vandalism to railway property recorded a staggering 6701 occurrences nationally. Furthermore, the Rapid Rail Police (RRP) of the South African Police Services (SAPS) made 15 615 arrests for crimes labelled as "illegally crossing the railway line" during the period (RSR, 2018).

If we wish to reduce the number of pedestrian-rail incidents, a thorough comprehension of current knowledge around railway trespassing needs to be undertaken, as well as the measures that have been used for the prevention of railway trespassing. Very little research exists in the specific area of railway trespassing, and especially in the South African social context, where inadequate knowledge of the motives and behaviour of pedestrians often affect the effectiveness of engineering solutions.

The work presented in this dissertation will focus on the subject of railway trespassing within the Western Cape Region and specifically, within the commuter rail service area in the greater City of Cape Town functional region.

This chapter outlines the current status quo of rail in the Western Cape (Section 1.1); Section 1.2 defines the research problem and Section 1.3 lists the objectives of the research. Section 1.4 poses the research questions, Section 1.5 explains the deficiencies in the existing knowledge and Section 1.6 lists who would benefit from the research. Section 1.7 defines the scope of this research. Finally, Section 1.8 summarises the structure of the entire report and includes an outline of the remaining chapters of the dissertation.

## **1.1 RAIL IN THE WESTERN CAPE – THE STATUS QUO**

In order to understand and contextualise rail in the region and to understand the challenges faced, it is important to acknowledge the role apartheid has played from a spatial planning perspective. The following section will provide a brief history of rail development in the Western Cape, after which the key rail institutions will be described, followed by a situational analysis of the current rail service offering in the region.

### **1.1.1 The beginning of rail in the Western Cape**

The discovery of precious metals and stones in South Africa in the 1860's saw rapid urban advancement along with an increased demand for transport and set the pace for rail development at the time (Fox, 2019). The 70-kilometer Cape Town to Wellington line was completed in 1863, led by William Brounger from the Cape Town Railway and Dock Company under the auspices of the Colonial Government at the time. This Northern Line connected Cape Town to Bellville via Eerste River en route to Wellington.

The privately owned Wynberg Railway Company followed by opening the branch line between Cape Town and Wynberg in 1864 (Fox, 2019). What we now know as the Southern Line, was extended to Muizenberg in 1882, and reached Simon's Town in 1890 (Boonzaaier, 2008).

Fast forward several years to 1948 and the introduction of apartheid, by the then National Government, which enforced laws that required separate development for different racial groups. As far as urban development is concerned, the key legislation that would shape the lay of the land were the Group Areas Act, 1950 and the Promotion of Bantu Self-Government Act, 1959 (SAHO, 2019). These Acts combined, deemed that white, Coloured, Indian and Africans, should not only live in separate areas, but also called for the forced removal and relocation of communities to undeveloped areas far from the centre of Cape Town (Turok, 1994); (SAHO, 2019).

Apartheid urban planning saw Coloured and Black housing projects flourish on the urban fringes of the city and transformed the Cape Flats, so called because it consisted of a vast sheet of unconsolidated Aeolian sand, into a vast sprawl of settlements called townships. These townships consisted of both formal housing, as

well as informal housing, called Shantytowns (SAHO, 2019). This apartheid spatial engineering necessitated the rapid construction of new railway lines to ensure that the largely Coloured and black labour force were still able to reach places of work in the City (Pirie, 2002).

The Cape Flats Line was constructed for this purpose, and later, in 2008, the rail line to Khayelitsha, where at the time it was believed that the population of Khayelitsha had more than one million inhabitants (Bray, 2019).

### **1.1.2 Railway institutions**

Railway originally developed around the need for agricultural and industrial growth and all assets under the former Colonies were unified in 1910 by the establishment of the South African Railways and Harbours (SAR&H); (DoT, 2015). The strategic direction, enabled by the South Africa Act of 1909, was to support development in-line with business principles whilst at the same time supporting communities by increasing access to affordable and “*cheap transport*” (DoT, 2015).

The South Africa Act was replaced by the Republic of South Africa Constitution Act 32 of 1961, and while it still focused on agricultural and industrial growth, it had less emphasis on social development. Rail development was still favoured during this time with a highly regulated road transport environment. This however, changed with the introduction of the Road Transport Act 74 of 1977, which introduced changes to start deregulating road transport.

The South African Transport Services Act No.65 of 1981 (SATS) replaced the SAR&H, with a renewed focus on economic development and the transport system required to support this development. Rail continued to grow around major growth nodes but did not extend to the areas of high population growth.

The De Villiers Report of 1986 then came at a time when rail transport was running at significant losses. According to De Villiers, “*the only way to preserve the railway (as distinct from a railway company) as a viable commercial operation is to have it concentrate on fulfilling those transportation functions in which it has inherent cost advantage*” (deVilliers, 1986). The adoption of this report by Parliament saw investment in rail severely curtailed and started the process which would restructure the rail (and transport) industry in its entirety (DoT, 2015). This period signalled the start of the decline in rail and was compounded by the complete

deregulation of road transport, with the promulgation of the Transport Deregulation Act No. 80 of 1988. Rail lost its market share to the road transport industry with significant impacts to the country as a whole.

Little is written about the state of SATS management structures during this time, but it would be safe to assume that this was not unaffected. The relationship between organisation safety cultures and the executive leadership of those organisations are intrinsically linked. This would directly affect safe working processes, risk assessments and control, as well as the competence and training of staff during this time, all affecting railway safety.

The Legal Succession to the South African Transport Services Act, 1989 replaced SATS and was the primary instrument to differentiate between the economically viable freight rail sector and the uneconomic commuter rail sector (deVilliers, 1986); (RSA, 2019).

The South African Rail Commuter Corporation (SARCC) was thus formed to manage commuter rail services and Transnet, through its Spoornet division, would be responsible for freight services. Despite this separation, the formation of SARCC and Spoornet, could not change the fortunes of the rail industry and the decline continued.

### ***PRASA and Metrorail***

The SARCC consolidated Metrorail for urban commuter services, as well as Shosholoza Meyl catering for inter-city long-distance commuter travel. The Passenger Rail Agency of South Africa (PRASA) was established in 2009 to “...ensure that, at the request of the Department of Transport, for rail commuter services are provided within, to and from the Republic in the public interest, and Provide, in accordance with the Department of Transport, for long-haul passenger rail and bus services within, to and from the Republic in terms of the principles set out in Section 4 of the National Land Transport Transition Act, 2000 [Act No. 22 of 2000]” (PRASA, 2019). PRASA’s focus would be to promote rail as the preferred mode of travel in high-density corridors. This, despite, a legacy of now ageing and inadequate railway assets and infrastructure.

Metrorail is operational in the Western Cape, Gauteng, KwaZulu-Natal and the Eastern Cape. Metrorail's offering in the Western Cape will be dealt with in more detail in Section 1.1.3.

### ***Transnet Freight Rail***

The Legal Succession to the South African Transport Services Act, 1989, allowed Transnet to focus on its core business of freight. Transnet Freight Rail (TFR) became Transnet's rail operating division; unlike commuter rail, TFR receives no government subsidy and funds. TFR owns all the 'rail-and-below' assets it operates and has agreements with PRASA to share rail infrastructure where mutually beneficial to both parties (DoT, 2015).

### ***The Railway Safety Regulator***

The Railway Safety Regulator (RSR) was established in 2002, by the passing of the National Railway Safety Regulator Act No 16 of 2002 by Parliament.

The purpose of the RSR according to the Act is thus to:

- “(a) provide for and promote safe railway operations;*
- (b) encourage the collaboration and participation of interested and affected parties in improving railway safety;*
- (c) recognise the prime responsibility and accountability of operators in ensuring the safety of railway operations;*
- (d) facilitate a modern, flexible and efficient regulatory regime that ensures the continuing enhancement of safe railway operations;*
- (e) promote the harmonisation of the railway safety regime of the Republic with the objectives and requirements of the Southern African Development Community for the operation of railways; and*
- (f) further the achievement of such purpose by establishing a suitable regulatory institution.” (RSR, 2019).*

### ***The South African Police Service and its Rapid Rail Police Unit***

With the consolidation and a focus on core business with the onset of SATS, a key goal was the reduction of staff. In 1986, this saw the South African Railway

Police Department separate from SATS and absorbed into the South African Police (SAPS, 2019).

After South Africa's transition to democracy in 1994, the South African Police (SAP) was reorganised into the South African Police Service (SAPS). This transport policing function was lost until the Railway Police was re-established in 2004. The Railway Police or as it is now known, the Rapid Rail Police Unit (RRPU), has its mandate embedded within the mandate of SAPS which is derived from Section 205 of the Constitution of the Republic of South Africa, 1996.

The functions of the RRPU include the:

- “a) Rendering of a visible police service within the environment to address safety of commuters, passengers, freight and the rail transport system*
- b) Conducting of preventative and reactive policing service within the rail environment*
- c) Providing of a rapid rail policing service within the rail environment, and*
- d) Executing of crime prevention and crime combating operations in the rail environment” (SAPS, 2019).*

### **1.1.3 Rail situational analysis**

This section will detail the current commuter rail offering in the Western Cape provided by Metrorail.

#### ***Overview***

Metrorail Western Cape has the second largest commuter rail network in the country after Gauteng. The rail network consists of 610km of track owned by PRASA and Transnet and operated by Metrorail. The 2012 Rail Census Report for the Western Cape sets the number of passengers for all lines per day at 621 833 (RHDHV, 2013). However, the service has seen a rapid decline since 2014 and it is estimated that the all-day boarding passenger numbers are now somewhere between 360,000 (CoCT, 2018) and 500,000 (IOL, 2018).

The rail system is characterised by grade-separated rights-of-way with several pedestrian and vehicular at-grade level crossings, high-level platforms and electric

multiple-unit cars. The system requires 88 train sets across the network but currently operate with around 48 train sets (ANA, 2019). The bulk of the fleet is made up of 5M2A train types with combinations of Metro Plus and Metro coaches, with the number of coaches per train between five and 14.

Traction power is received from overhead lines. The only exception is on limited, outlying sections of track which are serviced by diesel-powered locomotives.

### ***Operating environment***

The rail service operates from 4h30 in the morning, with the last service finishing around 21h30. The routes are fixed, and trains operate at set headways. Services operate daily, with weekday services operating 16 to 17h per day with frequencies typically between nine trains per hour at peak and three per hour during off-peak periods. Saturday services typically operate 15 hours a day, with service frequencies varying between one and three trains an hour. Sunday services also operate for approximately 15 hours a day, with services generally reduced to a single train an hour. The service has a fixed stopping pattern, with local and express services stopping at some 119 stations on the network. A total of 85 stations are owned by Metrorail and 34 stations are owned by Transnet (RHDHV, 2013). The service is very much geared towards peak commuting hours.

### ***Route network design***

The network is based on a trunk-and-branch design with Cape Town Station as the major attractor for all trip destinations and has a number of branches outwards to the South (Simon's Town and the Cape Flats), Southeast (Kapteinsklip and Khayelitsha), and East (Bellville, Monte Vista, Wellington, Strand and Stellenbosch lines.) See Figure 1: Route Network Diagram.

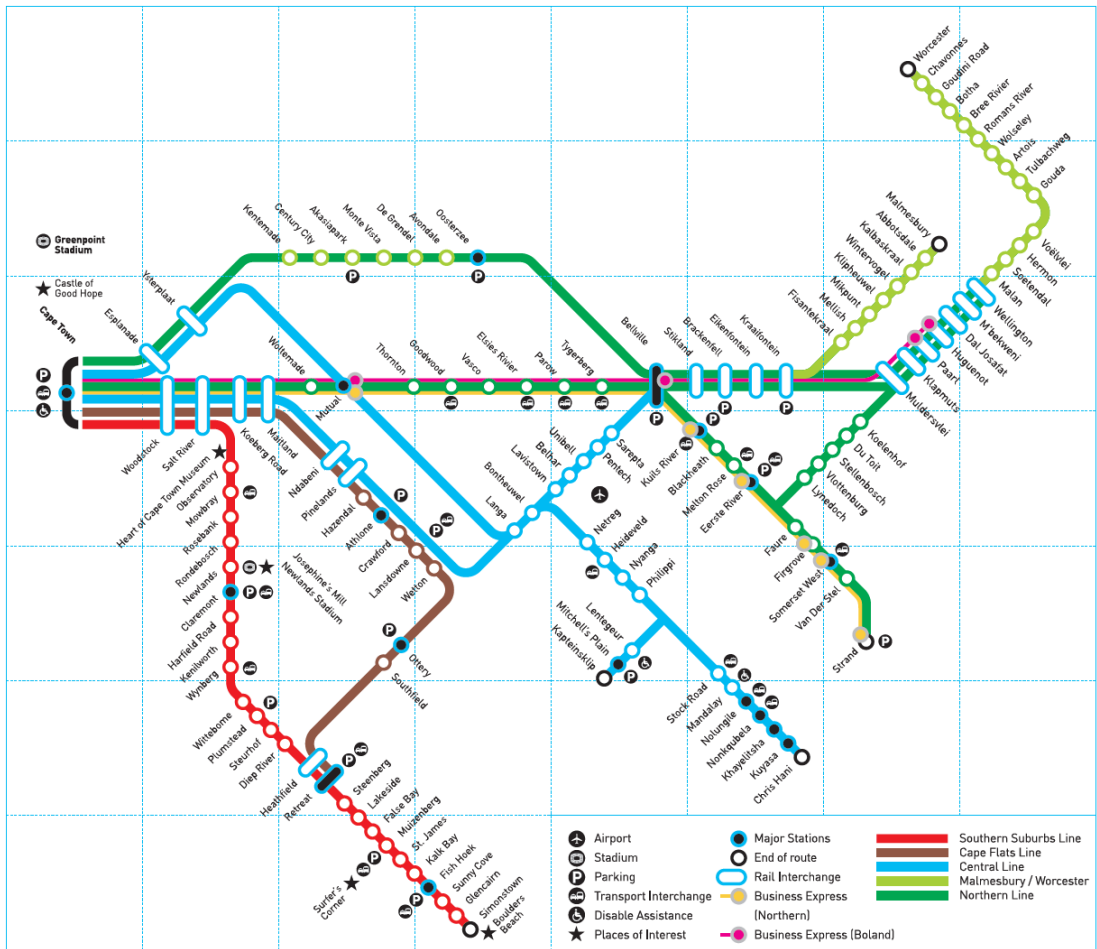


Figure 1: Route Network Diagram

Source: (Metrorail, 2010)

**Table 1: Rail Corridor Description**

<b>Corridor</b>	<b>Priority Category</b>	<b>Description</b>
Khayelitsha / Kapteinsklip to Cape Town	A	High priority route.
Wellington / Kraaifontein / Bellville – Cape Town via Monte Vista or Mutual	A	High priority route.
Simonstown – Cape Town and Retreat via Southfield	A	High priority route.
Strand – Cape Town via Bellville	B	Busy corridor with high forecasted growth.
Muldersvlei – Cape Town via Bellville	C	Low demand route.
Worcester - Wellington	C	Very low demand route.
Malmesbury - Fisantekraal	C	Very low demand route.

Source: (RHDHV, 2013)

**Table 2: Metrorail Fares Western Cape**

<b>Distance Zone (km)</b>	<b>MetroPlus</b>			<b>Metro</b>		
	<b>Single (R)</b>	<b>Weekly (R)</b>	<b>Monthly (R)</b>	<b>Single (R)</b>	<b>Weekly (R)</b>	<b>Monthly (R)</b>
<b>1-10</b>	10.50	80.00	250.00	7.50	47.00	140.00
<b>11-20</b>	11.50	90.00	280.00	8.00	50.00	150.00
<b>21-30</b>	13.50	110.00	340.00	9.00	59.00	175.00
<b>31-40</b>	16.50	135.00	420.00	10.00	65.00	190.00
<b>41-135</b>	19.50	160.00	500.00	13.00	80.00	250.00
<b>136-200</b>	23.50	195.00	605.00	18.00	115.00	360.00

Source: (GoMetro, 2019)

Train fares (see Table 2: Metrorail Fares Western Cape) are based on a zonal charging system based on distance. Fares can be purchased on a single, weekly or monthly basis and for either Metro (lower cost), or MetroPlus services (higher cost). Tickets can be purchased from station ticket offices or from Metrorail Ticket Officials with a portable ticketing machine.

### ***Rail in crisis***

Historic underinvestment in commuter rail services has had a detrimental impact on those factors which are important parameters that affect railway quality of service. Reliability, availability, maintainability and safety have all have suffered with increasing operating costs, unreliable infrastructure and rolling stock, declining fare revenue aligned with a decrease in patronage and low customer satisfaction levels (PRASA, 2019).

Compounding the rail crisis is operating in a challenging socio-economic environment, not only within the Western Cape but country-wide as well. High levels of unemployment, escalating crime levels and a general lack of government service delivery in other non-transport related areas have negatively affected rail operations. PRASA business performance has declined to an almost “total collapse” (PRASA, 2019).

### ***Towards rail reform***

Recognising that immediate and drastic action is required to prevent a total collapse, PRASA is strategising (Rescue Plan and Modernisation) to arrest the current decline in the rail commuter service. Key focus areas from the PRASA Corporate Plan 2020-2022 are to:

- Improve on-time performance,
- Reduce train cancellations,
- Ensure the safety of passengers, public and staff within the PRASA rail system environment,
- Improve customer experience and level of service,
- Decrease crime and crime-related costs by protecting rail corridors, and
- Increase revenue collected by the fare box (PRASA, 2019).

A central tenet to recovering the rail service and relevant to this dissertation is the recognition of the importance of Corridor Protection and seeking to mitigate the open nature of the rail system. In the Western Cape the focus will be on restoring a full service to the Central Line (PRASA, 2018).

## **1.2 DEFINING THE PROBLEM**

The rail operator has identified the broader problem with the openness of the rail reserve and the ease with which it can be accessed. The main problems caused by this “openness” are fare evasion, high levels of vandalism and theft of railway infrastructure, and illegal trespassing leading to pedestrian fatalities. These issues will be dealt with next by using references from statistical trends to support the importance of this research topic, and to specifically develop the problem statement.

### **1.2.1 Fare evasion**

As mentioned earlier, commuter rail is not an economically viable business enterprise. Revenue from the fare box is significantly less than Metrorail or PRASA’s operational expenditure, hence the requirement for a government subsidy. Fare revenue targets are consistently not being achieved with fare revenue declining from R2.3 billion to R1.8 billion for the 2017/18 financial period. (PRASA, 2018) This is mainly due to a number of reasons, some of which are:

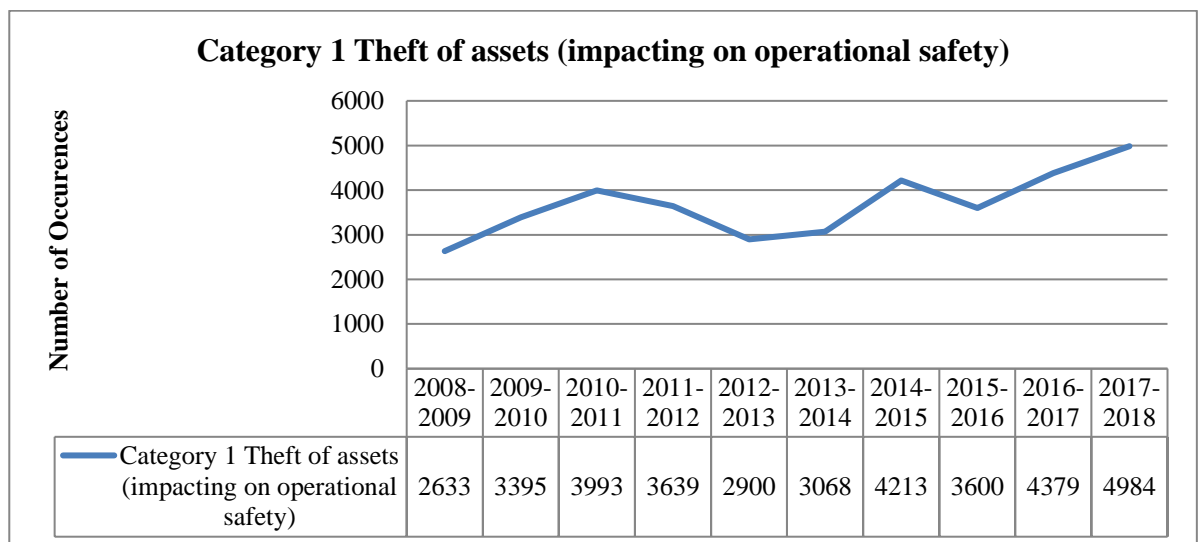
- Service disruptions and high levels of train cancellation means commuters are unwilling to purchase tickets, as a form of protest against a poor-quality rail service;
- Anticipated fare increases could not be implemented due to the ongoing poor quality of service provided;
- Increase in fare evaders who do not see the need to purchase tickets due to the “openness” of the rail system.

A fare evasion survey carried out in 2015 for the Western Cape determined that 10.2% of trips are made without valid tickets. The annual loss of fare revenue was estimated to be in the region of R30 million (DelMistro & Khanye, 2015). It is likely that the actual level of fare evasion is much higher.

### 1.2.2 Vandalism and theft

In terms of SANS 3000-1:2009, safety incidents and security occurrence data are captured in relevant categories and sub-categories, with safety-related occurrences captured in nine categories, numbered 1-9 (SANS, 2009).

Category 1 details the theft of assets impacting on operational safety; Category 2 details malicious damage (vandalism) to property. The main categories are further broken down into sub-categories for the different affected rail systems.



**Figure 2: Category 1 Theft of assets**

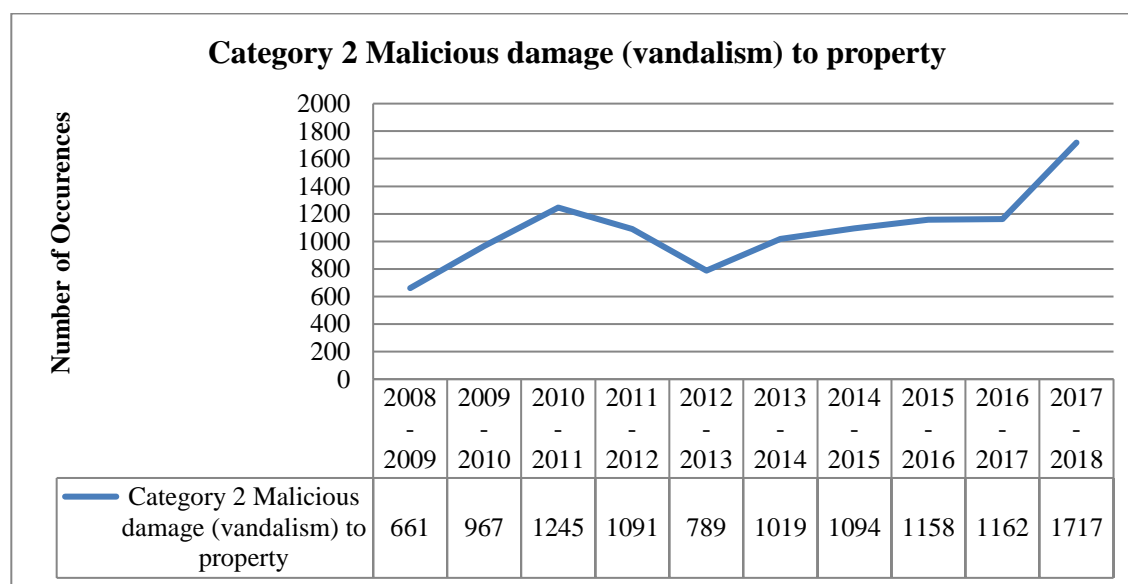
A review of the Railway Safety Regulator’s, State of Safety Reports (National data) between 2008 and 2018, shows that the theft of rail assets peaked during

2017/18 with 4984 reported occurrences (RSR, 2008-2018). Over the 10-year period, this equates to an 89% increase. See Figure 2: Category 1 Theft of assets.

On review of the occurrences per sub-category, the most affected asset, consistently over the period, is train control equipment (in section) with 2654 occurrences recorded in 2017-18. Cable theft related to train signalling equipment has a direct impact on rail safety and availability (delays and cancellations).

A review of the Category 2 occurrences, for malicious damage to property, (see Figure 3: Category 2 Malicious damage to property), shows a similar increasing trend in occurrences related to vandalism of rail property. In 2017/18, a total of 1717 occurrences of vandalism were recorded.

On review of the occurrences per sub-category, the most affected assets consistently over the period are rolling stock components (in section) with 692 occurrences and train control equipment (in section) recording 528 occurrences.



**Figure 3: Category 2 Malicious damage to property**

**Table 3: Security related incidents – Category 1 and Category 2 Sub-Category Breakdown**

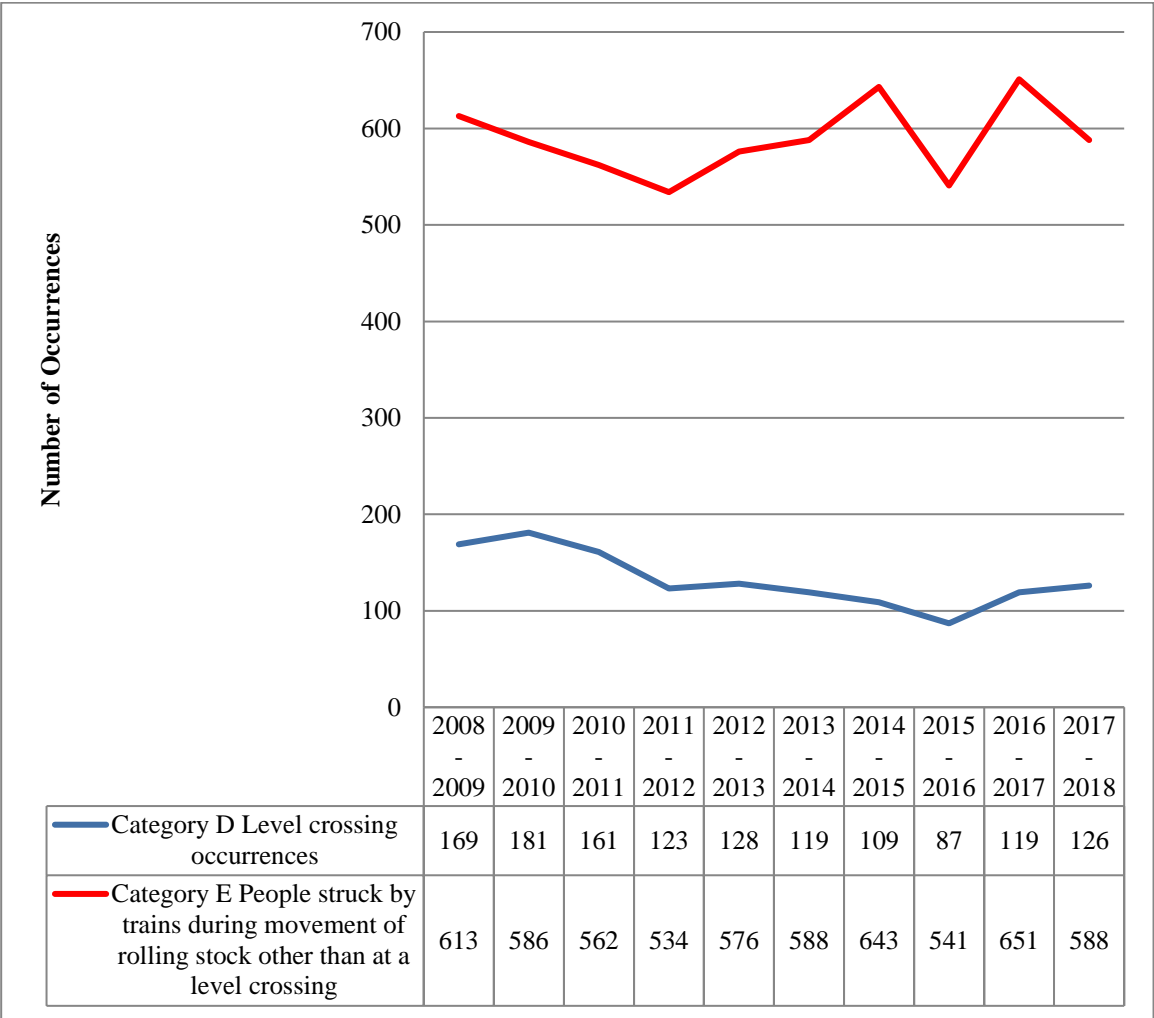
<b>Category</b>	<b>2008-2009</b>	<b>2009-2010</b>	<b>2010-2011</b>	<b>2011-2012</b>	<b>2012-2013</b>	<b>2013-2014</b>	<b>2014-2015</b>	<b>2015-2016</b>	<b>2016-2017</b>	<b>2017-2018</b>
<b>Category 1 Theft of assets (impacting on operational safety)</b>	<b>2633</b>	<b>3395</b>	<b>3993</b>	<b>3639</b>	<b>2900</b>	<b>3068</b>	<b>4213</b>	<b>3600</b>	<b>4379</b>	<b>4984</b>
<i>a: rolling stock components - section</i>	164	400	430	360	476	204	210	229	362	551
<i>b: rolling stock components - yard</i>	199	332	196	78	46	168	227	131	174	326
<i>c: civil infras - section</i>	760	586	960	1231	703	544	828	383	282	623
<i>d: civil infras - yard</i>	9	18	55	110	45	53	66	14	19	36
<i>e: overhead traction - section</i>	685	1007	775	411	188	213	321	298	212	559
<i>f: overhead traction - yard</i>	4	5	4	6	2	5	9	14	2	32
<i>g: train control equip - section</i>	767	1016	1488	1304	1329	1767	2413	2407	3140	<b>2654</b>
<i>h: train control equip - yard</i>	28	22	75	52	23	4	14	12	9	65
<i>i: ancillary equip</i>	17	9	10	87	88	110	125	112	179	138
<b>Category 2 Malicious damage (vandalism) to property</b>	<b>661</b>	<b>967</b>	<b>1245</b>	<b>1091</b>	<b>789</b>	<b>1019</b>	<b>1094</b>	<b>1158</b>	<b>1162</b>	<b>1717</b>
<i>a: rolling stock components - section</i>	64	358	526	248	276	341	336	421	373	<b>692</b>
<i>b: rolling stock components - yard</i>	75	121	129	111	20	63	94	100	90	152
<i>c: civil infras - section</i>	160	138	184	194	145	146	131	125	82	148
<i>d: civil infras - yard</i>	53	6	19	44	7	6	23	48	28	32
<i>e: overhead traction - section</i>	139	96	89	16	31	22	34	52	39	110
<i>f: overhead traction - yard</i>	0	0	6	41	2	1	2	3	2	3
<i>g: train control equip - section</i>	159	238	263	340	289	417	447	384	519	<b>528</b>
<i>h: train control equip - yard</i>	1	7	20	89	8	5	3	1	1	17
<i>i: ancillary equip</i>	10	3	9	8	11	18	24	24	28	35

Source: (RSR, 2008-2018)

### 1.2.3 Pedestrian-rail fatalities

Continuing the review of the Railway Safety Regulator’s, State of Safety Reports (National data) between 2008 and 2018, pedestrian fatality statistics will be reviewed next. The information provided describes the problem at a National level.

In terms of SANS 3000-1:2009, Category E, ‘People struck by trains during movement of rolling stock other than at a level crossing’, is the category most applicable to trespassing. Category E occurrences will be shown against Category D occurrences showing incidents at level crossings for context. See Figure 4: Category D & E occurrence comparison (RSR, 2008-2018).



**Figure 4: Category D & E occurrence comparison**

The number of Category E occurrences depicting pedestrian fatalities due to trespassing, far outweigh the Category D occurrences for level crossings. The number of people struck by trains over the 10-year period is consistently high, with an average of 588 occurrences over the 10-year period.

**Table 4: Category E Fatalities, Injuries and FWI**

<b>Year</b>	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016	2016 - 2017	2017 - 2018
<b>Category E</b>	<b>613</b>	<b>586</b>	<b>562</b>	<b>534</b>	<b>576</b>	<b>588</b>	<b>643</b>	<b>541</b>	<b>651</b>	<b>588</b>
<i>Fatalities</i>	341	400	364	354	355	394	410	370	414	343
<i>Injuries</i>	230	202	199	183	231	201	250	180	240	244
<i>FWI</i>	364	420.2	383.9	372.3	378.1	414.1	435	388	438	367

Table 4: Category E Fatalities, Injuries and FWI, shows a breakdown of the RSR data for fatalities, injuries and FWI (fatalities and weighted injuries). Over the period, the average number of fatalities and injuries were 374 and 216, respectively.

#### **1.2.4 Operational impacts**

The impact of being involved in a single or multiple pedestrian-train fatality has been documented in a few studies with regards to the impact on train drivers. Limosin et al. (2005), confirms that train drivers who have been involved in a collision resulting in a pedestrian fatality, experience acute psychological disturbances (Limosin, et al., 2005).

A study in Norway determined a plausible causal relationship between traumatic on-the-track experiences and long-term health problems in train drivers (Vatshelle & Moen, 1997). Having been involved in a fatality, the stress about worrying about being involved in a fatality, and its consequences, have far reaching effects beyond train drivers, and impacts other railway staff, rescue and clean-up teams as well as those witnessing the events.

Railway incidents could also impact train operations in other ways. Costs related to property and railway asset damage, rolling stock availability, delays and cancellations of service, emergency services costs, insurance and legal implications, as well as the over-arching cost of the loss of a human life, are all applicable factors impacted.

### **1.2.5 Problem statement**

The scale of railway trespass related fatalities and crime has shown consistently high figures over the years and is currently at its highest levels, showing no signs of abating. It is clear that existing strategies are not working and there is a need for more research on railway trespassing in order to inform the development of effective countermeasures.

## **1.3 OBJECTIVES**

Silla and Luoma (2012) confirms the importance of investigating the problem from a local perspective to develop a better understanding (Silla & Luoma, 2012). Rabdo et al, (2012) suggests that railway suicide and trespassing behaviour is specific to a location and/or area (Radbo et al., 2012). Skládáná et al, (2016) in reviewing typologies of trespassing risk localities encourages more research, due to the great variety of trespassing forms and how they can be influenced by sociocultural patterns and local conditions (Skládáná et al., 2016). With this in mind, the primary objective of this research is to broaden the knowledge related to trespassing within a local context.

The primary objectives are to:

- Carry out a demographic analysis of railway fatality data
- Carry out a detailed temporal analysis on and occurrences of railway theft and vandalism
- Carry out a detailed spatial analysis on pedestrian-rail occurrences, and occurrences of railway theft and vandalism.

Havârneanu et al. (2015) in a review of the literature on safety measures to prevent trespassing accidents, found only 22 studies with empirical evidence for the effectiveness of countermeasures with hardly any evaluations for combinations of measures (Havârneanu, et al., 2015). As part of this research, a case study will be investigated, evaluating the effectiveness of a specific trespass countermeasure.

The secondary objectives are therefore to:

- Evaluate the effectiveness of the Rail Enforcement Unit (REU), a project to reduce incidents of theft and vandalism with additional security personnel.

- Carry out interviews with subject matter experts and site visits at selected locations to validate and verify findings from the analysis.

In summary, it is the aim of this research to carry out a detailed analysis of trespassing and its main effects, to understand the problem locally, to develop tailored and effective responses.

#### 1.4 RESEARCH QUESTIONS

The following research questions (Q) and hypotheses (H) will be answered as part of this research.

<b>Research question / hypothesis</b>
FPS Q1: What are the demographic characteristics of rail related fatalities in the operating region?
FPS H <sub>01</sub> : No significant difference exists between genders of the victim for recorded deaths due to rail injury.
FPS H <sub>02</sub> : No significant difference exists between the age of the victim for recorded deaths due to rail injury.
FPS H <sub>03</sub> : No significant difference exists between the race of the victim and recorded deaths due to rail injury.
FPS H <sub>04</sub> : No significant difference exists between the gender of the victim for suicides.
RSR Q2: What are the temporal characteristics of Category E-a occurrences relating to pedestrian-rail related fatalities and injuries in the operating region?
RSR H <sub>06</sub> : No significant difference exists between the months of the year for the number of Category E-a occurrences.
RSR H <sub>07</sub> : No significant difference exists between the days of the week for Category E-a occurrences.
RSR H <sub>08</sub> : No significant difference exists between the hours of the day and Category E-a occurrences.

<b>Research question / hypothesis</b>
RSR H <sub>0</sub> 9: Zero correlation exists between the number of trains scheduled and E-a occurrences.
RSR Q3: What are the temporal characteristics of railway theft and vandalism occurrences in the operating region?
RSR H <sub>0</sub> 10: No significant differences exist between the months of the year for Category 1 and 2 occurrences.
RSR H <sub>0</sub> 11: No significant differences exist between the days of the week and Category 1 and 2 occurrences.
RSR H <sub>0</sub> 12: No significant differences exist between the time of day and Category 1 and 2 occurrences.
RSR Q4: What effect do incidents of theft and vandalism have on train operations?
RSR H <sub>0</sub> 13: Zero correlation exists between Category 1 and 2 occurrences and trains scheduled.
RSR H <sub>0</sub> 14: Zero correlation exists between Category 1 and 2 occurrences and trains cancelled.
RSR H <sub>0</sub> 15: Zero correlation exists between Category 1 and 2 occurrences and trains delayed.
RSR Q5: Where are the spatial concentrations of Category E-a occurrences in the operating region?
RSR Q6: Where are the spatial concentrations of fatalities and injury occurrences in the operating region?
RSR Q7: Where are the spatial concentrations of Category 1 and category 2 occurrences in the operating region?
RSR Q8: What are the characteristics of the combined Category E-a, 1 and 2 Spatial concentrations in the operating region?
CASE Q9: How effective is the specific countermeasure strategy?
CASE H <sub>0</sub> 16: No significant difference exists between Category 1 and 2 occurrences before and after implementation of the countermeasure.

<b>Research question / hypothesis</b>
CASE H <sub>0</sub> 17: No significant difference exists between Category E-a occurrences before and after implementation of the countermeasure.

## 1.5 DEFICIENCIES IN EXISTING KNOWLEDGE

A study on the literature currently available on railway suicides and trespassing incidents by Havârneanu et al. (2015) found 139 relevant publications of which only five could be attributed to South Africa (Havârneanu, et al., 2015). Most notable of the research carried out in South Africa, was that carried out by the Medical Research Council in 1996 and 1998 by Lerer and Matzopoulos. Considering the pedestrian-rail fatality rate in South Africa compared to that in Europe, there is a distinct lack of relevant research on this subject local to South Africa.

The importance of corridor protection as a means to ensure safe rail operations has been acknowledged by the railway operator in the Western Cape and supported on a number of projects by the local and provincial authorities. These include walling projects, pedestrian bridges, improved lighting and several measures to enhance security using both technology and personnel. To the researcher's knowledge, no studies have been completed evaluating the efficiency of any of the installed measures.

The City of Cape Town has also completed a number of studies, most notably a study looking into informal pedestrian movement along and across railway lines, (2014) and at the time of writing, a feasibility study looking into city-wide pedestrian-rail hot-spot locations. The major deficiency in both these studies is that they cover only the City of Cape Town region and excludes the portion of the Metrorail network through the neighbouring municipalities. The studies also propose remedial actions only within the mandate of the local authority and do not recommend any actions for the rail operator. A more holistic approach is required which also considers all stakeholders as well as other manifestations of trespassing, such as theft and vandalism on the rail network.

## **1.6 WHO WILL THE RESEARCH BENEFIT?**

This research will benefit rail infrastructure managers, rail operators, rail regulatory bodies and government organisations at provincial and local municipal level. The research will also add to the general body of knowledge relating to railway trespassing research.

## **1.7 SCOPE AND DELIMITATIONS**

### *Scope and boundary*

The scope of this research is limited to the extent of the commuter rail service area in the Western Cape, provided by the rail operator, Metrorail. This includes the local municipalities of Cape Town, Stellenbosch, Swartland, Drakenstein and Breede Valley.

The research is specific to trespassing and access and egress gained to track and stations from along line sections and end-of-platform areas. Excluded are passenger-rail fatalities related to the platform-train interface and at formalised level-crossings, which deserve separate research.

The research also excludes security incidents related to personal injury at stations and on trains.

### *Hot-spot mapping*

The production of hot-spot maps is a useful technique to visualise the problem being investigated, but care should be taken to acknowledge the underlying factors that contribute to the creation of the hot-spots. This involves the collection and analyses of additional data which could be held by numerous other stakeholders. The gathering of this data, which may include, micro-economic and social information was beyond the scope of this research.

### *Geolocation of incidents*

A key limitation is the degree of uncertainty regarding the actual geographical location of events. Locations are based on rail station geographic locations and points between stations to determine problem “areas”. The use of technology in recording railway incidents needs to be encouraged to improve this.

## 1.8 STRUCTURE OF THE REPORT

An overview of the structure of this dissertation is given below:

<p style="text-align: center;"><b>Introduction</b></p>	<p><b>Chapter 1</b></p> <p>The chapter presents the basis for the dissertation. It provides background and context needed to understand the intentions of the research, defines the research problem, lists the objectives and the research questions, and describes the structure of the dissertation.</p>
<p style="text-align: center;"><b>Theoretical Framework</b></p>	<p><b>Chapter 2</b></p> <p>The main body of the chapter gives the theoretical foundation and review of current understanding regarding railway trespassing, as well as matters associated with railway trespassing.</p> <p><b>Chapter 3</b></p> <p>A review of the Railway Safety Regulator’s State of Safety Reports is presented from 2008/09 till 2017/18 and describes the problem in detail at a National level. A comparison is also made with other countries worldwide.</p>
<p style="text-align: center;"><b>Scientific Methodology</b></p>	<p><b>Chapter 4</b></p> <p>This chapter presents the scientific approach used in this dissertation: methodology and research design, the participants, instruments, research framework, analysis methods and ethical framework.</p>
<p style="text-align: center;"><b>Results, and Quantitative Analysis</b></p>	<p><b>Chapter 5</b></p> <p>The results of the quantitative analysis is presented in this chapter. Answers to the research questions are presented along with the findings of the various hypotheses tests.</p> <p>This chapter provides a full interpretation and evaluation of the quantitative analysis.</p>

<p><b>Case Study Evaluation</b></p>	<p><b>Chapter 6</b></p> <p>This chapter provides an evaluation of the efficacy of an implemented countermeasure. The research questions related to the case study are also answered.</p>
<p><b>Interview and Site Visit Analysis</b></p>	<p><b>Chapter 7</b></p> <p>The outcome of the interviews with the subject matter experts are discussed as well as the findings from the site visits. The chapter includes an analysis and interpretation of the findings from the interviews and site visits.</p>
<p><b>Concluding Remarks</b></p>	<p><b>Chapter 8</b></p> <p>This chapter summarises the key findings in this dissertation and makes recommendations for further research.</p> <p>This chapter concludes the dissertation.</p>
<p><b>Appendices</b></p>	<p>The following appendices are included:</p> <ul style="list-style-type: none"> <li>Interview protocol</li> <li>Site inspection protocol</li> <li>Case study protocol</li> <li>Incident and occurrence maps</li> <li>Interview records</li> <li>Site inspection field notes</li> <li>Ethics clearance</li> </ul>

# Chapter 2: Literature Review

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A two-part literature review was completed. Firstly, a search through the main publication databases was carried out using the keywords (singularly and in various combinations) railway, trespassing, rail, pedestrian, fatalities, suicide and countermeasures. A number of smaller, more limited, literature reviews were carried out in relevant themes as it pertained to railway trespassing. These included the keywords metal theft, graffiti, transport and spatial planning, police crime analysis, apartheid, injury, accident analysis and human behaviour.

This search resulted in the discovery of about 173 documents including mainly journal submissions, conference papers, reports and ongoing project reviews of which 154 papers were selected for inclusion in this dissertation.

Secondly, the suite of State of Safety Reports as produced by the Railway Safety Regulator (RSR) from the reporting year 2008/09 till 2017/18 was reviewed. This second part is documented in 0 South African Rail State of Safety Reports.

The purpose of the literature review is to provide a comprehensive overview of current knowledge on all aspects as they relate to railway trespassing. The chapter begins with a historical background (Section 2.1) summarising the impact of apartheid on spatial planning and broader socio-issues followed by literature reviews on the following sub-headings: Defining railway trespassing (Section 2.2), developing an understanding of the definition of railway trespassing; Characteristics of trespassing accidents (Section 2.3), answering the When? Where? Who? Why? How? exploratory questions; and Trespass countermeasures (Section 2.4) reviews strategies and measures to combat trespassing. Section 2.6 discusses the implications of the literature review and provides a rationale for the need for and importance of the research problem.

## 2.1 HISTORICAL BACKGROUND

Matzopoulos and Lerer (1998), suggest that the level of poverty of communities adjacent to railway lines is a major factor of railway injury occurrences (Matzopoulos & Lerer, 1998). In the Western Cape, apartheid urban planning

uprooted the poorest communities and relocated them to the urban fringes with little regard to the travelling needs of these communities. Coloured and black townships flourished on the fringes and in rural areas, maximising the need for public transport, with townships located some 15-30km from the city centre (Pirie, 2002; Turok, 1994). Railways developed around the need to provide public transport to these, the poorest areas, to enable them to reach places of work, which in turn would then keep the economy of the region going. These distorted land-use patterns, often between transport trunks such as railway lines and major roads, required that pedestrians and those commuters using public transport, walk long distances and navigate across busy transport trunks as part of their journey.

Fatalities, due to pedestrians being struck by a train, has been an issue even before they were officially recorded in 1924. For the period between 1930 and 1970, 1264 railway fatalities have been recorded nationally, although it is acknowledged that incident records of fatalities of Blacks and Coloureds may be under-reported (Matzopoulos & Lerer, 1998).

Along with pedestrian-rail fatalities, crime and violence had also gradually been increasing since the 80s, but saw a significant spike at the start of the next decade, due to a combination of factors, including transition to a democracy, political violence and a faltering criminal justice system (Louw, 1997). Railways are described as a socio-technical system (Wilson et al., 2007), because of its symbiotic relationship with its environment and therefore it is no surprise that safety issues on trains, violent crime, theft and overcrowding became synonymous with the railways.

Since apartheid, the rail system served as a tool to facilitate discriminatory practices, and it remains in the sub-conscious of people, leading to a general culture of disregard for the law in general and acceptance of illegal practices, which inevitably also affects the railway. This may display itself as fare evasion, where large numbers of people refuse to pay fares for the perceived lack of a quality service and poor infrastructure. Alternatively, it results in people developing mutual relationships with those involved in crime, which leads to the levels of security occurrences seen on the railways today; an example of this is rampant signal cable theft.

The current South African situation of high levels of poverty, unemployment and inequality will continue to feed into people's attitudes and behaviour towards and with the rail system.

## **2.2 DEFINING RAILWAY TRESPASSING**

The legal definition of trespassing is provided in the South African Trespass Act 6 of 1959 as:

*(1) Any person who without the permission -*

*(a) of the lawful occupier of any land or any building or part of a building; or*

*(b) of the owner or person in charge of any land or any building or part of a building that is not lawfully occupied by any person,*

*enters or is upon such land or enters or is in such building or part of a building, shall be guilty of an offence unless he has lawful reason to enter or be upon such land or enter or be in such building or part of a building. (Trespass Act, 1959)*

Considering the above, railway trespassing can then be defined as any person, who without permission or lawful reason, enters any non-public side of railway property. Further to this, railway trespassers are people who are illegally in the railway reserve (Lobb, 2006) and using railway property for reasons not related to railway operations (Silla & Luoma, 2011).

Persons illegally in the railway reserve include those crossing railway lines at all informal locations (outside formal level crossings) and, walking or loitering on the railway tracks or in non-public railway areas where pedestrians are prohibited. Trespassers exclude passengers, railway staff, level crossing users or persons attempting suicide (Radbo et al., 2012). Trespassers do not expect to come to harm (Mills, 2019) and trespassing accidents are events which occur without will or conscious control, often resulting in death or injury.

Suicide differs then in that although it still involves entering the track area, and thereby trespassing, the intent is fundamentally different, with the victim purposefully initiating actions that lead to self-harm (Mishara & Bardon, 2015). In further work by Mishara and Bardon, they propose that the analysis of accidents and suicides be separated to gain better understanding (Mishara & Bardon, 2016).

Other authors argue that a pedestrian-train collision can occur only when one or more persons have entered the railway reserve whether it be intentionally or unintentionally (Radbo et al., 2012). Several authors have motivated considering countermeasures for both suicide and trespassing incidents together as it can be difficult in most circumstances to correctly identify a suicide because of a lack of information, in order to classify the death correctly (Radbo et al., 2012; Havârneanu et al., 2015; Lobb, 2006). Trespassing accidents and suicides, therefore, share common traits, but are different.

Someone contemplating suicide, may consider jumping or lying in front of a moving train (ICD10, 2019); they could, however, access railway property either as a pedestrian (i.e. trespassing) along line sections or as a passenger, from the station platform. For this literature review, suicide will be discussed as a sub-set of trespassing.

## **2.3 CHARACTERISTICS OF TRESPASSING ACCIDENTS**

This section will present current knowledge of railway trespassing and trespassers. The act of trespassing does not always result in a fatality or serious injury and trespassing is more common than fatality statistics would suggest (Silla & Kallberg, 2015; Savage, 2007). Trespassing is, therefore, analysed in terms of statistics on railway fatalities as well as specific observed behaviours associated with trespassing.

### **2.3.1 Time of trespassing accidents**

#### ***Hourly variations***

In general, trespassing related incidents occur throughout the day (Ozdogan et al., 2006; Lerer & Matzopoulos, 1996). Radbo (2005) confirms an even distribution of occurrences throughout the day but with a higher frequency in the evening period.

Savage (2015), found that trespassing fatalities occurred mostly during the morning and evening peak hours of 07h00 to 09h00 and 15h00 to 19h00. This is supported by the earlier study carried out in South Africa, which found that both fatal and non-fatal injuries occurred between the hours of 05h00 to 09h00 and 16h00 to 20h00 (Lerer & Matzopoulos, 1996).

The results from a study carried out by Silla (2012) showed that suicides were concentrated in the afternoon-to-night period between 15h00 to 18h00. These findings are contradicted by Radbo et al. (2005), which shows more suicides during daylight hours. There is a strong likelihood that the hourly pattern has less to do with a fixed hour but rather with the seasonal changes of the time of sunset (Mishara & Bardon, 2015).

Actual trespassing counts carried out over a period of 19 days in Finland showed that the period 11h00 to 19h00 was the busiest (Silla & Luoma, 2008). Further work by Silla and Luoma (2011) where the opinions of people living close to the railway line were gauged, could not define a specific hourly period and respondents observed the busiest periods for trespassing from highest to lowest as afternoon, morning, evening and noon, with no significant differences between the different periods.

#### ***Weekly variations***

An early study by Savage (2007), reviewing national railway fatality incidents across the United States, showed that the risk of a railway fatality was higher on Friday and Saturday evenings. Another study in the United States, in North Carolina, would seem to corroborate this, reporting that fatalities typically occurred on Friday, Saturday and Sunday nights (Pelletier, 1997). In comparison, an analysis of railway fatalities in Chicago showed that fatalities occurred at all times of the day, throughout the week, with an apparent increase in suicides on Fridays (Savage, 2015).

Mishara and Bardon Silla (2015) found that in general there are less suicides on weekends. In a study in Canada, this was true (Mishara & Bardon, 2016), and supported by Rabdo et al. (2005).

#### ***Monthly variations***

Most of the literature reviewed, originated from countries in the northern hemisphere, with winter, comprising the months December, January and February, and summer comprising the months of June, July and August. In countries with harsh winters, both intentional and unintentional deaths are unlikely. Fatal crashes peak from the start of spring, coinciding with March till around August (Savage, 2015; Pelletier, 1997; Radbo et al., 2005). A Turkish study on the epidemiology of railway

related casualties found that fatalities occurred throughout the year, but more frequently in summer (Ozdogan et al., 2006).

Silla (2012) found rail-pedestrian fatalities evenly distributed throughout the year, with no discernible peak. The months of May, July, August, November and December recorded the most suicides; the most accidents were recorded in March, July and November (Silla, 2012).

### **2.3.2 Location detail**

Trespassing and related pedestrian-rail collisions occur more frequently in densely populated areas (Radbo et al., 2005; Silla & Luoma, 2012) and more so in areas that are spatially divided by railway lines (Silla & Luoma, 2008).

Savage (2015) found that commuter trains account for 60% of fatalities, with 67% of those recorded as suicides. He also found that more unintentional deaths (60%) were recorded at grade crossings and stations, compared to unintentional deaths along line-sections (48%).

Higher train traffic densities are not necessarily associated with an increase in trespassing fatalities and lines with infrequent services are more problematic (Savage, 2015), however train traffic densities do show a relationship with railway suicide rates (Mishara & Bardon, 2015).

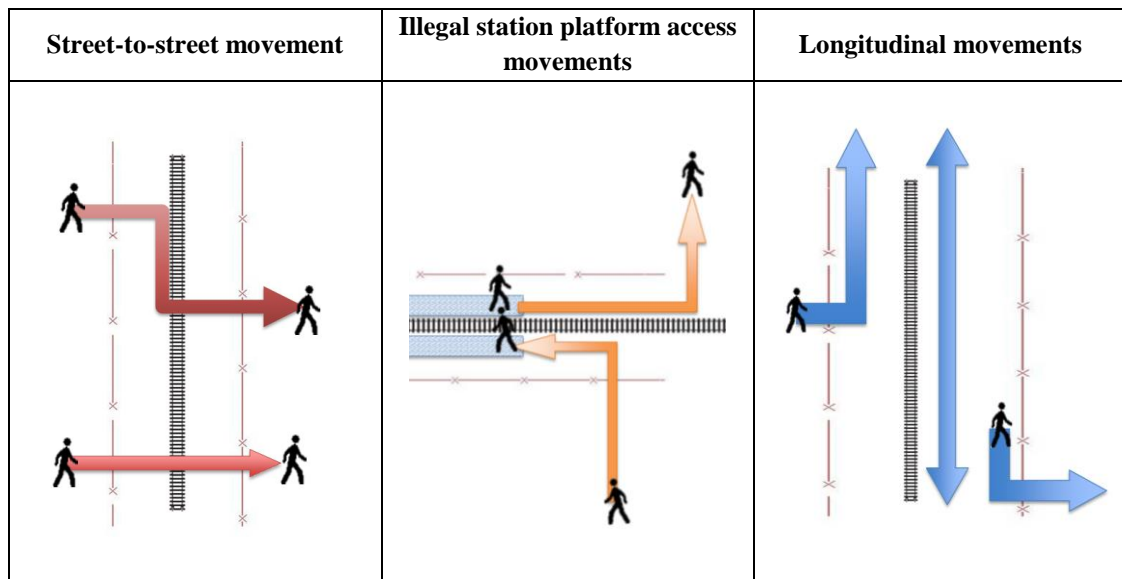
#### ***Location in the railway reserve***

Studies on railway fatality statistics have shown that incidents are more likely to occur at and close to railway stations (Silla & Luoma, 2012; Savage, 2015; Lerer & Matzopoulos, 1996) Although the rail tracks can be accessed anywhere along its length if no fencing is in place, a common access to the tracks are via station platform-end ramps (RSSB, 2018).

Informal pedestrian pathways across rail tracks were the location for 87% of pedestrian-rail incidents in a study on rail-pedestrian trespassing crash severity, with 13% of incidents occurring at formal level-crossings (Zhang et al., 2018).

Suicides follow a similar pattern, with 41% (Savage, 2015) and 58% (Silla, 2012) of intentional deaths occurring on open rail track areas, between stations (Lerer & Matzopoulos, 1996; Mishara & Bardon, 2016), with victims waiting on the tracks for a train to arrive or walking along the tracks. Patterns differ considerably

with (Mishara & Bardon, 2015) finding that female suicides are more likely to happen in station areas and male suicides on open rail track areas.



**Figure 5: Categories of pedestrian movement within the rail reserve at hot-spots**

Source: (Mvinjelwa, et al., 2019)

A study in Cape Town (Mvinjelwa et al., 2019) carried out at trespassing hot-spots identified three main movement patterns, namely i) Street-to-street, ii) Access via the platform ends, and iii) Longitudinal travel along pathways parallel to the tracks. See Figure 5: Categories of pedestrian movement within the rail reserve at hot-spots.

In the Czech Republic, trespassing locations with a high accident risk were classified into six categories (Skládaná et al., 2016): stations, shortcuts of everyday use, touristic paths, level crossings, places of meeting or lodging, and unclassified localities.

Ultimately, trespassing behaviour is specific to a certain location, (Savage, 2007) area, region or country, and influenced by a number of motives, sociocultural patterns, geographical and landscape conditions (Skládaná et al., 2016) which indicate that the characteristics of trespass locations could vary greatly, and the relationship between fatalities and variables cannot be generalised from one location to the other (Wang et al., 2016).

### 2.3.3 Gender and age

Trespass-related fatalities are rare for children under the age of 10 (Savage, 2007; Savage, 2015; Silla & Luoma, 2008).

There is a general consensus that the age group most at risk are adults between 16 and 45 years (Savage, 2007), 20 and 49 years (Pelletier, 1997), 20 and 59 years (Radbo et al., 2005). Savage (2015), found people in their 40s most at risk, followed by those in their 20s and 30s with those aged 60 and over having the lowest risk. In Turkey, those aged 60 and over had the highest fatality rate (Ozdogan et al., 2006).

Suicides are similarly, spread over a wide age band, with research suggesting that the most affected groups are the groups 13 to 19 years (Savage, 2015), 10 to 29 years (Silla, 2012) and 25 to 60 years (Mishara & Bardon, 2016).

From trespassing observations, Silla and Luoma (2008), found that majority of trespassers were adults (54%) followed by youngsters in the 12 to 20 years age group (35.6%). In Cape Town, at hot-spot locations, children accounted for approximately 40% of all trespassers (Venter & Shirley, 2014).

Many studies indicate that most victims of both trespassing and suicide fatalities are males (Savage, 2007; Pelletier, 1997; Radbo et al., 2005; Savage, 2015; Silla & Luoma, 2012; Mishara & Bardon, 2015; Ozdogan, et al., 2006).

### 2.3.4 Trespassing motives

In general, trespassing on railway property is an act carried out without evil intent (Havarneanu, 2017), with the main reason being to take a shortcut, using existing well-trodden paths (Skládaná et al., 2018; Silla & Luoma, 2008; Ryan, 2012; Savage, 2007; RSSB, 2018). Informal routes across railway lines are chosen by pedestrians as the shortest and fastest alternative (Silla & Luoma, 2008), and as a matter of convenience where the grade-separated crossing alternative is not suitably located (Lobb, et al., 2001; Skládaná et al., 2016). Skládaná et al (2016) further noted “*illegal but justifiable*” informal pedestrian routes across railway tracks used as shortcuts where the legal crossing was situated too far from pedestrian desire lines.

Railways commonly intersect communities and settlement structures, becoming obstacles to pedestrians travelling to regular trip attractors, such as schools, places of work, sports activities, shopping centres or just walking from one neighbourhood to another (Skládaná et al., 2018; Silla & Luoma, 2008; Mvinjelwa et

al., 2019). Other non-malicious motives for trespassing include pedestrian routes connecting tourism and recreation activities (Skládaná et al., 2016), children using the railway as a play area (Savage, 2007), people recovering lost property (Ryan, 2012) and people that are unfamiliar or confused about the railway environment (RSSB, 2018).

The motives specifically around platform-end trespassing are found to be risk-taking by children and youths, and last-minute platform changes to avoid the longer more formal route (RSSB, 2018; Mvinjelwa et al., 2019; Ryan, 2012) and rushing to catch the next train (Matzopoulos & Lerer, 1998).

Fare evasion and avoiding ticket control is listed as a motive for trespassing by the RSSB (2018), Matzopoulos and Lerer (1998) and Mvinjelwa and Kiewiet (2019). In a study on fare evasion in the Western Cape Metrorail region (DelMistro & Khanye, 2015), it was estimated that the average fare evasion rate was 10.2% with a 95% level of significance from a sample of 1658 respondents. From this, it was shown that, 7.23% of passengers travelled without a train ticket.

The other significant grouping of motives of railway trespassing are those carried out with criminal intent, including theft from rolling stock or line-side equipment, vandalism and graffiti (Havarneanu, 2017; Savage, 2007; Ryan, 2012).

#### ***Cable theft as a motive for trespassing***

It is estimated that metal theft costs South Africa billions of Rands per annum (Yorke-Smith, 2010; Georgiannis, 2017). Metal theft is not only a local phenomenon but is a problem world-wide, with copper being the most sought-after metal (Arendse, 2010). Rising copper prices have had a direct influence in the increase in copper theft since 2003 (Arendse, 2010; Sidebottom et al., 2011; Sidebottom et al., 2014) and especially the desirability of “live” copper cable. See Figure 6: Copper price 2004-2017.



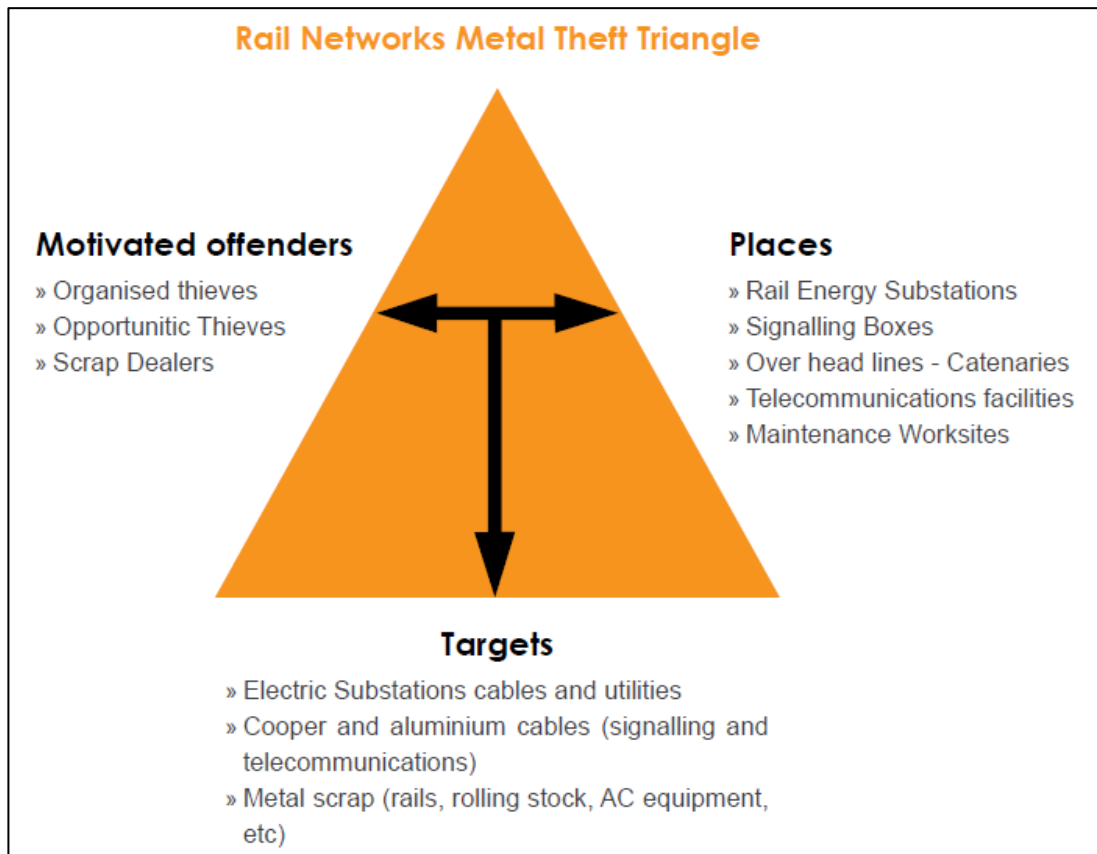
**Figure 6: Copper price 2004-2017**

Source: (InfoMine, 2019)

Copper prices, combined with a largely unguarded metal supply in the railway environment together with a low risk of being caught and prosecuted, have seen a marked increase in metal theft in the railways (UIC, 2013).

The primary targets are signalling cables, telecommunication cables, electric substations, overhead power lines, signalling boxes (known as live equipment) and metal non-live equipment such as metal fences to sell for scrap (Network Rail, 2019; UIC, 2013). (See Figure 7: Rail networks metal theft triangle.)

It is believed that cable theft is carried out by small-time opportunistic thieves as well organised crime syndicates (GRR, 2018; UIC, 2013).



**Figure 7: Rail networks metal theft triangle**

Source: (UIC, 2013)

Since the link between the theft of metal and its market value has been confirmed, the role of the scrap metal industry is, therefore, significant. Ashby and Bowers (2015) have shown that metal theft from railway lines was significantly more common in areas within close proximity to one or more scrap-metal dealers, areas easily accessed by the existing road network and in densely populated areas.

In South Africa, the scrap-metal industry is legislated by the Second-Hand Goods Act 6 of 2009 (Second Hand Goods Act, 2009). The Criminal Matters Amendment Act of 2015 determines bail and imposes minimum offences for essential infrastructure-related offences. This Act recommends a minimum sentence of three years for first-time offenders, whilst for career criminals caught instigating or causing damage to rail infrastructure, the maximum sentence is 30 years (Criminal Matters Amendment Act, 2015). Convictions are, however, scarce and still more needs to be done to educate the judiciary on the significant consequences of the actual crime committed (Arendse, 2010).

### *Suicides*

While crime related to theft and vandalism of railway infrastructure constitute the majority of trespass incidents, they are the minority of those killed as a victim of a pedestrian-rail incident (Savage, 2007). Most railway trespassers and those killed as a result of a pedestrian-rail collision, do not intend to put themselves in harm's way.

Railway suicides are, then, instances where persons trespass onto railway property with the deliberate intent to be struck by a train (Silla, 2012; Radbo et al., 2012). Mishara and Bardon (2015) include other means of railway suicide than by train, such as being electrocuted by intentionally making contact with high-voltage traction feeds.

Railway suicides are more prominent in Europe, with up to 3000 incidents annually representing 72% of all railway fatalities (Ryan et al., 2018). Suicide victims choose rail as a means of suicide because of the predictability that running on a timetable presents (Mishara & Bardon, 2015) and because it is believed to be a fast, easy and foolproof method (Botha et al., 2014). In Canada, a survey amongst people with suicide intentions showed that more than half of those surveyed thought that the metro was an effective way to kill themselves, and a significant portion chose rail because other suicide methods had failed them in the past (Mishara & Bardon, 2016).

#### **2.3.5 Trespass behaviour and attitudes**

Interviews with trespassers in Finland revealed that most thought trespassing to be fairly or completely safe as long as they were careful, and many believed trespassing to be legal (Silla & Luoma, 2008). In later work by Silla and Luoma (2011) on seeking the opinion of those living close to railways, 40.2% believed trespassing to be only slightly dangerous and 18.2% believed that crossing the tracks at informal locations was legal. Similarly, Skládaná et al. (2016), found that half of trespassers regarded trespassing as safe, but most considered it to be illegal.

A number of studies point to the role of alcohol in pedestrian-rail casualties. Savage (2007) found that two-thirds of trespasser casualties were adult males under the influence of alcohol. Pelletier (1997) found that 78% of trespassers were killed while intoxicated, and Silla (2012) found that 48.1% were under the influence of alcohol, drugs or medication, with males more likely to be intoxicated than females.

In Cape Town, the blood alcohol level of victims of railway injury were all above the legal limit for drunk driving in all categories of railway injury including pedestrian-rail incidents (39%) and suicides (27%) (Lerer & Matzopoulos, 1996).

Accidental deaths are more likely to involve alcohol and drugs and suicide victims are more likely to have histories of mental health problems (Mishara & Bardon, 2016; Silla, 2012).

### ***Pre-crash behaviour***

The literature presents a number of pre-crash behaviours associated with unintentional and intentional railway casualties.

In the United States, the most prominent pre-crash behaviours are walking and running (29.8%) and lying down or sleeping (22.9%) (Savage, 2007). A separate study in the United States researching trespassing injury severity between highway-rail grade crossings and non-crossings, found the most prominent pre-crash behaviour to be running or walking (44%) at non-crossings with lying or sleeping second at 29% for non-crossing sites (Zhang et al., 2018). Wang et al. (2016) report that accidents are more likely when trespassers are lying or sleeping on the tracks, accounting for 23.4% of crashes. Besides walking, running, sitting and lying, there are isolated cases of trespassers driving and riding on the tracks (Wang et al., 2016). Similarly, in Canada, trespassers were lying, sitting or walking on the tracks (Safe\_Kids\_Canada, 2004).

In Finland, walking across or along the tracks (34.4%) and lying or sitting on the tracks (28.1%) were the most common pre-crash behaviours (Silla, 2012). Lobb (2006), similarly, found that pedestrian-rail fatalities involved people walking across or along the tracks or sitting and lying on the tracks.

Suicides follow a similar behaviour pattern, with only a few jumping right in front of an oncoming train. Varying figures of 75% (Radbo et al., 2005) and 60% (Silla & Luoma, 2012) of suicide victims were seen loitering close to or on the tracks, waiting for a train. Underground railway suicides are slightly different in that victims are more likely to jump on the rails (66%) or jump in the path of an oncoming train (18%). Potential suicides are also likely to seek out station staff to speak about their distress and could display agitated, erratic behaviour and could also be crying (Mishara & Bardon, 2016).

Silla and Luoma (2008) found that trespassers seldom do so in large groups, with 69% being alone and 23% in pairs. A third of trespassers were carrying bicycles and over half were not carrying anything at all (Silla & Luoma, 2008).

### **2.3.6 Quantifying trespass numbers**

Not much is written about actual numbers of trespassers. In Finland, during 19 days of measurement at three locations, a total of 1954 trespasses were counted, amounting to approximately 40 trespassers per day (Silla & Luoma, 2008).

In stark contrast, at a location at Nomzamo in Cape Town, 3000 trespassers were counted during a morning peak period (Venter et al., 2014) and at the same location 4578 trespassers in a peak hour (Moosa, 2014). Pedestrian counts carried out at three locations along the Nomzamo section of rail track during a morning peak period resulted in 3879 pedestrians and 310 cyclists (Kok, 2016).

Venter et al. (2014), in a study of pedestrian movements along and across railway lines in Cape Town, identified 16 hot-spot locations where pedestrian volume counts were carried out. The results of the pedestrian counts found that the highest peak hour volume across the railway was 1858 persons; the highest peak hour volume along the railway was 2312 persons (Venter et al., 2014).

In a feasibility study for the location of a pedestrian bridge near Nyanga, in Cape Town, total two-way flows at three locations in close proximity of each other measured 834 persons in a three-hour morning peak period and 733 persons in a three-hour afternoon peak period (HHO, 2016).

In another feasibility study looking into remedial measures for trespassing hot-spot locations in Cape Town, both manual counts were completed to record pedestrian volumes as well as drone footage. The same sites were visited as in the 2014 study by Venter et al. and the pedestrian numbers at all locations differed significantly. The highest peak period volume across the railway was 875; the highest peak period volume along the railway was 921, and both were at different locations to the 2014 study. Counts were also carried out at illegal station platform accesses, with a high of 2545 pedestrians during a three-hour morning peak period, counted at Brackenfell Station (Mvinjelwa et al., 2019).

## **2.4 TRESPASS COUNTERMEASURES**

As illustrated thus far in the literature available, the motives, behaviour and various characteristics relating to railway trespassing is varied. In a similar fashion, the measures available to prevent trespassing and trespassing incidents cover a broad range of approaches. The following section will report on current literature available on trespass countermeasures.

### **2.4.1 Theoretical approaches**


In most cases, the main driver of trespassing behaviour is to get from ‘point A to point B’, without any criminal intent. However, the type of trespassing behaviour which has a significant impact of rail operations include those with the intent of theft and vandalism of railway infrastructure, as well as those trespassing, resulting in intentional and unintentional deaths.

Havârneanu (2017) proposes that trespassing and vandalism be treated concurrently as part of a “comprehensive protection” approach. Combining different countermeasures and developing collaborative partnerships with various stakeholders seeks synergies to address railway issues in one approach, thereby saving on limited resources available to railway operators and enforcement agencies (Havarneanu, 2017). In the same research, looking at countermeasures against trespassing and graffiti vandalism, Havârneanu (2017) also distinguishes between anti-social (enforcement, dissuasion, surveillance, detection and prosecution) and pro-social (mural projects, free walls, open galleries and arts-led regeneration activities) measures (Havarneanu, 2017).

In developing measures to limit trespassing via platform ends at stations, the RSSB (2018) links measures to the five crime reduction strategies, that is, Enabling, Education, Engineering, Enforcement and Evaluation. Havârneanu et al. (2015) suggests a simpler model of engineering measures and behavioural measures or “hard” and “soft” measures. Engineering measures include physical means to prevent trespassing and behavioural measures seek to influence the persons knowledge and attitude. Bosher et al. (2017) similarly refer to infrastructure or non-infrastructure treatments. Rabdo et al. (2012) use the categories technical and non-technical measures.

Although not specifically directed at railway trespassing, in a study looking at assessing the risk at railway level crossings in New Zealand, a risk hierarchy of controls is considered as an approach (Bosher et al., 2017). If one control is not achievable, then the sequential control in the hierarchy is chosen. See Table 5: Risk hierarchy of control.

**Table 5: Risk hierarchy of control**

<b>Risk hierarchy of control</b>	
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;"><b>Most effective</b></div>  <div style="margin-top: 10px;"><b>Least effective</b></div> </div>	<b>Elimination:</b> remove the hazard completely (e.g. grade separation)
	<b>Substitution:</b> replace a hazard with a less dangerous alternative
	<b>Isolation:</b> separate users from the hazard (e.g. fence)
	<b>Engineering Controls:</b> making changes to infrastructure or physical environment that reduces the likelihood and severity of the hazard
	<b>Administration:</b> putting policies, rules, signage or training in place to inform users of the hazard
	<b>Personal Protective Equipment (PPE):</b> Protective clothing and equipment (e.g. gloves, hats)

Source: Adapted from (Bosher, et al., 2017)

With regards to suicides and trespassing, there are two divergent approaches. Radbo et al. (2005) determined that intentional and accidental train-pedestrian collisions were similar enough in character to not warrant separate strategies for suicides and trespassing (Radbo, et al., 2005). Mishara and Bardo (2016) suggest that the analysis of accidental and intentional deaths be separated to allow for targeted preventative measures depending on the motive of the trespasser.

Sections 2.4.2, 2.4.3 and 2.4.4 will discuss the literature on countermeasures under three broad categories of educational, organisational and engineering measures.

### **2.4.2 Educational measures**

Educational measures include awareness campaigns, media campaigns, posters, signs, education drives in and out of schools and training. Educational measures are based primarily on two theories; the first, to highlight the dangers of walking along and across the railway tracks and to encourage use of designated crossing points, and secondly, to emphasise the illegality of crossing the tracks.

### *Educational campaigns*

Plaza et al., (2014), emphasise the key role schools can play at communicating railway safety messages. A railway safety education programme aimed at primary school children and teachers across Spain proved useful in improving knowledge, safe attitudes towards railway crossings and an improvement in the awareness of dangers of crossing the railway at informal locations. The study results indicate that schools located close to railway lines would especially benefit from such educational campaigns, as risky behaviour may be normalised due to the perception that crossing the railway tracks is “normal” behaviour.

Silla and Kallberg (2015) found that educational campaigns at schools may reduce railway trespassing but their effects are limited and therefore not the most effective and cost-efficient measure. Overall, education campaigns are supported, if they are well designed, and combined with combinations of other measures (Edquist et al., 2011; Silla & Kallberg, 2015; Silla & Luoma, 2011; Lobb et al., 2003). It is further necessary to adjust the content of the educational material to suit local characteristics, cultural differences, language, age etc. (Plaza, et al., 2014).

Lobb et al. (2001) evaluated a programme of educational and access prevention measures at a rail station in Auckland and found that when used in conjunction with other hard measures, educational campaigns are successful at encouraging the use of formal rail crossing points. The education campaign was successful in creating awareness about the illegality of crossing the railway but did little to influence the pedestrian’s perception of risk, i.e. most still believed it to be safe to cross the railway.

A study on a programme of interventions at a rail station close to a boys’ school, incorporating a communication programme, an education programme, “continuous punishment and intermittent reinforcement” and “intermittent punishment and intermittent reinforcement” was carried out by Lobb et al. (2003). The findings from this study were that the communications programme had little effect on unsafe crossings and that a targeted education programme may achieve better results in reducing the practice of unsafe crossings. Punishment, and specifically intermittent punishment, was deemed to be most effective at reducing and sustaining safe crossing practices and more practical to implement.

### *Communication campaigns*

The 'You Vs Train' initiative, championed by Network Rail and the British Transport Police in the United Kingdom, is a targeted campaign to reduce the number of train incidents involving young people under 18 years of age (You\_vs\_Train, 2019). The campaign includes safety videos based on the experiences of trespassing incident survivors based on real-life story events. Social media, influencer outreach messaging, local media engagement, and working with schools and local businesses, are some of the strategies used by the campaign, with information and support available on-line and free for anyone to use. 'You vs Train' launched in July 2018 and managed over 2.4million views, 360 media articles and reached an estimated 174million in its first four months. The RSSB claim that independent research results showed that 92% of children and 95% of adults are now more rail safety conscious and would, therefore, display safer behaviour. Trespass incidents involving young people reduced by 6% and youth fatalities reduced from six in 2017/18 to one fatality in 2018/19 (Mills, 2019).

Savage (2007) suggests that the behaviour of trespassers are uncommon or unusual to normal society and, therefore, mainstream communication campaigns would be ineffective as a medium to communicate the dangers of crossing the rail tracks. Targeted interventions at community forums, homeless shelters, soup kitchens and pubs that are located close to the railway may be more effective (Savage, 2007).

### *Signage*

An evaluation of warning signs seeking to reduce trespassing on railway property in Valladolid, Spain, showed that the implementation of warning signage as well as signage indicating the possibility of being fined, reduced trespassing numbers from 128 to 77 (Plaza et al., 2014). The number of people using broken-fence areas to access the tracks also reduced from 26 to four persons. This study would suggest that signage may be effective in reducing trespassing and unsafe behaviours and could be effective elsewhere if the content and information on the signs are relevant, are adapted to suit the context and country, avoiding overuse of signage and ensuring that signage is refreshed on a regular basis.

An alternate view is that many pedestrians would ignore or refuse to comply with warning signals or signs (Edquist et al., 2011). Due to the openness of railway

networks, the ability of signs to influence behaviour and covering all entry points to the rail network is not practical. Signage should therefore be placed at strategic locations such as platform ends and at known trespassing hot-spots, with clear and relevant messaging which would ideally include a graphic image or pictogram (Woods, 2006). Signage is appropriate where other measures are not practical and is a low-cost measure, both to install and maintain its effectiveness (Silla & Luoma, 2011).

In the United Kingdom, Wilson (2007) suggests that the wording "Keep out - private property. You are trespassing." is more appropriate to use than signs that read "Trespassers will be prosecuted". Wilson further cautions that property owners have a duty of care to trespassers to ensure they do not come to any harm, by putting up fencing and warning of possible danger. However, children may not yet be able to read and understand warning notices (Wilson, 2007).

### **2.4.3 Organisational measures**

Organisational measures include collaboration between organisations, risk assessments, patrols and enforcement, risk assessments, police cooperation and judiciary assistance.

#### ***Cross-organisation collaboration***

##### **RESTRAIL: REduction of suicides and trespasses on RAILway**

The RESTRAIL project was a three-year project coordinated by the International Union of Railways (UIC) with the aim of reducing the occurrences of suicides and trespassing on railway property. The project involves a consortium of 17 partners from 12 countries. The project collected and analysed data on countermeasure strategies and the assessment of countermeasures which resulted in a list of 25 recommended countermeasures (Havârneanu et al., 2016). (See Table 6: RESTRAIL family of countermeasures). A total of 11 pilot tests were also carried out to evaluate innovative new measures.

**Table 6: RESTRAIL family of countermeasures**

<b>RESTRAIL family of countermeasures</b>		
<b>Organisational and procedural measures</b>	1	Risk assessments
	2	Learning from best practice
	3	Collaboration between organisations
	4	Societal collaboration to prevent railway suicide
	5	Information sharing at regional level
	6	Patrols and enforcement
	7	Cooperation of the police and legal entities
<b>Physical and technological measures</b>	8	Fences at stations
	9	Fences outside stations
	10	Landscaping
	11	Detection and surveillance systems
	12	Lighting devices to influence behaviour
	13	Lighting to increase visibility at hot-spots
	14	Safety and emergency devices at stations
	15	Incident management and information platform
	16	Forward facing CCTV
<b>Public awareness and educational measures</b>	17	Campaigns to raise awareness
	18	Mass media campaigns
	19	Media guidelines
	20	Posters and warning signs
	21	Prohibitive signs
	22	Education in and outside schools
	23	Training to prevent suicide
	24	Training to prevent trespass
	25	Training and exercises to mitigate the consequences

Source: (Havârneanu, et al., 2016)

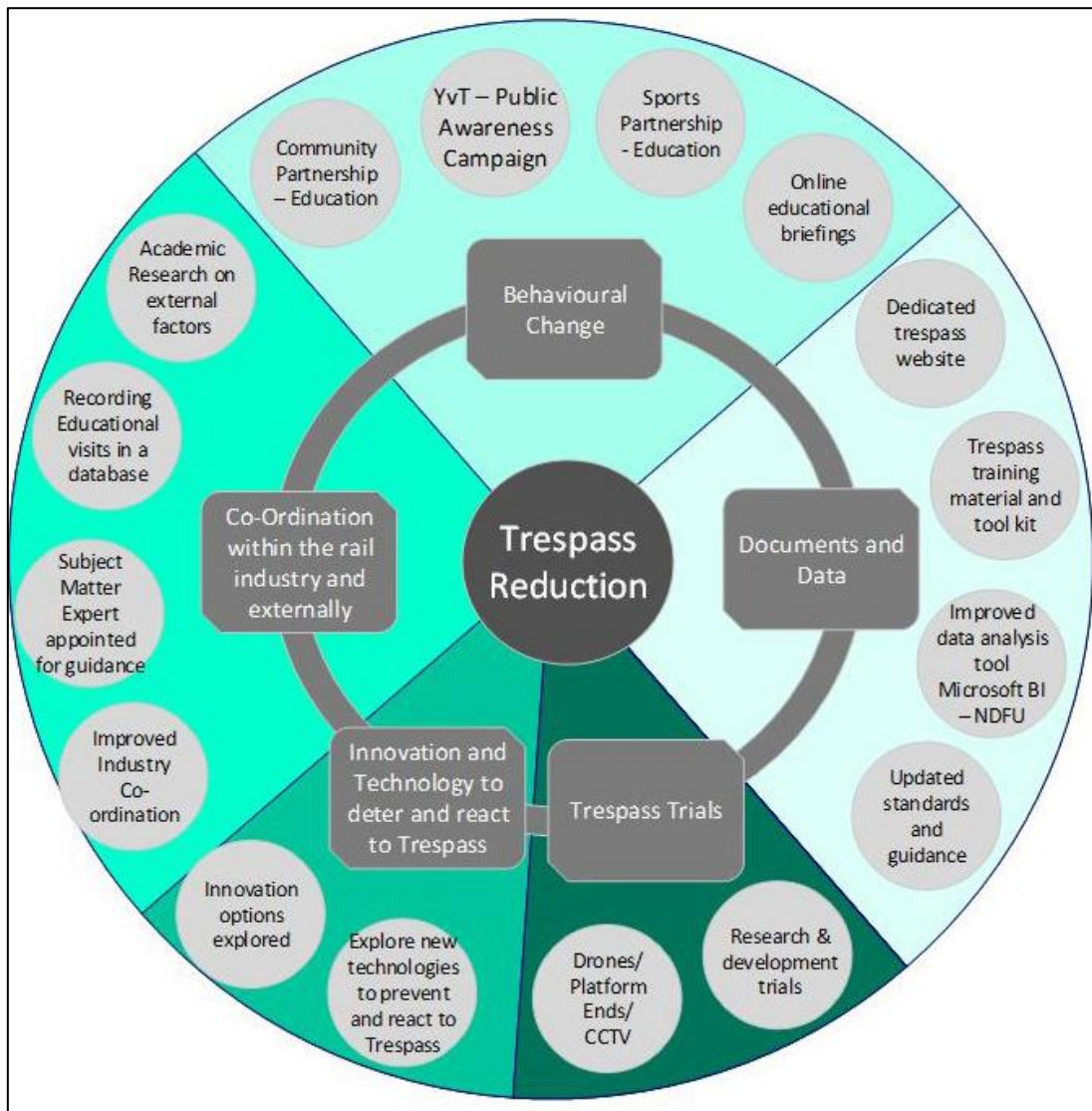
RESTRAIL additionally provides a toolbox that provides a practical problem-solving tool and a structured research framework to guide users on best practice implementation of various countermeasures. Each countermeasure is described under the following headings: description, recommendations, warning points, observations, study results, and is accompanied by a number of photographic examples.

Havârneanu et al. (2016) describes the benefits of the RESTRAIL project as having achieved the following:

- Improving safety by reducing fatalities and injuries,
- Improved train availability and return-to-service time after a pedestrian-rail incident, and
- Reduced rail industry direct and indirect costs arising from pedestrian-rail incidents.

#### *RSSB Trespass Improvement Programme*

The Trespass Improvement Programme was launched in January 2018 and is a cross-industry initiative including the RSSB, British Transport Police, Office of the Rail Regulator, Department for Transport, and Train and Freight Operating Companies (Mills, 2019). The programme provides guidance on frameworks and best practice to encourage safe public behaviour in the rail environment. The programme is based on four streams i) innovation and technology, ii) co-ordination within and externally to rail organisations, iii) documents and data and iv) behavioural change. See Figure 8: RSSB Traspas Improvement Programme.



**Figure 8: RSSB Trespass Improvement Programme**

Source: (Mills, 2019)

### ***Legal and non-legal sanctions***

Freeman and Rakotonirainy (2017), investigated deterrence-based approaches to reducing railway trespassing. Deterrence theory centres around three elements: the perceived certainty of being caught, the severity of the penalties and the swiftness with which the penalties are imposed. From a survey, including 636 respondents, it was found that 48% were not aware that trespassing was a fineable offence. In order to maximise the effectiveness of a deterrence-based approach, pedestrians need to be aware and warned of possible monetary penalties. Regarding non-legal sanctions, the study confirmed that trespassing behaviour can be influenced by informal sanctions such as fear of injury and peer stigma. An increase in police visibility was deemed to

be most effective at preventing trespassing violations. In a study of pedestrian non-compliance at railway level crossing gates, Edquist et al., (2011) supports this finding, stating increased visibility of police, coupled with an increase in the certainty of receiving a warning or fine for non-compliant crossing have been shown to reduce incidents of trespassing.

### ***Police interventions***

The Rapid Rail Police Unit is briefly described in Section 1.1.2, The South African Police Service and its Rapid Rail Police Unit (RRPU). The function of the RRPU essentially is to prevent crime in the railway environment.

Research by January and Mofokeng (2017) into the operational aspects of the RRPU in the Western Cape, found that the RRPU did not properly apply crime prevention operations; the RRPU does not implement any structured, known, crime prevention theories; the RRPU does not cooperate with the PRASA Protection Services, the public or communities through a community-oriented approach and due to the high levels of railway crime, they are failing at the most basic duties (January & Mofokeng, 2017). This puts the onus of protecting the railway environment heavily on the shoulders of the railway operators' own in-house security.

### **2.4.4 Engineering measures**

Engineering measures include fencing, landscaping, lighting, CCTV, drones, audio announcements, under and over-passes and other physical measures.

#### ***Physical barriers***

Simply put, for a pedestrian-train collision to occur, two elements are required, a pedestrian and a train. It is no surprise then that a common countermeasure to prevent trespassing-related fatalities and suicides is fencing or a physical barrier to prevent pedestrian access to the rail reserve (Havârneanu et al., 2015); (Silla & Luoma, 2011); (RSSB, 2018). Train drivers also support appropriate fencing that is high, strong and long when used as part of a combination of measures (Silla & Luoma, 2008).

Despite its popularity as a recommended countermeasure, there are very few studies providing specifics about its effectiveness and recommended details for implementation (Havârneanu et al., 2015). A design guide for pedestrian rail crossings suggests secure fencing is an important barrier to keeping people out of the

rail reserve and encourage the use of formal crossing points. In New Zealand, a 1.2-1.8m high mesh fence is specified as a barrier between any pedestrian pathway and the rail reserve. More secure palisade fencing is recommended where trespassing or vandalism is more common (Koorey et al., 2017).

In Auckland, a safety programme included fencing repairs, where people had cut holes in the fence and the installation of new high-security fencing. The new fencing was almost immediately vandalised and new access holes cut. The new holes were immediately smeared with heavy grease that would make it impossible to climb through without heavily soiling ones's clothes and then had the desired effect of deterring would-be trespassers. Trespassing behaviour at this specific location reduced from 59% to 36% (Lobb et al., 2001).

In Finland, 1.0m-high fencing was installed on both sides of the track and restricted access for approximately 100m on both sides of a formal crossing point. This measure saw trespassing reduce by 94.6%. In the same study, at a different location, physical barriers in the form of landscaping were trialled, involving steepening the shoulders of the railway reserve and creating a natural barrier using vegetation interspersed with large stones. The landscaping was roughly 1.5m in height and 200m long, and reduced trespassing by 91.3% (Silla & Luoma, 2011).

Landscaping measures such as planting trees and bushes may also provide refuge to those wishing to hide from public view in order to commit suicide or participate in criminal activities and should not be used as a barrier on its own (Koorey et al., 2017). Savage (2007) supports this view and suggests that vegetation be trimmed to aid visibility.

Mid-platform fencing is also recommended for island platforms to discourage suicide by jumping in front of trains, but these have limited use (Plaza et al., 2014).

In another location in Cape Town, fencing at selected stations had a limited effect on reducing pedestrian-rail injury rates and the fencing was commonly vandalised and the material used to build informal dwellings (Lerer & Matzopoulos, 1996). Nomzamo, Cape Town, is another example of where fencing and dedicated pedestrian routes have failed to limit trespassing (Venter et al., 2014).

### ***CCTV and video surveillance systems***

CCTV surveillance is one of the most practical and widely used trespass detection systems. Many rail networks already extensively covered by CCTV, are adapting existing CCTV capability to automatically detect trespassing (RSSB, 2018). Integrating image analysis capability of existing systems as well as extending the coverage of existing systems and improving the image quality is a cost-effective way to improve the efficiency of current CCTV systems (RSSB, 2018).

A three-year pilot of a video-based trespass monitoring and deterrent system consisting of video cameras, motion detectors, infrared illuminators, speakers, and central processing units was trialled on a railway bridge in New York in 2001 (daSilva et al., 2012). The system provided real-time surveillance of the bridge and a control room attendant would warn trespassers of oncoming trains, saving at least five lives during its period of operation. The system provided real-time video surveillance of the bridge and a control room attendant would respond by sounding out warnings via pole-mounted speakers near the bridge and would call law enforcement if required. Considering that the trial ended in 2004, considerable advances have been made since in detection technology. Key learning points from this pilot were that the assets were installed off railway property and therefore not reliant only on railway operators to install. The system also showed potential benefits for railway asset monitoring (daSilva et al., 2012).

### ***Drones***

Drones provide mobile, aerial CCTV capability and their use in the rail environment is still in development. Drones have been used to carry out surveys at trespassing hot-spot sites, providing video footage of pedestrian desire lines where the number of pedestrians and their movements were too complex to count manually (Mvinjelwa et al., 2019).

Drones are also being used as part of a combination of measures to combat theft from freight trains in Poland. In six months, the number of incidents of theft declined by 44% and the total value of stolen goods declined by almost 60% (PKP\_Cargo, 2019).

In Germany, on the Deutsche Bahn (DB), 14 000 graffiti incidents were recorded in a single year, costing the rail company €7m to remove. DB tested the

use of mini-drone's which were equipped with a high-resolution infrared camera able to spot trespassers at train depots and maintenance yards. Strict privacy laws in Germany limited the drone surveillance to daylight hours only, severely curtailing the effectiveness of the countermeasure (Lo, 2013).

The RSSB report, *Drones and the railways*, (2016), cautions that “hobby” drone operators would enter the rail reserve to retrieve grounded machines and this therefore, would inadvertently be a motive for trespassing.

### ***Lighting***

Lighting and improved lighting, either on its own or as part of a combination of measures, is recommended by the literature (Savage, 2007); (Havârneanu et al., 2015), to increase visibility at railway crossings, tunnels and trespassing hot-spots (Ryan & Kallberg, 2013).

Poor lighting of pedestrian rail subways and over-bridges could influence a pedestrian's decision on whether to use the facility or choose a “safer” option by crossing the tracks. The user's perception of safety and comfort is influenced by good lighting quality and is an important element of subway design (Burnett & Pang, 2004)

### ***Addressing pedestrian treatments across railway tracks***

This group of measures include the most expensive to implement and involves the construction of pedestrian grade-separated rail crossings, also known as pedestrian underpasses/subways and pedestrian over-bridges. It also includes treatments at informal at-grade pedestrian rail crossings.

As a train has full right-of-way in the railway environment, pedestrians are obliged to use formal railway crossing points where they have been provided. In theory then, the implementation of a means to isolate pedestrians from moving trains by using grade separated crossing points is very effective; should pedestrians decide to use them. The best countermeasure would be good planning for non-motorised transport (Koorey et al., 2017) and eliminating the need to cross railway lines in the first place. However, pedestrians frequently need to cross railway lines and should be provided with safe means to do so (Fitzpatrick et al., 2015).

In Cape Town, in a study addressing non-motorised transport movements along and across railway lines, pedestrian bridges and subways are proposed as part of combinations of interventions at a number of hot-spot locations (Venter & Shirley, 2014). Pedestrians will use the shortest most direct route to reach their destination, irrespective of formal pathways or crossing points and the siting of pedestrian bridges should have minimum deviation as is practical from a direct pathway (Boucher et al., 2008). Issues of personal safety are the greatest deterrent for pedestrians using pedestrian overbridges and subways, particularly at night, and should be a key factor in the design thereof (Burnett & Pang, 2004).

With regards to replacing an unused grade-separated pedestrian rail crossing with an at-grade crossing or formalising an informal at-grade pedestrian rail crossing, this is a measure that is strongly discouraged by many. In New Zealand, any new crossing must be designed with risks as low as reasonably possible from the outset, usually requiring grade separation. At existing crossings, this may also require grade separation or result in the closure of the crossing altogether (Koorey, et al., 2017). In South Africa, PRASA, the state-owned entity responsible for commuter rail operations, has a policy that no new level crossings, including pedestrian level crossings, be implemented (Venter et al., 2014).

The reluctance by rail companies and operators to view formalising informal at-grade crossings as a viable measure is not clearly defined in the literature available. There are a number of guidelines and documentation available dealing with pedestrian grade crossings, all providing best practice and procedures to ensure pedestrian safety, such as the Guidebook on Pedestrian Crossings of Public Transit Rail Services (Fitzpatrick et al., 2015), the UDOT Pedestrian Grade Crossing Manual (UDOT, 2013) and the Kiwi Rail Design Guidance for Pedestrian and Cycle Rail Crossings (Koorey et al., 2017).

In Nomzamo, Cape Town, one of the proposed measures to limit trespassing includes formalising the existing informal crossing. Venter et al. (2014) believe the at-grade crossing is warranted because there is only a single rail line at this location with low train frequencies and an exceptionally high number of pedestrians, as discussed earlier in this paper (Venter et al., 2014). It is, however doubtful, that this option would be considered by the rail operator.

#### **2.4.5 Countermeasure effectiveness**

Thus far, a number of countermeasures have been presented with evidence from literature on suggestions for their use and effectiveness. Numerous other potential countermeasures are suggested in the literature with no definitive measure of their effectiveness.

Many studies argue that trespassing characteristics are unique to specific locations (e.g. Law, 2004; Rail Safety and Standards Board, 2007; Savage, 2007). Therefore, countermeasures should be developed according to each location's specific characteristics, with a thorough understanding of the type and motives for trespassing (Silla & Luoma, 2011), understanding that the relationships between various variables will differ between locations (Wang et al., 2016). Havârneanu et al. (2015) supports this by advocating that measures be adopted to the problem and characteristics of the problem site and the intended and unintended consequences be thoroughly understood of the selected measures.

Researchers agree that combinations of measures are required (RSSB, 2018), using a systems approach (Silla & Luoma, 2012), to ensure the desired outcomes are achieved; emphasis should be placed on the monitoring and evaluation of measures to understand how they interact, singly and in combination (Ryan et al., 2018). Havârneanu et al. (2015) found empirical support for the effectiveness of measures in only 22 studies, with the evaluations of combinations of measures even more rare. Whilst better evaluation of measures requires adequate recorded examples over a long period, in the interim the experience of experts could be used to fill gaps in the current knowledge, as done by Ryan et al. (2018).

Importantly, irrespective of the countermeasure installed, an asset management programme ensuring a preventative and corrective maintenance regime is essential to retain the effectiveness (Silla & Luoma, 2011) of the measure over its whole life.

#### **2.4.6 Lessons from crime science**

##### ***Hot-spot policing***

The literature commonly refer to trespassing and suicide "hot-spot's" (Havârneanu et al., 2015; Freeman & Rakotonirainy, 2017; Silla & Luoma, 2011; Ryan & Kallberg, 2013; Ryan, 2012; RSSB, 2018; Havarneanu, 2017; Venter et al., 2014). Hot-spots are typically locations with high trespassing accident rates, high

trespassing rates or locations with high rates of railway crime. Rail operators usually focus their attention on hot-spots, which is the most natural and cost-effective strategy; however, it may not be the ideal strategy when there are large numbers of incidents spread across a broad network (Havârneanu et al., 2016).

With reference then to crime analysis literature, hot-spots are commonly those areas with the highest concentrations of crime in general or clusters of specific crime types (Braga et al., 2012). Hot-spot policing is thus a strategy that allows targeted police interventions to deal with majority of the crime efficiently at the most worrisome locations (Telep & Weisburd, 2012).

The effectiveness of hot-spot policing is widely evidenced. Braga et al. (2012) provides evidence of the effectiveness of the approach in a review of 19 studies investigating 25 hot-spot locations and the effect of police action on crime. A total of 80% of the sites showed significant crime control benefits directly attributed to hot-spot policing programmes. The typical crimes at the various sites varied greatly, from violent crime to property crime, drug offences, and disorder offences, showing the great versatility in the approach. One shortfall of the research carried out is the lack of a financial or cost assessment with which to assess the cost-benefit analysis of the hot-spot policing method versus conventional policing (Braga et al., 2012).

Clarke and Eck (2005), explain hot-spot areas as follows: i) Crime generators; places which attract large numbers of people for non-crime related reasons, such as rail stations; ii) Crime attractors are places known to criminals with many opportunities for crime, rail depots and yards, rail trackside assets and rolling stock would fall in this category and iii) Crime enablers are places where barriers have failed and order is lost, for example vandalised or no fencing allowing unrestricted access to the rail reserve, and stations void of staff (Clarke & Eck, 2005).

Once hot-spots have been identified, there are a number of interventions and measures, which can then be targeted at the problem. The most deployed tactic is to increase patrol time in the targeted hot-spot locations by carrying out random, intermittent stops and not spending more than 15 minutes in one location (Telep & Weisburd, 2012) before moving to the next location in a completely haphazard manner. Another measure is reducing the attractiveness of potential targets called “situational strategies”, by making it more difficult for potential criminals or

increasing the risk of being apprehended (Telep & Weisburd, 2012). Limiting access and target hardening are examples of such measures.

Care should be taken to conduct a detailed situational analysis after the discovery of a hot-spot to understand what environmental and social factors are contributing to the hot-spot and why other areas are free of crime (Clarke & Eck, 2005). The discovery alone of a hot-spot is not enough on which to base an effective countermeasure response. Additionally, it is essential that a hot-spot analysis include a detailed spatial analysis (Clarke & Eck, 2005).

### ***Problem-oriented policing***

Problem-oriented policing (POP) combines diverse approaches to solving crime with a focused action, usually in conjunction with other affected stakeholders (Clarke & Eck, 2005) in order to address the root causes responsible for generating recurring crime problems at hot-spots (Braga et al., 2012). Through this approach, the SARA model for problem solving was developed: i) Scanning: identifying and prioritising potential problems; ii) Analysis: developing an appropriate response to the problem with detailed analysis; iii) Response: is the measured response rightly guided to solve the problem? and iv) Assessment: assessing the impact of the response (Clarke & Eck, 2005).

The literature confirms that it is critical to fully analyse a larger problem of crime into more manageable categories in order to design tailor-made responses (Clarke & Eck, 2005; Telep & Weisburd, 2012).

### **2.4.7 Unlawful occupation**

Trespassing, irrespective of the intent of the trespasser, is usually a temporary occurrence, i.e. the trespasser will be in the rail reserve for a short period of time till their desired objective is achieved, before they would then leave the area. The time spent in the rail reserve could range from a few seconds, to take a short-cut to a few hours to steal a length of buried cable. An extension of trespassing is the occurrence of encroachment or unlawful occupation for the purpose of setting up an informal shelter or dwelling in the rail reserve. The definition of encroachment could also be used to include those dumping waste, defecating (Srivastava, 2015) or running services (such as illegal electrical connections and water pipes) through, in and across the railway reserve.

The Prevention of Illegal Eviction from and Unlawful Occupation of Land Act, 1998 (PAIE Act) defines an unlawful occupier as: “*a person who occupies land without the express or tacit consent of the owner or person in charge, or without any other right in law to occupy such land, ...*” (PAIE, 1998)

In research carried out by Poya and Mathebula (2013), a survey was carried out in communities in informal settlements at locations of unlawful settlement hot-spots within the rail reserve. The survey found that the community was unwilling to relocate away from the railway line with the hope that they would be provided with a government-funded house free of charge. Some lived close to the railway because it made access to the rail public transport system easier for them. The areas were characterised by pollution and sewage, illegal electrical connections affecting the rail signalling system, fencing vandalised and removed, animals roaming on the tracks, children playing on the tracks and numerous pedestrian pathways crossing the tracks (Poya & Mathebula, 2013).

Controlling unlawful occupations and encroachments are challenging for railway organisations and governments. Influencing factors such as rapid urbanisation, weak urban governance, housing shortages, lack of political will, poor laws and weak implementation of bye-laws, compensation for affected parties and a lack of consequences for transgressors (Srivastava, 2015) are not easily overcome. If not managed, the removal of transgressors can often lead to unrest and retaliation (Charbonneau, 2016), or re-encroachment (Srivastava, 2015).

In Delhi, India, the government introduced legislation to try and curb the increasing growth of encroachments on all public land. The Bill was widely criticised as discriminatory against the poorest and was unable to control the thousands of people migrating to cities and occupying land unlawful to them (Ghose, 1984). In Delhi, a massive project is currently underway to fence off critical areas of the railway to prevent encroachment. Concrete fences are used to secure the railway reserve along a 15m safety zone where 27500 structures were removed. Elsewhere, over 43000 structures have been identified in the railway reserve (Gandhiok, 2019).

A local example of encroachment can be found at the Eyadini informal settlement on sections of disused track in Philippi, as reported by Lali (2019). The disused area has been identified as the location for the construction of a new rail staging yard and depot, but since it carries no live traffic at present, more than

1000 (Lali, 2019) informal dwellings have been erected on the site as recently as April 2019. At the time of writing, no long-term solution has been found yet and the shacks are now spreading along the railway lines towards Nyanga station.

### ***Prosecuting trespassers***

In South Africa, trespassing is an offence known as a contravention of Section 1 of the Trespass Act 6 of 1959. If the person “trespassing” is an occupier, erects a structure on the property with the intention to live there, that person will be protected by the Prevention of Illegal Eviction from and Unlawful Occupation of Land Act, 1998 (PAIE). In this case, the complainant would need to seek legal advice to obtain an eviction order in terms of the PAIE legislation. An occupier may only be evicted under the authority of an eviction order issued by a competent court (SAPS, 2016).

According to PAIE, an organ of state, such as a rail company, “*may institute proceedings for the eviction of an unlawful occupier from land which falls within its area of jurisdiction, if it is in the public interest to grant such an order*”, in which case it would be if rail health and safety is a concern both for the travelling passengers and the unlawful occupiers. The law does not allow persons to unlawfully occupy property; however, the rail company should act as soon as they become aware of any unlawful occupation, i.e. they should act to obtain the necessary eviction order within a six-month window (PAIE, 1998).

### ***Resettlement Action Plans***

Resettlement Action Plans (RAP) have been used to manage large-scale relocation projects in Kibera, Kenya (Charbonneau, 2016) and Karachi, Pakistan (KUTC, 2015). The main purpose of a RAP is to minimise the negative social impacts of relocating already impoverished communities by providing criteria for fair compensation for loss of assets and livelihood, as well ensuring basic levels of service is maintained at the resettlement site. Critical to the success of these RAP’s are community liaison structures, constant awareness campaigns, continuous dialogue between community and political stakeholders and critically, strict criteria on those who are eligible to be included as an affected person (Charbonneau, 2016).

## **2.5 SECONDARY CONSEQUENCES OF RAILWAY TRESPASSING**

Train drivers are a select group of people, specially trained, and require a high degree of concentration and the ability to focus on multiple aspects simultaneously. Track incidents, normally occur without warning and the train driver is almost never able to avoid an accident, considering that a light rail train can require a distance of two soccer fields to come to a complete stop.

Train driving is a safety critical occupation and drivers are not only faced with numerous hazards on the track, but are also faced with a demanding physical environment, irregular work hours, sleeplessness, and fatigue. The combination of these factors, with the continuous risk of pedestrian-rail incidents, can have a deteriorating effect on the well-being of train drivers.

Various studies have documented the psychological distress caused to train drivers (Limosin, et al., 2005). Actual events, as well as near-misses has been shown to be equally distressing, and studies suggest a relationship between track incidents and long-term somatic and psychological complaints (Vatshelle & Moen, 1997). In a study on 76 train drivers on the London Underground, 17% of drivers displayed symptoms of Post-Traumatic Stress Disorder (PTSD), and 31% presented with neurotic depression, when interviewed one month after the event (Tranah & Farmer, 1994). Other studies have concluded that most of the psycho-behavioural disorders were observed immediately after the event and disappeared within a 12-month period (Cothereau, et al., 2004).

Pedestrian-rail incidents also impacts other railway staff besides train drivers, such as clean-up crews, rescue workers and those that witness the event (Silla & Luoma, 2011; Mishara & Bardon, 2015). Other impacts include property damage, railway infrastructure damage, delays to the rail service, legal costs and insurance costs. The societal costs involved with the loss of a human life, medical and burial costs, loss of income are also considerable (Havârneanu, et al., 2015). Although controversial, there is an increased demand for information on the value society is willing to put on a human life. Various methodologies exist to calculate the value of a life and the estimated range for a statistical life year is between \$7 - \$12 million (UK, 2016).

## 2.6 LITERATURE REVIEW IMPLICATIONS

The purpose of the literature review was to provide a comprehensive overview of current knowledge on all aspects pertaining to railway trespassing, as well as the methods and tools that are in use for the prevention of railway trespassing.

The literature suggests that railway trespassing behaviour is specific to a location and/or area and stresses the importance of investigating the problem from a local perspective to develop a better understanding. More research is encouraged due to the great variety of trespassing forms and how they can be influenced by sociocultural patterns and local conditions.

The literature review revealed several limitations:

i. Most of the literature and studies carried out has been in European and Northern American countries. Very little research has been carried out in developing or newly industrialised countries, with only a few studies conducted in South Africa.

ii. The City of Cape Town Municipality must be commended for the work carried out recently in trying to better understand pedestrian movements along and within the rail reserve. The study is, however, limited to the City of Cape Town, and the commuter rail network extends beyond the city's borders into four neighbouring municipalities. The studies were also focused on non-motorised transport movements within rail corridors without considering other manifestations of trespassing.

iii. The motives for trespassing in the literature has a strong emphasis on suicides, with it representing 72% of railway fatalities in Europe. Other motives for trespassing, such as those related to criminal activities, are seldom discussed in detail.

iv. Only a few studies, have studied actual trespass behaviour with several studies based solely on fatality statistics. As most trespassers do not intend to get harmed, the act of trespassing does not always result in an injury or fatality. Fatality statistics alone are therefore not adequate to describe trespassing.

v. The literature is unanimous in agreeing that there is not enough published research evaluating the efficiency of installed countermeasures to mitigate for trespassing-related incidents.

The limitations highlight the need to carry out a detailed analysis of trespassing and its main effects in a local context in order to develop tailored and effective responses. There is also a need for more documented evidence to support the current knowledge base around the effectiveness of installed and implemented countermeasures.

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# Chapter 3: Railway Safety Regulator State of Safety Reports

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This chapter continues the review of available literature and will discuss the South African Railway Safety Regulator's (RSR) annual State of Safety Reports from 2008/09 till 2017/18. The aim of this chapter is to show national trends in rail safety data and to provide a review of the general safety performance of rail in South Africa over the period of 10 years.

## 3.1 STATE OF SAFETY REPORTS

The State of Safety Report is produced in compliance with Section 20 of the National Railway Safety Regulator (RSR) Act, 2002 (Act No. 16 of 2002, as amended), which mandates "*the Regulator to submit to the Minister of Transport, an annual report on the safety of workers, the public and the environment associated with railway operations*" (RSA, 2019). The reports are produced annually to cover a "financial" year from April of the previous year till end of March of the current, known as the *reporting period*.

Occurrence data is submitted to the RSR daily and on a quarterly basis. With regards to the security-related data, these are collected independently from those collected by the SAPS and its RRPU. The police collect their data from the Case Administration System (CAS) while the RSR gathers data directly from railway operators (RSR, 2015). It is commonly found that passengers who are victims of personal security occurrences will report those to the railway operator's security personnel but not to the police. Similarly, some cases of theft and vandalism are generally reported to the RSR but not to the police (RSR, 2012). Data from the RSR and SAPS will therefore, always differ, and the SAPS data is seldom in a format that is compatible with that required by the RSR to incorporate into the reports.

Safety reporting before the 2008/09 financial year proved inadequate with regards to the detail railway operators were required to provide in order to make meaningful analysis. Revisions were subsequently made to SANS 3000-1 (2005), with new requirements that called for a more detailed account of occurrence data. Railway occurrences have since been captured in 12 categories, lettered A-L and

security incidents in nine categories, numbered 1-9 (RSR, 2009). See Table 7: SANS Description summaries for Categories A-L and 1-9. The main categories listed below are then further broken down into sub-categories.

**Table 7: SANS Description summaries for Categories A-L and 1-9**

<b>Operational Occurrence Categories</b>	
<b>Category</b>	<b>Category Description</b>
Category A	Collisions during movement of rolling stock
Category B	Derailments during movement of rolling stock
Category C	Unauthorised movements (rolling stock movements exceeding limit of authority)
Category D	Level crossing occurrences
Category E	People struck by trains during movement of rolling stock
Category F	People-related occurrences: trains outside station platform areas or in section
Category G	Passenger-related occurrences: travelling outside designated area of train
Category H	People related occurrences: platform- train interchange
Category I	People related occurrences: station infrastructure
Category J	Electric shock
Category K	Spillage/leakage, explosion or loss of dangerous goods
Category L	Fires
Category 1	Theft of assets (impacting on operational safety)
Category 2	Malicious damage (vandalism) to property
Category 3	Threats (to operational safety)
Category 4	Hijacking of trains
Category 5	Crowd-related occurrences
Category 6	Industrial action
Category 7	Personal safety on trains
Category 8	Personal safety on stations
Category 9	Personal safety outside station platform area (including yards, sidings and depots)

Source: (RSR, 2014)

The 2017/18 State of Safety Report is the first to report on harm to persons (the public, passengers and rail staff), described by the term, “*fatalities and weighted injuries*” (FWI). The combination of these two variables can be calculated using the formula (RSR, 2018):

$$\text{FWI} = [\text{number of fatalities}] + 0.1 \times [\text{number of injuries}]$$

The challenge of theft and vandalism of railway infrastructure (Category 1 and Category 2 occurrences), as well as the number of fatalities and injuries to people struck by trains (Category E) is a recurring theme throughout the suite of reports to date and these will be expanded on next.

### **3.2 CATEGORY “E” – PERSONS STRUCK BY ROLLING STOCK**

Occurrences where persons are struck during movement of rolling stock (other than at level crossings) are classified in terms of Category E (SANS 3000-1:2009). The sub-categories are as follows:

- E-a Occurrence where a member of the public is struck by rolling stock on a running line*
- E-b Occurrence where an employee is struck by rolling stock on a running line*
- E-c Occurrence where a contractor or contractor’s employee is struck by rolling stock on a running line*
- E-d Occurrence where a member of the public struck by rolling stock on a line other than a running line*
- E-e Occurrence where an employee is struck by rolling stock on a line other than a running line*
- E-f Occurrence where a contractor or contractor’s employee is struck by rolling stock on a line other than a running line*

The number of Category E occurrences or people struck by trains during movement of rolling stock other than at a level crossing are provided in Table 8: Category E Occurrences, Fatalities and Injuries. The average number of occurrences of people struck by trains for the 10-year period is 588.2, i.e. a mean of

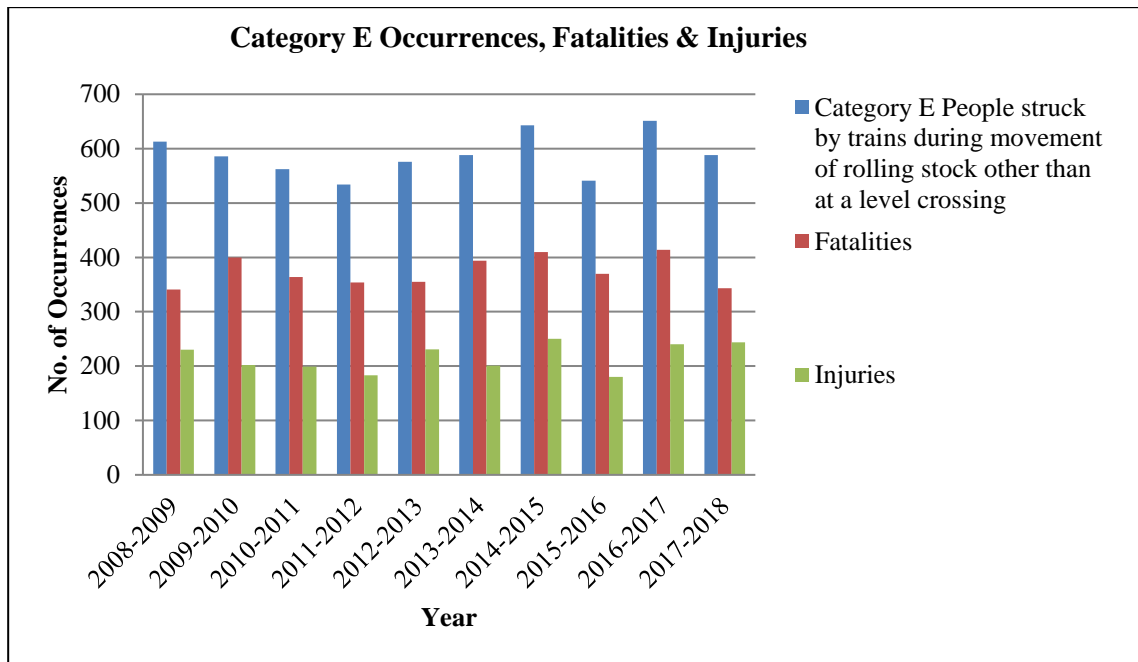
11.3 occurrences per week. The highest number of occurrences was recorded in 2016/17 with 651 events. The highest number of fatalities (414) was recorded in the same reporting period. Fatalities make up more than 60% of Category E occurrences with a mean of 7.2 deaths per week between 2008 and 2018.

**Table 8: Category E Occurrences, Fatalities and Injuries**

<i>Year</i>	<b>Category E People struck by trains during movement of rolling stock other than at a level crossing</b>	<i>Fatalities</i>	<i>Injuries</i>	<i>FWI</i>
2008-2009	<b>613</b>	341	230	364
2009-2010	<b>586</b>	400	202	420.2
2010-2011	<b>562</b>	364	199	383.9
2011-2012	<b>534</b>	354	183	372.3
2012-2013	<b>576</b>	355	231	378.1
2013-2014	<b>588</b>	394	201	414.1
2014-2015	<b>643</b>	410	250	435
2015-2016	<b>541</b>	370	180	388
2016-2017	<b>651</b>	<b>414</b>	240	438
2017-2018	<b>588</b>	343	244	367.4
<b>TOTALS</b>	<b>5882</b>	<b>3745</b>	<b>2160</b>	<b>3961</b>

Source: (RSR, 2008-2018)

The sub-category most applicable to trespassing is ‘Category E-a: Occurrence where a member of the public is struck by rolling stock on a running line’.



**Figure 9: Category E Occurrences, Fatalities and Injuries**

As can be seen graphically on Figure 9: Category E Occurrences, Fatalities and Injuries, the number of incidents remain consistent throughout the 10-year period. People struck by trains on running lines contribute the most to the overall number of fatalities caused by rail operations (RSR, 2018). The reports consistently repeat the same contributing issues year-on-year, including:

- the growing rate of informal settlements along railway lines
- the lack of formal crossing points
- disobedience in using formal crossing points when they are available
- openness of the railway system and inadequate fencing
- public ignorance of the risks associated with the rail environment
- fare evasion
- entering the station areas via illegal platform accesses
- lack of cooperation between rail operators, municipalities and communities
- railway security personnel not adequately performing their duties

(RSR, 2008-2018).

### 3.2.1 International comparisons

Using 2016 data, comparing South Africa to the top European Union member states for which data was available, for the passenger-kilometres-per-fatality, shows South Africa performing poorly in comparison to the other countries. See Table 9: International comparison for fatalities caused by persons struck by trains. Statistics on other African countries were not found.

**Table 9: International comparison for fatalities caused by persons struck by trains**

	Passenger-kilometers (in million)	Total number of persons killed in accidents	Passenger kilometers per fatality
Macedonia	83	14	5.92
Montenegro	84	9	9.32
Lithuania	280	22	12.71
<b>South Africa</b>	<b>9,872</b>	<b>*414</b>	<b>23.85</b>
Romania	4,731	187	25.30
Bulgaria	1,455	54	26.94
Turkey	4,325	153	28.27
Croatia	827	24	34.45
Hungary	7,626	151	50.50
Slovakia	3,484	59	59.05
Slovenia	611	9	67.88
Poland	18,753	259	72.41
Greece	1,192	14	85.18
Czech Republic	8,738	89	98.18
Portugal	4,266	31	137.62
Austria	12,021	84	143.11
Finland	3,868	13	297.52
Germany	95,465	295	323.61
Italy	51,132	127	402.62
Luxembourg	417	1	417.34
Spain	26,532	50	530.63
Sweden	12,800	24	533.33
France	90,324	131	689.49
Switzerland	19,602	28	700.06
Netherlands	17,980	19	946.32
Norway	3,695	3	1231.72
United Kingdom	68,010	40	1700.25
Denmark	6,209	2	3104.33

Source: Adapted from (Eurostat, 2018); (RSR, 2017)

\*Data used from the 2016/17 reporting year for fatalities

### 3.3 CATEGORY 1 OCCURRENCES - THEFT

Data extracted from the suite of State of Safety Reports for Category 1 occurrences are presented in Table 10: Category 1 Theft of assets (impacting on operational safety).

**Table 10: Category 1 Theft of assets (impacting on operational safety)**

Category	Category 1 Theft of assets (impacting on operational safety)										TOTALS
	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	
<i>a: rolling stock components - section</i>	164	400	430	360	476	204	210	229	362	551	<b>3386</b>
<i>b: rolling stock components - yard</i>	199	332	196	78	46	168	227	131	174	326	<b>1877</b>
<i>c: civil infras - section</i>	760	586	960	1231	703	544	828	383	282	623	<b>6900</b>
<i>d: civil infras - yard</i>	9	18	55	110	45	53	66	14	19	36	<b>425</b>
<i>e: overhead traction - section</i>	685	1007	775	411	188	213	321	298	212	559	<b>4669</b>
<i>f: overhead traction - yard</i>	4	5	4	6	2	5	9	14	2	32	<b>83</b>
<i>g: train control equip - section</i>	767	1016	1488	1304	1329	1767	2413	2407	3140	2654	<b>18285</b>
<i>h: train control equip - yard</i>	28	22	75	52	23	4	14	12	9	65	<b>304</b>
<i>i: ancillary equip</i>	17	9	10	87	88	110	125	112	179	138	<b>875</b>
<b>TOTALS</b>	<b>2633</b>	<b>3395</b>	<b>3993</b>	<b>3639</b>	<b>2900</b>	<b>3068</b>	<b>4213</b>	<b>3600</b>	<b>4379</b>	<b>4984</b>	<b>36804</b>

Source: (RSR, 2008-2018)

The sub-categories as taken from SANS 3000-1:2009 are as follows:

- 1-a Theft of rolling stock components in section*
- 1-b Theft of rolling stock components in yards (staged)*
- 1-c Theft of civil infrastructure components in section*
- 1-d Theft of civil infrastructure components in yards and sidings*
- 1-e Theft of overhead traction equipment in section*
- 1-f Theft of overhead traction equipment in yards and sidings*
- 1-g Theft of train control equipment (signalling) in section*
- 1-h Theft of train control equipment (signalling) in yards and sidings*
- 1-i Theft of ancillary equipment including public address systems, information boards, CCTV.*

Category 1 occurrences have increased by nearly 90% between 2008 and 2018, reaching a high of 4984 events in the 2017/18 reporting period.

Train signalling equipment (Category 1-g) is the most sought-after commodity by thieves and has a direct impact on safe rail operations. Together, cable theft and theft of rolling stock infrastructure components have been identified as root causes for collisions between rolling stock as well as derailments on running lines (RSR, 2018). It is also apparent from the data that the assets in section are more at risk than those in yards and depots.

### **3.4 CATEGORY 2 OCCURRENCES – MALICIOUS DAMAGE**

Data extracted from the suite of State of Safety Reports for Category 2 occurrences are presented in Table 11: Category 2 Malicious damage (vandalism) to property.

**Table 11: Category 2 Malicious damage (vandalism) to property**

Category	Category 2 Malicious damage (vandalism) to property										TOTALS
	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	
<i>a: rolling stock components - section</i>	64	358	526	248	276	341	336	421	373	692	<b>3635</b>
<i>b: rolling stock components - yard</i>	75	121	129	111	20	63	94	100	90	152	<b>955</b>
<i>c: civil infras - section</i>	160	138	184	194	145	146	131	125	82	148	<b>1453</b>
<i>d: civil infras - yard</i>	53	6	19	44	7	6	23	48	28	32	<b>266</b>
<i>e: overhead traction - section</i>	139	96	89	16	31	22	34	52	39	110	<b>628</b>
<i>f: overhead traction - yard</i>	0	0	6	41	2	1	2	3	2	3	<b>60</b>
<i>g: train control equip - section</i>	159	238	263	340	289	417	447	384	519	528	<b>3584</b>
<i>h: train control equip - yard</i>	1	7	20	89	8	5	3	1	1	17	<b>152</b>
<i>i: ancillary equip</i>	10	3	9	8	11	18	24	24	28	35	<b>170</b>
<b>TOTALS</b>	<b>661</b>	<b>967</b>	<b>1245</b>	<b>1091</b>	<b>789</b>	<b>1019</b>	<b>1094</b>	<b>1158</b>	<b>1162</b>	<b>1717</b>	<b>10903</b>

Source: (RSR, 2008-2018)

The sub-categories as taken from SANS 3000-1:2009 are as follows:

- 2-a *Malicious damage (vandalism) of rolling stock components in section*
- 2-b *Malicious damage (vandalism) of rolling stock components in yards and sidings (staged)*
- 2-c *Malicious damage (vandalism) of civil infrastructure components in section*
- 2-d *Malicious damage (vandalism) of civil infrastructure components in yards and sidings*
- 2-e *Malicious damage (vandalism) of overhead traction equipment in section*
- 2-f *Malicious damage (vandalism) of overhead traction equipment in yards and sidings*
- 2-g *Malicious damage (vandalism) of train control equipment (signalling) in section*
- 2-h *Malicious damage (vandalism) of train control equipment (signalling) in yards and sidings*
- 2-i *Malicious damage (vandalism) of ancillary equipment including public address systems, information boards, CCTV.*

Category 1 occurrences have increased by nearly 160% between 2008 and 2018, reaching a high of 1717 events in the 2017/18 reporting period. The most affected asset is Category 2-a, vandalism to rolling stock in section with 3635 events over the period. Category 1-g, train signalling equipment in section, is the second most vandalised asset (3584 events).

The theft of signalling equipment and the vandalising thereof may be related, as thieves may unsuccessfully attempt to steal cable and leave them damaged in the process. The 2012/13 report goes as far as suggesting that criminals purposely sabotage train signal cables to force trains to a halt, so the trains can be boarded between stations and the passengers robbed (RSR, 2013).

### 3.5 COUNTERMEASURES PROPOSED

Some of the suggested countermeasures in the State of Safety Reports to reduce the number of pedestrian fatalities and incidents of crime and theft on the rail network are listed below. See Table 12: Suggested countermeasures from the State of Safety Reports.

**Table 12: Suggested countermeasures from the State of Safety Reports**

<b>Countermeasure</b>	<b>Trespass</b>	<b>Crime</b>
Coordinate with key stakeholders to develop an integrated plan to reduce pedestrian fatalities and address the unique challenges faced by the rail operators	✓	✓
All key stakeholders to be consulted and approve any new rail side developments or settlements	✓	
TFR and PRASA to close the system (fencing)	✓	✓
TFR and PRASA to consult with Municipalities to provide street to street access (pedestrian bridges)	✓	
RSR to engage with SAPS / RRP to address suicide	✓	
Enhance education and awareness through partnership with key role players	✓	
Exercise enforcement mandate	✓	✓
Visible security and improved intelligence to deter and address vandalism and theft	✓	✓
Active partnerships with Community Policing Forum, Rapid Rail Police and other law enforcement agencies	✓	✓
Utilisation of technology to combat crime (e.g. drones)		✓
Improved Law Enforcement (punitive measures to be increased)	✓	✓
Early detection systems & target hardening		✓
Use a low theft/resale value material		✓
Participation in the Non-Ferrous Theft Combating Committee		✓

Source: (RSR, 2008-2018)

At first glance, the countermeasures suggested would seem rightly guided but no evidence on the effectiveness of any of the measures are evident, or the extent to which the measures have been implemented, or not.

Additionally, the RSR undertakes numerous education and awareness programmes at stations, level crossings, schools, community groups and sports tournaments with no evidence provided of its effectiveness.

### **3.6 IMPLICATIONS**

A review of the rail safety record for South Africa provides a very bleak outlook on the current state of affairs nationally. Although the nature of the problem seems to be understood, and several countermeasures identified, the number of safety and security occurrences show no sign of abating, which would indicate that existing strategies to combat trespass-related incidents are failing.

The State of Safety Reports presents an overview of the situation country-wide and does not provide a detailed account of the local situation specific to the operating regions.

This chapter, along with the literature review completed in Chapter 2, confirms that no recent research has been carried out on the subject of railway trespassing for the Western Cape Region in enough detail to be able to understand the problem fully.

# Chapter 4: Scientific Methodology

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This chapter describes the scientific methodology adopted in this study to achieve the aims and objectives stated in Section 1.3 of Chapter 1. Section 4.1 discusses the methodology and research design used in the study; Section 4.2 details the participants in the study; Section 4.3 lists all the instruments used in the study and justifies their use; Section 4.4 outlines the research procedure used; Section 4.5 discusses how the data was analysed; and finally, Section 4.6 discusses the ethical considerations of the research and its problems and limitations.

## 4.1 METHODOLOGY AND RESEARCH DESIGN

### 4.1.1 Research approach

For a long time, the two dominant research methods have been *Qualitative Research* and *Quantitative Research*.

Qualitative research, using data collection methods such as interviews, observation, and review of documents, provides insight into emerging processes and elicits the knowledge and experience of participants in providing detailed information about settings and contexts. Qualitative approaches may include case studies, grounded theory, ethnography, and phenomenology (Creswell et al., 2010).

Quantitative research involves the statistical analysis of numeric data to test hypothesis, specific research questions and theories. A problem will be defined in depth with as much information as possible and the relationships between measurable variables will be closely examined. Quantitative data provides evidence to enable inferences to be applied generally to a population. Some quantitative methods include descriptive surveys, observational studies, and controlled trials (Creswell et al., 2010).

A third methodology began emerging in the late 80s and early 90s known as *Mixed Method Research* (Clark, 2013). The mixed method approach can be defined as a methodology that (Creswell et al., 2010):

- i.) *“focuses on research questions that call for real-life contextual understandings, multi-level perspectives, and cultural influences;*

- ii.) *employs rigorous quantitative research assessing magnitude and frequency of constructs and rigorous qualitative research exploring the meaning and understanding of constructs;*
- iii.) *utilises multiple methods (e.g., intervention trials and in-depth interviews);*
- iv.) *intentionally integrates or combines methods to draw on the strengths of each; and*
- v.) *frames the investigation within philosophical and theoretical positions”.*

The research approach adopted for this study can be described as one that attempts to enhance current understanding of a particular problem in order to facilitate the development of effective, practical strategies. This can be theoretically categorised as a “pragmatic world view”, that seeks to use methods that “work” and incorporate as many different techniques as required when investigating a research problem (Creswell, 2012).

Table 13: Research approaches, adapted from Morgan (2007), suggests a framework for the various approaches to conducting research. While each approach has its own strengths and weaknesses, the pragmatic approach is more than just a bridge between the two primary perspectives of quantitative and qualitative research and may find itself moving back and forth between theories (Morgan, 2007) and appreciating both objective and subjective knowledge (Creswell et al., 2010).

The principal tenet of the mixed method approach is that the combination of qualitative and quantitative approaches can:

- provide a more complete understanding of a research topic (Creswell, 2014),
- obtain a greater validity and increased credibility of findings, and
- provide richer understanding of quantitative results and aid understanding of unexpected results (Clark, 2013).

**Table 13: Research approaches**

	<b>Qualitative Approach</b>	<b>Quantitative Approach</b>	<b>Pragmatic Approach</b>
<b>Connection of theory and data</b>	Induction – has a theory and seeks confirmation of the theory	Deduction – explores the consequences of a rule	Abduction – linking together of information
<b>Relationship to research process</b>	Subjectivity	Objectivity	Inter-subjectivity
<b>Inference from data</b>	Settings and Context	Generality	Transferability
<b>Methods</b>	Case studies, grounded theory, ethnography, and phenomenology	Descriptive surveys, observational studies, controlled trials, time-series designs	Combination of methods

Source: Adapted from (Morgan, 2007)

***Why mixed method for this research?***

The decision to use a mixed method approach for this particular research are twofold:

*The research problem*

The topic of railway trespassing and the specific nature of the various characteristics of the phenomena is complex. Trespassing manifests itself from non-malevolent pedestrian actions to organised crime targeting rail assets to illegal occupation by the homeless. The problem is not one-dimensional, so the solutions would equally require a multi-faceted approach.

Creswell (2012) proposes a mixed method approach when either of a qualitative or quantitative research methods is not enough to address the research problem and when more data is required to elaborate on the subject matter. For this

research, a quantitative analysis will be followed up with a smaller qualitative one to obtain more detailed, specific information to expand on the findings of the first set of data.

#### *The personal experiences of the researcher*

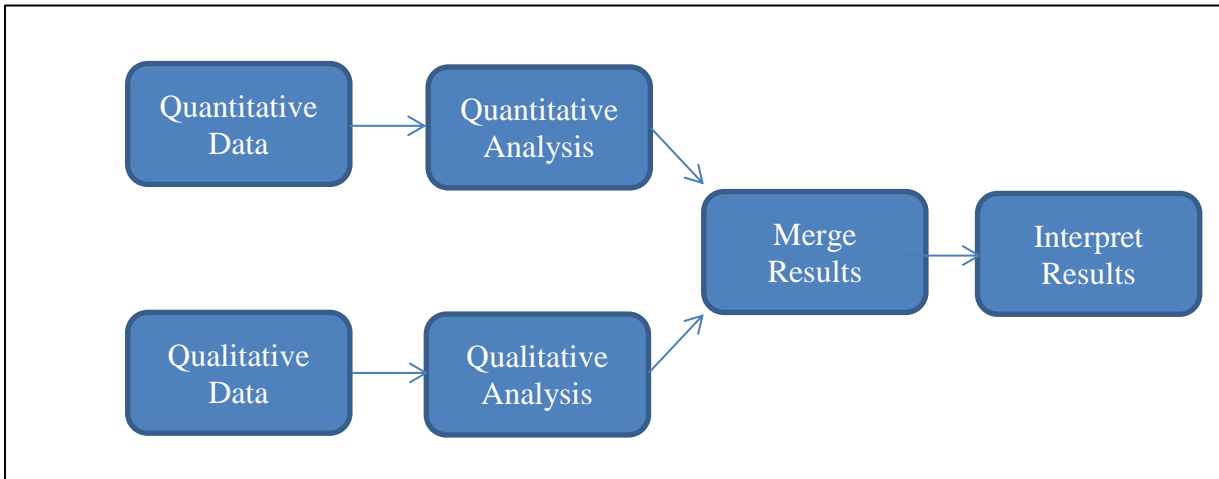
Some believe that to be able to use a mixed method methodology; the researcher must be competent in both quantitative and qualitative research methods to be able to determine the best path to take (Teddlie & Tashakkori, 2012). Since this researcher's own research experience is limited and he is a single researcher, he decided on a method that would not only suit the problem but also his training and experience. Having worked as a project manager at a nuclear power station and as a project engineer on an underground metro, I regularly had to solve engineering problems by following a process of defining the problem, gathering information, generating solutions, evaluating solutions and then determining the optimal solution. The solution would always have to be both cost-effective as well as implementable resulting in the least disruption to power or train operations. His belief is that an engineering approach to problem solving naturally tends to be "pragmatic", with a focus on developing solutions that work the best.

#### **4.1.2 Research design**

The logic of a mixed method design is based on whether the quantitative and qualitative elements are combined into one analysis or whether the quantitative follows the qualitative analysis, or vice versa. The three basic designs can be grouped as Concurrent Parallel, Sequential Explanatory and Sequential Exploratory designs.

##### *Concurrent (or convergent or parallel) designs*

A concurrent mixed method design [see Figure 10: Concurrent mixed method design, adapted from Clark, (2013)] is when the researcher simultaneously combines both quantitative and qualitative elements, thereby merging the data sets (Creswell et al., 2010). The main idea with this approach is that the quantitative and qualitative elements provide unique elements of information (Creswell, 2014) whereby the two sets of data together, offset each other's weaknesses to provide a better understanding of the research problem. Once merged, the datasets are compared and analysed, and the researcher can determine whether the results contradict or support each other (Creswell, 2012).

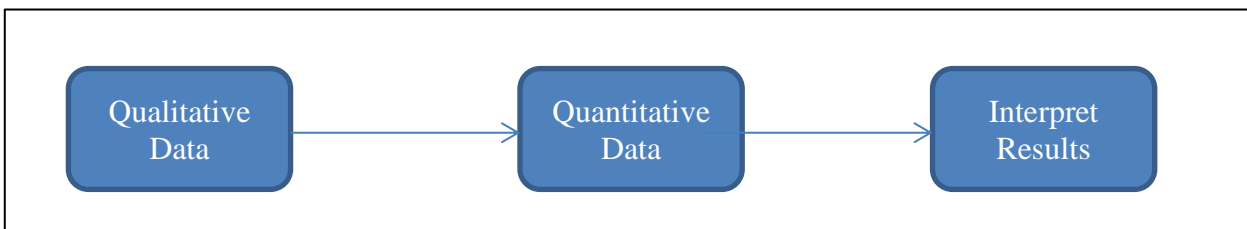


**Figure 10: Concurrent mixed method design**

***Sequential exploratory designs***

A sequential exploratory mixed method design starts with a qualitative phase followed by a quantitative phase (Creswell, 2012). See Figure 11: Sequential exploratory mixed method design.

The earlier qualitative phase is used to investigate a problem, using the findings to explain relationships in the second, quantitative phase. The second phase, therefore, builds on the first phase. Researchers often develop survey instruments from the qualitative phase which are then used to provide more detailed results in the second quantitative phase (Creswell, 2012). The researcher could use an approach involving a number of phases, with the first being exploratory, followed by an instrument development phase and finally, using the instrument to gather further data from a sample of a population (Creswell, 2014).



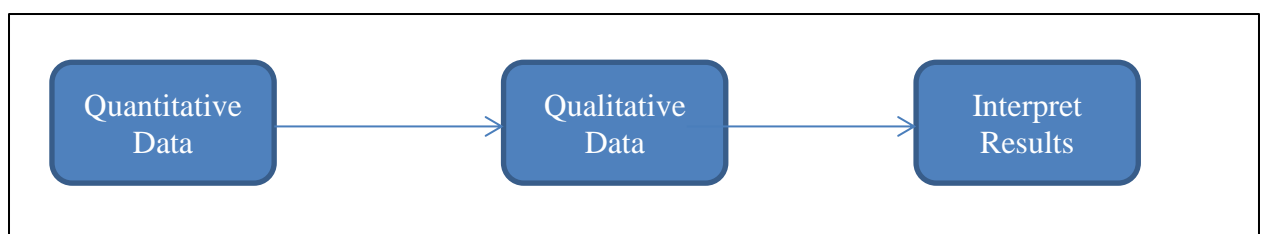
**Figure 11: Sequential exploratory mixed method design**

### *Sequential explanatory designs*

The third basic design, and the one used for this research is the sequential explanatory mixed method design. (See Figure 12: Sequential explanatory mixed method design). As opposed to the exploratory design, the qualitative phase is preceded by the quantitative phase. The quantitative phase provides the general context and background of the research problem, identifies relationships/differences/trends and guides the selection of participants for the second phase as well as the type of questions needed to provide more detail to the first phase (Creswell, 2014).

The sequential exploratory design places greater emphasis on the quantitative data (QUAN) analysis than on the qualitative data (qual) analysis. In a phased approach, the quantitative data is clearly identified and presented early in the work with the qualitative data providing further refinement by exploring a few typical cases, probing specific findings in more detail, or investigating anomalies (Creswell, 2012).

The challenges with this design are determining which elements of the quantitative results to elaborate on, i.e. significant or non-significant differences or outliers or extreme/typical cases (Clark, 2013). Only once the focus area is decided on, can the questions to ask in the follow-up phase be confirmed, in order to add more value to the first quantitative phase. Sequential exploratory designs can also be labour-intensive, with implications for informed consent approvals (Clark, 2013) and requiring more expertise and time to collect both quantitative and qualitative data (Creswell, 2012).



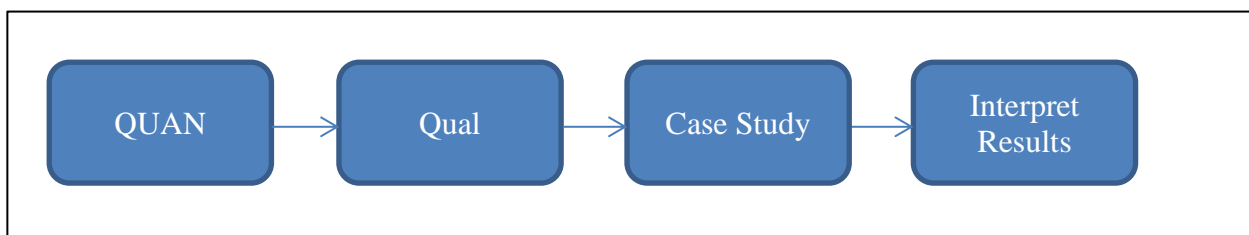
**Figure 12: Sequential explanatory mixed method design**

### ***The selected research design***

A sequential exploratory design was deemed suitable for this research because there exists a rich database of information that would form the major part of this work. The quantitative analysis element would, therefore, be the focus of the research.

To supplement the quantitative analysis, a smaller qualitative element will be incorporated to confirm the initial findings from the quantitative analysis as well as probe deeper into specific traits which cannot be fully explained with data.

Additionally, a case study looking into the effectiveness of a specific countermeasure was completed. The design of the research was thus as shown in Figure 13: Modified sequential explanatory mixed method design.



**Figure 13: Modified sequential explanatory mixed method design**

## **4.2 PARTICIPANTS**

The participants in this research are detailed in Table 14: Primary research participants.

Participants for the qualitative element of the research were chosen specifically for their knowledge and experience on the subject matter, who would best add to the current understanding on the subject.

**Table 14: Primary research participants**

<b>Participant Organisation</b>	<b>Basis for Selection</b>
<b>Metrorail / PRASA</b>	<p>Railway operational staff - knowledge of day-to-day issues on the network, its effect on rail operations and on rail staff</p> <p>Railway technical staff – knowledge of trespass countermeasures, countermeasure effectiveness, affected rail assets, costs</p> <p>Railway security personnel – knowledge of day-to-day- issues on the network, crime trends, hot-spots, countermeasures, countermeasure effectiveness</p> <p>Train performance data – train availability and reliability, delays and cancellations, fare box performance</p>
<b>Railway Safety Regulator</b>	<p>Rail safety and security occurrence data – central collector of all rail data for all rail operators in the Western Cape</p> <p>Rail safety inspectors – knowledge of safety and security issues and trends, education and awareness countermeasures</p>
<b>Forensic Pathology Services</b>	<p>Recorded deaths and mortality data – information on all official recorded deaths where the cause of death has been attributed to a railway occurrence, the only source of demographic data on railway fatalities</p>
<b>City of Cape Town</b>	<p>Metro security personnel - knowledge of day-to-day- issues on the network, crime trends, hot-spots, countermeasures, countermeasure effectiveness, neighborhood crime trends, metals theft unit, rail enforcement unit</p> <p>NMT specialists – research on pedestrian movements in the rail environment, engineering countermeasures, spatial planning issues</p>

## **4.3 INSTRUMENTS**

### **4.3.1 Quantitative analysis instruments**

Microsoft Excel was used for all the data analysis carried out.

Since “hot-spots” are commonly referred to for rail fatalities and security incidents, the question must be asked if the current analysis for determining hot-spot locations is accurate. As trespassing can be classified as a minor offence and one which may lead to other more serious crime on the rail network, it may be useful applying crime analysis techniques to the current situation; specifically, the spatial analysis of crime, to be able to better understand the nature of the crimes to be able to respond adequately. The rise in popularity in using hot-spot analysis in order to detect high-density crime areas is a technique used by crime analysts to visually display crime patterns by using a combination of database statistical technology and computerised mapping (Eck et al., 2005; Braga et al., 2012; Gill et al., 2015; Harries, 1999).

QGIS, an open-source GIS, was used to create, edit, visualise and analyse the geospatial information. A process was followed whereby the incident and occurrence data was geocoded and used to create maps with which to visualise the data, as “hot-spots”. The process followed, is explained in more detail later in the document, in Section 4.5.4.

### **4.3.2 Qualitative instruments**

#### ***Discussion guide and questionnaire***

Although the qualitative survey element was carried out encouraging free, and open-speech, a questionnaire was developed to ensure the salient issues were addressed and used as a prompt to initiate discussion. The instrument titled “Investigating Rail Trespassing Occurrences Discussion Guide and Questionnaire” was designed specifically for this research and is attached as Appendix A. The form contains both closed and open-ended questions so that information could be gathered that would support theoretical concepts in the literature and the earlier quantitative analysis phase. The open-ended questions allowed the responder to speak more freely about the prior issue providing an opportunity to expand on the earlier response.

For example, a closed-ended question was followed by an open-ended question:

*Is there a specific time of day in which trespassing is more prevalent? (Please tick as appropriate).*

*04h30 – 06h00*

*06h00 – 09h00*

*09h00 – 16h00*

*16h00 – 19h00*

*19h00 – 22h00*

*Do you wish to comment specifically about this?*

In this example, a closed-ended question was asked with a number of pre-determined responses. This was followed up with an open-ended question in which the respondent could elaborate on his earlier response.

The form was consulted on with rail staff to confirm the validity of the questions and thereafter, updated to improve the content before conducting the formal interviews.

### **4.3.3 Case study**

An evaluation of the effectiveness of a specific countermeasure was carried out as a case study. The evaluation criteria for the case study were taken from RESTRAIL, which has adopted the criteria based on previous rail research in the European Union (Ryan & Kallberg, 2013). The evaluation criteria provide a proven, practical structure for the collection of evidence about the effectiveness and use of the countermeasure.

A three-step scoring system can be used to rate the various criteria with values 2, 1 and 0 used, with 2 being the best and 0, the worst. The criterion can also be weighted to reflect its relative importance with reference to the characteristics of the specific site (Kallberg et al., 2012).

The researcher has chosen to omit the scoring element for this case study as only one countermeasure will be evaluated.

Some of the evaluation criteria, taken from RESTRAIL include:

- *Description of the measure*
- *Definition of target incidents*
- *Size of the problem*
- *Effect on incidents*
- *Additional information*

The instrument capturing these criteria has been adapted from the RESTRAIL version and named the “Trespass Countermeasure Evaluation Form”. (See Appendix C). The form was used as a guide to collect the best information available to carry out the evaluation.

#### **4.3.4 Site visits**

The Site Inspection Protocol can be found in Appendix B. The form was developed to standardise the recording of field observations.

The form includes some of the following headings: date, time, location, weather, describe nature of problem, describe surrounding area, define area and it includes a count of the frequency of trespassing per 15-minute interval.

## **4.4 RESEARCH PROCEDURE**

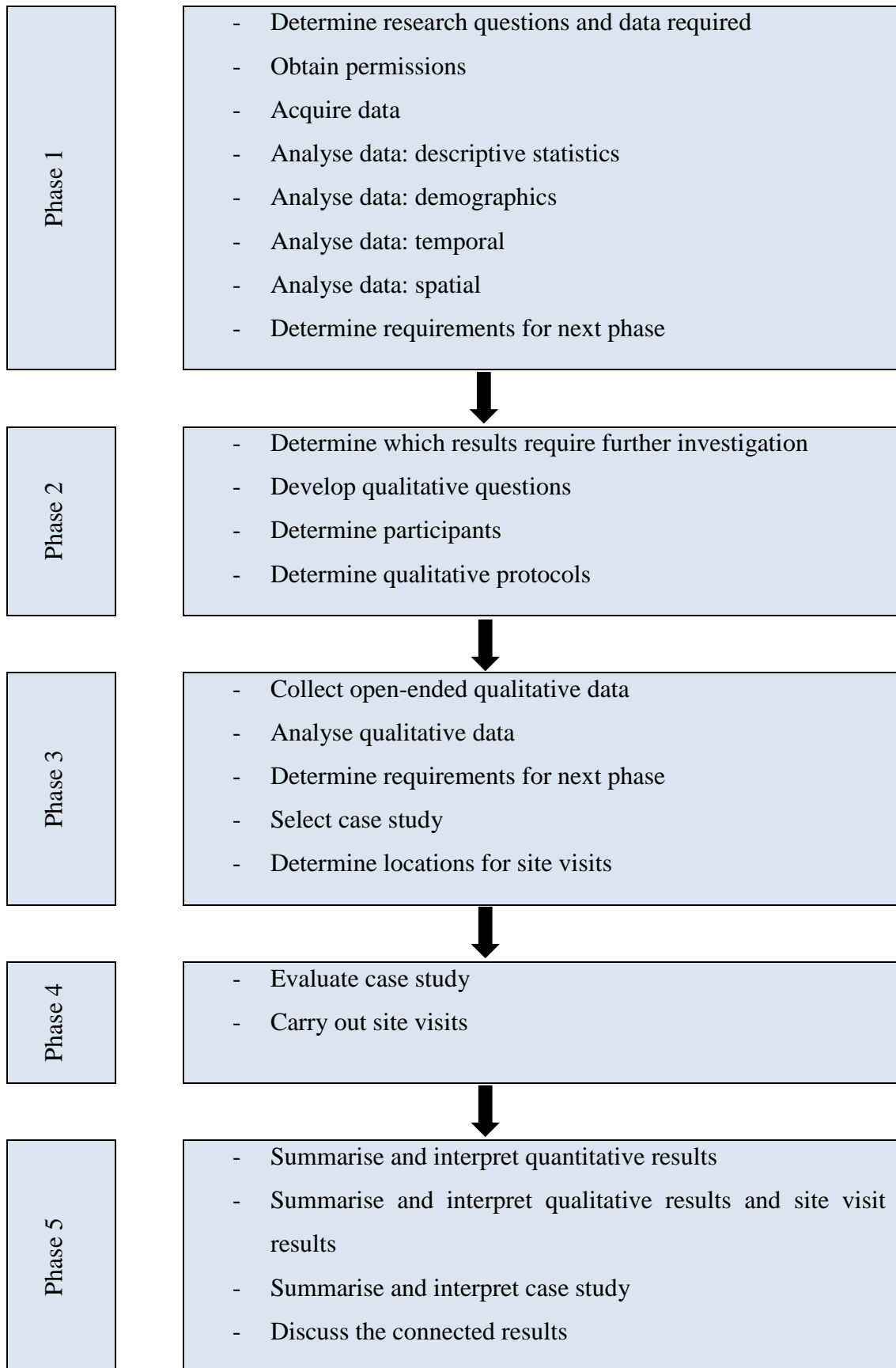
### **4.4.1 Research framework**

In order to structure the research, the following framework was used: See Table 15: Research framework.

The study can be broken down into five main phases:

- Phase 1 contains the main, quantitative element;
- Phase 2 lists the preparation elements for the following phase;
- Phase 3 contains the qualitative element of the work;
- Phase 4 continues with the selection of the case study, as well as the site visits; and
- Phase 5 interprets the results of all the subsequent phases.

**Table 15: Research framework**



#### 4.4.2 Research questions

The research questions (Q) and hypotheses (H) have been listed in Section 1.4.

#### 4.4.3 Variables

The variables in this research study were as follows:

**Table 16: Research variables**

<b>Dataset</b>	<b>Variables</b>
<b>FPS dataset</b>	Fatalities, year, month, day, time, suicides, age, race, gender
<b>RSR dataset</b>	Operator, year, month, day, time, place, occurrence category, fatalities, injuries
<b>Metrorail dataset</b>	Year, month, trains scheduled, trains cancelled, trains delayed

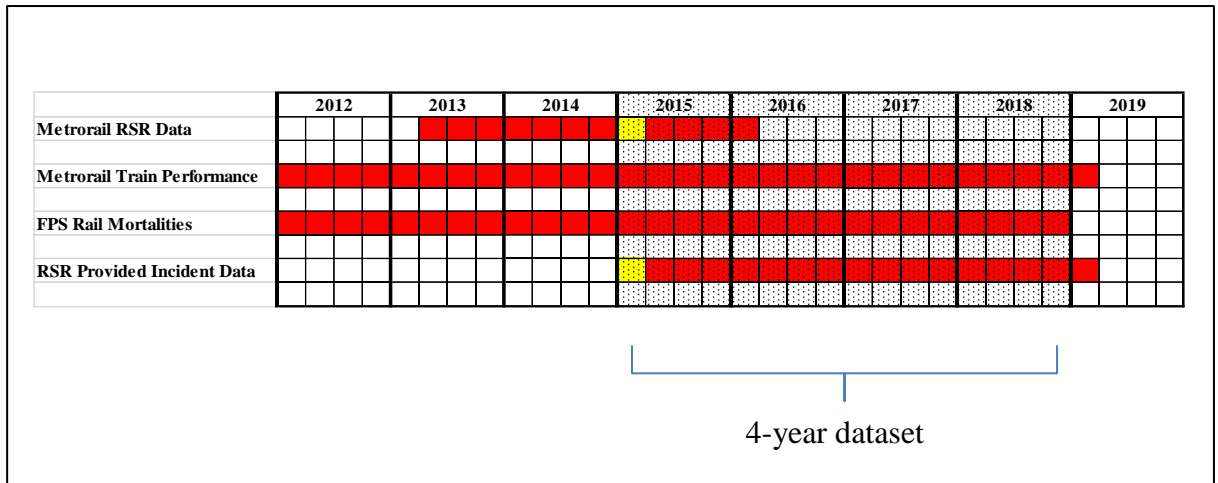
#### 4.4.4 Permissions and data acquisitions

Requests were made to Western Cape Department of Health for access to the Forensic Pathology Services data. A Data-user Agreement is required for anyone wishing to access health-related data from Western Cape Department of Health. Data for all rail-related casualties for the Western Cape were received for the period 2012 till 2018 for the full calendar years.

The second request for access to the data held by the Railway Safety regulator was made via the General Manager for Media and Communications. Incident and occurrence data were received for the financial year period of 2015/16 till 2018/19.

Permission to carry out research within Metrorail/Prasa was granted by the Acting Senior Manager for Human Resources for Prasa Western Cape. Metrorail train performance data was received for the financial year period 2009/10 till 2018/19.

On review of the various overlapping datasets, a combined database was established using the RSR and Metrorail data for safety incidents and security occurrences to provide a dataset covering four full calendar years including 2015 - 2018. (See Figure 14: Dataset timespans). The data for this four-year period was used for all the railway safety incident and security occurrence analysis.



**Figure 14: Dataset timespans**

The FPS data, as well as the Metrorail train performance data were used for the full calendar years including 2014 - 2018. These datasets could not be combined with the incident and occurrence data but was used to specifically compliment the analysis over the period 2015-2018.

## 4.5 ANALYSIS

### 4.5.1 Data description, cleaning and formatting

The cleaning of data involved formatting and editing the data to ensure uniformity across all inputs. Data presented on separate tabs were combined into one spreadsheet. This would be required for the later, spatial analysis where the Excel spreadsheet would need to be converted to a CVS file in order to use the database in QGIS. Additional columns were added to calculate the actual day and month from the officially recorded “day” of the incident.

The final FPS database was compiled in one tab in an Excel spreadsheet and included the years 2012 till 2018. The database was compiled with the following variables: forensic lab, police station, date, month, day, time, race, sex, age, official code description, official code category, suburb and scene of injury. The blood alcohol levels of victims were only available for one year and was therefore excluded from the analysis.

Although the FPS database contains location information related to the forensic laboratory the body was taken to, the police station where the death was reported as well as the town, suburb and scene and street of injury. On review of the level of detail, one could not relate the fatalities specifically to a location with even a

minimum amount of accuracy. The FPS dataset was, therefore, used only for a demographic analysis, which would provide important insights which the RSR dataset lacked, i.e. the RSR dataset does not contain information on gender, age or race. Detailed location analysis was not carried out on the FPS dataset.

The RSR dataset was similarly combined into one Excel spreadsheet in a single tab. The RSR data was originally presented in financial years, where a new financial year would start on 1 April and end on 31 March of the following year. The data was combined and analysed as a January to December calendar year for the years 2015 till 2018.

The RSR data contained a number of “unknown” entries without a SANS category. Each “unknown” entry was reviewed and where the incident had an adequate description that could be related to a trespassing event, that incident was placed into a logical category.

An example of this would be where the description read: *“The body of a male person was found with stab wounds next to the railway line. The body of the deceased person was taken to Tygerberg Morgue.”* Although this person could be classified as a trespasser, the death could not be attributed to a train incident. This would, therefore, remain as an unclassified SANS category and would be analysed as such. Where the description of an incident read: *“Body parts were found next to the railway line. No identification could be made on scene and the body parts were taken to Paarl Morgue”*, this incident was classified as a Category E-a fatality.

With regards to the RSR data, the following steps were followed:

All Category E-a incidents and Category 1 and 2 occurrences were combined into one spreadsheet for the years 2015 – 2018. The “place of occurrence “location data was then reviewed, and the following process followed: -

- Spelling mistakes were corrected, and the full station name was inserted.
- Places that referred to “staging yard”, “yard”, “terminals”, “substation” locations were assigned to the nearest main station in order to simplify the geocoding step.

- Incidents and occurrences are not geocoded as part of the incident recording / reporting process by any of the rail operators. It is therefore not possible to know the exact location of incidents unless the occurrence description provided more detail. It was not possible to manually geocode the locations as part of this study due to time constraints. Where the location is described as a point between two stations, an approximate mid-point location was manually selected.
- The Excel file was saved as a CSV file (UTF-8).
- The latitude and longitude of all occurrences were added manually to the CSV sheet. The addresses for the station locations were taken from Google Maps and a sample cross-checked for correctness on Nominatim, which is the search engine for OpenStreetMap data.
- Once all the locations were manually geocoded, they were loaded into QGIS by adding the CSV file as a delimited text layer.
- Any errors made whilst inputting the X and Y coordinates were then highlighted and fixed in the source CSV file.

Both the FPS and RSR databases were now ready for the next step in the analysis process.

#### **4.5.2 FPS data analysis**

A demographic analysis was carried out on the FPS dataset which contained information on the gender, race and age of all rail related deaths. The analysis includes rail-related deaths officially classified as suicides.

Descriptive statistics on the demographic variables describing the mean, standard deviation, frequency and percent as appropriate have been completed. The descriptive statistics are supported by a number of graphic representations including bar charts, pie charts, and histograms in order to adequately describe the data. Analysis of the data was made for recorded deaths due to railway injury, as well as suicides by gender (male or female), race (black, Coloured, white), and age (0-11yrs, 12-19yrs, 20-59yrs, 60yrs+).

### *Statistical hypothesis testing*

Human judgement or a researcher's "previous experience" cannot be solely relied on to make scientific decisions. Statistical significance tests are thus employed to conclude that something has or hasn't achieved "statistical significance". A "statistically significant difference" simply means there is statistical evidence that there is a difference; it does not present absolute, conclusive proof that a relationship exists, but rather provides one piece of evidence in support of the research hypothesis.

The null hypothesis ( $H_0$ ) is thus a claim about a population trait that is treated as valid unless the evidence strongly suggests that  $H_0$  is false, in favour of the competing claim, the alternative hypothesis (Peck, et al., 2016). Statistical tests, test the null hypothesis only. The null hypothesis test takes the form of: "There is no difference among the groups" for difference tests and "There is no association" for correlation tests. A statistical hypothesis test can only determine if there is strong support for the alternative hypothesis (by rejection of the null hypothesis). When the null hypothesis is not rejected, it does not mean strong support for  $H_0$ —only lack of strong evidence against it.

#### *General Steps taken*

- i. The statement of the research null alternative hypotheses to be tested is made.
- ii. The significance level ( $\alpha$  - alpha) of 5%, corresponding to a value of 0.05 is used. This empirically corresponds to a confidence level of 95%.
- iii. Excel was used to perform all statistical and mathematical calculations to compute the relevant test statistics (S) and obtain the relevant "P value".
- iv. Decision made to either "reject" or "not reject" the null hypothesis in favour of the alternative hypothesis. The decision rule is to reject the null hypothesis ( $H_0$ ) if  $P \leq \alpha$ . If the  $P >$  than 0.05, the null hypothesis is not rejected.
- v. If the null hypothesis was rejected, further post hoc tests were carried out to determine which groups of data differed.

### *Statistical tests employed*

- T-tests: Used to test the differences between two group means for the same variables. These tests were used in the case study evaluation.
- ANOVA: Used to test differences between three or more groups to determine if the means are statistically different from each other. The results of all ANOVA calculations in Excel are shown in ANOVA tables.
- Correlation: The Covariance and Coefficient of Correlation was used to measure the strength and direction of possible linear relationships between two numerical variables. A correlation is an indication of whether the variables increase together in a perfect positive correlation or go in opposite directions in a perfect negative correlation or in fact if there is no correlation at all (Levine, et al., 2010). The coefficient of correlation ( $r$ ) is a value between -1, 0 and 1. As the value gets closer to -1 and 1, the linear relationship between the two variables will be a strong one. Values close to 0 are an indication of no or little linear relationship. A weak correlation doesn't necessarily indicate that a linear relationship does not exist, but rather that some other type of non-linear relationship may be in effect (Rumsey, 2011).
- Scatterplots: Scatterplots was used to graphically display the strength of the correlation, between the two variables is. The closer the data points fall along a straight line, the higher the correlation.
- Standardisation: Z Scores were calculated in some instances in order to facilitate comparisons when the null hypothesis was rejected. Z scores indicate how many standard deviations a value is above or below the mean.
- Tukey: If the ANOVA determined that there was a significant F-statistic, Tukey was used to calculate the confidence intervals for the difference for each pairwise comparisons, i.e. which specific groups differed. Tukey controls the confidence level at approximately 95% when the procedure is computed on multiple data sets (Peck, et al., 2016).

### **4.5.3 RSR data analysis**

Descriptive statistics on the RSR dataset was carried out where relevant to adequately describe the data. Variables describing the mean, standard deviation, frequency and percent as appropriate were completed. The descriptive statistics were supported by a number of graphic representations including bar charts, pie charts, stem-and-leaf displays, and histograms in order to further describe the data.

A temporal analysis was also completed for the RSR dataset. Only the SANS Categories relevant to this research were analysed in detail. These were Category E-a (Occurrence where a member of the public is struck by rolling stock on a running line), Category 1 (Theft of assets impacting on operational safety) and Category 2 (Malicious damage/vandalism to property) occurrences. Data was analysed over a four-year period including years 2015 to 2018. Data were analysed by year (2015-2018), month (January-December), day of the week (Monday – Sunday), and time of day (in 2hr slots).

Detailed analyses were made of Category E-a sub-categories for fatalities and injuries as well as Category 1 sub-categories a-i and Category 2 sub-categories a-i.

The RSR data was also analysed in relation to train operational performance data.

### **4.5.4 Spatial analysis**

The following section details the approach taken in the spatial analysis of incidents and occurrences used in this research applicable to the following research questions: RSR Q5, Q6, Q7 and Q8.

As established in the earlier literature review section of this document, trespassing could be considered as a criminal act, even in its most innocent guise as a “short-cut”. Trespassing could also be the lesser of a more sinister criminal intent when it comes to theft and vandalism damage to rail property.

Incidents of fatalities, theft and vandalism occur in both space and time. Spatial analysis is the science of investigating the geographic aspects of events, through analytic mapping of the geographic database (Rayment, 1995). Temporal analysis recognises that the spatial footprints of incidents are clustered together during short time periods (Levine, 2013) and examines the time components of variables, such as year, month, day and hour. With regards to the RSR dataset, incidents of theft and

vandalism are mainly crimes against property, the exact times are therefore not definite.

The appeal of hot-spot crime strategies and their effectiveness has been explained earlier in this document. An effective hot-spot strategy will allow railway operators and police to focus limited resources on a small number of high-crime locations (Braga et al., 2012). Developments in GIS capability continue to improve and provide numerous options to analysts for carrying out a hot-spot spatial analysis. However, which spatial analysis tools are most useful for identifying hot-spots?

The most common form of crime mapping using a GIS is the act of assigning points to a map, called “point mapping” (Eck et al., 2005). Using built-in GIS capabilities, this task is made easy by using graduated symbols and colour gradient dots (Rayment, 1995). Eck et al. (2005) list point mapping, spatial ellipses using hierarchical and K-means clustering, thematic area mapping, quadrant mapping, interpolation and continuous smoothing as recognised methods of crime mapping. Rayment (1995) applies a method of contour mapping to carry out a spatial-temporal analysis of crime in Boston.

Harries (1999) identified five common methods of hot-spot analysis including visual interpretation, choropleth mapping, grid cell analysis, cluster analysis and spatial autocorrelation.

Newton (2004) goes further and discusses the complexities around examining crime hot-spots on public transport networks. Newton states that traditional crime analysis focuses on ‘static’ crime events and argues that for the purposes of crime analyses, the differences between static and non-static crimes are arbitrary, and therefore it is possible to capture non-static crimes as static. Essentially then, a static crime occurs at a specific point, whilst a non-static crime occurs between two points and between a set of times and could be depicted as a ‘line’ representing a specific event (Newton, 2004).

Tompson et al. (2008) developed the “Hot Route” method specifically to visualise crime patterns occurring in a linear pattern. Tompson et al. (2008) states that the main limitation of other hot-spot techniques is that it cannot provide a localised street level view to pin-point the exact location of the crime. The Hot Route

method calculates the rate of crime per linear metre of a network route and presents a thematically shaded map of risk distribution along the network.

A number of specific crime analysis tools have been developed to assist in detecting whether meaningful patterns and clusters exist. One such is SANET (Spatial Analysis on a NETWORK), which was specifically developed to analyse events on a network. SANET provides a GIS toolbox to perform network spatial analysis with the aim of avoiding false interpretations of hot-spots which may be produced by traditional planar spatial analysis. A detailed explanation of the capabilities of SANET is beyond the scope of this dissertation, but some of the tools available include the production of Voronoi diagrams, Delaunay diagrams, Kernel density estimation, Interpolation, Point clustering method, Random points generator, and Shortest-path distances between points in a point set (Okabe, 2006).

CrimeStat is another spatial analysis tool developed to analyse crime incident location data. A stand-alone Windows program, CrimeStat provides analysts with spatial statistical procedures that can be linked to a GIS. It is especially useful for the analysis of point pattern data and provides various levels of analysis to cater for simple distributions of spatial data to more complex tools to develop temporal-spatial theories (Levine, 2013). CrimeStat's statistical methods include: i) *hierarchical clustering* - based on the nearest neighbour analysis technique; this method groups incidents into first-order clusters and then creates second order clusters, grouping the closest first order clusters, continuing in this manner till all clustering possibilities are exhausted. ii) *K-means clustering* – groups crime incidents into a defined number of clusters as specified by the user. The analysis seeks out the best centre location for each cluster and then groups each crime incident to the centre location points (Levine et al., 2010).

GeoDa is an open source and cross-platform tool that analysis geospatial data and like CrimeStat, provides a functionality allowing for simple description and visualisation of data to more complex exploration and modelling (Anselin, 2016). GeoDa uses either point coordinate data to carry out spatial data analysis but is especially suited to analysis of area data patterns. GeoDa's functionality includes mapping and geovisualisation, exploratory data analysis, spatial autocorrelation analysis, space-time analysis and spatial regression analysis (Anselin, 2016).

## *The adopted spatial analysis methodology*

The approach used as a methodology for this research is explained next.

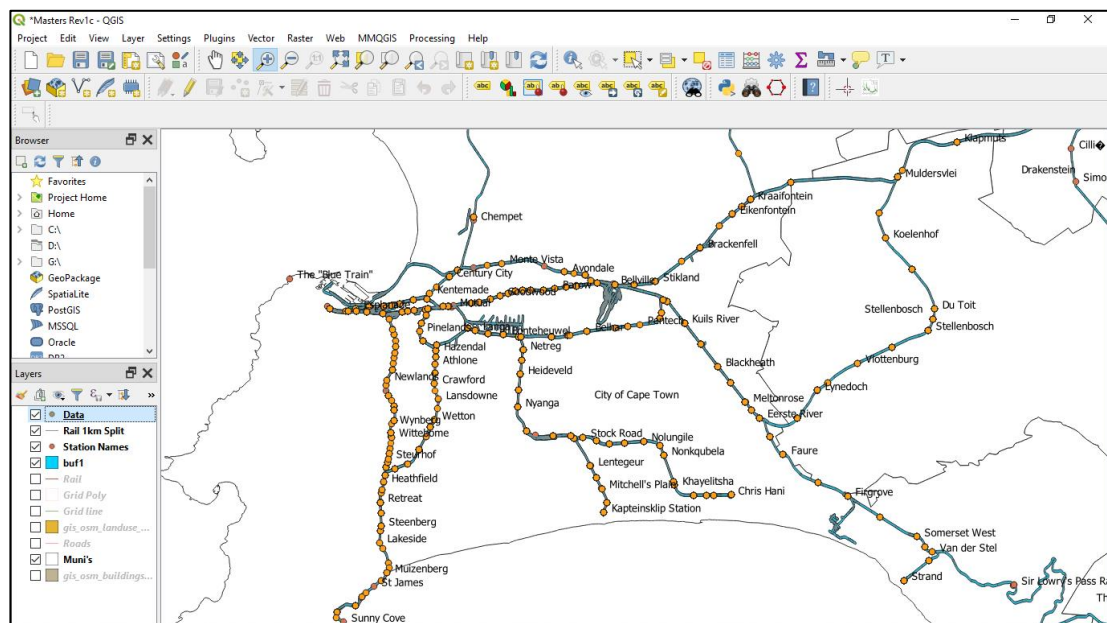
### Stage 1

The RSR data in Excel format was used to analyse whether the Iron Law of Troublesome Places or more practically known as the 80-20 Rule applies. This rule suggests that majority of crime will take place in only a few places (Wilcox & Eck, 2011; Clarke & Eck, 2005).

### Stage 2

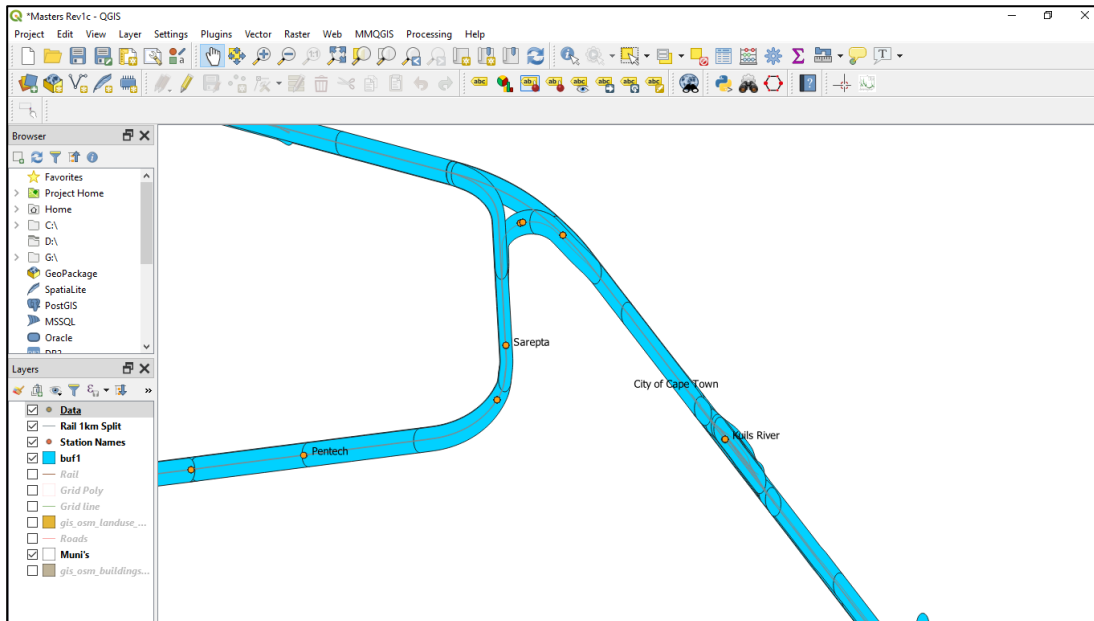
The next stage of the analysis involved using a GIS to visually analyse the data. The main steps followed will be explained next.

- The RSR Excel sheet was saved as a Comma Separated Values (CSV) file and loaded into QGIS as a Delimited Text Layer. This projected all the data as points on the QGIS canvas.
- The rail network shape file was sourced from Geofabrik (Geofabrik, 2019). Other shape files were sourced from UCT - City of Cape Town databases and Western Cape Government databases for the rail station names, roads and municipal boundaries shape files. These were all added as separate layers to QGIS. (See Screenshot 1).



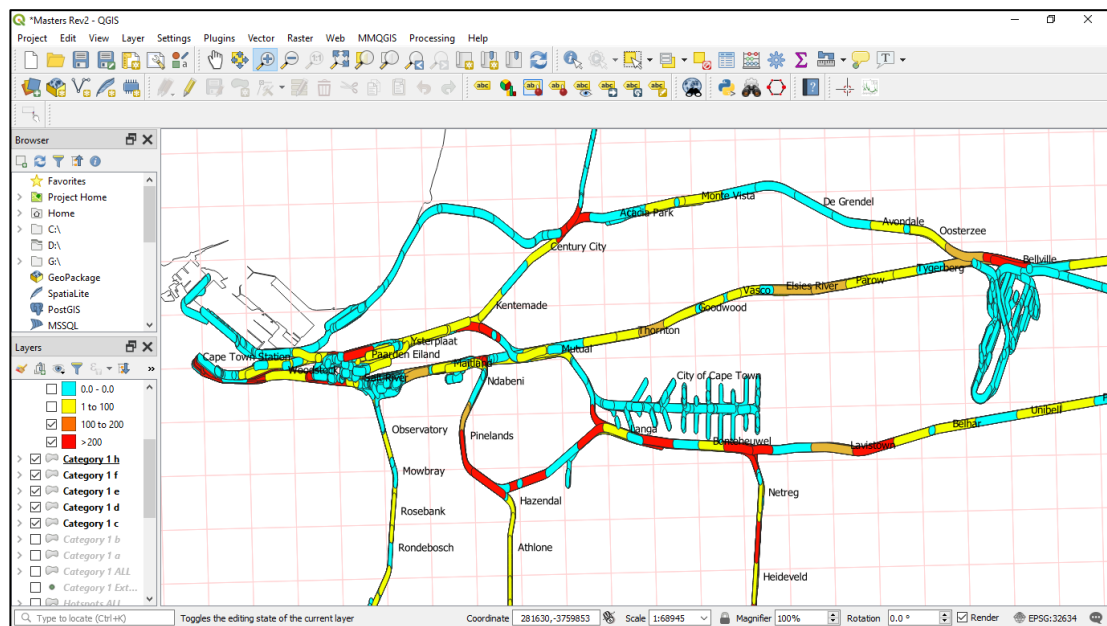
**Screenshot 1**

- The rail network was then portioned into 1km sections using the Grass plugin's **v.split** function and the length of each section was then added to the attribute table.
- A buffer was created around the now split rail section using the MMQGIS (Minn, 2019) plugin and the function **Create Buffers**. (See Screenshot 2).



**Screenshot 2**

- A choropleth map was created for each occurrence category using a weighting to prioritise the individual sub-categories. This allowed the point density in each buffered 1km section of railway to be calculated with the added weighting and coloured according to the number of occurrences in each section. This produced a network hot-spot map for each occurrence category which could be overlaid on to each other. (See Screenshot 3).



**Screenshot 3**

#### 4.5.5 Qualitative analysis

The qualitative part of this research comprised of three phases: an interview phase, a case study analysis and a site inspection phase. The core characteristics that define a qualitative research study were met as follows:

- Data was collected up-front and with face-to-face direct interaction in the respondents own natural setting.
- The interviews, case study and site visits were conducted by this researcher. Survey protocols for the interviews were developed by the researcher and utilised as a guide but not solely relied on.
- Multiple sources of data were used.
- An emergent approach was used, where the primary quantitative analysis, as well as the interview phase were used to select the case study example and site visits.

##### *Expert interviews*

A select number of interviews were completed with individuals chosen for their specific, expert knowledge on the subject matter, from their respective viewpoints. All interviews were conducted per individual apart from the railway

safety inspectors which consisted of a three person focus group. The interview record can be found in Appendix E.

Unstructured and semi-structured interviews were conducted and only one of the interviews was recorded. Transcribing the audio from the one interview was very time-consuming and, due to time constraints, the researcher decided against this approach. Interviews were captured by taking interview notes and consolidating the information afterwards.

A thematic content analysis was carried out on the interview information. The interviews were re-read, reviewed and divided into themes. The most useful information was selected and written on including quotes from the interviewees.

The final step was selecting several sites for validating the information discovered during the interviews.

### ***Case study analysis***

The research question relating to the case study is CASE Q9.

The case study was selected based on the following:

- The researcher's own personal experience and involvement in the project.
- The availability of data and information to quantitatively and qualitatively assess the effectiveness of the countermeasure.
- Feedback from interviews.

The protocol adapted from RESTRAIL and named the "Trespass Countermeasure Evaluation Form" was completed by the researcher with information gathered from the interviews, occurrence data analysis, review of project reports, as well as the researchers own personal experience of being involved on the project as well as a similar project in the past.

The quantitative element of the case study evaluated the impact on safety and security occurrences data over a 6-month period. The hypothesis, CASE H<sub>0</sub>16 and H<sub>0</sub>17 were tested using the statistical evaluation techniques described earlier in this document.

### ***Site visit observations***

Based on the feedback from interviews the following sites were selected for further investigation and validation of some of the information gathered during the interviews. (See Table 17: Site visit locations). Site visits were carried out during daylight operational hours and during weekdays. Due to the risky nature of some of the locations, the researcher enlisted the help of two colleagues to accompany me on the site visits. One person always remained in the vehicle and the other assisted in note and photograph taking.

**Table 17: Site visit locations**

<b>Sites visited</b>	
Elsies River Station	Line section between Nyanga and Philippi Stations
Line section between Parow and Elsie's River Station	Line section between Strand and Van der Stel Stations
Line section between Parow and Tygerburg Station	Line section between Du Toit and Koelenhof Stations
Parow Station	Line section between Heideveld and Netreg Stations
Mbekweni Station	Bonteheuwel Station
Line section between Mbekweni and Dal Josafat Stations	Kraaifontein Station
Klapmuts Station (north side)	Klapmuts Station (south side)

Field notes were captured on the site visit protocol developed for this purpose. (See Appendix B).

The field notes were reviewed and catalogued in an Excel spreadsheet. The main themes from the site visits are discussed in Section 7.2. Photographs were taken at all locations visited, and the full list of field notes and photographs are catalogued in Appendix F.

## **4.6 ETHICAL FRAMEWORK**

Ethics clearance for this study was granted by the UCT, Faculty of Engineering and the Built Environment Ethics Committee. (See Appendix G).

The ethical framework for this research is discussed under the following headings: a) data collection, b) data processing, and c) data storage.

### **4.6.1 Data collection**

The following general principles have applied throughout this research:

- No private identification or personal sensitive data is used or was required for this research.
- Some personal data was used such as gender and age, but no identifiable information has been included.
- No sensitive personal data, such as names, has been required or used, and will not be published as part of this research.
- Data on racial or ethnic origin has not been used or included.
- The research contains no sensitive personal data on:  
political opinion, religious beliefs, physical health, mental health, sexual orientation, or any criminal records.
- Interviews were performed on a voluntary basis, with the respondents fully briefed on the purpose and nature of the research. Interviews were conducted with personnel who are considered to have expert knowledge on the subject matter and no personal sensitive data is concerned.
- Certain photographs taken on site needed to incorporate persons in the act of trespassing to demonstrate evidence of a certain behaviour. The identity of the individuals in the photographs was obscured where their facial features were clearly identifiable.

#### **4.6.2 Data processing**

The data used in this research has been:

- Fairly processed
- Only processed for the intended purpose of this research and once the required data base has been formed, all private identification data was discarded
- Only processed in a manner that is relevant and shall not reveal anything about individual persons
- Verified for accuracy.

#### **4.6.3 Data storage**

The data shall:

- Not be kept for longer than is required.
- Not be shared or transferred to any other party or with any other researchers.
- At a minimum the database must have user-level security, may not be housed on laptops or external media unless these are encrypted.

### **4.7 PROBLEMS ENCOUNTERED IN METHODOLOGY**

#### *Surveys and interviews*

The trespassing questionnaire was originally designed to be distributed by hand or e-mail or completed on-line via Google Forms but due to a very low response rate from respondents, this was abandoned. Instead, one-on-one interviews were conducted with purposefully selected subject matter experts and hard copies of the form completed during the interview. The interviews were recorded by means of written notes.

#### *Forensic Pathology Services data*

A number of studies point to the role of alcohol in pedestrian-rail casualties. The alcohol blood level for fatalities and recorded deaths were requested as part of the mortuary dataset but the request was not approved for the following reasons:

- i.) Many the records were considered as *sub judice* and the potential leakage of such information may negatively impact the outcome of any judicial review

of the case. It was believed that the identity of the deceased could be obtained indirectly through linkages with other information sources.

ii.) The presence of alcohol in the decedent's blood does not necessarily indicate that it was the cause of the incident. As such it was believed that the provision of these results may lead to an incorrect inference as to the potential role that alcohol may or may not have had leading up to the cause of death.

iii.) Not all fatalities were analysed for the presence of alcohol; and if an analysis was requested not all results have been received. An incomplete record, therefore, exists.

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# Chapter 5: Data Analysis & Results

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This chapter contains a full discussion, interpretation and evaluation of the results of the quantitative analysis carried out and describes the results from the research to answer the questions (Q1-Q8) and hypothesis (H<sub>01</sub>-H<sub>015</sub>) listed in Chapter 1. The relevant research hypotheses applicable to the main chapter section are listed as sub-headings. Section 5.1 provides an analysis of the demographic data, Section 5.2 and 5.3 discusses the temporal analysis of occurrences and Section 5.4 discusses the effect of theft and vandalism on train operations. Sections 5.5, 5.6, 5.7 and 5.8 details the spatial analysis. Finally, Section 5.9 summarises the chapter.

## **5.1 THE DEMOGRAPHIC CHARACTERISTICS OF RAIL RELATED FATALITIES**

Answering research question FPS Q1.

The FPS data was analysed as it was the only source of data providing consistent, demographic information on victims, where the primary cause of death was attributed to railway injury. The FPS data is also the only official classification of intentional deaths by railway injury, i.e. suicides, as well the only classification by race. The race of the victims is deemed relevant as they could assist in ensuring that communication or education countermeasures are rightly pitched. The importance of analysing the racial demographics was corroborated by the expert interviews carried out.

### **5.1.1 By gender**

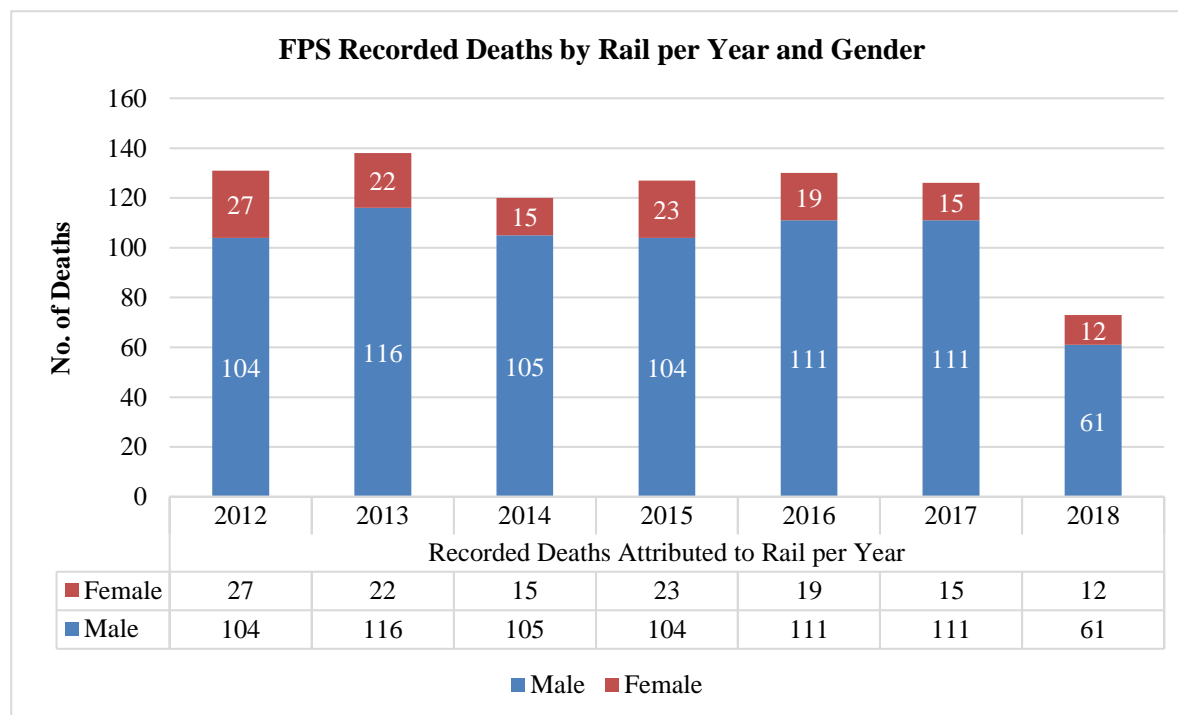
The number of deaths attributed to railway injury as the main cause of death is shown in Table 18: Recorded deaths attributed to rail per year by gender, and graphically in Figure 15: FPS recorded deaths by rail per year and gender. The maximum number of fatalities was recorded in 2013 (n=138) and the lowest in 2018 (n=73). The total number of fatalities over the seven-year period is 845, at an average of 121 fatalities per annum. (See Table 19: Descriptive statistics). The standard deviation is large at 21.74 and this can be attributed to the low number of fatalities recorded for 2018. The total annual number of fatalities are constant over the period apart from only 73 (n=73) deaths in 2018.

**Table 18: Recorded deaths attributed to rail per year by gender**

Recorded Deaths Attributed to Rail per Year by Gender								
Gender	2012	2013	2014	2015	2016	2017	2018	Grand Total
Male	104	116	105	104	111	111	61	712
Female	27	22	15	23	19	15	12	133
Grand Total	131	138	120	127	130	126	73	845

**Table 19: Descriptive statistics**

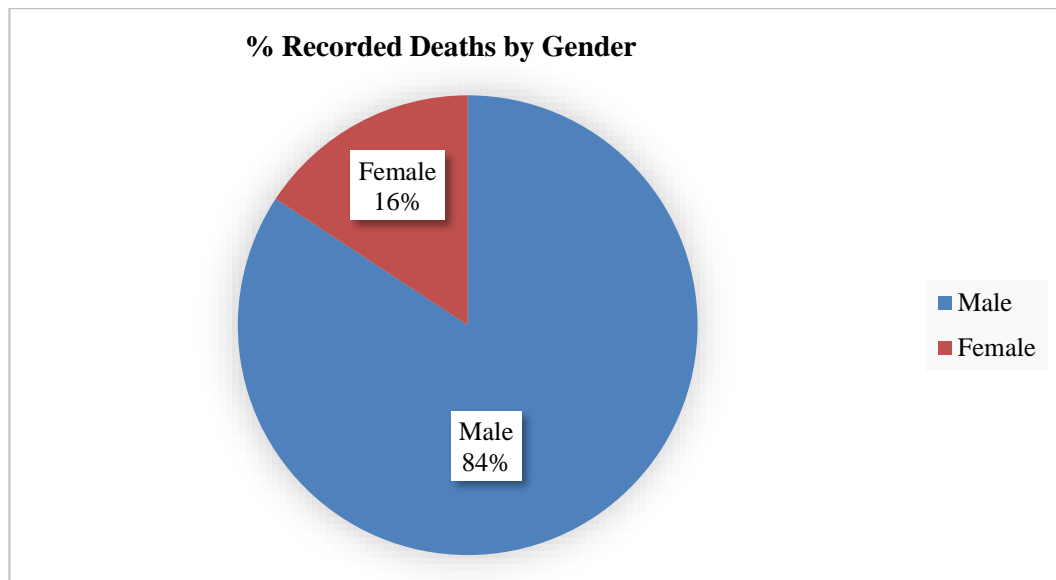
Statistic	Value
Mean	120.7142857
Standard Error	8.21645934
Median	127
Standard Deviation	21.73870807
Range	65
Minimum	73
Maximum	138
Sum	845
Count	7



**Figure 15: FPS recorded deaths by rail per year and gender**

Males make up most of the fatalities at 84% (n=712). This is consistent with the findings of (Savage, 2007; Pelletier, 1997; Radbo et al., 2005; Savage, 2015; Silla & Luoma, 2012; Mishara & Bardon, 2015 and Ozdogan et al., 2006).

Females accounted for 16% of fatalities (n=133) over the period. See Figure 16: % Recorded deaths by gender.



**Figure 16: % Recorded deaths by gender**

### 5.1.2 By age

The most vulnerable of pedestrians, those under the age of 11 years (n=11) and the elderly, those 60 years and older (n=47), combined make up 7% of the fatalities (n=58), supporting the findings of Savage, (2007); Savage, (2015) and Silla and Luoma, (2008) that trespass related fatalities are rare for these age groups.

Adults between 20 and 59 years make up the largest demographic at 86% of recorded fatalities (n=726), as found by Savage, (2007); Savage, (2015); Pelletier, (1997) and Radbo et al., (2005). (See Table 20: Recorded deaths attributed to rail per year by age).

**Table 20: Recorded deaths attributed to rail per year by age**

Recorded Deaths Attributed to Rail per Year by Age								
Age Group	2012	2013	2014	2015	2016	2017	2018	TOTAL
<b>0-11yrs</b>	4	2	2	1	1	0	1	<b>11</b>
<b>12-19yrs</b>	6	14	9	7	10	9	6	<b>61</b>
<b>20-59yrs</b>	111	116	104	112	110	112	61	<b>726</b>
<b>60yrs+</b>	10	5	5	7	9	5	6	<b>47</b>
<b>Total</b>	<b>131</b>	<b>137</b>	<b>120</b>	<b>127</b>	<b>130</b>	<b>126</b>	<b>74</b>	<b>845</b>

### 5.1.3 By age and gender

A closer look at the fatalities by age group and gender shows that 86.9% and 79.7% of fatalities can be attributed to the 20-59 years age group for both males and females respectively. (See Table 21: Recorded deaths attributed to rail per year by gender and age).

**Table 21: Recorded deaths attributed to rail per year by gender and age**

Recorded Deaths Attributed to Rail per Year by Gender and Age				
Age Group	Male	%	Female	%
<b>0-11yrs</b>	6	0.8%	5	3.8%
<b>12-19yrs</b>	52	7.3%	9	6.8%
<b>20-59yrs</b>	619	86.9%	106	79.7%
<b>60yrs+</b>	35	4.9%	13	9.8%
<b>Total</b>	<b>712</b>	<b>100.0%</b>	<b>133</b>	<b>100.0%</b>

#### *Age distribution*

Figure 17: Distribution of fatalities by age, provides more insight into the breakdown of age groups, with a clear peak between the ages of 20 to 35-year olds. The result shows a slightly right skewed plot. The transition from adolescent to adulthood would be a focus for any educational interventions, targeting school children.

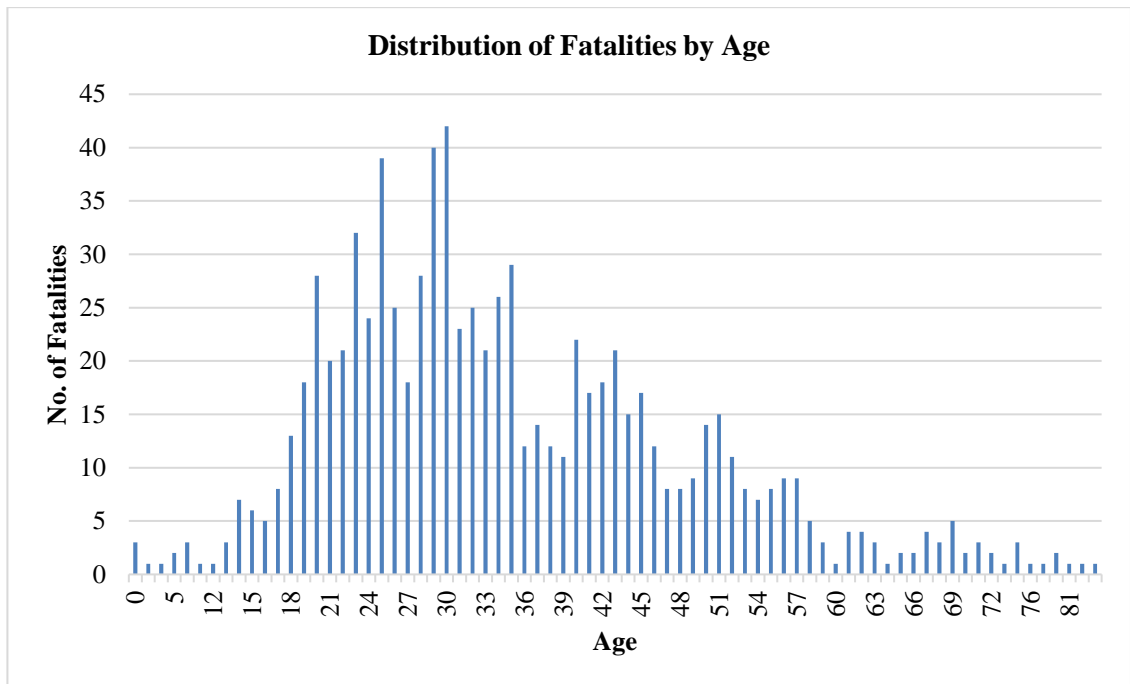


Figure 17: Distribution of fatalities by age

#### 5.1.4 By race

Figure 18: % Fatalities by race, displays the breakdown of deaths by racial demographics. 61.5% of deaths (n=520) can be attributed to Blacks, with Coloureds making up 35.6% (n=301) and Whites, 2.7% (n=23) of fatalities. No separate classification is made in the data for Indians.

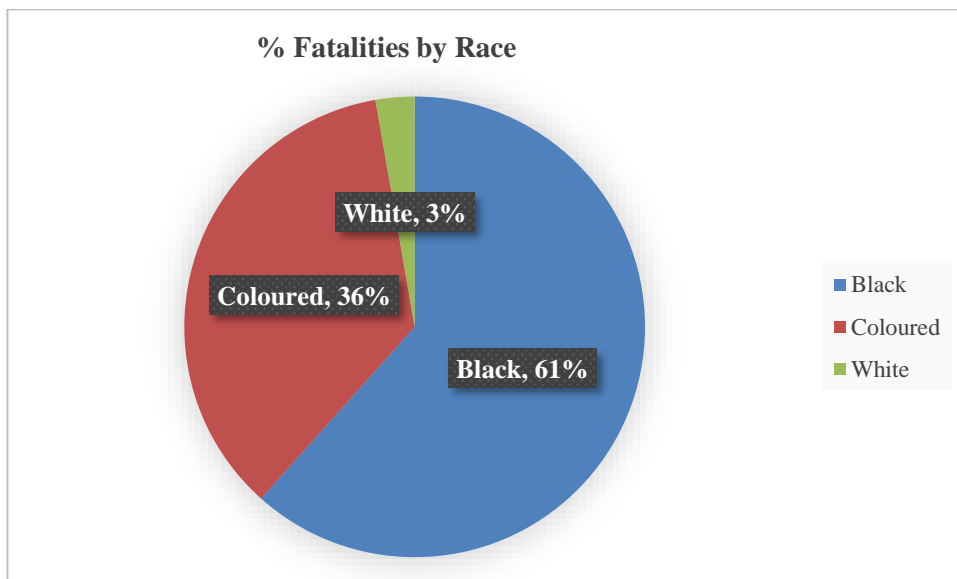


Figure 18: % Fatalities by race

### ***By race and gender***

Table 22: Recorded deaths by race and gender, show that black males are more at risk of death than for all the other race groups (n=448). Notably more Coloured females (n=57), making up 19% of all Coloured deaths is apparent. White females make up the lowest demographic accounting for only four (n=4) deaths over the study period.

**Table 22: Recorded deaths by race and gender**

<b>Gender</b>	<b>Black</b>	<b>Coloured</b>	<b>White</b>	<b>Grand Total</b>	<b>%</b>
<b>Male</b>	448	244	19	<b>712</b>	<b>84.2</b>
<b>Female</b>	72	57	4	<b>133</b>	<b>15.7</b>
<b>Grand Total</b>	<b>520</b>	<b>301</b>	<b>23</b>	<b>845</b>	<b>100</b>

### **5.1.5 Suicides**

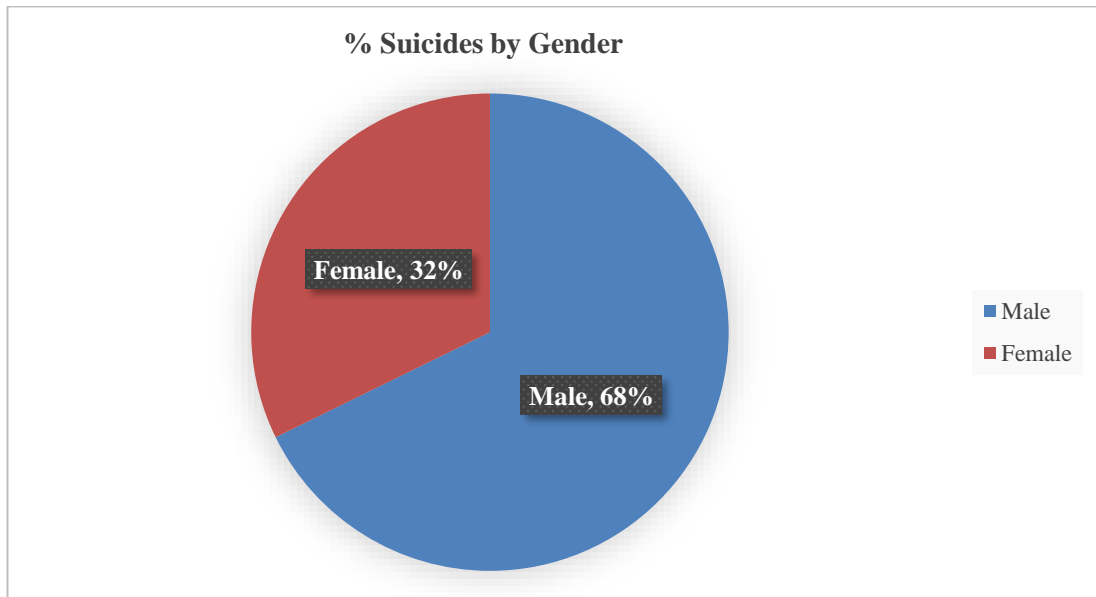
Suicides make up 3.7% (n=31) of all recorded deaths attributed to rail casualties. (See Table 23: Recorded deaths by category per year). The low numbers could indicate that suicides-by-rail is not a popular choice for those wanting to take their own life. Alternatively, the low figures could indicate a degree of under-reporting, as a result of the uncertainty with regards to the classification of suicides.

**Table 23: Recorded deaths by category per year**

<b>Year</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>Unknown</b>	<b>Grand Total</b>
<b>Train Casualty</b>	122	131	109	123	123	119	66	1	<b>794</b>
<b>Suicide</b>	7	5	7	2	5	2	3	0	<b>31</b>
<b>Grand Total</b>	<b>129</b>	<b>136</b>	<b>116</b>	<b>125</b>	<b>128</b>	<b>121</b>	<b>69</b>	<b>1</b>	<b>825</b>

### *Suicides by gender*

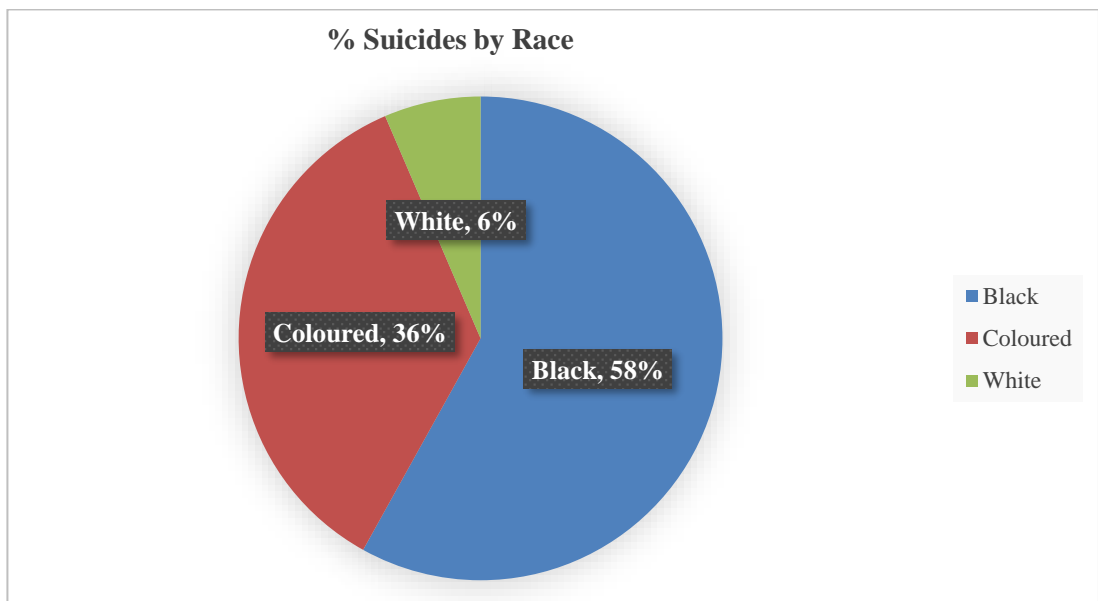
68% of all suicides (n=21) are by males and 32% (n=10) by females. See Figure 19: Suicides by gender.



**Figure 19: Suicides by gender**

### *Suicides by race*

Suicides by train casualty have been recorded as the official cause of death in 58.1% (n=18) of blacks, 35.5% (n=11) of Coloured and 6.5% (n=2) of whites. See Figure 20: Suicides by race.



**Figure 20: Suicides by race**

### *Suicides by gender and race*

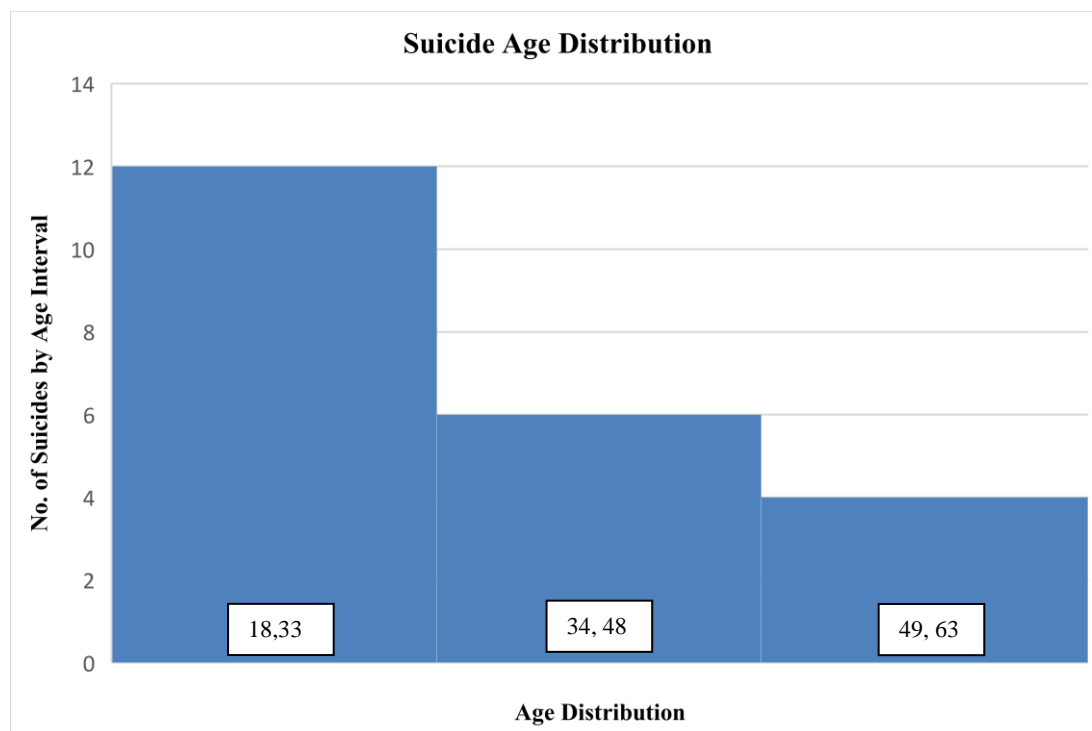
Black males have the most deaths formally classified as a suicide (n=14) with more Coloured females (n=6) than in any other race group. (See Table 24: Suicides by gender and race).

**Table 24: Suicides by gender and race**

Suicides by Gender and Race					
Suicide	Black	Coloured	White	Grand Total	%
Male	14	5	2	21	67.7%
Female	4	6	0	10	32.3%
Grand Total	18	11	2	31	100.0%

### *Suicides by age interval*

The distribution of suicides over the age intervals can be seen in the histogram in Figure 21: Suicide – age distribution. More suicides fall into the 18-33-year-old age group than any other.



**Figure 21: Suicide – age distribution**

### 5.1.6 Hypothesis tests $H_{01}$ – $H_{04}$

*FPS  $H_{01}$ : No significant difference exists between genders of the victim for recorded deaths due to rail injury.*

Using statistical tests to check if there is a significant difference in the number of deaths between the two gender categories, split into the variable's "males" and "females" for the variable "years".

The null hypothesis that no significant difference exists between recorded deaths and the gender of the victim.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

Gender	Male (A)	Female (B)	Total
2012	104	27	131
2013	116	22	138
2014	105	15	120
2015	104	23	127
2016	111	19	130
2017	111	15	126
2018	61	12	73
Total	712	133	845

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F Statistic	P-value
Treatment	23,945.7857	1	23,945.7857	129.1209	8.8574e-08
Error	2,225.4286	12	185.4524		
Total	26,171.2143	13			

### Conclusion from Anova:

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the one or more categories are significantly different.

NULL HYPOTHESIS IS REJECTED

It is concluded that the number of deaths for males is statistically significant.

***FPS H<sub>02</sub>: No significant difference exists between the age of the victim for recorded deaths due to rail injury.***

Using statistical tests to check if there is a significant difference in the number of deaths for the four age categories, split into the variables “0-11yrs”, “12-19yrs”, “20-59yrs” and “+60yrs” for the variable “years”.

The null hypothesis is that no significant difference exists between recorded deaths and the age of the victim.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

Age Group	0-11yrs (A)	12-19yrs (B)	20-59yrs (C)	60yrs+ (D)	Total
2012	4	6	111	10	131
2013	2	14	116	5	137
2014	2	9	104	5	120
2015	1	7	112	7	127
2016	1	10	110	9	130
2017	0	9	112	5	126
2018	1	6	61	6	74
Total	11	61	726	47	845

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F Statistic	P-value
Treatment	50,660.1071	3	16,886.7024	177.1332	2.2204e-16
Error	2,288.0000	24	95.3333		
Total	52,948.1071	27			

**Conclusion from Anova:**

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the one or more categories are significantly different.

NULL HYPOTHESIS IS REJECTED

**Post-hoc Tukey HSD Test results:**

Treatments Pair	Tukey HSD Q statistic	Tukey HSD P-value	Tukey HSD Inference
A vs B	1.9355	0.5276790	insignificant
A vs C	27.6780	0.0010053	p<0.01
A vs D	1.3936	0.7378850	insignificant
B vs C	25.7425	0.0010053	p<0.01
B vs D	0.5419	0.8999947	insignificant
C vs D	26.2844	0.0010053	p<0.01

It is concluded that the number of deaths in the age-group 20-59 years for victims is statistically significant.

***FPS H<sub>03</sub>: No significant difference exists between the race of the victim and recorded deaths due to rail injury.***

Using statistical tests to check if there is a significant difference in the number of deaths for the four race categories, split into the variables “black”, “Coloured”, “white” and “unknown” for the variables “male” and “female”.

The null hypothesis that no significant difference exists between recorded deaths and the race of the victim.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

	Black (A)	Coloured (B)	White (C)	Unknown (D)	Grand Total
Male	448	244	19	1	712
Female	72	57	4	0	133
Grand Total	520	301	23	1	845

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F Statistic	P-value
Treatment	91,512.3750	3	30,504.1250	1.3821	0.3694
Error	88,285.5000	4	22,071.3750		
Total	179,797.8750	7			

**Conclusion from Anova:**

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the categories are not significantly different for that level of significance.

NULL HYPOTHESIS IS NOT REJECTED

It is concluded that no statistically significant difference exists between recorded deaths and the race of the victims.

***FPS H<sub>04</sub>: No significant difference exists between the gender of the victim for suicides.***

Using statistical tests to check if there is a significant difference in the number of suicides for the two gender categories, split into the variables “male” and “female” for the variable “years”.

The null hypothesis that no significant difference exists between suicides and the gender of the victim.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

Suicide	Male (A)	Female (B)	Total
2012	2	5	7
2013	4	1	5
2014	7	0	7
2015	1	1	2
2016	4	1	5
2017	0	2	2
2018	3	0	3
Total	21	10	31

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F Statistic	P-value
Treatment	8.6429	1	8.6429	2.0862	0.1742
Error	49.7143	12	4.1429		
Total	58.3571	13			

### Conclusion from Anova:

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the treatments are not significantly different for that level of significance.

### NULL HYPOTHESIS IS NOT REJECTED

No statistical difference exists between suicides and the gender of the victim. The number of males involved in fatalities recorded as suicides, is statistically insignificant.

## 5.2 THE TEMPORAL CHARACTERISTICS OF CATEGORY E-A OCCURRENCES RELATING TO PEDESTRIAN-RAIL RELATED FATALITIES AND INJURIES

Answering research question RSR Q2.

### 5.2.1 By year

The total number of Category E-a occurrences over the 4-year period is 596 (n=596), with Prasa accounting for 94.1% of all occurrences (n=561). (See Table 25: No. of E-a occurrences by operator per year). The number of E-a occurrences has dropped by 8.7% since the high of 185 (n=185) in 2016 to 133 (n=133) in 2018.

Table 25: No. of E-a occurrences by operator per year

No. of E-a Occurrences by Operator per Year						
	2015	2016	2017	2018	Grand Total	%
<b>PRASA RAIL</b>	112	180	147	122	<b>561</b>	<b>94.1%</b>
<b>Transnet Freight Rail</b>	9	5	9	9	<b>32</b>	<b>5.4%</b>
<b>Shosholoza Meyl</b>	1	0	0	1	<b>2</b>	<b>0.3%</b>
<b>Other</b>	0	0	0	1	<b>1</b>	<b>0.2%</b>
<b>Totals</b>	<b>122</b>	<b>185</b>	<b>156</b>	<b>133</b>	<b>596</b>	<b>100.0%</b>

A total of 330 fatalities due to a member of public being struck by a train was recorded over the period, at an average of 82.5 fatalities per year. The highest number of fatalities was recorded in 2016 (n=105), decreasing to 61 (n=61) fatalities in 2018. Prasa accounts for 94.2% of all fatalities (n=311) over the period and Transnet Freight Rail (TFR) 5.2% (n=17). (See Figure 22: E-a fatalities by major operator per year).

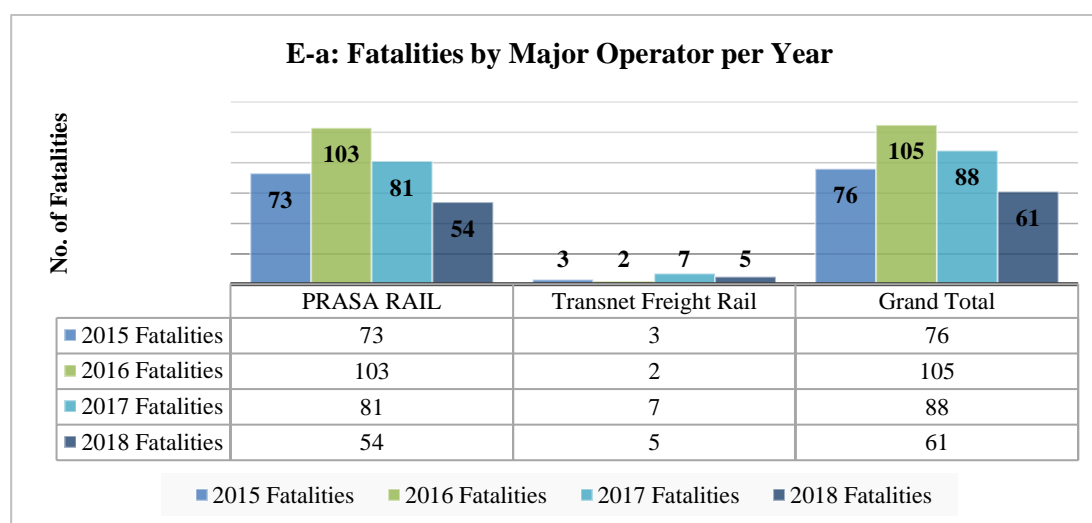
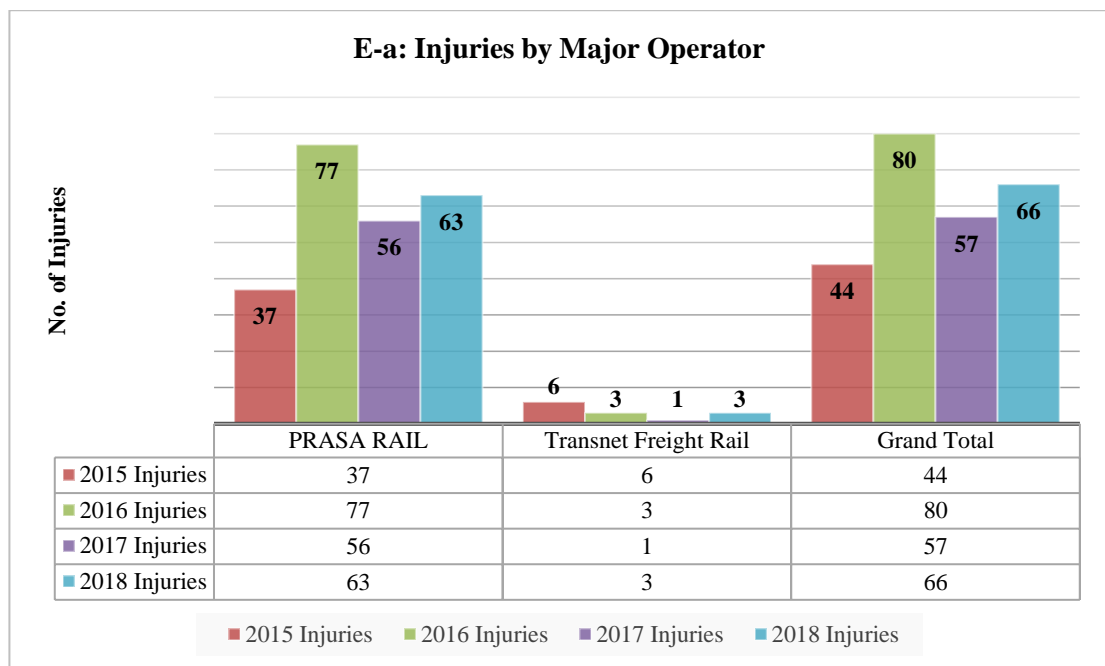


Figure 22: E-a fatalities by major operator per year

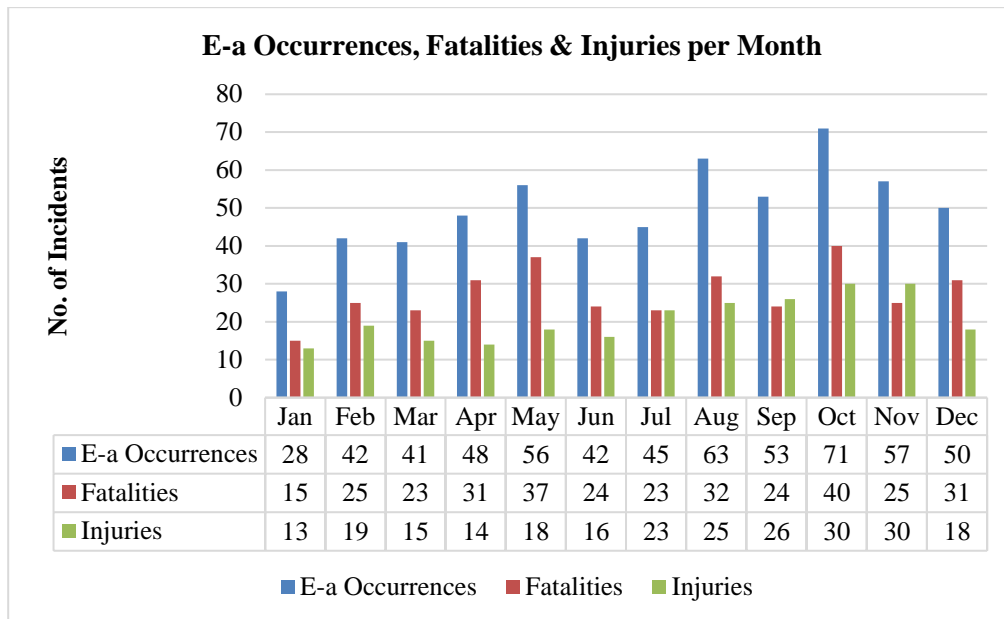
A total of 247 injuries, due to a member of public being struck by a train were recorded over the period, at an average of 61.8 injuries per year. The highest number of injuries was recorded in 2016 (n=80), the lowest in 2015 (n=44). Prasa accounts for 94.3% of all injuries (n=233) over the period and TFR 5.3% (n=13). (See Figure 23: E-a injuries by major operator).



**Figure 23: E-a injuries by major operator**

### 5.2.2 By month

The number of E-a occurrences, fatalities and injuries have been grouped into the month in which they took place in Figure 24: E-a occurrences, fatalities & injuries per month. More E-a occurrences and fatalities have been recorded in October than any other month. More incidents have been recorded in the months which fall in the second half of the year from July-December (n=339) as opposed to the first half the year (n=257). However, occurrences don't show a seasonal trend corresponding with the start of spring or summer as it does in the Northern hemisphere (Savage, 2015; Pelletier, 1997; Radbo et al., 2005). The winter months of June and July show a consistent number of occurrences with the rest of the year where one might have thought visibility would be poorer with extended hours of darkness in the morning and afternoon peaks, leading to more incidents. However, this is not the case in Cape Town.



**Figure 24: E-a occurrences, fatalities & injuries per month**

There were on average nearly 50 pedestrian-train incidents per month over the period, which results in an average of 27.5 fatalities and 20.6 injuries per month. The standard deviation is large which mean the values are widely spread from the mean. See Table 26: Category E-a, fatalities and injuries descriptive statistics.

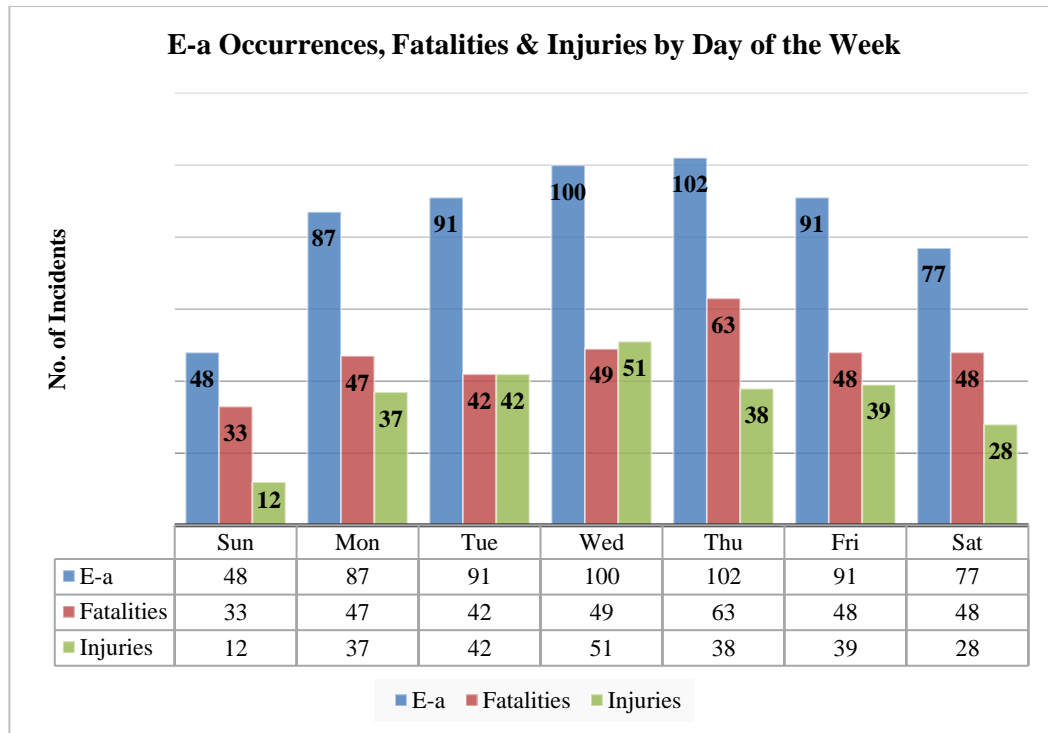
**Table 26: Category E-a, fatalities and injuries descriptive statistics**

	E-a Occurrences	Fatalities	Injuries
Mean	49.66666667	27.5	20.58333333
Standard Error	3.285259395	1.994310088	1.742770058
Median	49	25	18.5
Mode	42	25	18
Standard Deviation	11.38047238	6.908492797	6.037132572
Range	43	25	17
Minimum	28	15	13
Maximum	71	40	30
Sum	596	330	247
Count	12	12	12

### 5.2.3 By day of the week

The number of E-a occurrences, fatalities and injuries per day of the week are shown in Figure 25: E-a occurrences, fatalities & injuries by day of the week. More E-a occurrences have been recorded on a Wednesday (n=100) and Thursday (n=102)

than any other day of the week over the period. Thursdays have the most fatalities (n=63) and 129 (n=129) fatalities in total have been recorded over a Friday, Saturday, Sunday-weekend period. Sundays, generally, have lower figures under all cases which is likely due to a reduced service being operated on the day.



**Figure 25: E-a occurrences, fatalities & injuries by day of the week**

### 5.2.4 By time of the day

Figure 26: E-a occurrences, fatalities & injuries by time of day, clearly illustrates the concentration of incidents around the morning and afternoon peak periods, supporting research carried out by Savage, (2015) and Lerer & Matzopoulos, (1996). A particularly acute morning peak between 6AM and 8AM has 103 (n=103) E-a occurrences, 57 (n=57) fatalities and 42 (n=42) injuries recorded in similar time periods over the analysis period. The afternoon peak period is a bit wider, from 4PM till 8PM, with a combined 206 (n=206) E-a occurrences, 103 (n=103) fatalities and 99 (n=99) injuries. Pedestrian-rail occurrences outside of normal train operating hours were because of out-of-service-trains returning to rail siding areas or staging yards. These would occur after 23h00 in the evenings at a time when trespassers would least expect trains to be moving around.

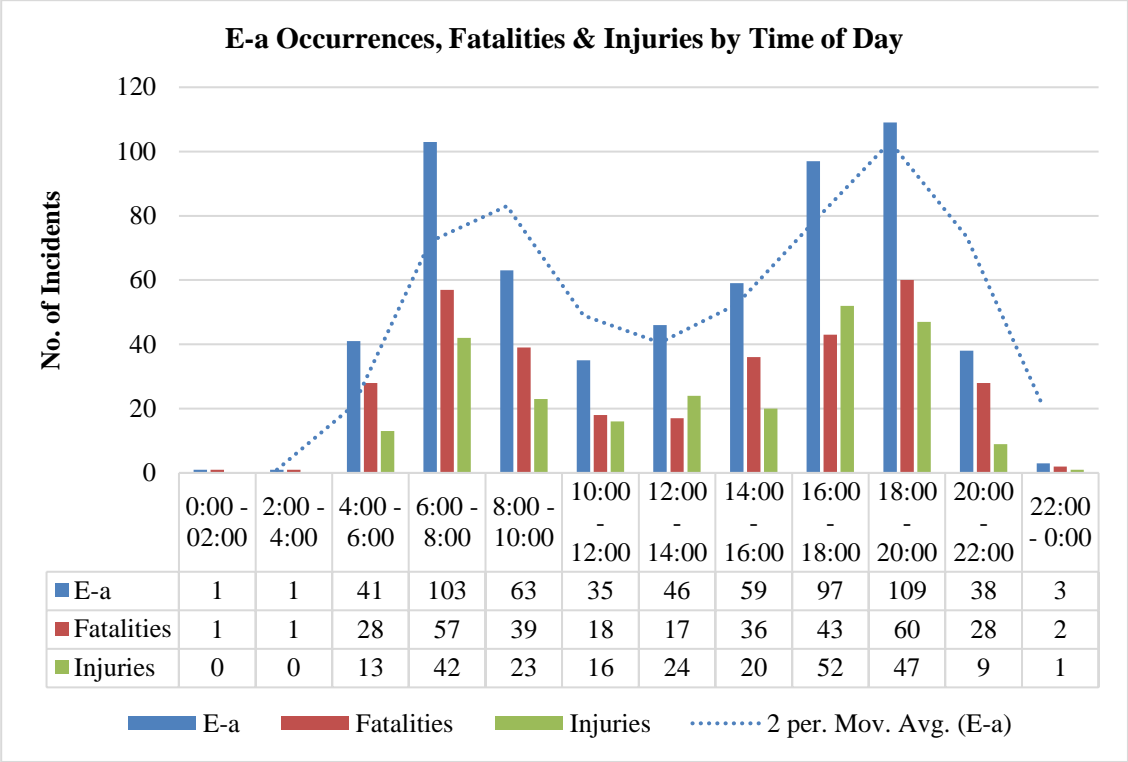


Figure 26: E-a occurrences, fatalities & injuries by time of day

5.2.5 Other results

- a.) There were 34 recorded E-a occurrences that have no fatalities or injuries, in other words, the person involved with a train collision escaped unscathed.
- b.) There were 115 records that were not assigned SANS categories. In this group, 40 fatalities were recorded and 48 injuries. With regards to the fatalities, in most cases, the cause of death was not apparent, and the bodies discovered were mostly intact, indicating other non-train causes of death.

## 5.2.6 Hypothesis tests H<sub>06</sub> – H<sub>09</sub>

*RSR H<sub>06</sub>: No significant difference exists between the months of the year for the number of Category E-a occurrences.*

Using statistical tests to check if there is a significant difference in the numbers of pedestrian-train incidents over the 12 months of the year, split into the variables for the study year periods (2015-2018) and the months of the year (January – December).

The null hypothesis is that no significant difference exists between the months of the year and the number of E-a occurrences.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

E-a	2015	2016	2017	2018	Grand Total
Month					
Jan	0	9	13	6	28
Feb	0	17	17	8	42
Mar	0	11	24	6	41
Apr	15	13	8	12	48
May	11	20	14	11	56
Jun	7	19	7	9	42
Jul	12	14	8	11	45
Aug	17	19	19	8	63
Sep	15	15	10	13	53
Oct	21	25	10	15	71
Nov	11	14	13	19	57
Dec	13	9	13	15	50
Grand Total	122	185	156	133	596

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F Statistic	P-value
Treatment	194.1667	3	64.7222	2.2828	0.0922
Error	1,247.5000	44	28.3523		
Total	1,441.6667	47			

### Conclusion from Anova:

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the treatments are not significantly different for that level of significance.

### NULL HYPOTHESIS IS NOT REJECTED

A statistically insignificant difference exists between the months of the year and the number of E-a occurrences.

A standardisation exercise was carried out to calculate the Z scores for each month to allow an alternative comparison. (See Table 27: Standardising with Z scores). The months scoring above the mean are highlighted in red. The two months that have a total Z score adding up to more than two standard deviations above the mean are August (2.4329) and October (3.8927).

**Table 27: Standardising with Z scores**

	2015	Z	2016	Z	2017	Z	2018	Z	Sum of Z
<b>E-a</b>									
Jan	0	-2.3	9	-0.6	13	0.1064	6	-1.1708	-3.9535
Feb	0	-2.3	17	0.84	17	0.8363	8	-0.8059	-1.3989
Mar	0	-2.3	11	-0.3	24	2.1136	6	-1.1708	-1.5814
Apr	15	0.47	13	0.11	8	-0.8059	12	-0.0760	-0.3041
May	11	-0.3	20	1.38	14	0.2889	11	-0.2585	1.1556
Jun	7	-1	19	1.2	7	-0.9884	9	-0.6234	-1.3989
Jul	12	-0.1	14	0.29	8	-0.8059	11	-0.2585	-0.8515
Aug	17	0.84	19	1.2	19	1.2013	8	-0.8059	2.4329
Sep	15	0.47	15	0.47	10	-0.4410	13	0.1064	0.6082
Oct	21	1.57	25	2.3	10	-0.4410	15	0.4714	3.8927
Nov	11	-0.3	14	0.29	13	0.1064	19	1.2013	1.3381
Dec	13	0.11	9	-0.6	13	0.1064	15	0.4714	0.0608
<b>Total</b>	<b>122</b>		<b>185</b>		<b>156</b>		<b>133</b>		
			Mean						
			10.2						
			Stand Dev P						
			6.73						

***RSR H<sub>07</sub>: No significant difference exists between the days of the week for Category E-a occurrences.***

Using statistical tests to check if there is a significant difference in the numbers of pedestrian-train incidents over the days of the week, split into the variables for the study year periods (2015-2018) and the days of the week (Sunday – Saturday).

The null hypothesis that no significant difference exists between the days of the week and the number of E-a occurrences.

For a 95% confidence level and an alpha level of 0.05.

Observed values:

Day of the Week	Sunday	Mon	Tues	Wed	Thurs	Friday	Sat	Totals
2015	8	21	16	22	20	16	19	122
2016	12	32	28	28	40	21	24	185
2017	17	17	27	27	22	24	22	156
2018	11	17	20	23	20	30	12	133
Totals	48	87	91	100	102	91	77	596

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F Statistic	P-value
Treatment	505.7143	6	84.2857	2.2519	0.0780
Error	786.0000	21	37.4286		
Total	1,291.7143	27			

**Conclusion from Anova:**

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the categories are not significantly different for that level of significance.

NULL HYPOTHESIS IS NOT REJECTED

No statistically significant difference exists between the days of the week for the number of E-a occurrences.

***RSR H<sub>08</sub>: No significant difference exists between the hours of the day and Category E-a occurrences.***

Using statistical tests to check if there is a significant difference in the numbers of pedestrian-train incidents over the course of a day, split into the variables for the study year periods (2015-2018) and four-hour segments.

The null hypothesis that no significant difference exists between the time of day and the number of E-a occurrences.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

4-hour segment	0:00 - 04:00 (A)	04:00 - 08:00 (B)	08:00 - 12:00 (C)	12:00 - 16:00 (D)	16:00 - 20:00 (E)	20:00 - 0:00 (F)	Totals
2015	1	26	13	24	50	8	122
2016	0	55	22	22	69	17	185
2017	0	33	33	29	50	11	156
2018	1	30	29	29	39	5	133
Totals	2	144	97	104	208	41	596

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F Statistic	P-value
Treatment	6,676.8333	5	1,335.3667	18.2027	1.7681e-06
Error	1,320.5000	18	73.3611		
Total	7,997.3333	23			

**Conclusion from Anova:**

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the one or more treatments are significantly different.

**NULL HYPOTHESIS IS REJECTED**

A statistically significant difference exists between the time of day and the number of E-a occurrences.

**Post-hoc Tukey HSD results:**

Treatments Pair	Tukey HSD Q statistic	Tukey HSD P-value	Tukey HSD Inference
A vs B	8.2894	0.0010053	p<0.01
A vs C	5.5458	0.0108901	p<0.05
A vs D	5.9544	0.0059183	p<0.01
A vs E	12.0255	0.0010053	p<0.01
A vs F	2.2767	0.5919277	insignificant
B vs C	2.7437	0.4131370	insignificant
B vs D	2.3351	0.5698634	insignificant
B vs E	3.7361	0.1372779	insignificant
B vs F	6.0128	0.0054239	p<0.01
C vs D	0.4086	0.8999947	insignificant
C vs E	6.4798	0.0026964	p<0.01
C vs F	3.2691	0.2396567	insignificant
D vs E	6.0711	0.0049689	p<0.01
D vs F	3.6777	0.1477738	insignificant
E vs F	9.7489	0.0010053	p<0.01

It can be concluded that category “E” corresponding with the time slot 16:00 – 20:00 is statistically significant and corresponds to the afternoon peak period.

***RSR H<sub>0</sub>9: Zero correlation exists between the number of trains scheduled and E-a occurrences.***

To determine if there is any relationship between the number of E-a occurrences and train traffic densities, stating the null hypothesis, zero correlation exists between the number of E-a occurrences and the number of trains scheduled.

Therefore:

Year	E-a	Trains Scheduled
2016	185	201745
2017	156	198740
2018	133	170822
Totals	474	571307

(X-Xbar)	(Y-Ybar)	Xbar x Ybar	(X-Xbar) <sup>2</sup>	(Y-Ybar) <sup>2</sup>
27	11309.33	305352	729	1.28E+08
-2	8304.333	-16608.667	4	68961952
-25	-19613.7	490341.67	625	3.85E+08
0	2.91E-11	779085	1358	5.82E+08

Therefore:

Xbar	158
Ybar	190435.7
n-1	2
Sum	779085
Covariance	389542.5
Sx	26.05763
Sy	2.91E+08
r	0.876674

“r” = 0.876674 is calculated to be close to 1, therefore a strong positive correlation exists.

The scatterplot for the train traffic densities against the number of E-a occurrences is shown in Figure 27: Trains scheduled vs E-a occurrences. The linear relationship can clearly be seen and would suggest that as train density increases (number of trains scheduled), the number of pedestrian-rail incidents (E-a occurrences) would also increase.

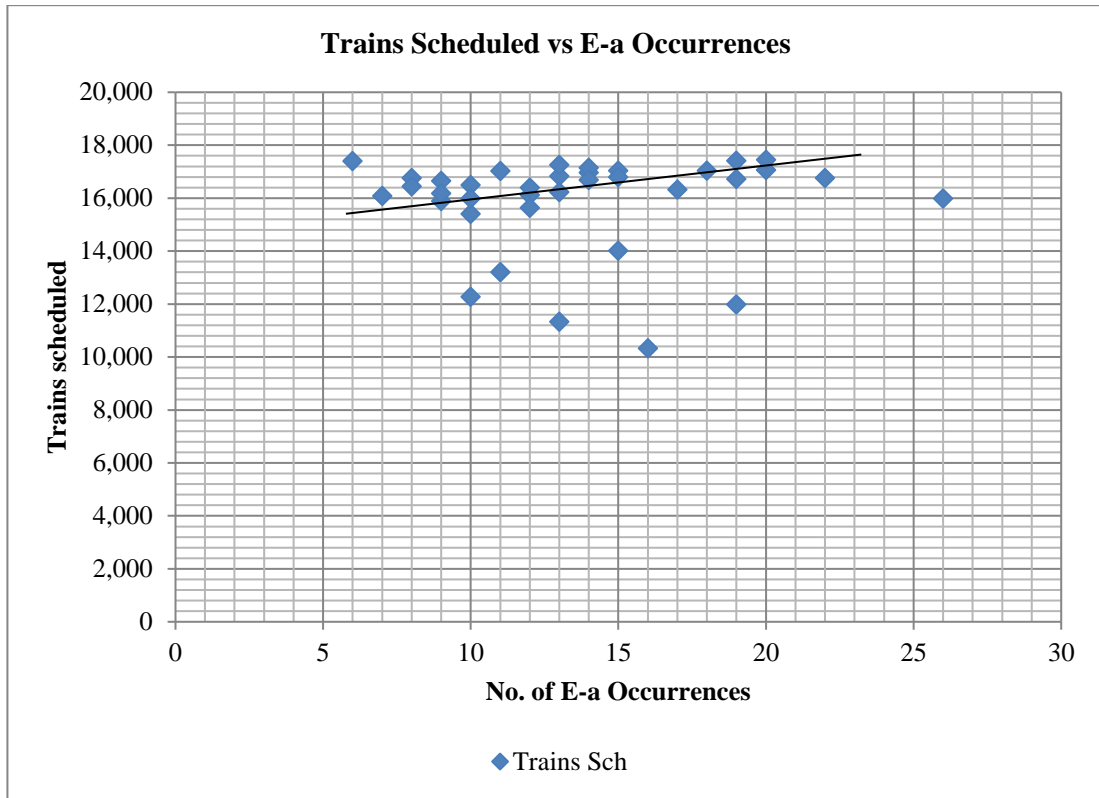


Figure 27: Trains scheduled vs E-a occurrences

### 5.3 THE TEMPORAL CHARACTERISTICS OF RAILWAY THEFT AND VANDALISM OCCURRENCES

Answering research question Q3.

#### *By year*

A total of 4715 (n=4715) Category 1 and Category 2 occurrences for theft and vandalism of railway assets were recorded over the research period. Of all occurrences, 87% were on Prasa assets (n=4103), 10.2% on TFR (n=481) and 2.8% on the long distance Shosholozza Meyl service (n=131). (See Table 28: Security occurrences by operator). The average number of occurrences per year is 1178.75.

Occurrences on Prasa assets increased by 23% between 2015 and 2018 with a high of 1471 (n=1471) occurrences in 2017. Occurrences on TFR assets have increased by 443% between 2015 (n=44) and 2018 (n=239).

**Table 28: Security occurrences by operator**

Operator	2015	2016	2017	2018	Grand Total	%
<b>PRASA RAIL</b>	734	996	1471	902	<b>4103</b>	87.0%
<b>Transnet Freight Rail</b>	44	56	142	239	<b>481</b>	10.2%
<b>Shosholozza Meyl</b>	25	27	44	35	<b>131</b>	2.8%
<b>Grand Total</b>	<b>803</b>	<b>1079</b>	<b>1657</b>	<b>1176</b>	<b>4715</b>	100.0%

***By month***

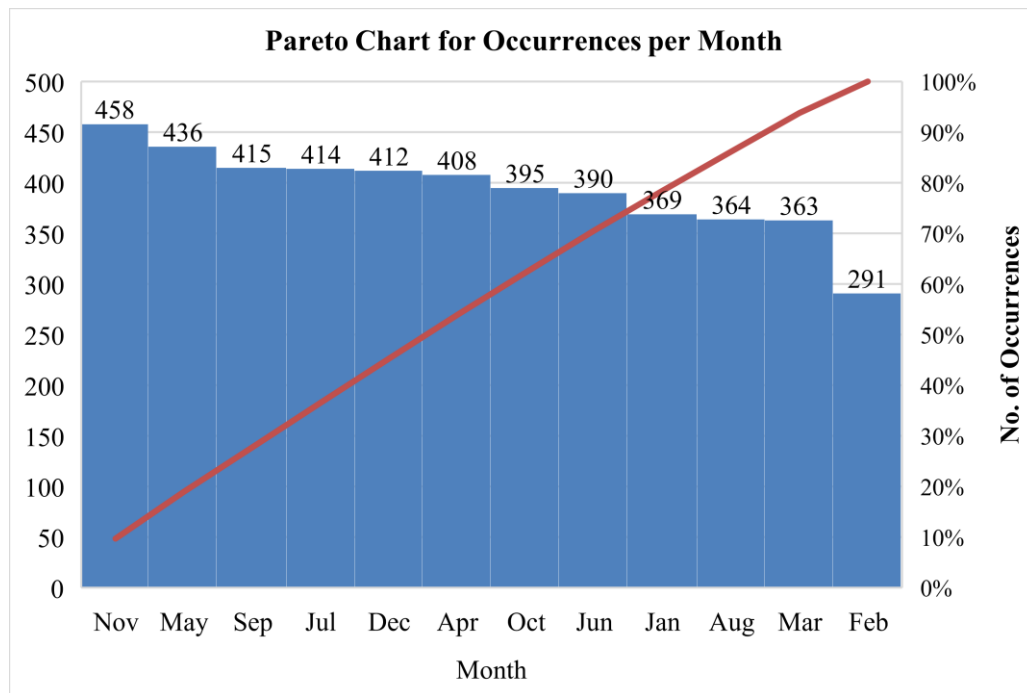
Table 29: Security occurrences by month, combines Category 1 & 2 occurrences for theft and malicious damage to rail assets. The mean of the totals for the month is 393 occurrences with a standard deviation of 43. November has the largest number of occurrences (n=458) and February the lowest (n=291).

Attacks on rolling stock components in section peaks in April (n=132) and May (n=148) and train control equipment records the highest number of occurrences in November (n=248).

**Table 29: Security occurrences by month**

Category 1 + 2		Month												Grand Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
a	Rolling stock components in section	77	43	51	132	148	118	132	89	116	112	127	106	1251
b	Rolling stock components in yards	36	26	46	42	30	31	36	32	45	23	20	37	404
c	Civil infrastructure components in section	44	57	49	41	65	44	32	39	41	47	42	57	558
d	Civil infrastructure components in yards and sidings	3	3	4	3	4	2	1	1	1	2	3	1	28
e	Overhead traction equipment in section	13	5	17	6	8	3	4	4	6	6	7	6	85
f	Overhead traction equipment in yards and sidings	0	0	1	0	1	2	0	2	2	2	0	3	13
g	Train control equipment (signalling) in section	185	141	185	174	173	180	195	182	194	186	248	189	2232
h	Train control equipment (signalling) in yards and sidings	3	6	4	6	1	3	5	4	1	6	7	9	55
i	Ancillary equipment including public address systems, information boards, CCTV.	8	10	6	4	6	7	9	11	9	11	4	4	89
<b>Grand Total</b>		<b>369</b>	<b>291</b>	<b>363</b>	<b>408</b>	<b>436</b>	<b>390</b>	<b>414</b>	<b>364</b>	<b>415</b>	<b>395</b>	<b>458</b>	<b>412</b>	<b>4715</b>

The Pareto chart in Figure 28: Pareto chart for occurrences per month, graphically illustrates the most problematic months. There is no indication of any seasonal trends with November signalling the start of Summer and the second highest occurrence month, May, commencing with the start of Winter.



**Figure 28: Pareto chart for occurrences per month**

### *By day of the week*

Category 1 and 2 occurrences are most prevalent on a Thursday with 527 and 240 occurrences respectively on the day. The Friday (n=689), Saturday (n=632) and Sunday (n=558) weekend-period has a combined occurrence count of 1879 events, which amounts to approximately 40% of the total occurrences per week. (See Table 30: Category 1 & 2 occurrences by day of the week).

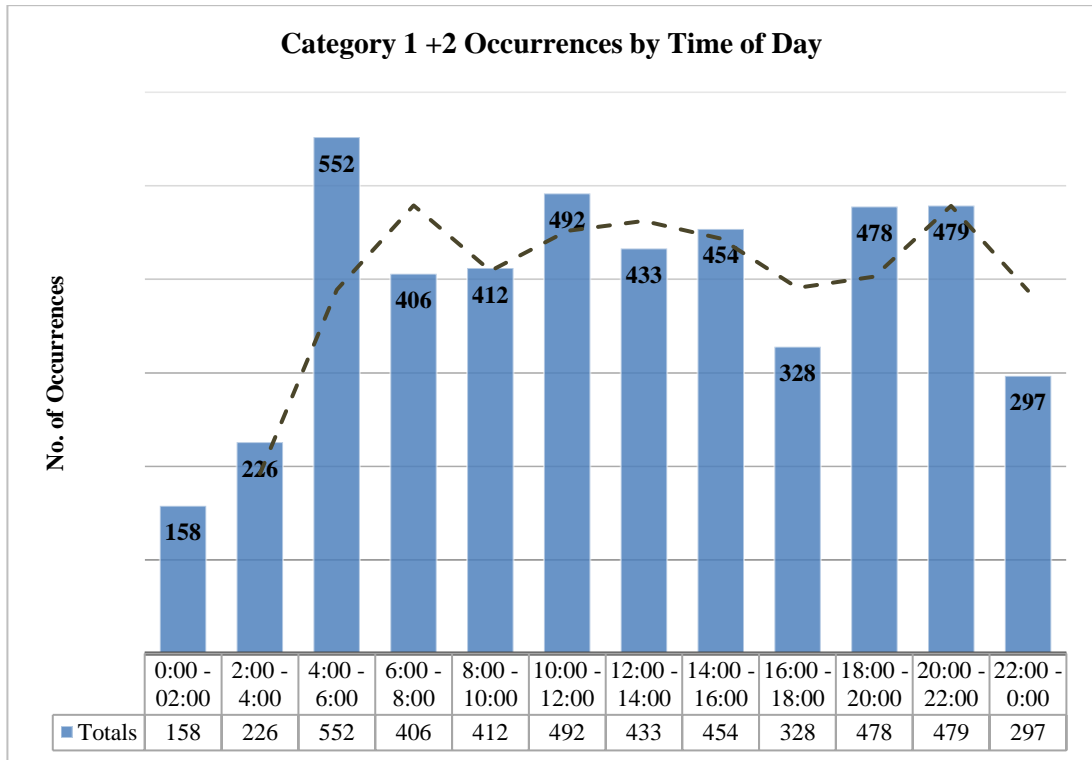
Theft of train control equipment occurs consistently throughout the week accounting for nearly half of all occurrences (n=2232). Most train control equipment theft takes place on a Friday (n=346). Rolling stock equipment are more at risk on Thursdays with 217 occurrences recorded.

**Table 30: Category 1 & 2 occurrences by day of the week**

Category 1 + 2		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Grand Total
<b>a</b>	<b>Rolling stock components in section</b>	183	190	192	217	188	145	136	1251
<b>b</b>	<b>Rolling stock components in yards</b>	65	64	65	74	55	36	45	404
<b>c</b>	<b>Civil infrastructure components in section</b>	79	86	94	88	73	68	70	558
<b>d</b>	<b>Civil infrastructure components in yards and sidings</b>	7	5	3	6	0	4	3	28
<b>e</b>	<b>Overhead traction equipment in section</b>	11	10	15	11	10	19	9	85
<b>f</b>	<b>Overhead traction equipment in yards and sidings</b>	4	1	1	2	1	2	2	13
<b>g</b>	<b>Train control equipment (signalling) in section</b>	294	319	315	342	346	337	279	2232
<b>h</b>	<b>Train control equipment (signalling) in yards and sidings</b>	7	9	9	7	6	11	6	55
<b>i</b>	<b>Ancillary equipment including public address systems, information boards, CCTV.</b>	9	14	18	20	10	10	8	89
<b>Grand Total</b>		<b>659</b>	<b>698</b>	<b>712</b>	<b>767</b>	<b>689</b>	<b>632</b>	<b>558</b>	<b>4715</b>

***By time of the day***

Occurrences of theft and malicious damage show no discernible trends apart from a morning pre-peak period between 4AM and 6AM with 552 occurrences. Occurrences happen consistently between 6AM and 10PM with only the 4PM to 6PM period recording lower than 400 occurrences (n=328). (See Figure 29: Category 1 & 2 occurrences by time of day). The fact that no clear temporal trend exists is an indication of the rampant nature of occurrences of theft and vandalism on the rail network, with a total of 4715 combined Category 1 and 2 occurrences over the research period. The assets most at risk are train control equipment in sections, which means that the entire network is potentially a target for criminals.



**Figure 29: Category 1 & 2 occurrences by time of day**

### 5.3.1 Hypothesis tests $H_{010}$ – $H_{012}$

***RSR  $H_{010}$ : No significant differences exist between the months of the year for Category 1 and 2 occurrences.***

Using statistical tests to check if there is a significant difference in the number of Category 1 and 2 occurrences taking place over the 12 months of the year, split into the variables for the study year periods (2015-2018) and the months of the year (January – December).

The null hypothesis that no significant difference exists between the months of the year and the number of Category 1 and 2 occurrences.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

Cat 1 + 2	2015 (A)	2016 (B)	2017 (C)	2018 (D)	Total
Jan	65	106	84	114	369
Feb	66	54	98	73	291
Mar	81	70	110	102	363
Apr	77	82	150	99	408
May	86	60	189	101	436
Jun	74	72	136	108	390
Jul	63	102	147	102	414
Aug	50	126	131	57	364
Sep	77	130	110	98	415
Oct	58	95	133	109	395
Nov	54	91	184	129	458
Dec	52	91	185	84	412
Total	803	1079	1657	1176	4715

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F statistic	P-value
Treatment	31,655.7292	3	10,551.9097	18.4293	6.8455e-08
Error	25,192.7500	44	572.5625		
Total	56,848.4792	47			

### Conclusion from Anova:

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the one or more categories are significantly different.

**NULL HYPOTHESIS IS REJECTED**

A statistically significant difference exists between the months of the year and the number of Category 1 and 2 occurrences.

A Tukey calculation was performed as an ad hoc test but was not conclusive. Standardising the scores produces the following Z scores for a mean of 98.229 and a standard deviation of 34.414:

	2015	2016	2017	2018	Sum of Z
Jan	-0.9655	0.225803	-0.41347	0.458264	-0.69496325
Feb	-0.9365	-1.2852	-0.00666	-0.7331	-2.96146363
Mar	-0.5006	-0.82027	0.342033	0.109572	-0.86930944
Apr	-0.6168	-0.47158	1.504341	0.022399	0.438286932
May	-0.3553	-1.11085	2.637591	0.080514	1.251902453
Jun	-0.7040	-0.76216	1.097533	0.283918	-0.08475161
Jul	-1.0236	0.109572	1.417168	0.109572	0.612633115
Aug	-1.4014	0.806956	0.952245	-1.19802	-0.84025174
Sep	-0.6168	0.923187	0.342033	-0.00666	0.641690812
Oct	-1.1689	-0.09383	1.01036	0.312976	0.060536869
Nov	-1.2852	-0.21006	2.492303	0.89413	1.891171791
Dec	-1.3433	-0.21006	2.521361	-0.41347	0.554517721

The months with values that are above the mean are shaded. The analysis would indicate that incidents of theft and vandalism are statistically more prevalent in the months of April, May, July, September, October, November and December. The month of November has a score significantly above the mean ( $n=1.89$ ) as the worst month for recorded occurrences. Conversely, incidents of theft and vandalism are less likely to occur in February, with a Z score of  $-2.96$  ( $n=-2.96$ ) below the mean.

***RSR H<sub>011</sub>: No significant differences exist between the days of the week and Category 1 and 2 occurrences.***

Using statistical tests to check if there is a significant difference between the number of Category 1 and 2 occurrences and the days of the week, split into the variables for the study-year periods (2015-2018) and the days of the week (Sunday – Saturday).

The null hypothesis is that no significant difference exists between the days of the week for the number of Category 1 and 2 occurrences.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

Cat 1+2	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Total
2015	105	103	114	124	138	111	108	803
2016	116	160	173	174	160	161	135	1079
2017	207	227	233	243	278	257	212	1657
2018	130	169	178	171	191	160	177	1176
Total	558	659	698	712	767	689	632	4715

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F statistic	P-value
Treatment	6,584.4286	6	1,097.4048	0.4024	0.8691
Error	57,274.2500	21	2,727.3452		
Total	63,858.6786	27			

**Conclusion from Anova:**

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the treatments are not significantly different for that level of significance.

**NULL HYPOTHESIS IS NOT REJECTED**

No significant difference exists between the days of the week for the number of Category 1 and 2 occurrences.

***RSR H<sub>012</sub>: No significant differences exists between the time of day and Category 1 and 2 occurrences.***

Using statistical tests to check if there is a significant difference in the number of Category 1 and 2 occurrences, happening over the course of a day, split into the variables for the study year periods (2015-2018) and four-hour segments.

The null hypothesis that no significant difference exists between the time of day and the number of Category 1 and 2 occurrences.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

4-hour segments	0:00 - 04:00	04:00 - 08:00	08:00 - 12:00	12:00 - 16:00	16:00 - 20:00	20:00 - 0:00	Totals
2015	71	182	168	157	133	92	803
2016	89	206	205	204	197	178	1079
2017	129	316	293	301	277	341	1657
2018	95	254	238	225	199	165	1176
Totals	384	958	904	887	806	776	4715

One-way ANOVA:

Source	Sum of Squares SS	Degrees of Freedom vv	Mean Square MS	F statistic	P-value
Treatment	53,953.2083	5	10,790.6417	2.5890	0.0621
Error	75,020.7500	18	4,167.8194		
Total	128,973.9583	23			

**Conclusion from Anova:**

The p-value corresponding to the F-statistic of one-way ANOVA is higher than 0.05, suggesting that the categories are not significantly different for that level of significance.

NULL HYPOTHESIS IS NOT REJECTED

A statistically insignificant difference exists between the time of day and the number of Category 1 and 2 occurrences. This would suggest that the occurrences of theft and vandalism is rife and happens through the day.

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## 5.4 THE EFFECT OF OCCURRENCES OF THEFT AND VANDALISM ON TRAIN OPERATIONS

Answering research question Q4.

Table 31: Train service information, displays the commuter rail yearly train service information for the reporting years 2011/12 to 2018/19. The average train set availability at March 2019 was at 42, which is 48% of the number of train sets required to run an efficient service.

Delays during the peak period has increased by 24% from 809 delayed services in 2011/12 to 1006 delayed services in 2018/19. Similarly, delays during the off-peak period has increased by 100% from 1579 delayed services in 2011/12 to 3173 delayed services in 2018/19.

The overall train service has deteriorated significantly with only 47.8% of trains running on-time during the peak period.

**Table 31: Train service information**

Train Service Information	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Train sets required	88	88	88	88	88	88	88	88
Average train set availability	**	**	83	85	79	71	49	42
Train sets correctly configured	**	**	**	**	**	**	**	16
Delays (Peak)	809	635	857	1058	990	1020	1156	1006
Delays (Off Peak)	1579	1192	676	2168	2060	2273	3316	3173
Cancellations (Peak)	145	32	91	154	180	484	895	477
Cancellations (Off Peak)	103	42	78	143	208	634	1338	1109
% On Time (Peak)	75.7%	81.5%	75.3%	70.2%	71.7%	66.8%	53.7%	47.8%
% On Time (Off Peak)	82.6%	87.0%	82.5%	77.6%	78.4%	74.8%	58.9%	54.6%

\*\* Data not available

The regional train performance in Table 32: Regional train performance, shows the number of scheduled trains at an all-time low of 155502 scheduled trains, at the end of the 2018/19 reporting year. The total number of cancelled services increased by 181% in 2015/16 from 6829 to 19223 cancelled services. Similarly, the total number of delayed services increased from 20129 trains in 2009/10 to 67541 trains in 2017/18. Overall only 57% of all scheduled services run on-time.

**Table 32: Regional train performance**

Year	Scheduled	Cancelled	Delayed	% Trains cancelled	% Trains right time
2009/2010	197,081	2,772	20,129	1.39%	90%
2010/2011	199,362	7,372	25,470	3.78%	87%
2011/2012	195,193	4,731	38,532	2.43%	80%
2012/2013	194,971	1,265	29,731	0.65%	85%
2013/2014	204,087	3,408	41,028	1.67%	79%
2014/2015	206,599	5,421	51,421	2.61%	74%
2015/2016	205,713	6,829	48,477	3.33%	76%
2016/2017	200,957	19,223	51,765	9.59%	71%
2017/2018	198,477	37,542	67,541	18.87%	57%
2018/2019	155,502	24,761	62,218	16.12%	52%

Patronage and ticket issue data is summarised in Table 33: Patronage & ticket issues), for the reporting years 2011/2012 till 2018/19. Patronage has shrunk by -75% from a high of 185520887 (n=185520887) in 2013/14 to a low of 46986046 (n=46986046) in 2018/19. Similarly, ticket sales show a decline for the same period of -64% from a high of 32478907 (n=32478907) to a low of 11715433 (n=11715433) ticket issues. Metro Plus ticket issues have fallen by 79% from its high in 2013/14 of 4240058 (n=4240058) ticket issues to only 872537 (n=872537) issues in 2018/19.

**Table 33: Patronage & ticket issues**

Patronage & Ticket Issues - Yearly Trend								
CATEGORY	2011/2012	2012/2013	2013/2014	2014/2015	2015/16	2016/17	2017/18	2018/19
Patronage	173,969,013	180,409,642	185,520,887	174,934,932	162,997,599	127,745,294	75,121,677	46,986,046
Total Issues	32,784,367	31,231,302	32,478,907	31,246,175	28,932,898	24,254,440	15,899,058	11,715,433
Single Issues	22,925,133	22,392,198	23,148,588	22,821,546	21,398,231	18,660,559	12,740,582	9,766,107
Return Issues	5,014,577	4,390,964	4,521,096	4,078,683	3,568,382	2,655,918	1,567,230	960,867
Weekly	3,283,755	2,747,602	2,913,518	2,614,357	2,284,824	1,613,818	812,786	522,512
Monthly	1,560,902	1,700,538	1,895,705	1,731,589	1,681,461	1,324,145	778,460	465,947

### 5.4.1 Hypothesis tests $H_014 - H_016$

***RSR  $H_014$ : Zero correlation exists between Category 1 and 2 occurrences and trains scheduled.***

To determine if there is any relationship between the number of Category 1 and 2 occurrences and trains scheduled, stating the null hypothesis; zero correlation exists between the number of Category 1 and 2 occurrences and the number of trains scheduled.

Therefore:

Year	Cat 1 + 2	Trains Scheduled
2016	1079	44309
2017	1657	43673
2018	1176	34835
Totals	3912	122817

(X-Xbar)	(Y-Ybar)	Xbar x Ybar	(X-Xbar) <sup>2</sup>	(Y-Ybar) <sup>2</sup>
-225	3370	-758250	50625	11356900
353	2734	965102	124609	7474756
-128	-6104	781312	16384	37258816
0	0	988164	191618	56090472

Therefore:

Xbar	1304
Ybar	40939
n-1	2
Sum	988164
Covariance	494082
Sx	309.53029
Sy	28045236
r	0.301416

“r” = 0.301416, therefore a weak to moderate positive correlation exists. The scatterplot in Figure 30: Trains scheduled vs occurrences scatterplot, displays this weak-to-moderate positive linear relationship. The weak positive correlation is inconclusive, and it cannot be inferred with any confidence that there is a linear relationship between Category 1 and 2 occurrences and the number of trains

scheduled. This could indicate that other factors may be influencing the number of trains scheduled, and not solely occurrences of theft and vandalism.

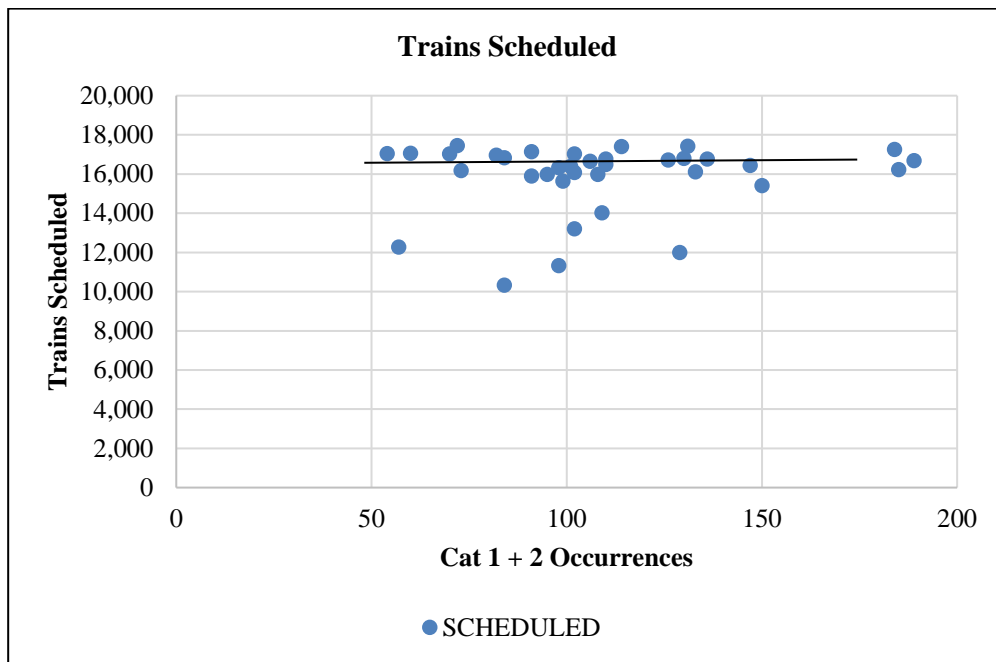


Figure 30: Trains scheduled vs occurrences scatterplot

***RSR H<sub>015</sub>: Zero correlation exists between Category 1 and 2 occurrences and trains cancelled.***

To determine if there is any relationship between the number of Category 1 and 2 occurrences and trains cancelled, stating the null hypothesis; zero correlation exists between the number of Category 1 and 2 occurrences and the number of trains cancelled.

Therefore:

Year	Cat 1 + 2	Trains Cancelled
2016	1079	17817
2017	1657	27568
2018	1176	34076
Totals	3912	79461

(X-Xbar)	(Y-Ybar)	Xbar x Ybar	(X-Xbar) <sup>2</sup>	(Y-Ybar) <sup>2</sup>
-225	-8670	1950750	50625	75168900
353	1081	381593	124609	1168561
-128	7589	-971392	16384	57592921
0	0	1360951	191618	133930382

Therefore:

Xbar	1304
Ybar	26487
n-1	2
Sum	1360951
Covariance	680475.5
Sx	309.53029
Sy	66965191
r	0.2686487

“r” = 0.2686487, therefore a weak positive correlation exists.

The scatterplot in Figure 31: Trains cancelled vs occurrences scatterplot) displays this weak positive linear relationship, with points loosely distributed around the trend-line. The weak positive correlation is inconclusive, and it cannot be inferred with any confidence that there is a linear relationship between Category 1 and 2 occurrences and the number of trains cancelled.

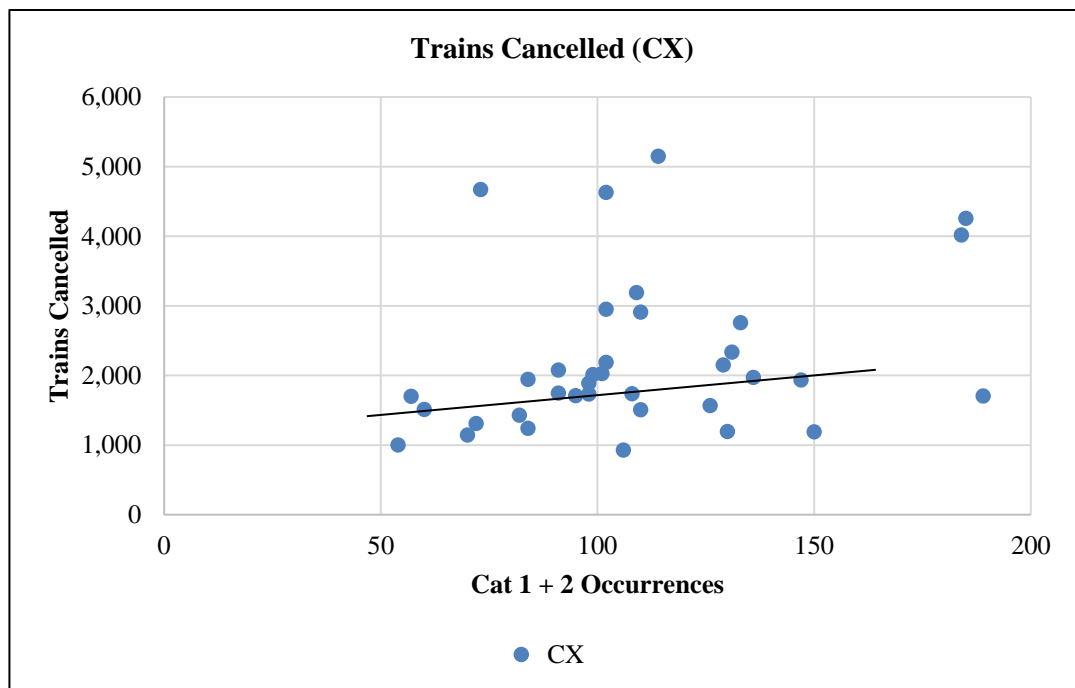


Figure 31: Trains cancelled vs occurrences scatterplot

***RSR H<sub>0</sub>16: Zero correlation exists between Category 1 and 2 occurrences and trains delayed.***

To determine if there is any relationship between the number of Category 1 and 2 occurrences and trains delayed, stating the null hypothesis; zero correlation exists between the number of Category 1 and 2 occurrences and the number of trains delayed.

Therefore:

Year	Cat 1 + 2	Trains Delayed
2016	1079	50358.656
2017	1657	59984.69
2018	1176	69587.34
Totals	3912	179930.69

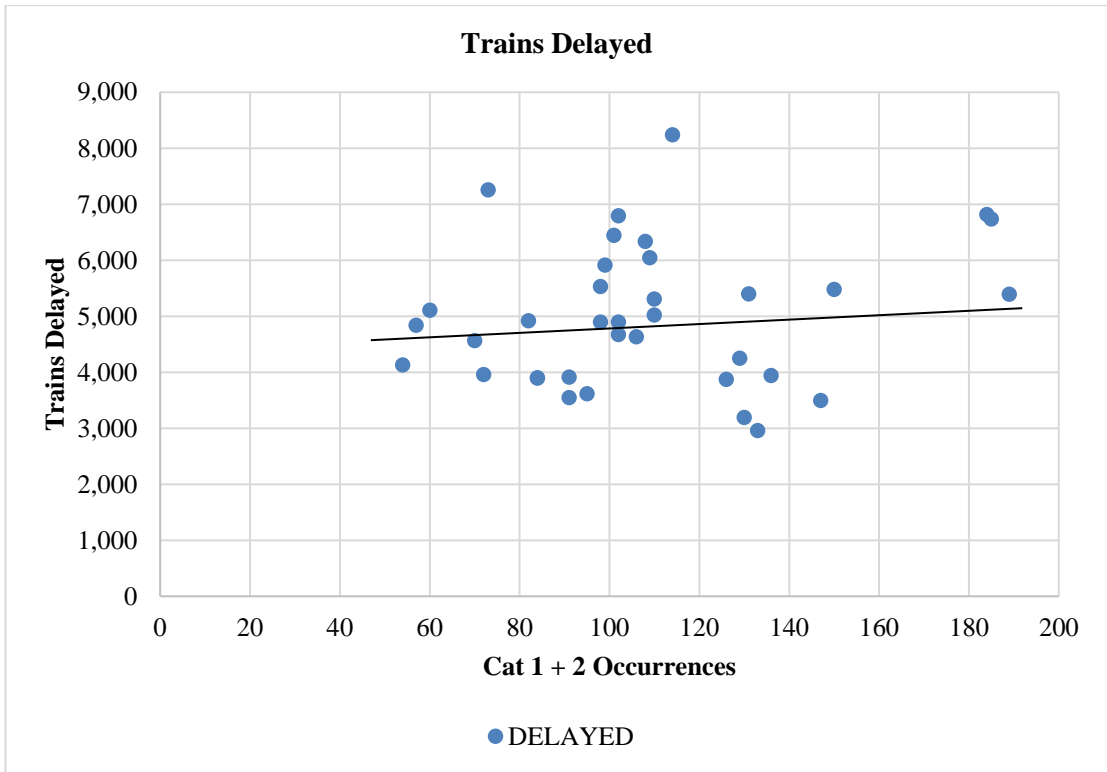
(X-Xbar)	(Y-Ybar)	Xbar x Ybar	(X-Xbar) <sup>2</sup>	(Y-Ybar) <sup>2</sup>
-225	-9618.239	2164103.8	50625	92510526
353	7.7949974	2751.6341	124609	60.761985
-128	9610.4442	-1230137	16384	92360638
0	0	936718.6	191618	184871225

Therefore:

Xbar	1304
Ybar	59976.895
n-1	2
Sum	936718.6
Covariance	468359.3
Sx	309.53029
Sy	92435612
r	0.1573825

“r” = 0.1573825, therefore a weak positive correlation exists.

The scatterplot in Figure 32: Trains delayed vs occurrences scatterplot displays this weak-to-moderate positive linear relationship, with points loosely distributed around the trend-line. The weak positive correlation is inconclusive, and it cannot be inferred with any confidence that there is a linear relationship between Category 1 and 2 occurrences and the number of trains delayed.



**Figure 32: Trains delayed vs occurrences scatterplot**

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## 5.5 THE SPATIAL CONCENTRATIONS OF CATEGORY E-A OCCURRENCES

Answering research question Q5.

Commuter routes account for 94% of all pedestrian-rail occurrences in the research region, compared to 60% as found by (Savage, 2015) with the balance of occurrences belonging to the freight and long-distance rail operators. A total of 75% of occurrences were recorded at stations and 25% along line sections, compared to the 60% unintentional deaths at crossings and stations and 48% unintentional deaths along line-sections found by (Savage, 2015).

Table 34: Category E-a top 20 locations, shows the top 20 locations that have the most E-a occurrences over the research period. The section of the line between Bonteheuwel Station and Khayelitsha Station has seven stations within the top 10 worst locations. Interestingly, Philippi, Nyanga and Nolungile Stations all show zero E-a occurrences for 2018. Similarly, for the year 2018, Bonteheuwel and Heideveld Stations show an improvement by recording only four E-a occurrences between them.

The first area, along the Philippi to Nyanga Station corridor is the site where the entire corridor was walled off with a concrete fence. This countermeasure has proved effective in reducing the number of E-a occurrences to zero in 2018. The second area at Bonteheuwel Station, part of the notorious Bonteheuwel-Lavistown-Netreg split that has been subject to intense enforcement measures to combat rampant theft of rail assets in the area. The enforcement measures may have had a positive effect on the number of pedestrian-rail occurrences as well.

Northern Line stations also feature prominently with Parow, Elsies River, Bellville and Kuils River Stations all recording more than nine occurrences over the period. Closer to the CBD, Salt River, Woodstock and Esplanade Stations are hot-spot areas for E-a occurrences. In Stellenbosch Municipality, Du Toit and Klapmuts Station areas are worst performing and in the Drakenstein Municipality, Mbekweni Station has nine occurrences. The network wide hot-spot map for E-a occurrences is shown in Figure 33 Category E-a occurrences hot-spot map.

**Table 34: Category E-a top 20 locations**

	<b>Station Area</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>Totals</b>	<b>%</b>	<b>Cum %</b>
1	Philippi Station	6	10	11	0	27	4.5%	4.5%
2	Nyanga Station	6	9	7	0	22	3.7%	8.2%
3	Bonteheuwel Station	5	7	6	2	20	3.4%	11.6%
4	Kraaifontein Station	3	3	6	8	20	3.4%	14.9%
5	Heideveld Station	2	5	7	2	16	2.7%	17.6%
6	Nolungile Station	4	6	5	0	15	2.5%	20.1%
7	Woodstock Station	3	4	2	6	15	2.5%	22.7%
8	Khayelitsha Station	4	3	6	1	14	2.3%	25.0%
9	Nonkqubela Station	3	5	3	1	12	2.0%	27.0%
10	Bellville Station	1	3	4	2	10	1.7%	28.7%
11	Langa Station	2	3	4	1	10	1.7%	30.4%
12	Elsies River Station	1	4	1	3	9	1.5%	31.9%
13	Kuils River Station	3	2	3	1	9	1.5%	33.4%
14	Mbekweni Station	1	1	0	7	9	1.5%	34.9%
15	Parow Station	4	3	2	0	9	1.5%	36.4%
16	Salt River Station	1	3	1	4	9	1.5%	37.9%
17	Du Toit Station	2	3	2	1	8	1.3%	39.3%
18	Esplanade Station	2	3	1	2	8	1.3%	40.6%
19	Klapmuts Station	2	1	1	4	8	1.3%	41.9%
20	Lentegeur Station - Philippi Station	3	0	2	3	8	1.3%	43.3%

## Category E-a Hotspot Map

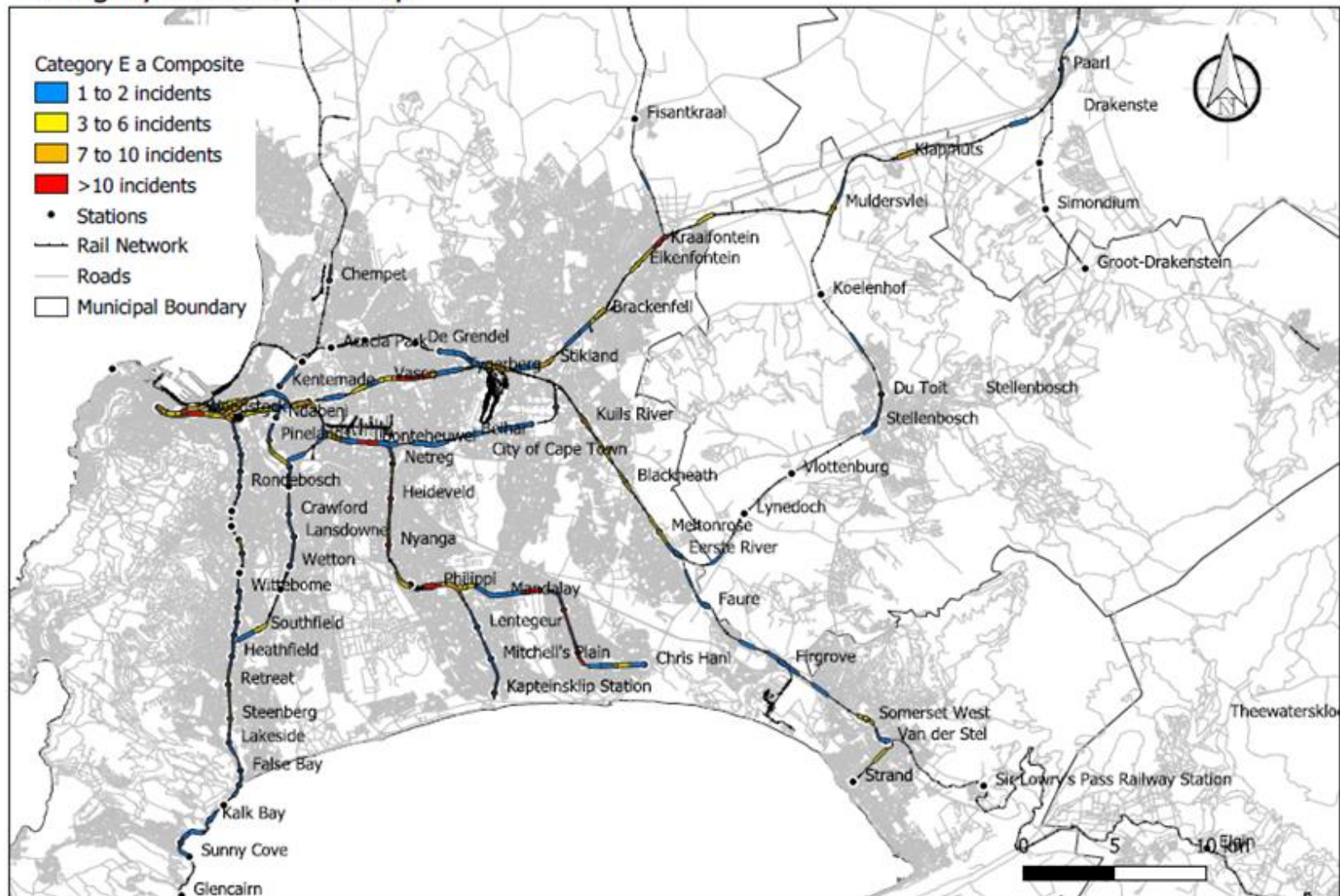


Figure 33 Category E-a occurrences hot-spot map

## 5.6 THE SPATIAL CONCENTRATIONS OF FATALITIES AND INJURY OCCURRENCES

Answering research question Q6.

### *Fatalities*

The top five locations for pedestrian-rail fatalities have all recorded more than 10 fatalities over the research period. Nyanga (n=18), Kraaifontein (n=15), Heideveld (n=13) and Philippi (n=13) and Khayelitsha (n=11) Stations are the worst performing. (See Table 35: Category E-a fatalities – Top 20 location). The fatality rate for the stations listed above have all shown improvement in 2018 with all stations recording zero fatalities for the year, apart from Kraaifontein Station where the fatality rate has increased to six (n=6) over 2018. The section of line between Kraaifontein Station and Muldersvlei Station also shows an increase in fatalities in 2018, indicating that this is becoming a high-risk area.

**Table 35: Category E-a fatalities – Top 20 location**

	Station Area	2015	2016	2017	2018	Totals	%	Cum %
1	Nyanga Station	6	6	6	0	18	5.5%	5.5%
2	Kraaifontein Station	3	1	5	6	15	4.5%	10.0%
3	Heideveld Station	2	6	5	0	13	3.9%	13.9%
4	Philippi Station	2	6	5	0	13	3.9%	17.9%
5	Khayelitsha Station	3	3	5	0	11	3.3%	21.2%
6	Bonteheuwel Station	4	5	1	0	10	3.0%	24.2%
7	Bellville Station	1	2	2	2	7	2.1%	26.4%
8	Lentegeur Station - Philippi Station	3	0	2	2	7	2.1%	28.5%
9	Kraaifontein Station - Muldersvlei Station	1	1	1	3	6	1.8%	30.3%
10	Kuils River Station	2	1	2	0	5	1.5%	31.8%
11	Langa Station	1	1	3	0	5	1.5%	33.3%
12	Netreg Station	2	2	1	0	5	1.5%	34.8%
13	Nolungile Station	1	2	2	0	5	1.5%	36.4%
14	Nyanga Station - Philippi Station	1	3	0	1	5	1.5%	37.9%
15	Ysterplaat Station	0	3	1	1	5	1.5%	39.4%
16	Blackheath Station - Kuils River Station	0	0	1	3	4	1.2%	40.6%
17	Cape Town Station	1	3	0	0	4	1.2%	41.8%
18	Elsies River Station	1	1	1	1	4	1.2%	43.0%
19	Klapmuts Station	2	0	0	2	4	1.2%	44.2%
20	Koeberg Road Station	1	1	2	0	4	1.2%	45.5%

The network wide E-a fatalities hot-spot map is shown in Figure 34: Category E-a fatalities hot-spot map.

### Category E-a Fatalities Hotspot Map

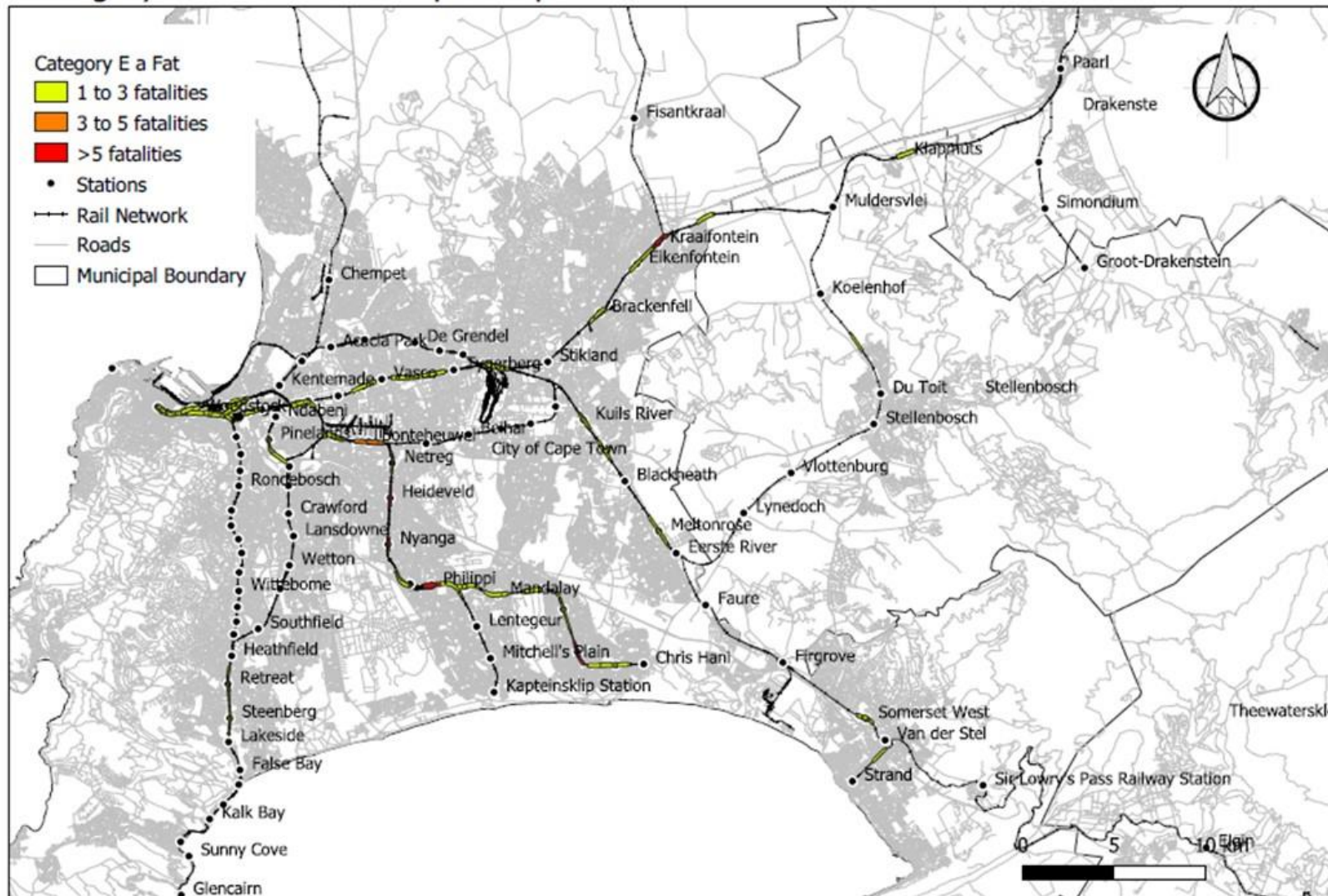


Figure 34: Category E-a fatalities hot-spot map

## *Injuries*

The worst locations for injuries related to E-a occurrences are shown in Table 36: Category E-a injuries top 20 locations. Philippi Station has the greatest number of occurrences (n=14) but shows an improvement in 2018 with zero (n=0) occurrences. Woodstock Station in the City as well as the section of line running through Paarl have the highest number of injuries (n=4 each) for 2018. Woodstock Station is a popular boarding and alighting station for fare evaders. Kenilworth Station also has four (n=4) injury occurrences in 2018 after having recorded zero (n=0) injuries the previous reporting years. The network wide E-a injuries hot-spot map is shown in Figure 35: Category E-a injuries hot-spot map.

**Table 36: Category E-a injuries top 20 locations**

	<b>Station Area</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>Totals</b>	<b>%</b>	<b>Cum %</b>
1	Philippi Station	4	4	6	0	14	5.7%	5.7%
2	Bonteheuwel Station	1	2	4	2	9	3.6%	9.3%
3	Nolungile Station	3	4	2	0	9	3.6%	13.0%
4	Woodstock Station	1	4	0	4	9	3.6%	16.6%
5	Du Toit Station	2	3	2	1	8	3.2%	19.8%
6	Dal Josafat Station - Mbekweni Station	0	1	1	4	6	2.4%	22.3%
7	Nonkqubela Station	1	3	2	0	6	2.4%	24.7%
8	Bellville Station	0	1	4	0	5	2.0%	26.7%
9	Elsies River Station	0	3	0	2	5	2.0%	28.7%
10	Esplanade Station	2	2	1	0	5	2.0%	30.8%
11	Heideveld Station	0	1	2	2	5	2.0%	32.8%
12	Maitland Station	2	2	0	1	5	2.0%	34.8%
13	Parow Station	3	2	0	0	5	2.0%	36.8%
14	Stikland Station	1	2	1	1	5	2.0%	38.9%
15	Blackheath Station	1	0	3	0	4	1.6%	40.5%
16	Brackenfell Station	0	0	1	3	4	1.6%	42.1%
17	Kenilworth Station	0	0	0	4	4	1.6%	43.7%
18	Kraaifontein Station	0	2	0	2	4	1.6%	45.3%
19	Langa Station	1	1	1	1	4	1.6%	47.0%
20	Melton Rose Station	1	0	2	1	4	1.6%	48.6%

## Category E-a Injuries Hotspot Map

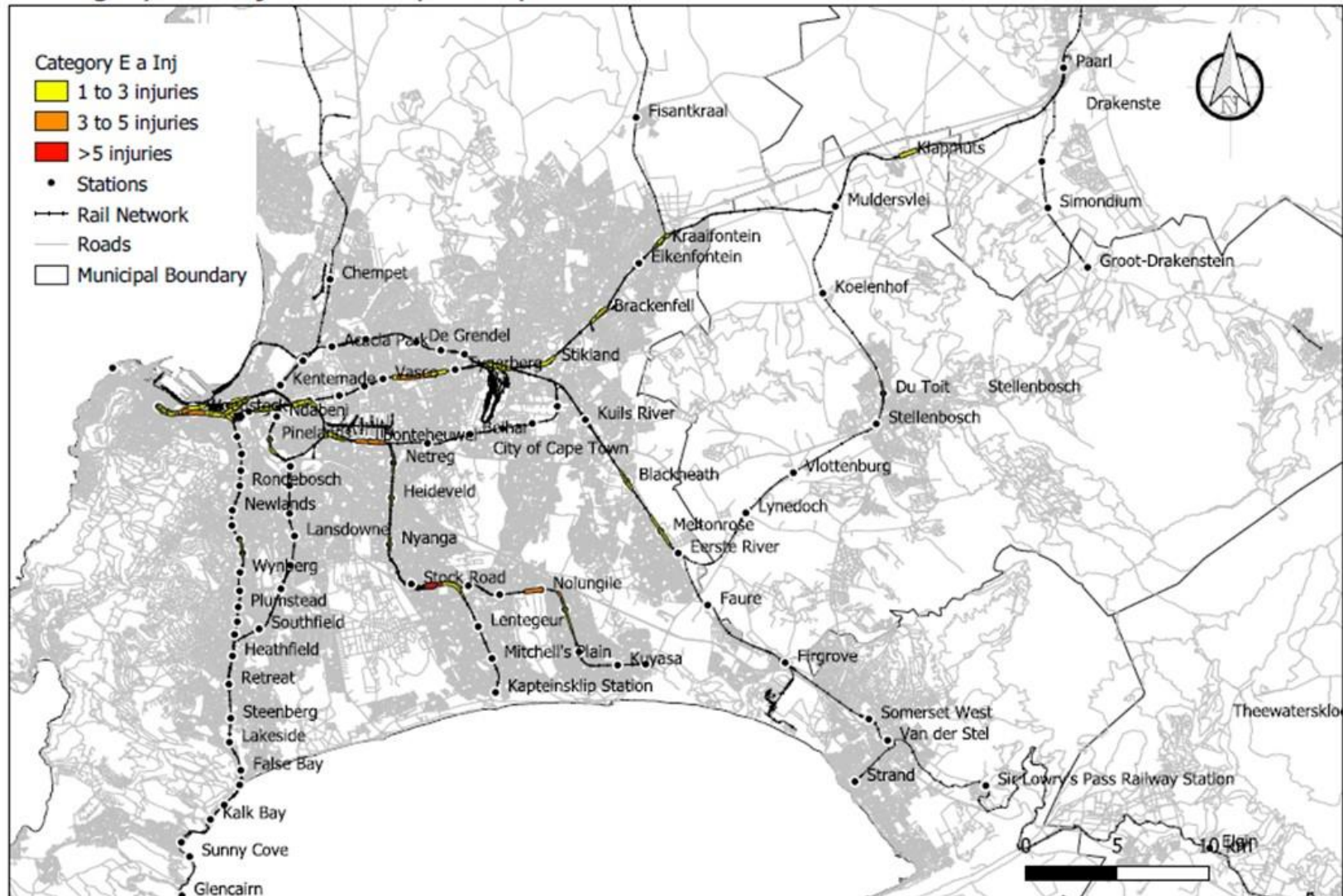


Figure 35: Category E-a injuries hot-spot map

## 5.7 THE SPATIAL CONCENTRATIONS OF CATEGORY 1 AND 2 OCCURRENCES

Answering research question Q7.

An analysis of the top 40 locations for theft and vandalism for 2018 reveals that 45% of occurrences took place at stations and 55% along line sections. Terminal stations, and stations that have a siding, yard or depot attached are regularly targeted, with Cape Town, Bellville, Kraaifontein, Wellington and Chris Hani Stations all featuring in the top 10.

The hot-spot locations for the combined Category 1 and Category 2 occurrences for theft and malicious damage to rail infrastructure is shown in Table 37: Combined Category 1 & 2 occurrences – Top 20 locations. Cape Town and Paarden Eiland Stations account for the most occurrences overall within the CBD region (n= 354 and n=247 respectively).

**Table 37: Combined Category 1 & 2 occurrences – Top 20 locations**

	Locations	2015	2016	2017	2018	Totals	%	Cum %
1	Cape Town Station	55	106	117	76	354	7.5%	7.5%
2	Paarden Eiland Station	40	112	82	13	247	5.2%	12.7%
3	Bonteheuwel Station - Netreg Station	33	84	83	15	215	4.6%	17.3%
4	Bellville Station	7	16	101	34	158	3.4%	20.7%
5	Bonteheuwel Station - Lavistown Station	31	45	56	8	140	3.0%	23.6%
6	Nyanga Station - Philippi Station	33	30	50	18	131	2.8%	26.4%
7	Chris Hani Station	7	19	78	19	123	2.6%	29.0%
8	Kraaifontein Station	10	20	56	27	113	2.4%	31.4%
9	Kapteinsklip Station	6	11	71	16	104	2.2%	33.6%
10	Belhar Station - Lavistown Station	37	32	29	4	102	2.2%	35.8%
11	Heideveld Station - Nyanga Station	21	43	31	6	101	2.1%	37.9%
12	Wellington Station	12	12	52	24	100	2.1%	40.0%
13	Cape Town Station - Woodstock Station	10	28	25	36	99	2.1%	42.1%
14	Heideveld Station - Netreg Station	15	20	31	17	83	1.8%	43.9%
15	Salt River Station	17	15	29	18	79	1.7%	45.6%
16	Lentegeur Station - Philippi Station	28	20	12	15	75	1.6%	47.2%
17	Worcester Station	3	9	20	22	54	1.1%	48.3%
18	Bonteheuwel Station - Langa Station	4	12	26	9	51	1.1%	49.4%
19	Langa Station - Mutual Station	3	5	25	18	51	1.1%	50.5%
20	Langa Station - Pinelands Station	4	9	22	16	51	1.1%	51.6%

The Central Line grouping of stations between Langa and Chris Hani cumulatively account for 1125 (n=1125) occurrences. The second largest grouping are those within the CBD accounting for 779 (n=779) occurrences. The third group

contains Bellville and Kraaifontein Stations who combined have 271 (n=271) occurrences.

The network wide combined Category 1 and 2 occurrences hot-spot map is shown in Figure 36: Category 1 + 2 medium and high occurrences hot-spot map. Individual hot-spot maps for all sub Category 1 and sub Category 2 occurrences were produced, and these are attached to this document in Appendix D.

## 5.8 THE CHARACTERISTICS OF THE COMBINED CATEGORY E-A, 1 AND 2 SPATIAL CONCENTRATIONS

Answering research question Q8.

Each location will be viewed in more detail with a description of the type of occurrences specific to the individual areas. The overall combined Category E-a, Category 1 and Category 2 hot-spot areas for the region is shown in Figure 37: All category hot-spot map – Metro.

### *Breede Valley*

The stations and section between Worcester and Chavonnes Stations have 26 Category 2-a occurrences mostly train windows being broken as a result of stone-throwing. (See Figure 38: All category hot-spot map – Breede Valley).

There are 16 occurrences of theft of train control equipment (see Table 38: Breede Valley occurrences) with the most targeted assets being cabling, relay rooms and electrical substations.

**Table 38: Breede Valley occurrences**

Location	1-a	1-b	1-c	1-e	1-g	1-i	2-a	2-c	2-g	E-a	Grand Total
Chavonnes Station	0	0	0	0	5	0	0	0	0	0	5
Chavonnes Station - Worcester Station	0	0	0	0	2	0	3	0	0	0	5
Worcester Station	6	1	4	5	9	1	23	3	2	2	56
Grand Total	6	1	4	5	16	1	26	3	2	2	66

### Category 1 + 2 Composite - Medium and High Occurrences Hotspot Map

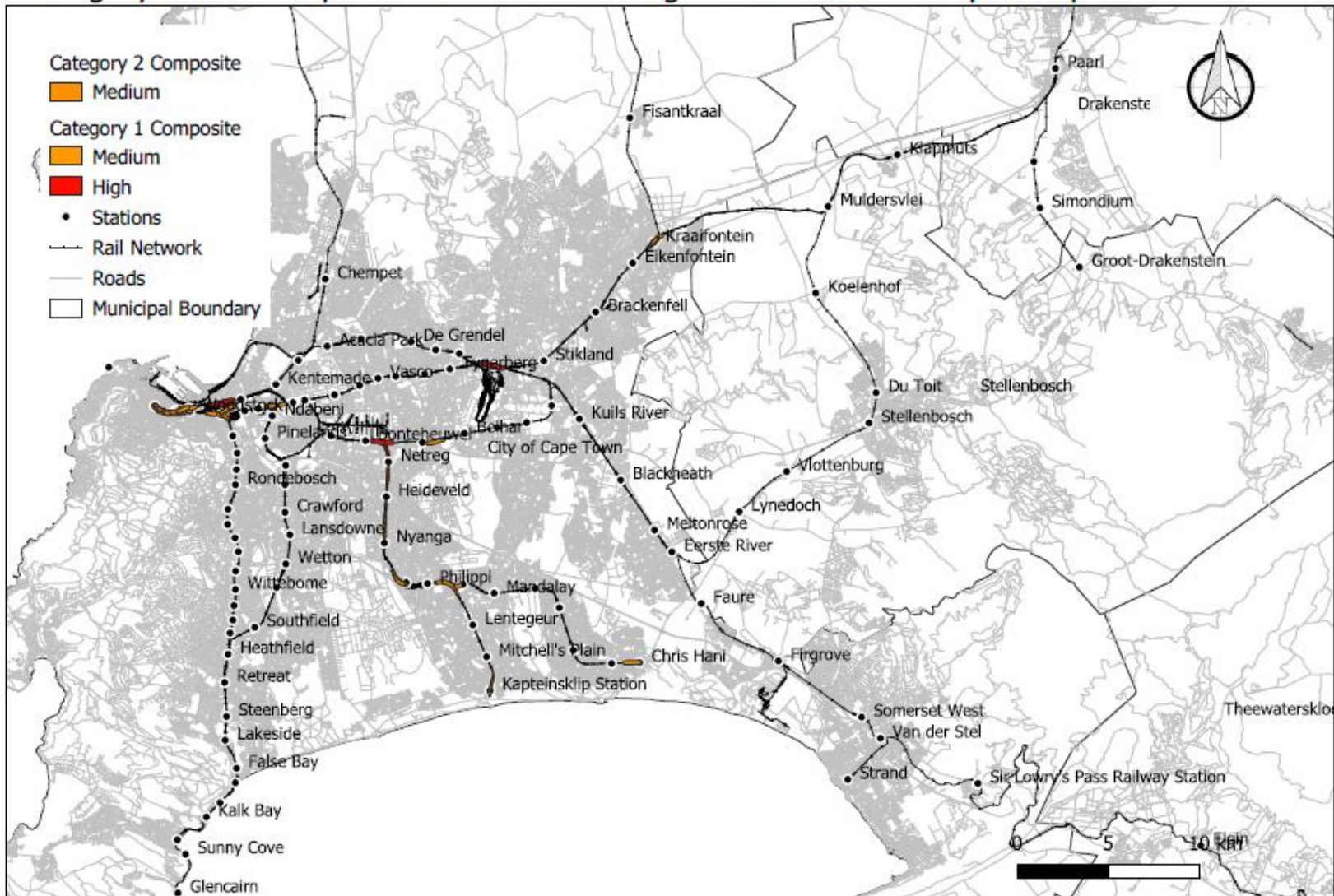


Figure 36: Category 1 + 2 medium and high occurrences hot-spot map

### All Category Hotspot Map

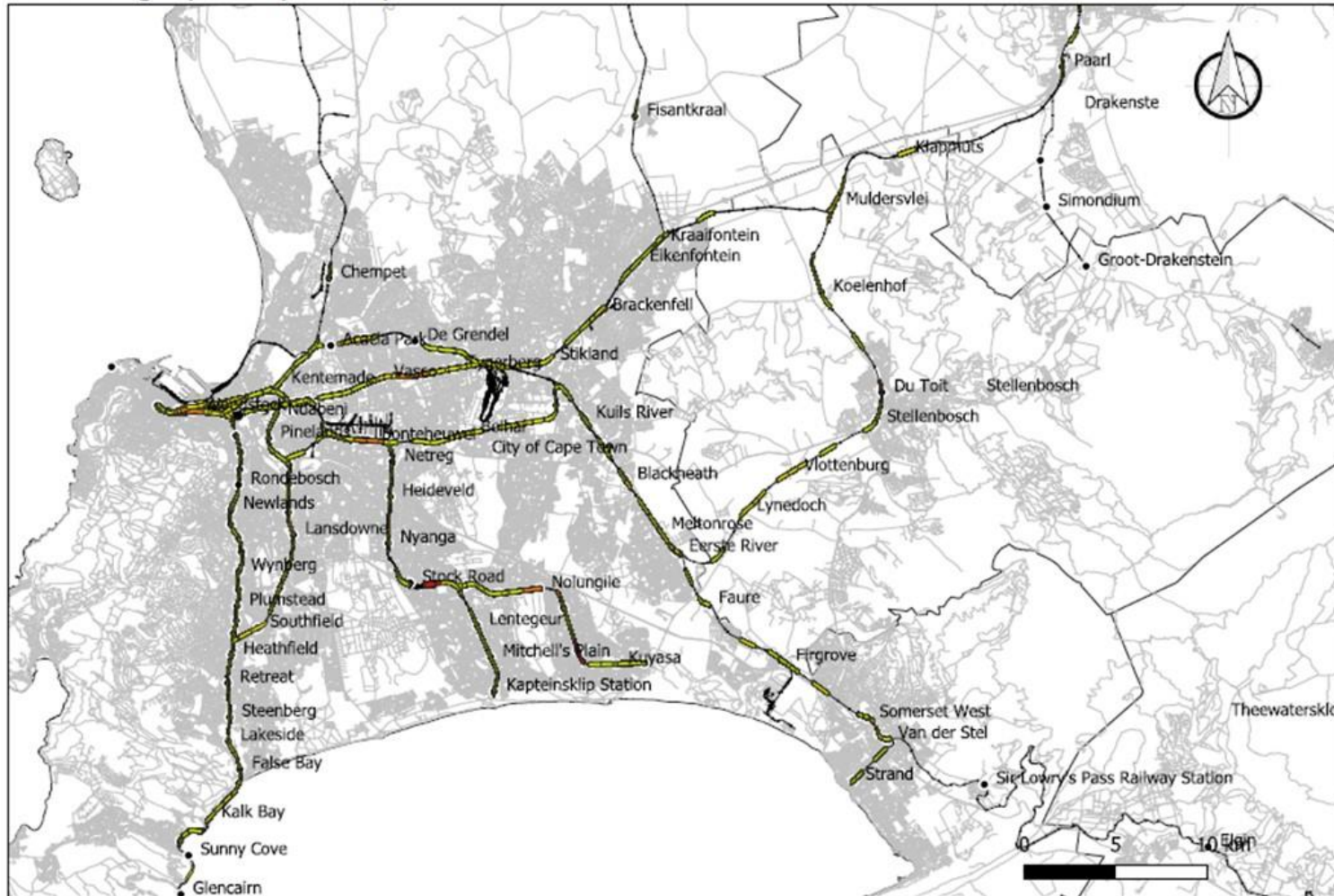


Figure 37: All category hot-spot map – Metro

### All Category Hot-Spot Map - Breede Valley

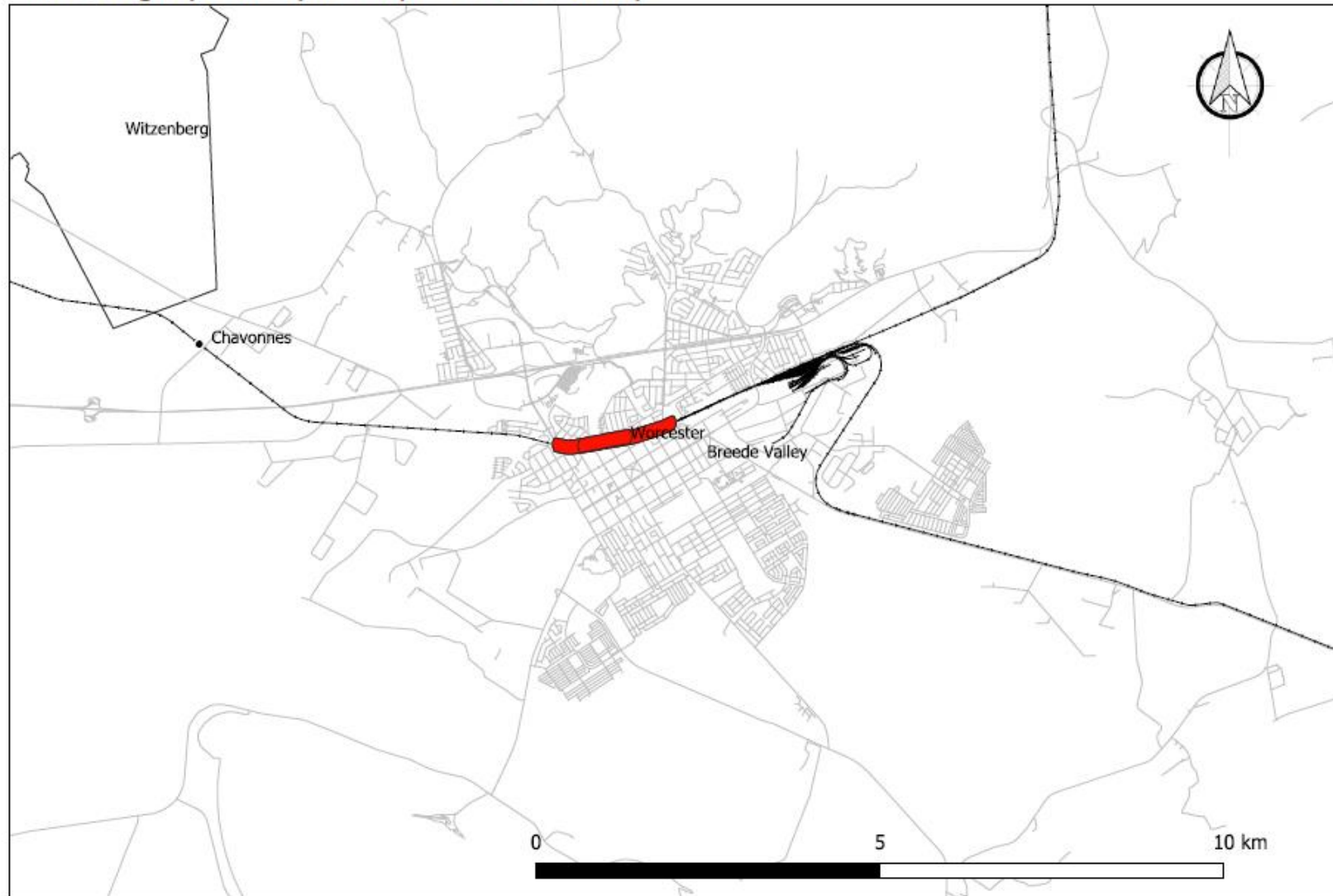


Figure 38: All category hot-spot map – Breede Valley

## ***Cape Flats***

The Cape Flats section is discussed in three areas as shown in Figure 39: All category hot-spot map – Cape Flats.

### **Area 1 – Netreg Station to Philippi Station**

Occurrences of theft of train control equipment is rife with 224 (n=224) incidents involving mainly the theft of signal cabling. (See Table 39: Cape Flats occurrences – Area 1). Track boxes and equipment inside apparatus cases also targeted.

The second most targeted group for incidents of theft are civil infrastructure components in section (Category 1-c) which include the theft of railway clips and springs, track box cages, transformers, apparatus cases and doors.

113 (n=113) E-a occurrences were recorded with Philippi and Nyanga Station’s accounting for more than half (n=62).

**Table 39: Cape Flats occurrences – Area 1**

Location	1-a	1-c	1-d	1-e	1-f	1-g	1-h	1-i	2-a	2-c	2-e	2-g	2-i	E-a	Grand Total
Heideveld Station	1	4	0	0	0	1	0	1	2	0	0	0	0	16	25
Heideveld Station - Netreg Station	1	19	0	6	0	35	0	0	4	6	6	6	0	1	84
Heideveld Station - Nyanga Station	0	9	0	3	0	72	0	0	2	2	1	12	0	8	109
Netreg Station	8	3	0	3	0	1	0	0	6	1	0	3	0	8	33
Nyanga Station	0	3	0	0	0	5	3	0	5	0	0	3	1	25	45
Nyanga Station - Philippi Station	4	10	0	4	0	82	0	0	7	8	0	16	0	14	145
Philippi Station	1	1	1	0	1	3	4	0	6	0	0	3	0	37	57
Philippi Station - Stock Road Station	1	2	0	1	0	25	0	0	1	1	0	8	0	4	43
Grand Total	16	51	1	17	1	224	7	1	33	18	7	51	1	113	541

### **Area 2 - Philippi Station to Chris Hani Station**

Category 1-a occurrences for theft of rolling stock components in section has 99 (n=99) occurrences over the period with 90 (n=90) of those recorded at Chris Hani Station. A review of the descriptions provided in the data shows that a number of incidents uses the term “...stolen on route from Chris Hani”, indicating that Chris Hani was the station where the train started its journey but is not necessarily an indication of exactly where the crime took place. The same applies to Category 2-a occurrences for Chris Hani Station. This significantly skews the data for Chris Hani Station.

### All Category Hot-Spot Map - Cape Flats

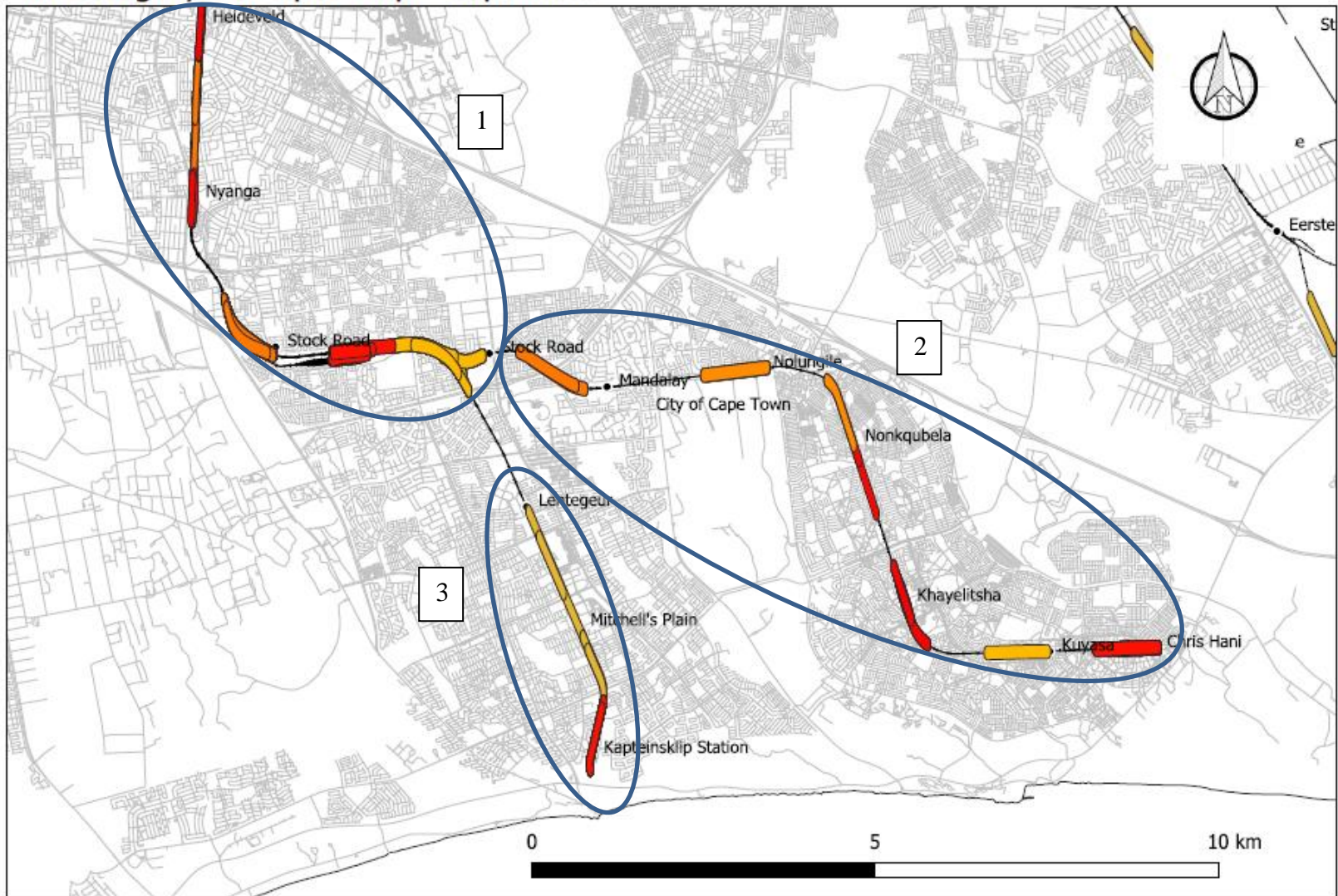


Figure 39: All category hot-spot map – Cape Flats

Nolungile, Khayelitsha and Nonkqubela Stations fair the worst for E-a occurrences with 41 (n=41) incidents. A review of the E-a occurrences showed that there were 20 fatalities and 17 injuries at the three stations concerned. (See Table 40: Cape Flats occurrences – Area 2).

**Table 40: Cape Flats occurrences – Area 2**

Location	1-a	1-c	1-d	1-e	1-g	1-i	2-a	2-c	2-e	2-g	2-h	2-i	E-a	Undefined	Grand Total
Chris Hani Station	90	1	1	0	1	1	24	4	0	1	0	0	1	2	126
Chris Hani Station - Kuyusa Station	0	2	0	0	0	0	1	1	0	2	0	0	1	0	7
Khayelitsha Station	8	0	0	0	0	0	1	0	0	2	0	1	14	1	27
Khayelitsha Station - Kuyusa Station	0	0	0	0	3	0	3	0	1	8	0	0	3	0	18
Khayelitsha Station - Nonkqubela Station	0	3	0	0	9	0	2	1	0	8	0	0	3	1	27
Kuyusa Station	0	0	0	0	0	1	0	0	0	0	0	0	5	1	7
Mandalay Station	1	0	0	0	0	2	1	1	0	0	0	1	3	1	10
Mandalay Station - Nolungile Station	0	0	0	0	6	0	0	1	0	7	0	0	1	2	17
Mandalay Station - Stock Road Station	0	6	0	2	24	0	0	2	0	12	0	0	1	0	47
Nolungile Station	0	0	0	0	3	0	0	0	0	0	1	1	15	2	22
Nolungile Station - Nonkqubela Station	0	1	0	0	5	0	0	0	0	0	0	0	2	2	10
Nonkqubela Station	0	0	0	0	2	0	1	1	0	0	0	1	12	3	20
Stock Road Station	0	0	0	0	1	0	1	4	0	1	0	0	5	0	12
Grand Total	99	13	1	2	54	4	34	15	1	41	1	4	66	15	350

### Area 3 – Philippi Station to Kapteinsklip Station

Similarly, to Chris Hani Station, Kapteinsklip is also a terminal station and all journey crimes get logged to it, without knowing where exactly the incident took place en route to its destination. Category 1-g occurrences related to train control equipment has 80 (n=80) recorded incidents with majority of them taking place in section between Lentegeur and Philippi Stations, which also has eight (n=8) Category E-a occurrences. (See Table 41: Cape Flats occurrences – Area 3). Seven fatalities were recorded between Lentegeur and Philippi Stations with six of the seven fatalities all as a result of being struck by a train.

**Table 41: Cape Flats occurrences – Area 3**

Location	1-a	1-b	1-c	1-d	1-e	1-g	1-h	1-i	2-a	2-b	2-c	2-e	2-g	2-i	E-a	Undefined	Grand Total
Kapteinsklip Station	58	0	0	1	0	5	3	0	34	0	1	0	1	1	0	0	104
Kapteinsklip Station - Mitchell's Plain	1	0	11	0	0	12	0	0	0	0	0	0	5	0	1	1	31
Lentegeur Station	0	1	0	0	0	0	3	2	1	0	0	0	2	1	3	1	14
Lentegeur Station - Mitchell's Plain Station	0	0	7	0	0	16	0	0	2	1	0	1	6	0	0	0	33
Lentegeur Station - Philippi Station	0	0	7	0	2	47	0	0	4	0	1	1	13	0	8	1	84
Mitchell's Plain Station	1	0	1	0	0	0	0	0	0	0	0	0	0	1	2	1	6
Grand Total	60	1	26	1	2	80	6	2	41	1	2	2	27	3	14	4	272

## ***Ikapa***

The results for the Ikapa area are divided into six areas as shown in Figure 40:

All category hot-spot map – Ikapa.

### Area 1 – Cape Town Station to Salt River Station, Cape Town Station to Ysterplaat

With Cape Town being a terminal station, all journey crimes on rolling stock are attributed to the location the theft or damage was discovered. Cape Town Station therefore has a disproportionate number of Category 1-a (n=181) and Category 2-a (n=145) occurrences. (See Table 42: Ikapa occurrences – Area 1).

The area includes the major train staging yard at Paarden Eiland which is the location for all Category 1-b occurrences of theft of rolling stock components in yard (n=186).

Theft and damage of train control equipment has 145 and 42 occurrences recorded mainly between Cape Town and Salt River Stations.

Woodstock Station has 15 Category E-a occurrences, including four fatalities and nine injuries.

**Table 42: Ikapa occurrences – Area 1**

Location	1-a	1-b	1-c	1-d	1-g	1-h	1-i	2-a	2-b	2-c	2-d	2-g	2-h	2-i	E-a	Undefined	Grand Total
Cape Town Station	181	0	2	0	15	0	1	145	0	2	0	6	0	2	7	9	370
Cape Town Station - Esplanade Station	0	0	1	0	2	0	0	1	0	1	0	0	0	0	0	0	5
Cape Town Station - Paarden Eiland Station	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Cape Town Station - Woodstock Station	1	1	2	0	70	0	0	5	3	0	0	17	0	0	4	2	105
Esplanade Station	4	12	1	0	1	0	1	2	2	1	0	2	0	1	8	2	37
Esplanade Station - Paarden Eiland Station	0	0	4	0	5	0	0	0	0	1	0	2	0	0	0	0	12
Esplanade Station - Ysterplaat Station	1	0	5	0	3	0	0	0	0	0	0	1	0	0	1	0	11
Paarden Eiland Station	8	186	0	0	1	2	0	1	48	0	0	0	1	0	3	1	251
Paarden Eiland Station - Ysterplaat Station	0	0	1	0	4	0	0	0	0	0	0	1	0	0	0	1	7
Salt River Station	2	45	1	1	3	2	0	3	19	0	1	2	0	0	9	0	88
Salt River Station - Woodstock Station	0	0	4	0	32	0	0	3	0	1	0	9	0	0	7	2	58
Woodstock Station	2	0	1	0	6	0	0	3	0	0	0	1	0	0	15	1	29
Ysterplaat Station	4	0	0	0	3	0	0	3	0	0	0	1	0	0	8	2	21
Grand Total	203	244	22	1	145	4	2	167	72	6	1	42	1	3	62	20	995

## All Category Hot-Spot Map - Ikapa

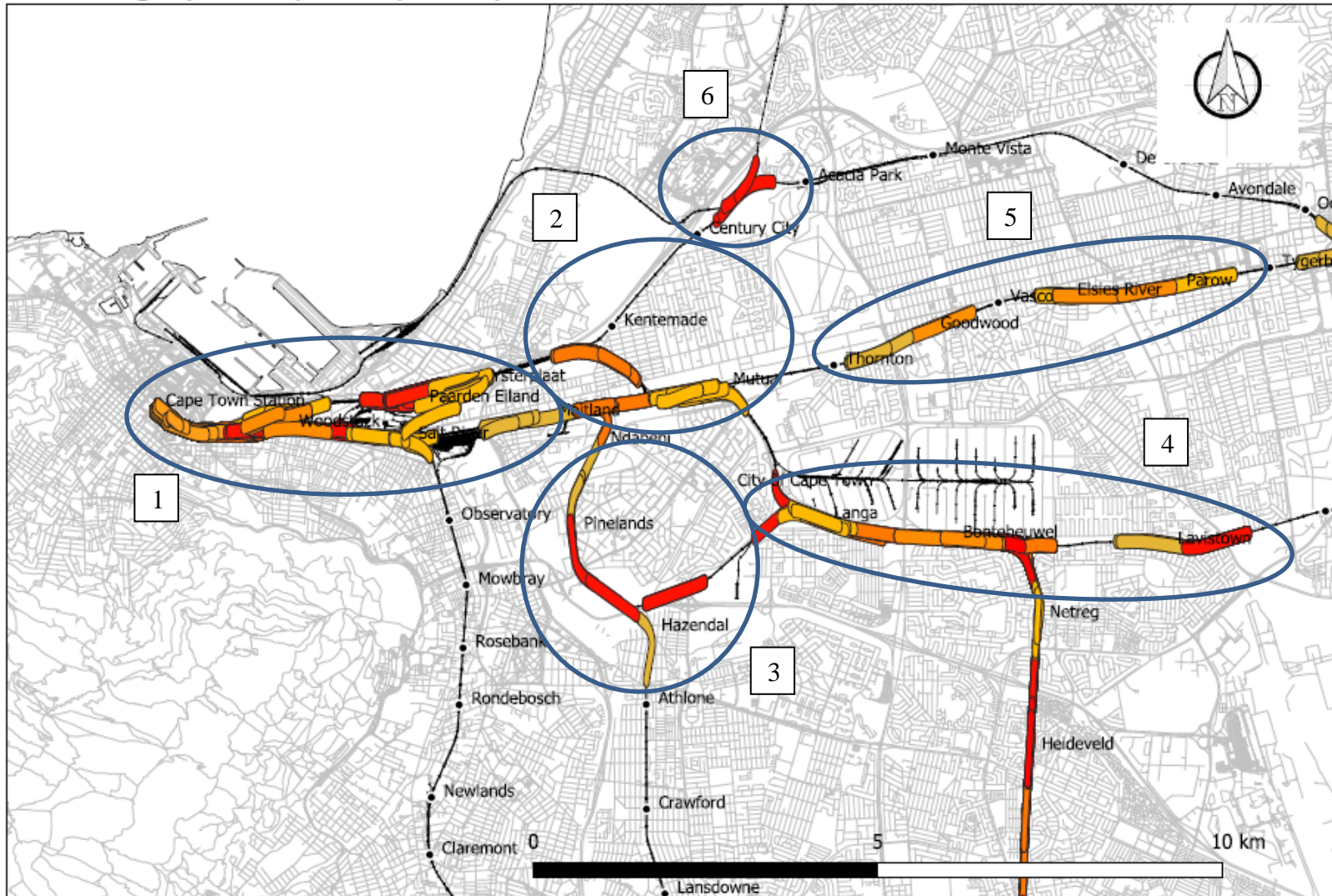


Figure 40: All category hot-spot map – Ikapa

Area 2 – Salt River Station to Mutual Station, Ysterplaat Station to Mutual Station, Maitland Station to Pinelands Station

Category 1-g and 2-g related to the theft and damage of train control equipment feature most prominently with 86 and 31 occurrences respectively. Control equipment theft regularly occurs in the sections between Maitland Station and Woltemade Station (n=23), Woltemade Station to Ysterplaat Station (n=12) and Mutual Station to Ysterplaat Station and Ndabeni Station to Pinelands Station with 10 occurrences each. (See Table 43: Ikapa occurrences – Area 2).

A total of eight (n=8) E-a occurrences were recorded at Mutual Station, six (n=6) at Maitland Station and five (n=5) at Koeberg Road Station. Combined the number of fatalities at the three stations amounted to nine (n=9), with eight (n=8) injuries.

**Table 43: Ikapa occurrences – Area 2**

Location	1-a	1-c	1-d	1-g	1-h	1-i	2-a	2-b	2-c	2-g	2-h	E-a	Undefined	Grand Total
Koeberg Road Station	3	0	0	1	0	2	3	0	0	0	0	5	3	17
Koeberg Road Station - Maitland Station	0	5	0	9	0	0	0	0	2	3	0	1	0	20
Maitland Station	1	4	0	3	2	1	1	1	1	1	1	6	1	23
Maitland Station - Mutual Station	1	1	0	2	0	0	0	0	0	0	0	0	0	4
Maitland Station - Ndabeni Station	1	5	0	7	0	0	0	0	1	4	0	0	0	18
Maitland Station - Woltemade Station	0	13	0	23	0	0	0	0	3	7	0	3	0	49
Mutual Station	6	0	0	0	0	1	4	0	1	0	0	8	1	21
Mutual Station - Thornton Station	0	5	0	5	0	0	1	0	1	2	0	0	0	14
Mutual Station - Woltemade Station	0	3	0	4	0	0	0	0	0	1	0	2	0	10
Mutual Station - Ysterplaat Station	2	5	0	10	0	0	1	0	0	4	0	1	0	23
Ndabeni Station	0	0	0	0	0	0	2	0	0	1	0	0	0	3
Ndabeni Station - Pinelands Station	0	2	0	10	0	0	1	0	0	0	0	0	0	13
Pinelands Station	0	0	0	0	0	0	1	0	1	0	0	2	0	4
Woltemade Station	1	3	3	0	0	1	0	0	0	2	0	0	1	11
Woltemade Station - Ysterplaat Station	0	7	0	12	0	0	0	0	1	6	0	0	0	26
Grand Total	15	53	3	86	2	5	14	1	11	31	1	28	6	256

Area 3 – Athlone Station to Hazendal Station

A total of 32 (n=32) occurrences of train control equipment theft was recorded in the line section between Hazendal and Pinelands Stations. (See Table 44: Ikapa occurrences – Area 3).

**Table 44: Ikapa occurrences – Area 3**

Location	1-c	1-g	2-a	2-g	2-h	E-a	Undefined	Grand Total
Athlone Station	0	2	2	0	0	0	0	4
Athlone Station - Crawford Station	1	2	0	1	0	0	0	4
Athlone Station - Hazendal Station	1	9	1	0	0	0	0	11
Hazendal Station	0	5	0	1	1	1	1	9
Hazendal Station - Pinelands Station	4	32	0	8	0	4	0	48
Grand Total	6	50	3	10	1	5	1	76

#### Area 4 – Langa Station to Lavistown Station

A total of 765 occurrences have been recorded in this area in total. The section of track between Bonteheuwel and Netreg Stations are the most active with 222 occurrences in the section alone, with the main target for theft and malicious damage being train control equipment, with 141 occurrences. (See Table 45: Ikapa occurrences – Area 4).

A significant number of E-a occurrences involving a member of public being struck by a train has been recorded at Bonteheuwel (n=20) and Langa (n=10) Stations, with a total of 15 fatalities and 13 injuries between the two stations combined.

**Table 45: Ikapa occurrences – Area 4**

Location	1-a	1-c	1-d	1-e	1-g	1-h	1-i	2-a	2-c	2-d	2-e	2-g	2-h	2-i	E-a	Undefined	Grand Total
Belhar Station	1	0	5	0	1	2	0	0	0	0	0	0	0	0	1	0	10
Belhar Station - Lavistown Station	2	12	0	0	77	0	0	1	1	0	0	9	0	0	2	0	101
Bonteheuwel Station	3	2	2	0	5	1	1	2	1	1	0	5	2	1	20	7	53
Bonteheuwel Station - Netreg Station	6	19	0	4	141	0	0	6	9	0	5	25	0	0	1	6	222
Bonteheuwel Station - Langa Station	2	7	0	0	21	0	0	6	2	0	0	13	0	0	3	2	56
Bonteheuwel Station - Lavistown Station	2	7	0	0	117	0	0	2	2	0	0	10	0	0	2	1	143
Langa Station	3	1	0	0	2	0	0	5	0	0	0	2	1	0	10	3	27
Langa Station - Pinelands Station	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Langa Station - Mutual Station	1	3	0	0	37	0	0	3	1	0	0	6	0	0	1	1	53
Langa Station - Pinelands Station	1	3	0	0	38	0	0	0	1	0	0	8	0	0	1	2	54
Lavistown Station	13	1	0	0	12	0	0	8	1	0	0	3	0	0	1	2	41
Grand Total	34	55	7	4	453	3	1	33	18	1	5	81	3	1	42	24	765

### Area 5 – Thornton Station to Parow Station

Elsies River and Parow Stations both have nine (n=9) Category E-a occurrences with eight (n=8) fatalities and 10 injuries combined. (See Table 46: Ikapa occurrences – Area 5).

**Table 46: Ikapa occurrences – Area 5**

Location	1-a	1-c	1-e	1-f	1-g	1-h	1-i	2-a	2-c	2-e	2-g	E-a	Undefined	Grand Total
Elsies River Station	1	1	1	0	0	1	0	1	1	0	3	9	1	19
Elsies River Station - Parow Station	0	9	0	0	10	0	0	0	3	1	4	3	0	30
Elsies River Station - Tygerberg Station	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Elsies River Station - Vasco Station	0	0	0	0	9	0	0	1	1	0	3	0	0	14
Goodwood Station	4	0	1	2	1	0	0	1	0	0	2	5	1	17
Goodwood Station - Thornton Station	0	6	0	0	11	0	0	1	1	0	7	0	0	26
Goodwood Station - Vasco Station	0	2	0	0	7	0	0	0	0	0	1	1	0	11
Parow Station	1	1	0	0	0	0	4	2	1	0	0	9	1	19
Parow Station - Tygerberg Station	1	4	0	0	3	0	0	0	1	0	0	2	1	12
Thornton Station	0	0	0	0	1	0	0	2	0	0	0	1	0	4
Tygerberg Station	0	1	0	0	1	0	5	1	0	0	0	3	3	14
Grand Total	7	25	2	2	43	1	9	9	8	1	20	33	7	167

### Area 6 – Century City Station to Acacia Park Station

Theft (Category 1-g) and malicious damage (Category 2-g) to train control equipment combined has 44 out of the total of 61 occurrences, with more than half taking place between Acacia Park and Century City Stations (n=26). (See Table 47: Ikapa occurrences - Area 6).

**Table 47: Ikapa occurrences - Area 6**

Location	1-a	1-c	1-e	1-g	2-a	2-c	2-e	2-g	2-h	2-i	E-a	Undefined	Grand Total
Acacia Park Station - Century City Station			1	26	1		1	8	1			1	39
Acacia Park Station - Monte Vista Station				1	1								2
Century City Station	3			4	1	1					1		10
Century City Station - Kentemade Station		1						1			1		3
Kentemade Station		1	1	1				1					4
Monte Vista Station				2	1								3
Grand Total	3	2	2	34	4	1	1	10	1	1	1	1	61

## ***North***

Area North has 2 hot-spot areas: Area 1 – Bellville and Area 2 – Kraaifontein. (See Figure 41: All category hot-spot map – North).

### Area 1 – Bellville Station and surrounds

The area around Bellville Station includes the Bellville Staging Yard as well as the Belcon Terminals used mainly by TFR and covers a broad expanse of land. A review of the occurrence descriptions for Bellville Station, indicates that a number of route crimes are allocated to Bellville Station, without a definite location of the incident. This is true for several TFR occurrences. Bellville Station (and surrounds) account for 173 occurrences with 108 and 61 of those applicable to Prasa and TFR respectively. (See Table 48: North occurrences – Area 1). Out of 13 E-a occurrences, 10 (n=10) occurred at Bellville Station with seven (n=7) fatalities and five (n=5) injuries. One specific incident included three (n=3) injuries and one (n=1) fatality.

**Table 48: North occurrences – Area 1**

Location	1-a	1-b	1-c	1-d	1-e	1-g	1-h	1-i	2-a	2-b	2-c	2-d	2-e	2-g	2-h	2-i	E-a	Undefined	Grand Total
Bellville Station	47	8	7	4	1	24	9	6	33	3	4	1	1	4	4	2	10	5	173
Bellville Station - Avondale Station	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bellville Station - Brackenfell Station	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Bellville Station - Kuils River Station	1	0	3	0	1	9	0	0	1	0	2	0	0	11	0	0	0	0	28
Bellville Station - Oosterzee Station	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	1	0	4
Bellville Station - Sarepta Station	1	0	0	0	1	5	0	0	0	0	2	0	0	6	0	0	0	1	16
Bellville Station - Stikland Station	0	0	1	0	0	3	0	0	1	0	0	0	0	4	0	0	1	0	10
Bellville Station - Tygerberg Station	0	0	8	0	0	12	0	0	1	0	1	0	0	3	0	0	0	0	25
Grand Total	49	8	20	4	3	55	9	6	36	3	9	1	1	29	4	2	13	6	258

### Area 2 – Kraaifontein Station and surrounds

Kraaifontein Station and surrounds includes the Kraaifontein yard which explains the occurrences of theft (n=18) and damage (n=17) to rolling stock components in yard while trains are staged. A review of the descriptive text indicates the target assets to be grid and motor covers, cables and light fittings. Kraaifontein Station has 20 E-a occurrences over the period with 15 fatalities and four (n=4) injuries. (See Table 49: North occurrences – Area 2).

**Table 49: North occurrences – Area 2**

Location	1-a	1-b	1-c	1-e	1-g	1-h	1-i	2-a	2-b	2-e	2-g	2-i	E-a	Undefined	Grand Total
Brackenfell Station	1	0	1	0	6	1	0	1	0	0	0	0	7	2	19
Brackenfell Station - Eikenfontein Station	0	0	0	0	1	0	0	2	0	0	0	0	0	1	4
Brackenfell Station - Kraaifontein Station	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
Brackenfell Station - Stikland Station	0	0	0	0	0	0	0	2	0	0	0	0	1	0	3
Eikenfontein Station	0	0	0	0	1	0	0	1	0	0	1	0	3	0	6
Eikenfontein Station - Kraaifontein Station	0	0	1	0	2	0	0	1	0	0	1	0	4	1	10
Kraaifontein Station	13	18	3	1	20	0	2	28	17	1	9	1	20	7	140
Kraaifontein Station - Muldersvlei Station	0	0	1	0	7	0	0	5	0	0	0	0	6	0	19
Kraaifontein Station - Stikland Station	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Grand Total	14	18	6	1	37	1	2	41	17	1	11	1	44	11	205

### *Paarl*

The hot-spot route in the Drakenstein Municipality includes the stretch of rail line between Paarl and Wellington Stations. The line passes by the informal settlement along Mbekweni where nine (n=9) E-a occurrences have been recorded of which there were four (n=4) fatalities. (See Figure 42: All category hot-spot map - Paarl and Table 50: Paarl occurrences).

Shosholoza Meyl and Prasa rolling stock are routinely victims of stone throwing incidents as they pass through Wellington, with 45 Category 2-a occurrences. All three (n=3) E-a occurrences at Wellington resulted in a fatality.

**Table 50: Paarl occurrences**

Location	1-a	1-b	1-c	1-d	1-e	1-g	1-i	2-a	2-b	2-e	2-f	2-g	E-a	Undefined	Grand Total
Huguenot Station	0	0	1	2	2	10	2	15	0	0	1	2	3	1	39
Huguenot Station - Paarl Station	0	1	0	0	0	11	0	1	0	0	0	1	3		17
Mbekweni Station	0	0	0	0	1	7	0	15	0	0	0	0	9		32
Mbekweni Station - Wellington Station	0	0	0	0	0	0	0	4	0	0	0	0	3		5
Paarl Station	0	0	1	0	2	26	1	3	1	1	0	3	3		41
Wellington Station	22	4	0	1	1	14	0	45	4	1	0	8	3		103
Grand Total	22	5	2	3	6	68	3	83	5	2	1	14	24	1	239

## All Category Hot-Spot Map - North



Figure 41: All category hot-spot map – North

## All Category Hot-Spot Map - Paarl

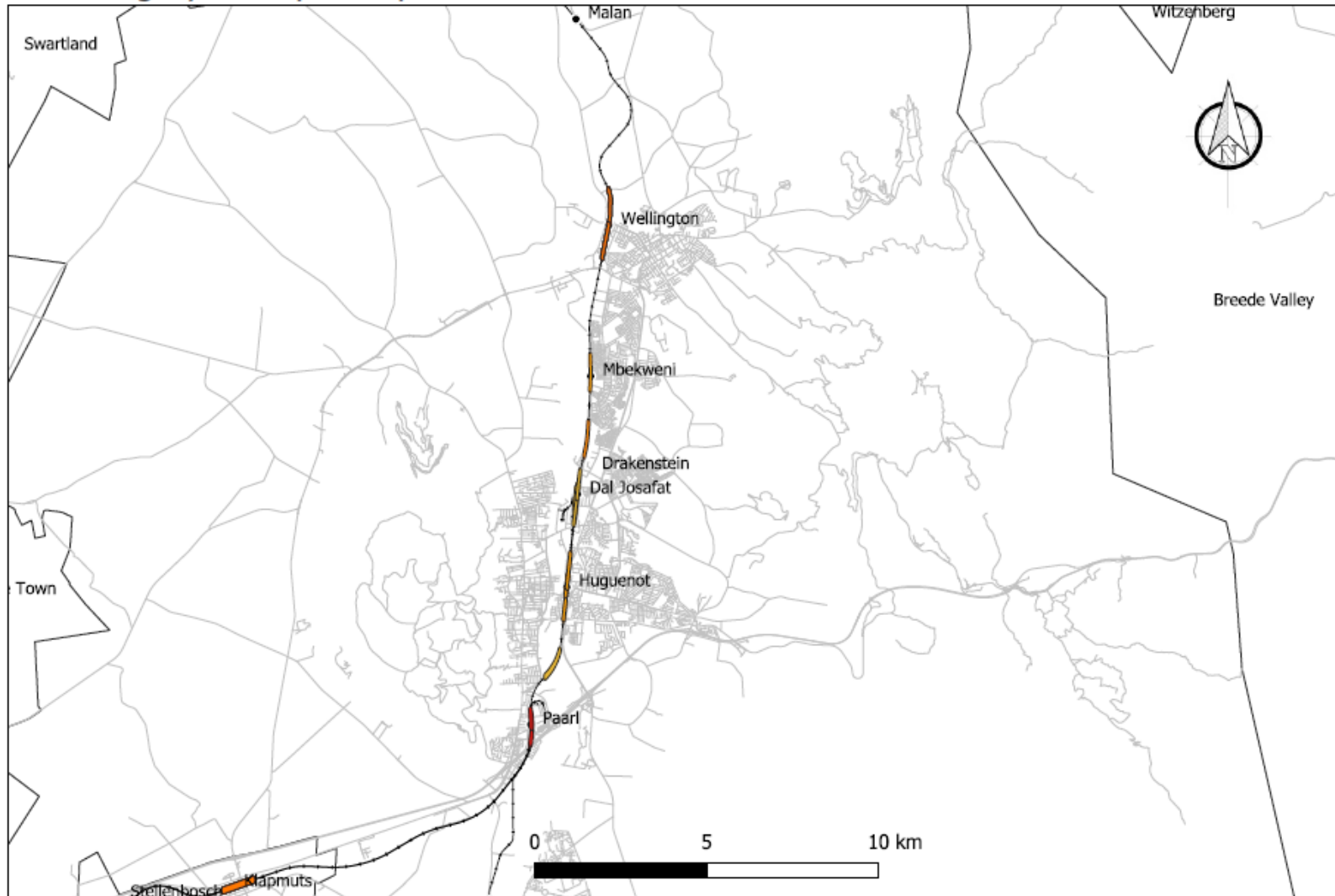


Figure 42: All category hot-spot map - Paarl

### All Category Hot-Spot Map - Southern



Figure 43: All category hot-spot map – Southern

## ***Southern***

The hot-spots on the Southern Line fall in 3 main areas. See Figure 43: All category hot-spot map – Southern.

### **Area 1 – Retreat Station**

The area around Retreat Station includes the Retreat Staging Yard. Three fatalities and one injury make up the four (n=4) Category E-a occurrences at Retreat Station. (See Table 51: Southern occurrences – Area 1).

**Table 51: Southern occurrences – Area 1**

Location	1-a	1-b	1-c	1-e	1-g	1-i	2-a	2-b	2-c	2-g	E-a	Undefined	Grand Total
Retreat - Heathfield	0	0	2	0	0	0	1	0	0	1	0	0	4
Retreat - Steenberg	0	0	3	2	2	0	0	0	0	1	0	0	8
Retreat Station	5	4	0	0	0	1	11	6	2	0	4	1	34
Retreat Station - Steenberg Station	0	0	0	0	0	0	0	0	0	1	0	0	1
Retreat -Steenberg	0	0	0	0	0	0	0	0	0	1	0	0	1
Grand Total	5	4	5	2	2	1	12	6	2	4	4	1	48

### **Area 2 – Harfield Road Station to Plumstead Station**

The section of the line between Wittebome and Kenilworth Stations recorded 31 out of the 51 Category 1-g occurrences for theft of train control equipment.

Kenilworth Station has five (n=5) E-a occurrences with two (n=2) fatalities and four (n=4) injuries, while Wittebome Station has three (n=3) E-a occurrences one of which was a fatality involving a 15-year-old school boy. (See Table 52: Southern occurrences – Area 2).

**Table 52: Southern occurrences – Area 2**

Location	1-c	1-g	1-i	2-c	2-g	E-a	Undefined	Grand Total
Harfield Road Station	0	0	0	0	1	0	0	1
Harfield Road Station - Kenilworth Station	2	9	0	0	1	0	0	12
Kenilworth Station	0	7	0	0	1	5	1	14
Kenilworth Station - Wynberg Station	2	14	0	0	6	0	0	22
Plumstead Station	0	0	0	0	0	2	0	2
Plumstead Station - Steurhof Station	0	2	0	1	2	1	0	6
Plumstead Station - Wittebome Station	0	1	0	0	0	0	0	1
Steurhof Station	0	1	0	0	0	1	0	2
Wittebome Station	0	0	1	0	0	3	0	4
Wittebome Station - Wynberg Station	1	17	0	0	10	0	0	28
Wynberg Station	1	0	0	0	1	1	0	3
Grand Total	6	51	1	1	22	13	1	95

### Area 3 - Wetton Station to Ottery Station

Rail clips and springs, point machine wiring and transformers were some of the targeted civil infrastructure assets targeted under Category 1-c which recorded 17 (n=17) occurrences. The section of track between Ottery and Wetton Stations recorded the most occurrences (n=26). (See Table 53: Southern occurrences – Area 2).

**Table 53: Southern occurrences – Area 2**

Location	1-c	1-g	2-a	2-c	2-g	2-h	Grand Total
Ottery Station	3	0	0	0	0	0	3
Ottery Station - Southfield Station	1	7	3	0	4	0	15
Ottery Station - Wetton Station	10	10	0	1	5	0	26
Wetton Station	3	0	1	0	1	1	6
Grand Total	17	17	4	1	10	1	50

### *Stellenbosch*

The routes within Stellenbosch Municipality has 2 main hot-spot areas. (See Figure 44: All category hot-spot map – Stellenbosch).

### Area 1 – Klapmuts Station to Muldersvlei Station

Most of the Category 1-a occurrences (n=11) cannot be accurately allocated to Muldersvlei Station as they are route crimes and the incidents were recorded as either “...on route to Muldersvlei..” or “...discovered at Muldersvlei...”. Theft and damage of train control equipment is most prominent at Klapmuts (n=37) and Muldersvlei (n=18) Stations. (See

Table 54: Stellenbosch occurrences – Area 1). Eight (n=8) Category E-a occurrences were recorded at Klapmuts Station of which four (n=4) occurrences resulted in fatalities and three (n=3) in injuries.

**Table 54: Stellenbosch occurrences – Area 1**

Location	1-a	1-g	2-a	2-b	2-g	E-a	Undefined	Grand Total
Klapmuts Station	1	37	2	0	10	8	2	60
Klapmuts Station - Muldersvlei Station	0	1	1	0	0	1	0	3
Klapmuts Station - Paarl Station	0	0	0	0	0	3	1	4
Muldersvlei Station	11	18	7	1	6	4	1	48
Grand Total	12	56	10	1	16	16	4	115

### Area 2 – Stellenbosch Station to Du Toit Station

Theft of train control equipment occurs mostly between Du Toit Station and Vlottenburg Station with a combined 40 occurrences along the route. (See Table 55: Stellenbosch occurrences – Area 2).

Du Toit Station has the most incidents involving a person struck by a train (n=8) with all eight occurrences resulting in injuries with no fatalities.

The section of the track between Du Toit and Koelenhof Station has three (n=3) E-a occurrences resulting in three fatalities, one of which was that of a 14-year-old boy.

**Table 55: Stellenbosch occurrences – Area 2**

Location	1-a	1-c	1-d	1-e	1-g	1-i	2-a	2-b	2-g	E-a	Undefined	Grand Total
Du Toit Station	0	0	0	0	0	0	3	0	0	8	1	12
Du Toit Station - Koelenhof Station	0	3	0	2	1	0	6	1	0	3	0	16
Du Toit Station - Stellenbosch Station	0	0	0	0	15	0	2	0	1	1	0	19
Stellenbosch Station	3	0	1	0	12	1	2	0	4	3	1	27
Stellenbosch Station - Vlottenburg Station	0	1	0	0	13	0	1	0	2	0	0	17
Grand Total	3	4	1	2	41	1	14	1	7	15	2	91

## All Category Hot-Spot Map - Stellenbosch

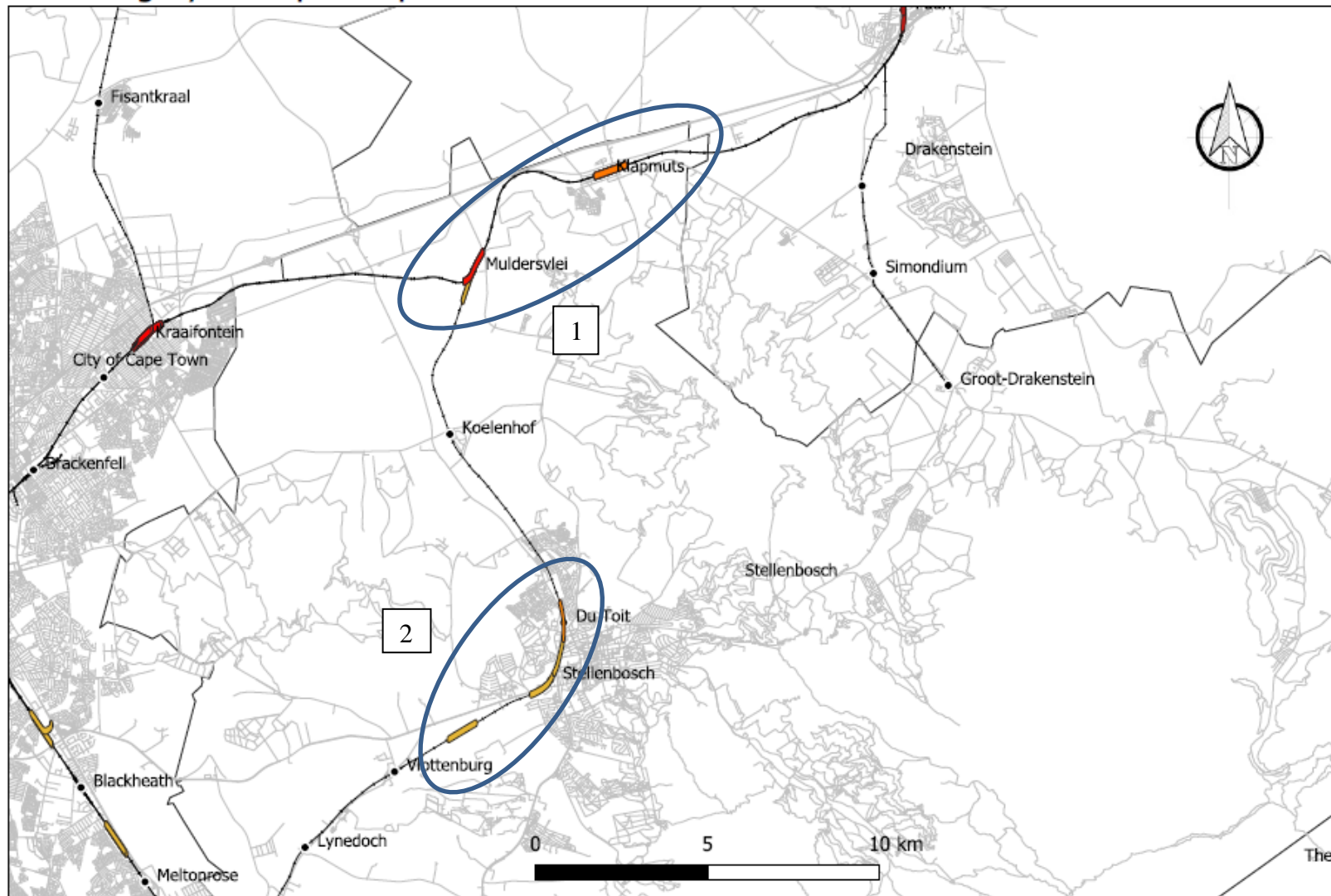


Figure 44: All category hot-spot map – Stellenbosch

## All Category Hot-Spot Map - Swartland



**Figure 45: All category hot-spot map – Swartland**



Trespassing on the tracks at  
Klapmuts Station in  
Stellenbosch Municipality

## *Swartland*

Malmesbury Station is a terminal station for the commuter rail service operated by Prasa to the Swartland Municipality. Trains will occasionally be staged there which leaves them vulnerable to criminals. Route crimes under Category 1-a cannot confidently be ascribed to Malmesbury Station as they are recorded at the destination terminal station and not necessarily where the incident occurred. Kalbaskraal Station consists only of a platform nosing/edge and despite its quiet location, it has two (n=2) pedestrian-rail incidents. (See Table 56: Swartland occurrences and Figure 45: All category hot-spot map – Swartland).

**Table 56: Swartland occurrences**

Location	1-a	1-b	1-c	1-g	1-i	2-a	E-a	Grand Total
Kalbaskraal Station	0	0	1	2	1	2	2	8
Malmesbury Station	6	7	2	0	1	1	0	17
Grand Total	6	7	3	2	2	3	2	25

### **5.9 SUMMARY OF THE CHARACTERISTICS OF THE SPATIAL CONCENTRATIONS OF THE THE COMBINED CATEGORY E-A, 1 AND 2 OCCURRENCES**

The combined Category E-a, 1 and 2 occurrences for 2018 produce the following hot-spot areas:

Area 1 – Bonteheuwel to Mutual Stations

Area 2 – Netreg to Stock Road and Lentegeur Stations

Area 3 – Bellville to Kraaifontein Stations

Area 4 – Paarl to Wellington Stations

Area 5 - Cape Town to Salt River and Esplanade Stations

Area 6 - Klapmuts to Muldersvlei Station

Reviewing the occurrence data individually for pedestrian-rail incidents as well as that for theft and vandalism has shown that there are a number of overlaps, i.e. a location that has high pedestrian-rail occurrences is also likely to have high incidents of theft and vandalism.

The areas above are characterised by common traits, including:

- Widespread trespassing with a myriad of pedestrian desire lines crossing the railway line, with the railway acting as a barrier to pedestrian movements;
- Residential areas synonymous with social problems, including gang activity, high crime rates and high unemployment levels;
- Informal settlement encroachment in areas;
- High occurrences of train control equipment theft and pedestrian-rail incidents; and
- Heavily trafficked areas such as public transport interchanges, and areas containing rail depot and siding areas.

A review of the location data would suggest that Matzopoulos & Lerer, (1998) was correct when they suggested that the level of poverty of communities is a major factor of railway injury occurrences. This could now be extended to include not only railway injury but also occurrences of railway theft and vandalism. The highest number of occurrences are recorded as the rail line passes through Coloured and Black townships within the City of Cape Town and neighbouring municipalities.

The townships are characterised by dense populations as stated by Radbo et al., (2005); Silla and Luoma, (2012) and commonly the rail line acts as a barrier between places of residence and places of work or shopping supporting findings by Silla and Luoma, (2008).

In Section 5.2 the relationship between pedestrian-rail incidents and train traffic density was discussed. It was inferred that the likelihood of a pedestrian-rail incident is increased with an increase in train traffic. What we have now learnt is that pedestrian-rail incidents on train lines with a less frequent service is equally risky for trespassers and would now move a bit closer to the statement from Savage, (2015) that lines with infrequent services are “more” problematic but rather, equally problematic. Locations such as Klapmuts and the Paarl line to Wellington are evidence of this.

Evidence from the quantitative analysis confirms criminal actions including theft and vandalism as a motive for trespassing as found by Havarneanu, (2017); Savage, (2007) and Ryan, (2012). Theft of train control equipment has reached

epidemic proportions as well as theft of other metal components such as apparatus doors, track box cages with substations and transformer units commonly targeted.

After analysis of the quantitative data, one critical element is highlighted; pedestrian-rail incident data and theft and vandalism occurrence data, even when coupled with data provided on death and mortality statistics from mortuaries, merely provides a glimpse into the full scale of trespassing across the rail network. If any meaningful impact is to be made in reducing trespassing numbers, and the associated negative consequences, we cannot rely only on occurrence data as a measure of rail safety performance.

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# Chapter 6: Case Study - Rail Enforcement Unit

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The Case Study evaluation of a specific countermeasure is carried out in detail in this chapter. The case study includes a quantitative analysis to provide empirical evidence of the measure's effectiveness. The research question (Q9) and hypotheses (H<sub>0</sub>16 and H<sub>0</sub>17) relating to the case study will be dealt with in this section, as well as an analysis on the effectiveness of the countermeasure.

## 6.1 BACKGROUND

The establishment of a Rail Enforcement Unit (REU) saw collaboration amongst both local and provincial government and the railway operator to respond to incidents of crime and vandalism currently being experienced on the Metrorail network. The partnership between the City of Cape Town (the City), the Western Cape Government's Department of Transport and Public Works (the Department) and PRASA, was established as the SAPS Rapid Rail Police have been unable to effectively respond to the challenges the railway system currently face.

The REU builds on the successes of the City of Cape Town's "Copperheads" Metals Theft Unit that was established to address attacks on city infrastructure. The unit currently operates under the direct command and control of the City of Cape Town's Safety and Security Directorate's Law Enforcement Services. While it cannot be expected that the REU fully resolve the serious issues facing rail, it is hoped that it can be an effective part of a broad and comprehensive solution to the current rail crisis.

The pilot includes the training and deployment of a force of 100 Law Enforcement/Metals Theft Officers, with 60% allocated to commuter safety and 40% allocated to infrastructure protection. These officers are deployed across the Metrorail network with their primary focus on crime and vandalism hot-spots.

## **6.2 METHODOLOGY TO EVALUATE THE PILOT MEASURE**

The following methods were used to evaluate this measure:

Qualitative interviews with enforcement officials and rail security staff – Semi-structured interviews were carried out based on the Trespass Countermeasure Evaluation Form. The interviews were analysed and categorised into main themes.

Quantitative analysis of railway safety and security occurrences from 27 October 2018 till 28 February 2019 (the pilot period). RSR incident and occurrence data was analysed for PRASA events and limited to those locations occurring within the City of Cape Town boundary. The dataset was compared to an equivalent four-month period prior to the commencement of the REU operations for the period from 27 June 2018 till 26 October 2018 (the control period).

## **6.3 DEFINITION OF TARGET INCIDENTS**

The intention is for the unit to address both the ongoing attacks on rail infrastructure and improve security for passengers.

The objectives of the project are:

- To support SAPS Rapid Railway Police, through PRASA, to ensure improved commuter safety and reduction of personal crime on the rail network.
- To deliver effective and efficient enforcement toward infrastructure theft and vandalism with operations informed by crime intelligence data.
- To ensure a reduction in the incidents of vandalism and theft within the PRASA domain.

## **6.4 SIZE OF THE PROBLEM**

This section presents an analysis of safety and security incidents and occurrences for the control period 27 June 2018 till 26 October 2018 to illustrate the nature of the problem. The issues could be summarised as inadequate security for passengers and rail assets, rampant crime against commuters, delayed trains and disrupted services, and train “rage” attacks on rail infrastructure by commuters frustrated with the level of service.

### 6.4.1 Control period - Total number of occurrences

There was a total of 580 combined safety and security occurrences in the control period leading up to the start of the pilot, with an average of 116 occurrences per month. The highest number of occurrences were in July (n=155), September (n=155) and October (n=150). The trend over the period can be seen in Figure 46: Control period – Total occurrences.

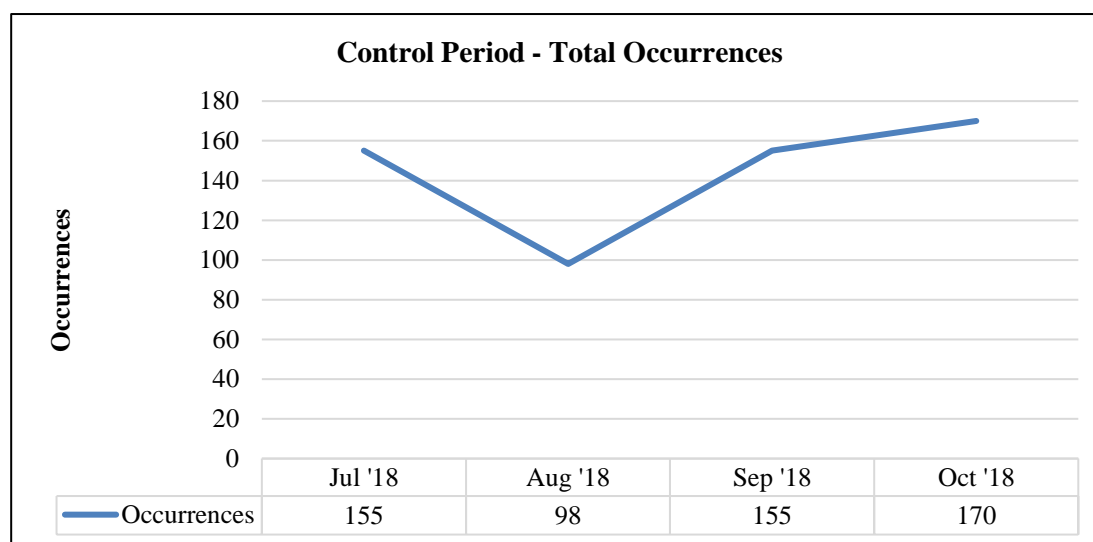


Figure 46: Control period – Total occurrences

### 6.4.2 Control period – Security occurrences

There was a total of 441 security occurrences in the control period. Table 57: Control period - Top 10 security occurrences, below shows that the top four occurrence categories account for nearly half the number of occurrences. Category 1-g, theft of train control equipment (signalling) in section (n=95), 2-g, malicious damage (vandalism) of rolling stock components in yards and sidings (n=48), 2-a, Malicious damage (vandalism) of rolling stock components in section (n=44) and 1-c, Theft of civil infrastructure components in section (n=32) recorded the highest number of occurrences for crimes against rail property.

Personal safety on trains and stations (Categories 7 and 8) combined, account for 33.6% amongst the top 10 occurrence categories with robberies and assaults being the most prevalent.

**Table 57: Control period - Top 10 security occurrences**

<b>Rank</b>	<b>Category</b>	<b>Total</b>
<b>1</b>	<b>1-g</b> Theft of train control equip - section	95
<b>2</b>	<b>2-g</b> Vandalism to train control equip - section	48
<b>3</b>	<b>2-a</b> Vandalism to rolling stock components - section	44
<b>4</b>	<b>7-f</b> Aggravated robbery - trains	39
<b>5</b>	<b>1-c</b> Theft of civil infrastructure components - section	32
<b>6</b>	<b>7-d</b> Assault – trains	24
<b>7</b>	<b>8-f</b> Aggravated robbery – stations	23
<b>8</b>	<b>7-g</b> Common robbery – trains	21
<b>9</b>	<b>8-d</b> Assault – stations	21
<b>10</b>	<b>8-g</b> Common robbery - stations	20

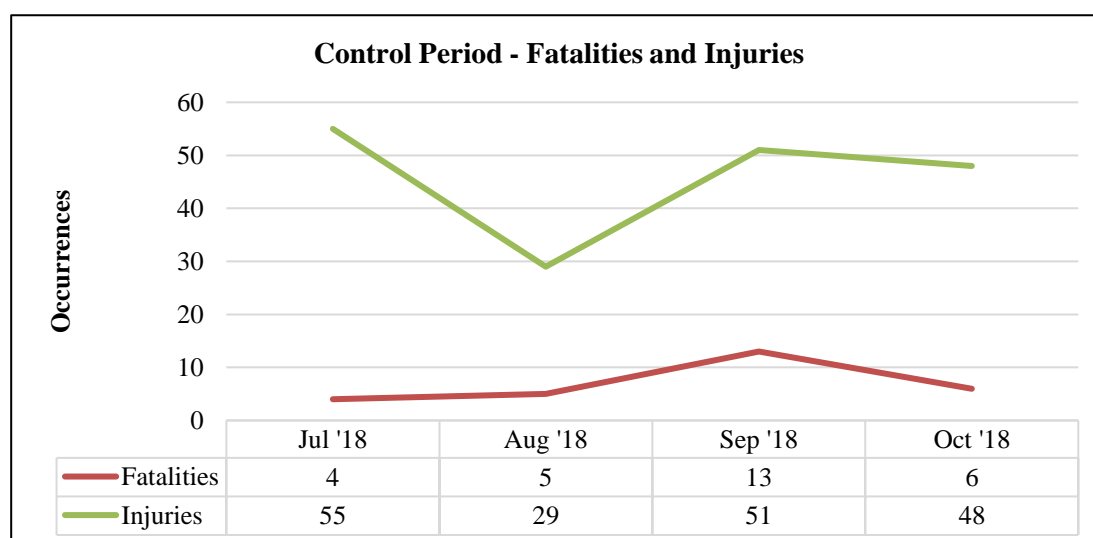
### **6.4.3 Control period – Safety occurrences**

There were 139 safety-related occurrences in the period leading up to the start of the pilot. The top 10 safety occurrence categories are shown in Table 58: Control period – Top 10 safety occurrences.

Category E-a occurrences where a member of the public is struck by rolling stock on a running line, had the highest occurrences (n=42). Associated with this are the number of fatalities and injuries over the control period at 30 and 188, respectively. See Figure 47: Control period – Fatalities and injuries. Thirteen fatalities were recorded in September, with the average at six fatalities per month over the period.

**Table 58: Control period – Top 10 safety occurrences**

Rank	Category	Total
1	<b>E-a</b> Member of the public is struck by rolling stock on a running line	42
2	<b>H-b</b> Passenger fell on the platform whilst entraining/detraining a stationary or moving train	39
3	<b>F-a</b> Person fell or was pushed from inside a moving or stationary train	15
4	<b>G-a</b> Passengers travelling outside the designated passenger area of the train	11
5	<b>C-a</b> Signal passed at danger (SPAD) on a running line	8
6	<b>I-b</b> Occurrence resulting in injuries and fatalities to passengers due to infrastructure defects in a passenger area of the station	8
7	<b>H-a</b> Passenger fell between the train and the platform whilst entraining/detraining a stationary or moving train	5
8	<b>A-b</b> Collision of rolling stock with an obstruction on a running line	4
9	<b>J-d</b> Electrical shock to the member of the public	2
10	<b>B-a</b> Derailment of rolling stock on a running line	1



**Figure 47: Control period – Fatalities and injuries**

#### 6.4.4 Control period – Location analysis

Occurrences are widespread across the network with the top 20 locations shown in Table 59: Control period – Top 20 locations. Distinct hot-spots can be identified by grouping stations that are geographically close to each other as follows:

- Cape Town – Woodstock – Salt River – Maitland,
- Heideveld – Nyanga – Philippi, and
- Bellville – Elsie River – Vasco.

**Table 59: Control period – Top 20 locations**

<b>Rank</b>	<b>Location</b>	<b>No of Occurrences</b>
<b>1</b>	Cape Town	34
<b>2</b>	Bellville	20
<b>3</b>	Cape Town - Woodstock	18
<b>4</b>	Salt River	13
<b>5</b>	Philippi	11
<b>6</b>	Lavis Town	10
<b>7</b>	Nolungile	10
<b>8</b>	Eerste River	9
<b>9</b>	Kuils River	8
<b>10</b>	Elsies River - Vasco	7
<b>11</b>	Maitland	7
<b>12</b>	Salt River - Woodstock	7
<b>13</b>	Woodstock	7
<b>14</b>	Ysterplaat	7
<b>15</b>	Heideveld	6
<b>16</b>	Kenilworth	6
<b>17</b>	Langa	6
<b>18</b>	Nyanga - Philippi	6
<b>19</b>	Blackheath - Meltonrose	5
<b>20</b>	Elsies River	5

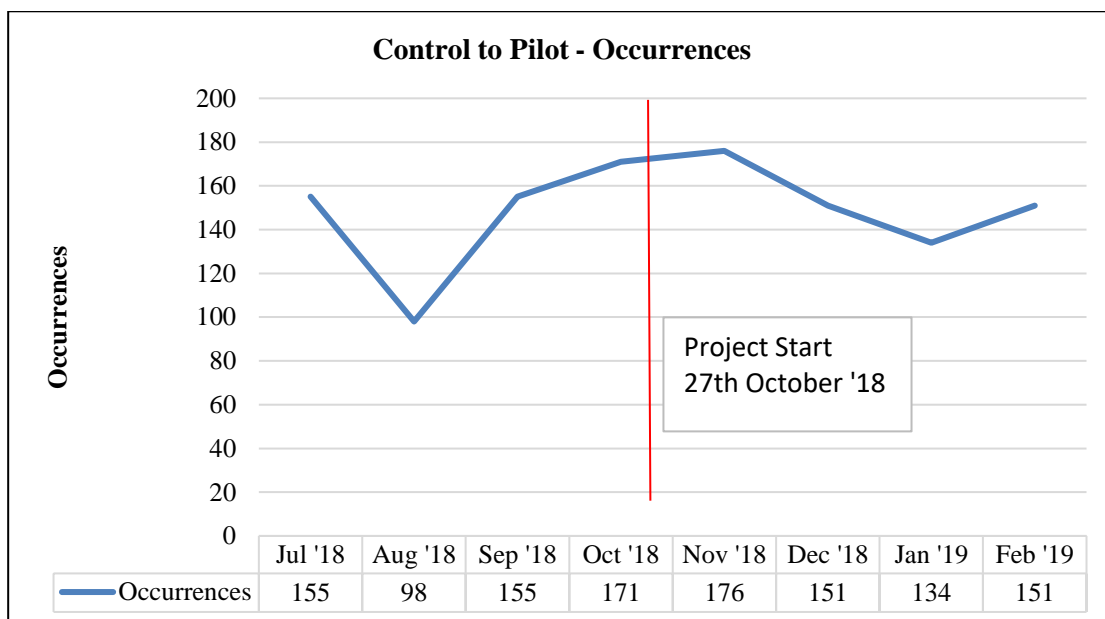
## 6.5 EFFECT ON INCIDENTS

### 6.5.1 Evaluating the effectiveness of the specific countermeasure strategy

Answering research question CASE Q9.

#### *Pilot period - Total number of occurrences*

There was a total of 632 combined safety and security occurrences in the control period leading up to the start of the pilot, with an average of 126.4 occurrences per month. The trend over the period can be seen in Figure 48: Total occurrences over evaluation period.



**Figure 48: Total occurrences over evaluation period**

The number of occurrences over the pilot period has increased from 580 events in the control months. To compare the control to the pilot period an occurrence rate is proposed as follows:

$$\text{Occurrence Rate} = \frac{\text{No. of Incidents}}{\text{Relevant Population Size}}$$

For the occurrence rate a value of 100 000 is proposed. For the population size, the total patronage for 2018/19 is 46 986 046.

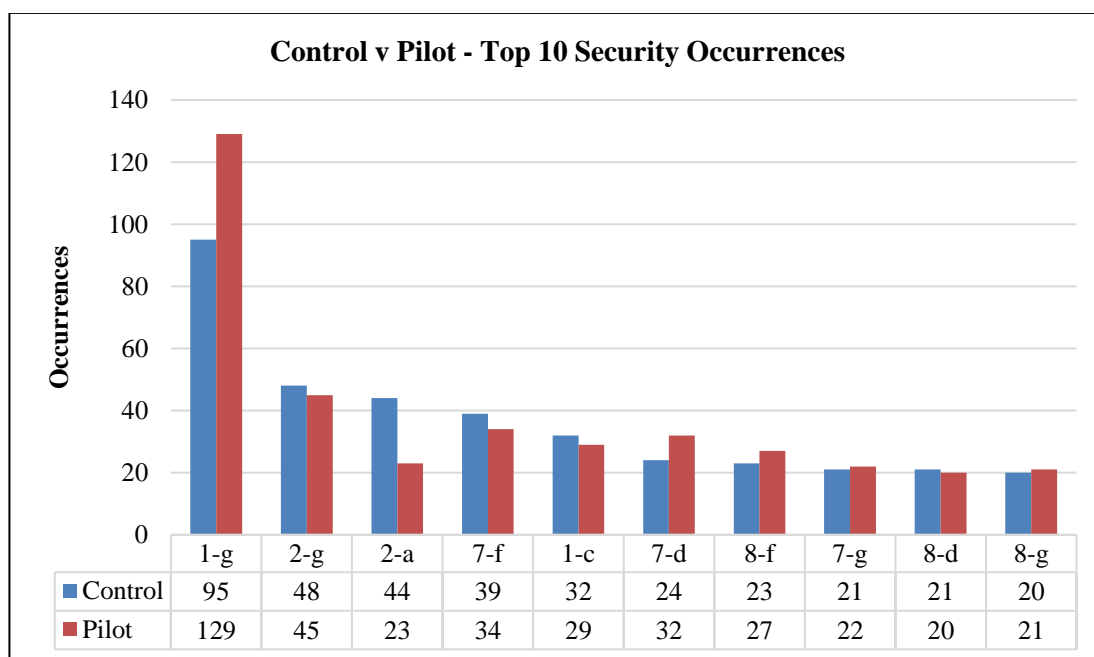
The occurrence rate for the control period is thus calculated to be 1.23. The occurrence rate for the pilot period is calculated to be 1.35. This works out to a 9.8% increase in total occurrences.

### *Pilot period – security occurrences*

There was a total of 474 security incidents in the pilot period compared to 441 security incidents in the control period. Table 60: Occurrences comparison over the evaluation period, shows the number of occurrences and the differences between the control and pilot periods. A negative number indicates a drop in occurrences and a positive number an increase in occurrences. Overall the security occurrences increased by 33 cases.

Category 1-g, theft of train control equipment (signalling) in section, remains high with 129 occurrences. Categories 1-a and 2-a both show a decrease in occurrences and indicates that rolling stock has become a less attractive target for theft and vandalism.

Personal safety on trains remain a concern with incidents of aggravated robbery on stations and trains increasing. Figure 49: Control v pilot period – Top 10 security occurrences), shows the comparison between the control and pilot period occurrences graphically.



**Figure 49: Control v pilot period – Top 10 security occurrences**

**Table 60: Occurrences comparison over the evaluation period**

<b>Occurrence Category</b>	<b>Control</b>	<b>Pilot</b>	<b>Difference</b>
1-a Theft of rolling stock components in section	18	8	-10
1-b Theft of rolling stock components in yards (staged)	4	6	2
1-c Theft of civil infrastructure components in section	32	29	-3
1-d Theft of civil infrastructure components in yards and sidings	1	2	1
1-e Theft of overhead traction equipment in section	6	1	-5
1-g Theft of train control equipment (signalling) in section	95	129	34
1-h Theft of train control equipment (signalling) in yards and sidings	2	8	6
1-i Theft of ancillary equipment including public address systems, information boards, CCTV	8	9	1
2-a Malicious damage (vandalism) of rolling stock components in section	44	23	-21
2-b Malicious damage (vandalism) of rolling stock components in yards and sidings (staged)	4	7	3
	6	7	1
2-c Malicious damage (vandalism) of civil infrastructure components in section	0	2	2
2-d Malicious damage (vandalism) of civil infrastructure components in yards and sidings	3	7	4
	0	1	1
2-e Malicious damage (vandalism) of overhead traction equipment in section	48	45	-3
2-f Malicious damage (vandalism) of overhead traction equipment in yards and sidings	0	2	2
2-g Malicious damage (vandalism) of train control equipment (signalling) in section	2	2	0
7-d Assault	24	32	8
7-f Aggravated robbery	39	34	-5
7-g Common robbery	21	22	1
7-h Theft	7	7	0
8-a Murder	1	1	0
8-b Attempted murder	1	2	1
8-c Rape	1	0	-1
8-d Assault	21	20	-1
8-f Aggravated robbery	23	27	4
8-g Common robbery	20	21	1
8-h Theft	3	7	4
9-a Murder	0	1	1
9-c Rape	1	1	0
9-d Assault	3	5	2
9-f Aggravated robbery	2	5	3
9-g Common robbery	1	1	0
<b>TOTALS</b>	<b>441</b>	<b>474</b>	<b>33</b>

***CASE H<sub>0</sub>16: No significant difference exists between Category 1 and 2 occurrences before and after implementation of the countermeasure.***

Using the t-test to check if there is a significant difference in the number of Category 1 and 2 occurrences before and after implementation of the countermeasure, split into the variables for the “control” and “pilot” periods and the various occurrence categories.

The null hypothesis that no significant difference exists between the number of Category 1 and 2 occurrences before and after implementation of the measure.

For a 95% confidence level and an alpha level of 0.05:

Occurrence Cat	Control Observed Values	Pilot Observed Values
1-a	18	8
1-b	4	6
1-c	32	29
1-d	1	2
1-e	6	1
1-g	95	129
1-h	2	8
1-i	8	9
2-a	44	23
2-b	4	7
2-c	6	7
2-d	0	2
2-e	3	7
2-f	0	1
2-g	48	45
2-h	0	2
2-i	2	2
Totals	273	288

F Test = 0.430249

T Test = 0.73633

In both instances if  $P > \alpha$  then null hypothesis is not rejected.

Therefore;

**NULL HYPOTHESIS IS NOT REJECTED**

No statistically significant difference exists between the number of Category 1 and 2 occurrences before and after implementation of the countermeasure.

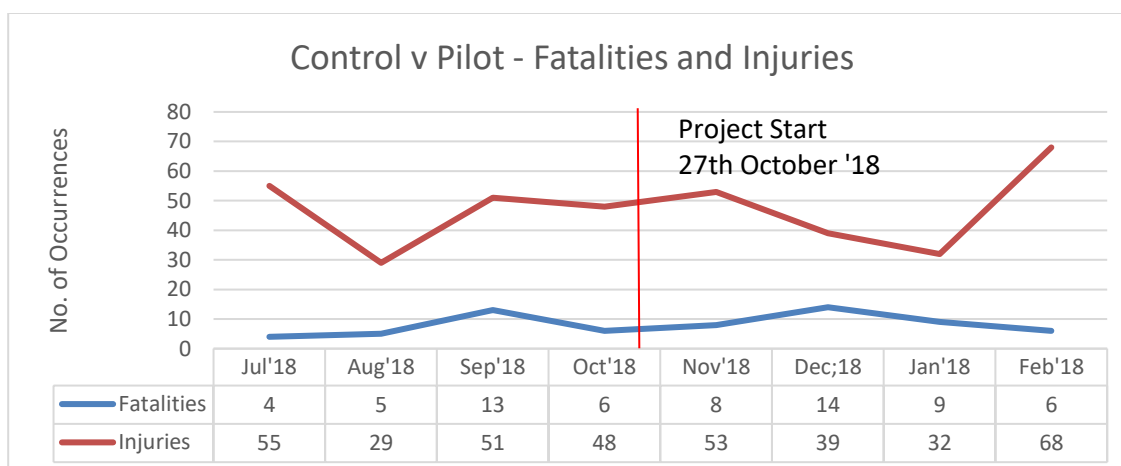
### ***Pilot period – safety occurrences***

There were 141 safety related occurrences in the pilot period up from 139 safety occurrences during the control period. The difference in the control and pilot periods are shown in Table 61: Safety occurrences comparison over the evaluation period. Category E-a, occurrences where a member of the public is struck by rolling stock on a running line remains high with an increase to 46 occurrences.

**Table 61: Safety occurrences comparison over the evaluation period**

<b>Occurrence Category</b>	<b>Control</b>	<b>Pilot</b>	<b>Difference</b>
<b>E-a</b> Member of the public is struck by rolling stock on a running line	42	46	4
<b>F-a</b> Person fell or was pushed from inside a moving or stationary train	15	7	-8
<b>G-a</b> Passengers travelling outside the designated passenger area of the train	11	16	5
<b>TOTALS</b>	68	69	1

The number of fatalities and injuries over the pilot period increased to 37 and 203 occurrences respectively. There was a marked increase in injuries in February (68 occurrences from 32 the previous month). See Figure 50: Fatalities and injuries over the evaluation period. Fourteen Fatalities were recorded in December, with the average at 7.4 fatalities per month over the period (up from six fatalities per month for the control period).



**Figure 50: Fatalities and injuries over the evaluation period**

***CASE H<sub>0</sub>17: No significant difference exists between Category E-a occurrences before and after implementation of the countermeasure.***

Using the t-test to check if there is a significant difference in the number of Category E-a occurrences before and after implementation of the countermeasure, split into the variables for the “control” and “pilot” periods and the months under consideration.

The null hypothesis that no significant difference exists between the number of Category E-a occurrences before and after implementation of the measure.

For a 95% confidence level and an alpha level of 0.05:

Observed values:

A-e per Month	Control – Observed Values	Pilot – Observed Values
Month 1	9	13
Month 2	8	13
Month 3	10	7
Month 4	13	13
Totals	40	46

F Test = 0.60316

T Test = 0.476484

In both instances if  $P > \alpha$  then null hypothesis is not rejected.

Therefore;

**NULL HYPOTHESIS IS NOT REJECTED**

No statistically significant difference exists between the number of Category E-a occurrences before and after implementation of the measure

### 6.5.2 Pilot period – Location analysis

Occurrences continue to be widespread across the network with the top locations shown in Table 62: Pilot period – Top 20 locations, with the relative movement showing either an increase or decrease in occurrences.

**Table 62: Pilot period – Top 20 locations**

Location	No. of Occurrences - Pilot	Movement
Cape Town	31	⬇️
Bellville	29	⬆️
Kraaifontein	16	new
Cape Town - Woodstock	12	⬇️
Heathfield	12	⬆️
Salt River	11	⬇️
Kenilworth - Wynberg	10	new
Maitland	10	⬆️
Langa	9	⬆️
Langa - Bonteheuwel	9	new
Phillipi - Stock Road	9	new
Parow - Tygerberg	8	new
Bellville - Kuilsriver	7	new
Eerste River	7	⬇️
Eikenfontein	7	new
Esplanade	7	new
Langa - Mutual	7	new
Nonkqubela	7	new
Paarden Eiland	7	new
Woodstock	7	↻️

Like the control period, the occurrences are widespread. Only nine locations from the control period remain in the top 20, with 11 new locations. This could be an indication of geographical displacement as a number of new locations are close to those that have recorded high occurrences in the past. For example, Kuilsriver Station is no longer in the top 20 but the section of track between Bellville and Kuislriver Station now is. The hot-spot locations shift slightly to:

- Cape Town – Woodstock – Paarden Eiland - Salt River – Maitland,
- Mutual - Langa – Bonteheuwel, and
- Kraaifontein - Bellville – Kuilsriver – Eerste River.

## 6.6 COSTS

The costs for the project for a year are split equally between the 3 contributing stakeholders. The costs include salaries, overtime, uniform, protective gear, radios, firearms and training. The annual costs, although not relevant to the study, provides a useful insight into the expenses involved and is summarised in Table 63: Rail Enforcement Unit cost breakdown.

**Table 63: Rail Enforcement Unit cost breakdown**

Description	No.	Cost per Annum	Sub-Total
<b>Personnel Requirements</b>			
Enforcement Officers Training and deployment of 100 personnel	100	R34,033,200.00	<b>R40,166,467.00</b>
Supervisory Staff Including: 8 Inspectors 4 Senior Inspectors 2 Principal Inspectors	14	R4,970,418.00	
Admin Staff Including: 1 Professional Officer 3 Clerks	4	R1,162,849.00	
<b>Vehicle Requirements</b>			
Transporter Lease	6	R1,800,000.00	<b>R6,600,000.00</b>
Bukkie Lease	15	R3,600,000.00	
Motorbike Purchase	10	R1,200,000.00	
<b>Training Requirements</b>			
Tactical and Street Survival Techniques	50	R4,872.00	<b>R11,807.00</b>
Peace Officer & Traffic Warden Training	50	R6,935.00	
<b>Sundries</b>			
Protective Gear	50	R8,271.00	<b>R18,799.00</b>
Equipment	50	R1,652.00	
Motorbike Equipment	10	R8,876.00	
<b>TOTAL</b>			<b>R46,797,073.00</b>

## 6.7 SUMMARY ANALYSIS: HOW EFFECTIVE IS THE SPECIFIC COUNTERMEASURE STRATEGY?

Armed, security patrols remain a popular choice by government officials, politicians and railway operators as an appropriate response to counter criminal behaviour on the rail network. This despite, literature, cautioning about the limits of its effectiveness as a singular response.

In evaluating the counter-measure, several factors need to be considered. These are discussed next.

### ***Geographical displacement of crime***

On evaluation of the control and pilot data, the total number of occurrences increased by 9.8% from the previous three months. This provides a slightly distorted view on the effectiveness of the initiative. The location data of the occurrences was evaluated in tandem with the empirical data and evidence of geographic displacement of crime is evident. Geographic displacement occurs when a countermeasure is successfully implemented at a specific location, and criminals move to other areas to offend.

Of the top 20 locations for occurrences in the control period, only nine locations were in the top 20 locations in the pilot period, with 11 new locations. Another telling feature is that the 11 new locations are close to the original hot-spots, where crimes have taken place before.

Enforcement measures are temporary by their very nature and due to the large area that needs to be covered it is inevitable that criminals will alter their tactics and either wait till the enforcement subsides or they will move to a less risky area.

### ***Diffusion of benefits***

Diffusion occurs when the positive knock-on effects of a countermeasure affects areas not originally targeted. The rail operator has indicated that where the REU has been active, a marked increase in fare revenue and ticket sales was recorded at the target stations. The commuter's perception on safety has also improved, but without a Customer Satisfaction Survey being carried out, this cannot be verified.

### ***Overall statement on effectiveness***

The countermeasure is directed at crime and must only be evaluated for its effect on crime on rail infrastructure, for which it is believed that it is an effective measure, but for a limited period and at the specific location where the patrols are deployed. The effectiveness of enforcement countermeasures on trespassing in general and its effect on reducing pedestrian-rail incidents is uncertain; for this case study it has proved ineffective in this regard.

Due to the vast expanse of the rail network and the limited resources available, enforcement and security type initiatives are by their nature, temporary. No

enforcement response can be everywhere, all the time. This limited review proves that enforcement countermeasures need to be considered in combination with other measures to ensure its durability and reduce significant temporal displacement.

In summary, the REU has shown limited effectiveness over the short evaluation period. A more detailed evaluation is recommended over a minimum period of one year, also taking into effect the diffusion of benefits of the project.

***Recommendations for improvement***

The REU has encountered a number of problems during the pilot period, most of which is typical when a new cross-organisation agreement is entered into. Differing financial reporting year periods, funding constraints, recruitment bureaucracy, and the temporary nature of the project all limit the project's success. A firm commitment from all stakeholders as well as a longer project period would bring more stability to the project.

Effective co-operation with the police is essential. The SAPS RRPUs plan their responses based on reported crime whilst the rail protective officers plan their responses using incident data. Joint planning is recommended so that both data sets are considered, and the appropriate responses devised.

Finally, it is recommended that the use of CCTV technology be employed more widespread across the network to enable continuous monitoring, with coverage of stations, line sections as well as high value targets such as substations and signal equipment.

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**Figure 51: Rail Enforcement Unit officers at Cape Town Station**



**Figure 52: An assortment of weapons and drugs confiscated on a typical patrol**

# Chapter 7: Expert Interviews and Site Visits

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This chapter details the results of the qualitative analysis of this research. Section 7.1 presents the findings from the subject matter experts interviewed to expand on the results from iii.).

A number of locations were selected for further investigation and validation of the results from the quantitative analysis as well as the information gathered during the interviews. Section 7.2 describes the findings from several site visits carried out to confirm and validate information from the literature review, data analysis and interviews carried out. Thirteen sites were visited and the Site Inspection Field Notes along with photographs are included as Appendix F.

Finally, Section 7.3 provides an analysis of the chapter.

## 7.1 EXPERT INTERVIEWS

Interviews were carried out with select individuals as subject matter experts to provide another layer of information to expand on what was discovered thus far from the literature reviews and quantitative data analysis. With very little information provided in the literature about the effectiveness of countermeasures, a specific focus of the interviews was to gather opinions on various measures implemented and to garner firsthand experience on what works and what does not. The interviews were also used to determine opinions on where the worst locations for trespassing are on the network to further inform the Site Visit element of this research.

The following sections discuss the results from the interviews under a number of themes. These are: Section 7.1.1, general trespasser characteristics; Section 7.1.2, reasons for trespassing, and Section 7.1.3 the findings around trespassing hot-spots. Trespassing countermeasures will be discussed in Section 7.1.4; and the final theme will be priority focus areas in Section 7.1.5.

## **7.1.1 Theme 1 – General trespasser characteristics**

### *Number of trespass occurrences*

Respondents were asked how many instances of trespassing they believe occur daily on the rail network.

Four out of five respondents answered that trespassing is a major problem and the numbers are too high to count. The Nomzamo informal crossing was cited as an example where more than 3000 pedestrians cross the railway in one direction, with all-day movements in both directions. Brackenfell Station was also used to describe the phenomenon of accessing the station via the platform ends, where up to 2000 people do so in the morning peak alone.

What became clear was that trespass incidents related to crime could be quantified but the numbers of people trespassing with no criminal intent are “not regularly counted or quantified”. One respondent believed that there are a number of contributory factors that would ensure continued growth in railway trespassing numbers, these being i) the need to access services and the lengthy time it takes to correct spatial inadequacies; ii) the poor state of the country’s economy, meaning that people will walk more to save money and more will attempt to use the train without paying fares; iii) the time saving to be gained from taking a short-cut; and lastly, iv) “behavioural decay”. More people are finding it acceptable to break the rules where even “ladies with dresses” would not think twice about taking a short-cut across the tracks.

With regards to quantifying trespass numbers, pedestrian-rail accident data are not thought to be a reliable indicator. High trespassing locations could have very low fatalities or none at all.

### *Time of day*

Respondents were asked what time of the day they believed trespassing to be more prevalent.

Overall, trespassing was considered to occur throughout the day with discernible peaks in the morning (6h00 – 9h00) and afternoon (16h00 – 19h00) periods.

Respondents agreed that peak flows depended on the location of the trespass site: its location relative to the major trip attractors, and the land-use surrounding the

site. If one considers Cape Town as an example, the further the ‘origin’ stations are from the city, the earlier the peak times would be. Stations closer to the city would have later peak times. The location of industrial areas around stations would also have concentrations of people trespassing around ‘clock-in’ times between 7h00 and 8h00 and then again in the evenings between 17h00 and 18h00. Similarly, the location of schools around stations would influence the peak trespassing times resulting in an early afternoon peak period starting from around 14h30. Where trespassing sites are located close to shopping areas and public transport facilities, all day activity is common.

One respondent highlighted a specific time of the day posing a risk for pedestrian-rail incidents, which is the period after train services have ended, i.e. after 22h00. During this time, trains do not pick up passengers and may be en route to a staging yard; it is at this time that trespassers least expect trains and may become involved in a train incident.

Another respondent suggested that people will avoid trespassing at night as most locations are not very well lit, making it ideal hide-out places for criminals, and would choose a “safer” crossing point instead. “Safer” in this context does not refer to the likelihood of being involved in a train collision but rather the likelihood of being a victim of crime.

### ***Gender and age group***

Respondents were asked whether trespassers were likely to be either male or female and whether more children, adolescents or adults would trespass.

Trespassers were thought more likely to include both males and females, but with a larger proportion of males. One respondent cited an example at Cape Town Station, where larger number of trespassers enter the railway reserve to avoid paying fares and walk longitudinally down the track to either Woodstock or Esplanade Station to board a train. In this specific example, trespassers were more likely to be male as they were more physically capable to climb over cable runs and navigate crossing multiple rail lines, in probably one of the most high-risk areas for a pedestrian-train incident. Trespassers were also considered more likely to be adults. Children would more commonly trespass if there was a school near a railway line or rail station. Children were seldom victims of railway incidents.

### 7.1.2 Theme 2 – Reasons for trespassing

Respondents were asked about what they believed to be the main reasons for trespassing.

Four primary reasons were identified:

i.) The shortest and most convenient route

“In the worst areas for trespassing, you will find that stations are much farther apart, with less formal crossing opportunities. The alternate route is not only a major diversion but is very unsafe for personal safety.” A respondent pointed out that large numbers of people use the rail reserve as a pedestrian corridor and walk along routes in parallel with the rail tracks. Reasons commonly cited for using a short-cut include there being no formal crossing point available or the formal pedestrian route is deemed as unsafe.

A respondent identified a general issue, that not enough is being done to ensure people are able to access basic services and the role of transport corridors as barriers to movement. This is a problem which affects not only rail but can be found on major road arterials and freeways. “The N1, N2, R300 all have people crossing them (at informal points)” for basic needs.

ii.) Fare evasion

“Fare evasion is large before big destination stations, such as Cape Town.” Trespassers will avoid paying train fare and avoid station ticket inspectors by simply walking along the tracks to the next station. “People will detrain and walk along the tracks,” to exit somewhere along the rail reserve, normally through a hole in the fencing.

iii.) Deteriorating social and behavioural attitudes

One respondent specifically highlighted the issue of deteriorating social norms, where it has become acceptable to break rules and the law if it can be justified. “Bad behaviour in the road environment spills over into the rail environment”, where people are becoming increasingly willing to take risks. In the rail environment this is exacerbated by the

fact that bad behaviour is copied by others, “.... when I see other people doing something, then I can also do it”. It was also felt that trespassing was becoming more common-place amongst “middle-income and educated communities”.

Another respondent suggested that a number of station precinct areas have “been left to deteriorate and have become little crime infested slums.” Commuters could justify their behaviour by taking an alternate route across the tracks to avoid these “no-go zones” where they risk being robbed.

iv.) Encroachment

The erection of informal dwellings and structures on railway property was mentioned by two respondents and described in slightly different ways. The first mentioned the increase in the “number of homeless people using the railway reserve to build make-shift shelters.” The second respondent described a more organised erection of informal dwelling and used the location at Philippi Station as an example, where an informal settlement has spread in a rail staging yard area and shacks are being built “right on the tracks”.

v.) Other

A number of other reasons for trespassing were discussed such as suicides, thrill-seeking and graffiti but these were not believed to be a major problem.

### 7.1.3 Theme 3 - Trespassing hot-spots

Several specific locations were used by respondents as examples to describe a particular phenomenon taking place. These locations are listed in Table 64: Trespassing locations.

**Table 64: Trespassing locations discussed during interviews**

<b>Location</b>	<b>Description</b>
<b>Cape Town Station</b>	Fare evasion, High numbers of trespassing, Station precinct degradation
<b>Esplanade Station</b>	Fare evasion, High numbers of trespassing
<b>Staging yards</b>	Graffiti
<b>Philippi Station and Staging Yard</b>	Encroachment
<b>Nyanga Station – Philippi Station</b>	High numbers of trespassing
<b>Van Der Stel Station – Strand Station</b>	High numbers of trespassing
<b>Salt River Station – Woodstock Station</b>	High numbers of trespassing
<b>Muizenberg Station – St. James Station</b>	Formal at-grade pedestrian crossing
<b>Bonteheuwel Station</b>	High numbers of trespassing
<b>Kuils River Station</b>	High numbers of trespassing
<b>Eerste River</b>	High numbers of trespassing
<b>Heideveld Station</b>	Formalised pedestrian bridge
<b>Blackheath Station</b>	Trespassing
<b>Nyanga Station</b>	Concrete walling
<b>Du Toit Station – Koelenhof Station</b>	High numbers of trespassing
<b>Parow Station</b>	Trespassing, Station precinct degradation

#### **7.1.4 Theme 4 – Trespassing countermeasures**

Respondents were asked to discuss what they believed were the most effective countermeasures to reduce trespassing and suggest strategies where appropriate.

##### ***Fencing***

“Fencing as the first line of defence must be broadly expanded to secure the network entirely.” Nearly all respondents agreed that fencing can be a very effective countermeasure. The type of fencing needs to correspond to the level of risk of the surrounding area and currently no guidance document on a fencing specification exists.

The most successful fencing project identified by a respondent was that installed between Nyanga and Philippi Stations. The fence consists of a concrete wall which has proven to be very effective in reducing trespassing and has till now resisted any damage from vandalism. The fence is, however, “visually unappealing” and reinforces the “barrier” effect and is considered as a “last resort” option.

Irrespective of the type of fence installed, it was agreed that a robust maintenance programme is essential. One respondent identified ownership issues around maintenance responsibilities between railway operators and local authorities, which hampers immediate responses to issues such as vandalised fences.

##### ***Technology***

Detection and surveillance technology incorporating CCTV and drones was identified as an effective countermeasure, especially when used in combination with enforcement measures.

It was also suggested that technological advancements in the fields of crime analysis, target hardening of high-risk assets as well as modern rail signalling systems be explored. Theft of signal cables was one of the most concerning issues affecting railway safety and has the biggest knock-on operational effects. “The manual train authorisations procedure used in the event of a signalling system being disrupted is problematic and has contributed to railway incidents countrywide.”

### ***Improved visibility***

Improving visibility and detection at high risk locations with improved lighting and removal of dense track-side vegetation was suggested.

### ***Patrols and enforcement***

Patrols and enforcement were deemed to be a very effective countermeasure, but issues were raised around its sustainability. Staffing and capacity issues often limit the effectiveness of such measures and “as soon as the patrols move off the behaviour returns”.

Closer cooperation with the SAPS RRPUs and the railway operators’ protective services, leading to more joint deployments, more visibility on the network and “following through on opened criminal dockets” was deemed essential by one respondent.

Enforcement outside of the railway environment was also highlighted. The example used was where mini-bus taxi’s would “legitimise” unlawful pedestrian behaviour by picking up and dropping off passengers at commonly used trespass locations. It was felt that municipal traffic officials need to do more to regulate the mini-bus taxi industry and punish such practice.

### ***Education and awareness campaigns***

While one respondent felt that awareness, education and media campaigns were ineffective countermeasures, others suggested that such campaigns be targeted at specific audiences. The demographics at a specific location need to be studied and an awareness campaign developed specifically for the target audience. “It’s no use doing a media campaign on the internet or at a school when you should be going into shebeens and taverns instead”. The importance of evaluating the effectiveness of awareness campaigns was also raised.

One respondent suggested a campaign targeted at individuals wearing headphones or earphones to make them more aware of the dangers of not being able to hear oncoming danger and quoted a train driver who had a near-miss incident where a trespasser narrowly missed being hit by a train and not hearing the train’s warning siren.

### *An informed Judiciary*

With regards to railway crime, it was felt that the judiciary needs to be educated on rail law and the issues facing the rail industry. “Crime against railway infrastructure is still seen as a minor crime and dedicated courts would facilitate the prosecution of criminals, which is essential to deter crime on the network,” was the opinion of one respondent.

Prosecuting trespassers is, however, not recommended, especially where no criminal intent is shown, as the sheer numbers of trespassers would make this logistically a very high-resource activity.

### *Pedestrian grade separation*

Pedestrian bridges are not considered as an effective countermeasure as they are costly to build and maintain, and “could become white elephants if not sited correctly.” The importance of considering pedestrian movements in the design process when considering grade-separation is of vital importance.

Currently no warrants exist to guide the planning of pedestrian grade-separated crossings, and it was suggested that a standard be developed to guide the spacing of formal crossing opportunities along transport corridors to provide more such crossing opportunities.

A proposal to formalise certain high-traffic informal at-grade pedestrian crossings was suggested by two respondents. The example of a formalised pedestrian at-grade crossing near Muizenberg Station was highlighted. The current railway operator’s policy prevents the formalisation of at-grade pedestrian crossings. It is believed that this stance is not practical, nor does it reduce risk and that “the technology exists to make it a safe option”.

“The solutions are there. We must consider what will work in our local context considering human behaviour and the growing lack of compliance with basic rules and laws.”

The construction of new subways as a grade-separation option will only be considered by communities, “if it can be proved that the existing subways on the network can be properly managed.” Subways are known for being crime hot-spots, being poorly maintained and with poor drainage, they regularly flood after heavy rains, making them unusable to pedestrians.

### **7.1.5 Theme 5 – Priority focus areas**

Respondents were asked what areas on the network should be prioritised for immediate response. Some of the responses were:

“You need to focus on where you have control. Secondly, there needs to be a focus on securing fare revenue. Trespassing at and near stations need to be prioritized for these reasons.”

“The main priority should be to eliminate illegal movements onto stations via the platform ends. If this can be eliminated this will have a knock-on effect on trespassing in section areas.”

“We also need better cross stakeholder involvement. These aren’t only rail or transport problems but societal issues. Unemployment, crime, homelessness; these aren’t rail issues, but it affects rail.”

“The broken window principal needs to be applied to our station precinct areas.”

Respondents were unanimous that the priority focus area for immediate attention should be to secure the station precinct area and specifically access to stations. This would eliminate many illegal pedestrian movements as well as improve revenue collection at stations.

### **7.1.6 The impacts of a pedestrian-train fatality**

The interviews highlighted an often-overlooked element of railway trespassing and pedestrian-rail incidents; these are the effect that such occurrences have on train drivers.

Trespassing has been highlighted as a big concern to train drivers. Trespassers are oblivious to the risks involved and their behavior is a major cause of on-the-job-stress for train drivers.

The impact of a rail fatality on train drivers not only affects the mental well-being of the individual, but also has the knock-on effect of affecting operational planning. Train drivers are often unable to return to work after a fatality and could only return once cleared after a series of psychological assessments. The pool of available train drivers is constantly diminishing and bureaucratic delays in the recruitment process hampers the timeous filling of vacant positions. This often

means that current rostered train drivers must do longer or more shifts, which can cause further stress on the train drivers. Recently there have also been a number of attacks on train drivers which further compounds the difficult conditions train drivers currently work under.

## 7.2 SITE VISITS

The locations visited are listed in Table 65: Site visit locations, along with the reasons for selecting the specific sites. The major criteria for selecting the sites were as follows:

- Several sites outside of the City of Cape Town were selected so that the problem in neighbouring municipalities could be assessed.
- Sites identified as hot-spots from the quantitative analysis phase.
- Sites specifically mentioned during the expert interview stage.
- Safety and accessibility.
- Sites selected based on personal knowledge of known trespassing.

**Table 65: Site visit locations**

<b>Location</b>	<b>Reason for Site Selection</b>
<b>Elsies River Station</b>	Example of an “unfriendly” subway, discouraging use of the formal rail crossing point.
<b>Elsies River Station – Parow Station</b>	High number of occurrences involving pedestrian-train incidents.
<b>Parow Station – Tygerberg Station</b>	High number of occurrences involving pedestrian-train incidents.
<b>Parow Station</b>	High number of occurrences involving pedestrian-train incidents.  Station precinct area identified as a crime hot-spot.
<b>Mbekweni Station</b>	Location in Drakenstein Municipality with high number of occurrences involving pedestrian train incidents.

<b>Location</b>	<b>Reason for Site Selection</b>
<b>Dal Josafat Station – Mbekweni Station</b>	Location in Drakenstein Municipality with high number of occurrences involving pedestrian train incidents.
<b>Klapmuts Station</b>	Location in Stellenbosch Municipality with high number of occurrences involving pedestrian train incidents.
<b>Du Toit Station – Koelenhof Station</b>	Location in Stellenbosch Municipality with a known informal at-grade pedestrian crossing.
<b>Strand Station – Van der Stel Station</b>	Location with a known trespassing hot-spot.
<b>Netreg Station – Heideveld Station</b>	Example of a universally accessible grade-separated pedestrian crossing.
<b>Nyanga Station – Philippi Station</b>	Hot-spot area with high number of occurrences involving pedestrian train incidents as well as occurrences of theft and vandalism.  Example of concrete fencing installed as a countermeasure.
<b>Bonteheuwel Station</b>	High number of occurrences involving pedestrian-train incidents as well as occurrences of theft and vandalism.
<b>Kraaifontein Station</b>	High number of occurrences involving pedestrian-train incidents.

### **7.2.1 Location analysis**

Trespassing or evidence of trespassing was identified at all 13 locations visited. (See Table 66: Site visit – Nature of trespassing). Five of the locations were at train stations including the area immediately adjacent to the stations and eight locations were along line sections. Encroachment was identified at four of the locations with the shacks adjacent to the tracks between Mbekweni and Dal Josafat Stations in Paarl posing the most significant risk. The shacks were not only located to nearly within the kinematic envelope of the train but there was also evidence of human waste,

water waste and litter which could undermine the structural integrity of the rail ballast. See Figure 53: Encroachment of shacks in Mbekweni, Paarl. Loitering was evident at two of the locations, where people were inside the rail reserve for no apparent reason.

**Table 66: Site visit – Nature of trespassing**

Location	Trespassing	Encroachment	Loitering
Bonteheuwel Station	✓		
Du Toit Station - Koelenhof Station	✓		✓
Elsies River Station	✓		
Elsies River Station - Parow Station	✓		
Heideveld Station - Netreg Station	✓		
Klapmuts Station	✓		
Kraaifontein Station	✓		✓
Mbekweni Station	✓		
Mbekweni Station - Dal Josafat Station	✓	✓	
Nyanga Station - Philippi Station	✓		
Parow Station	✓	✓	
Strand Station - Van der Stel Station	✓	✓	
Tygerburg Station - Parow Station	✓	✓	
<b>Total</b>	<b>13</b>	<b>4</b>	<b>2</b>



**Figure 53: Encroachment of shacks in Mbekweni, Paarl**

An informal MBT ranking facility was situated immediately alongside one location at the Khayamandi Mall informal crossing, near Du Toit Station. (See Figure 54: Site visit – Khayamandi Mall informal crossing).

Outside the Nomzamo informal crossing, the arterial road, M153, Strand Main Road, is along a taxi route and MBT operators collect and pick-up passengers at this location. Both locations recorded the greatest number of trespassers during the site visit.

The only location visited adjacent to an informal settlement was that at Mbekweni in Paarl. An attempt was made to visit the staging yard at Philippi Station, but being unfamiliar with the area, this could not be done safely. (See Table 67: Site visits – Adjacent land-use).

**Table 67: Site visits – Adjacent land-use**

<b>Location</b>	<b>Industrial</b>	<b>Residential</b>	<b>Public Transport Facility</b>	<b>Retail</b>	<b>Informal Settlement</b>
<b>Bonteheuwel Station</b>	✓	✓			
<b>Du Toit Station - Koelenhof Station</b>	✓		✓	✓	
<b>Elsies River Station</b>	✓		✓		
<b>Elsies River Station - Parow Station</b>	✓	✓			
<b>Heideveld Station - Netreg Station</b>		✓			
<b>Klapmuts Station</b>		✓		✓	
<b>Kraaifontein Station</b>		✓			
<b>Mbekweni Station</b>					✓
<b>Mbekweni Station - Dal Josafat Station</b>					✓
<b>Nyanga Station - Philippi Station</b>		✓			
<b>Parow Station</b>		✓	✓	✓	
<b>Strand Station - Van der Stel Station</b>		✓	✓*		
<b>Tygerburg Station - Parow Station</b>		✓			
<b>Grand Total</b>	<b>4</b>	<b>9</b>	<b>3</b>	<b>3</b>	<b>2</b>

\*Informal MBT pick-up and collection point



**Figure 54: Site visit – Khayamandi Mall informal crossing**

A 15-minute all-direction pedestrian count was completed at each location to give an indication of the numbers of trespassers. (See Table 68: Site visits – 15minutes trespass counts). The Nomzamo location between Strand and Van der Stel Stations (n=384), as well as the Khayamandi Mall location between Du Toit and Koelenhof Stations (n=303) recorded the highest number of pedestrians. A significant number of trespassers were counted at Kraaifontein (n=54) and Klapmuts (n=25) Stations. The counts were all completed during off-peak times.

**Table 68: Site visits – 15minutes trespass counts**

<b>Location</b>	<b>Trespass 15min Count</b>
<b>Strand Station - Van der Stel Station</b>	384
<b>Du Toit Station - Koelenhof Station</b>	303
<b>Kraaifontein Station</b>	54
<b>Klapmuts Station</b>	25
<b>Tygerburg Station - Parow Station</b>	15
<b>Bonteheuwel Station</b>	12
<b>Mbekweni Station</b>	9
<b>Elsies River Station</b>	7
<b>Elsies River Station - Parow Station</b>	7
<b>Mbekweni Station - Dal Josafat Station</b>	3
<b>Parow Station</b>	3
<b>Heideveld Station - Netreg Station</b>	0
<b>Nyanga Station - Philippi Station</b>	0
<b>Grand Total</b>	<b>822</b>

Direct pedestrian crossing action was witnessed at nine of the locations and longitudinal movement at nine locations. Trespassing to access the station via the platform-end was witnessed at five of the locations including Du Toit Station, Elsies River Station, Klapmuts Station, Mbekweni Station and Kraaifontein Station.

Trespassers were mainly adult males and females with just under half of the sites also having child trespassers. See Table 69: Site visit – Demographic data. A few of trespassers were elderly (male and female) and a man with a walking stick was witnessed trespassing during the visit to Klapmuts Station. (See Figure 55)



**Figure 55: Klapmuts Station – Elderly man with walking stick using a short cut across the tracks**

**Table 69: Site visit – Demographic data**

<b>Location</b>	<b>Adult</b>	<b>Child</b>	<b>Male</b>	<b>Female</b>	<b>Elderly</b>	<b>Cyclists</b>	<b>Homeless</b>
<b>Bonteheuwel Station</b>	✓	✓	✓	✓	✓		
<b>Du Toit Station - Koelenhof Station</b>	✓	✓	✓	✓	✓	✓	
<b>Elsies River Station</b>	✓		✓				
<b>Elsies River Station - Parow Station</b>	✓		✓				
<b>Klapmuts Station</b>	✓	✓	✓	✓	✓		
<b>Kraaifontein Station</b>	✓	✓	✓	✓			
<b>Mbekweni Station</b>	✓		✓	✓			
<b>Mbekweni Station - Dal Josafat Station</b>	✓	✓	✓	✓			
<b>Parow Station</b>	✓		✓	✓			✓
<b>Strand Station - Van der Stel Station</b>	✓	✓	✓	✓	✓	✓	✓
<b>Tygerburg Station - Parow Station</b>	✓		✓	✓			
<b>Grand Total</b>	<b>11</b>	<b>6</b>	<b>11</b>	<b>9</b>	<b>4</b>	<b>2</b>	<b>2</b>

A number of the locations visited had formal, alternate crossing points, with most locations (n=8) having a formal pedestrian overbridge. Two locations had subways/underpasses at Elsies River and Klapmuts Stations, both of which were not very “friendly” for pedestrians. See Table 70: Site visits – Closest formal crossing point.

Eleven (n=11) of the locations had fencing installed either partially or fully and nearly all fencing was vandalised several points along its length to facilitate access to the railway reserve. The only fence that showed resistance to vandalism was the section of concrete fencing between Nyanga and Philippi Station. This concrete wall-fence was also the most obtrusive and imposing.

Klapmuts Station has a significant level difference between the tracks and street including a rock-filled gabion used as an earth retaining structure, which could be considered as a landscaping barrier. See Figure 56: Site visits – The level difference between the street and track at Klapmuts Station. This measure was largely ineffective as pedestrians created a pathway through the obstruction to access the tracks.

**Table 70: Site visits – Closest formal crossing point**

<b>Location</b>	<b>Subway</b>	<b>Over-bridge</b>	<b>Formal Pedestrian Route</b>	<b>No Safe Crossing</b>
<b>Bonteheuwel Station</b>		✓		
<b>Du Toit Station - Koelenhof Station</b>				✓
<b>Elsies River Station</b>	✓			
<b>Elsies River Station - Parow Station</b>				✓
<b>Heideveld Station - Netreg Station</b>		✓		
<b>Klapmuts Station</b>	✓	✓		
<b>Kraaifontein Station</b>		✓		
<b>Mbekweni Station</b>		✓		
<b>Mbekweni Station - Dal Josafat Station</b>				✓
<b>Nyanga Station - Philippi Station</b>		✓		
<b>Parow Station</b>		✓		
<b>Strand Station - Van der Stel Station</b>		✓	✓	
<b>Tygerburg Station - Parow Station</b>				✓
<b>Grand Total</b>	<b>2</b>	<b>8</b>	<b>1</b>	<b>4</b>



**Figure 56: Site visits – The level difference between the street and track at Klapmuts Station**

## 7.3 ANALYSIS OF INTERVIEWS AND SITE VISITS

The interviews, although only with a limited number of individuals, provided an additional level of information that provided context to the quantitative analysis as well as information on the effectiveness of various countermeasures. The site visits were used to validate and verify the information and provide an insight into actual witnessed behaviour.

### 7.3.1 General analysis

Trespassing is more widespread and commonplace than initially thought. A finding from the expert interviews was that the actual number of people trespassing is unprecedented and apart from a few very high traffic locations where counts have been carried out, the actual numbers of trespassers across the network is unknown. At the 13 sites visited, the average number of people trespassing was 63 persons/15-minutes or 252 persons/hour. The occurrence data which captures an element of trespassing, only represents a fraction of the problem as confirmed by (Silla & Kallberg, 2015) and (Savage, 2007).

The locations that have recorded the highest number of trespassers are characterised by direct pedestrian crossing action at one primary location. The trespassing behaviour at all other locations are characterised by random pedestrian movements, using diagonal or longitudinal paths across and along the tracks. Trespassers frequently use the platform ends to gain access to the stations. These findings support the research carried out by (Mvinjelwa et al., 2019).

The “typical” trespasser does not exist. Trespassers included both male and females, young and old, the physically fit and those less mobile such as trespassers carrying shopping bags or babies on their arms. We need to however distinguish between the motives for trespassing. One respondent during the expert interviews summed it up as follows: “We specifically don’t call it trespassing but ‘*informal crossing of railway lines*’.” This decriminalises the pedestrian whose sole aim is to cross the tracks in an “illegal but justifiable” manner as denoted by (Skládaná, et al., 2018).

It is difficult to determine whether an individual trespassing on the railway, is doing so with a criminal intent. Certain locations have been identified as fare evasion hot-spots (RSSB, 2018; Matzopoulos & Lerer, 1998; Mvinjelwa et al., 2019), where

it is clear that large numbers of trespassers do so to avoid ticket inspectors. From the study carried out in 2015 by (DelMistro & Khanye, 2015), where it was estimated that 7% of passengers travelled without a train ticket, based on the number of trespassers at fare evasion hot-spots, this number would seem to be increasing.

Nearly all trespassing acts witnessed during the site visits were without criminal intent (Havarneanu, 2017) and purely to take a short-cut along well-trodden pedestrian desire lines (Skládaná et al., 2018; Silla & Luoma, 2008; Ryan, 2012; Savage, 2007; RSSB, 2018).

The interviews confirmed the quantitative analysis finding that suicides are not a major contributor to railway fatalities, compared to that in Europe where suicides contributed to 72% of all fatalities (Ryan et al., 2018).

Contrary to the findings of (Silla & Luoma, 2008), trespassers were regularly seen in groups at several of the sites visited. A reason given for this is that “bad behaviour will often be copied by others” but another may be that the actual behaviour has been reinforced to the degree that it has become second nature and deemed to be acceptable practice. Walking in groups is also a common characteristic in school children pedestrian behaviour and this was evident in the rail environment as well where train stations have schools close by.

Unlawful occupation or encroachment into the railway reserve is widespread. These encroachments generally display itself on three levels:

- The first happens as a result of the expansion of informal settlements adjacent to railways. This is becoming more commonplace as a combination of critical housing shortages in cities and lack of employment opportunities in rural areas have led to the rapid expansion of informal settlements. Corrugated steel and wooden dwellings are erected for permanent/long term purposes. The dwelling arrangements may be well organised and planned or they could be dense where space is limited. The layouts are usually co-ordinated by a community facilitator, leader or chief. Examples of these types of encroachments are at Philippi, Langa and Mbekweni areas.

- The second type of encroachment consists of ramshackle shelters of a less formal nature. These shelters could consist of tents or flimsily constructed with cardboard and bits of plastic sheeting. Shelters would occasionally use the natural

shelter provided by trackside vegetation or be situated along the railway reserve boundary fencing or walls. The location of these “dwellings” are unstructured, haphazard and scattered, and are commonly found under bridges and highway flyovers, on the fringes of rail stations, abutments and any place along the rail reserve that provides any sort of natural cover or protection. These encroachments are widespread and have been seen all across the network.

- The third type of encroachment witnessed was fly-tipping, where the rail reserve is used as a rubbish dump and the tracks as a toilet and washing area (Srivastava, 2015). A number of features were identified that are common to areas of unlawful occupation as listed by (Poya & Mathebula, 2013) including pollution and sewage, fencing vandalised and removed, and numerous pedestrian pathways crossing the tracks.

A direct consequence of water and sewage waste being disposed of on the tracks as well as the physical act of the foot traffic of hundreds of pedestrians lead to the erosion and eventual structural damage to the track foundation and formation layers. The most apparent example of this was at the Nomzamo location between Strand and Van der Stel Stations, where railway sleepers are used to shore up the track ballast. (See Figure 57: Railway sleepers used to shore up track ballast at the Nomzamo informal crossing).



**Figure 57: Railway sleepers used to shore up track ballast at the Nomzamo informal crossing**

Apart from rubbish and waste being strewn inside the railway reserve, the general station and track-side environment is in a poor condition. Trackside vegetation is left to grow unabated across the network, impairing visibility for both trespassers and train drivers and hampers surveillance and detection of criminal activity. A number of station precinct areas are reduced to slums, with the areas overtaken by transients, informal traders and rampant drug use.

### **7.3.2 Countermeasure effectiveness**

Two clear countermeasure approaches became apparent from the expert interviews, one with a focus on trespassers as pedestrians and the other with a focus on trespassers as criminals. There are some countermeasures which would be equally effective with both pedestrians and criminals, such as fencing, while other countermeasures may be more specific to either pedestrians, such as grade-separation, or specific to rail crime, such as drones and CCTV.

The human behaviour element and the erosion of social norms in society in general are a concern that hampers the effectiveness of engineering measures. The human behavior element, as with all elements of life in modern day South Africa, is a complicated problem to deal with, which not only affects rail but may be a spill-over from non-compliance in general society. This is evident in the road environment; unacceptable road user behavior is rapidly becoming a common practice and road users need to be forced to behave in a certain way. In the rail environment then, the only effective engineering measures are the type which forces a certain behaviour. People cannot be expected to simply comply with rules and standards and where given a choice, they would most likely still choose the risky and unsafe option. What became apparent from the interviews was that the solution to trespassing cannot be down to only the railway operator and needs a coordinated multi-stakeholder approach.

During the site visits, while witnessing the behaviour of pedestrians crossing the tracks at the busiest locations, trespassers were not specifically looking out for an oncoming train before or during the act of crossing the tracks. Trespassers seemed oblivious to the dangers and will purposely avoid safer, formal crossing options where they were available.

The number of fences vandalised, with holes cut through them to create access points are an indication of the intention of the pedestrian to overcome or bypass the first engineering measure as an entry to the railway reserve. Fencing is largely ineffective as a barrier as most fencing is easily vandalised (and not maintained) to make access to the rail reserve. The only fence that has shown any longevity is the one installed between Nyanga and Philippi Stations and consists of a solid concrete wall construction. The maintenance of fencing is deemed critical to maintain the effectiveness of the countermeasure.

Existing formal crossings, such as subways, pedestrian overbridges and formal pedestrian routes are seldom used by pedestrians to cross the railway. From personal experience, majority of the available formal crossing options are a significant diversion from the main pedestrian desire lines, feel unsafe to use from a personal safety perspective and are poorly maintained.

Specific countermeasures targeted at rail crime have seen a number of combined measures implemented at high crime hot-spot areas.

Hot-spot policing strategies is recognised by Braga et al., (2012) and Telep & Weisburd, (2012) as an effective crime fighting strategy. These measures include the use of special armed tactical response units guided by drone surveillance systems and backed up by sophisticated crime analytics and crime intelligence.

These measures in combination have proven to be very effective where targeted interventions were made. The sustainability of enforcement focused measures are under scrutiny as their effects are short-lived and are resource heavy, placing huge burdens on operational expenditures of railway operators.

The strategy supporting greater controls around station access and kerbing illegal access onto stations from the platform-end ramps is widely supported. Measures focused around platform-end trespassing would greatly reduce trespass numbers at a number of locations as well as counter fare evasion.

Finally, there are at least 2 examples where the formalisation of an at-grade pedestrian crossing would greatly improve conditions for pedestrians and reduce the risks to rail operations. These locations are at the Nomzamo crossing in Strand and the Khayamandi mall crossing in Stellenbosch. Both these locations have thousands of pedestrians crossing the tracks daily and current rail policy prevents any

meaningful change being implemented. A risk-based approach should be used to evaluate sites such as these taking into consideration the duty-of-care of the railway operator and local municipalities in safe-guarding human life. International best practice guidelines exist to enable an effective at-grade solution to be developed at both these sites. See Figure 58: Double maze layout at a busy at-grade crossing in New Zealand and Figure 59: Layout plans for maze approaches for examples of how at-grade crossings are treated in New Zealand.



**Figure 58: Double maze layout at a busy at-grade crossing in New Zealand**

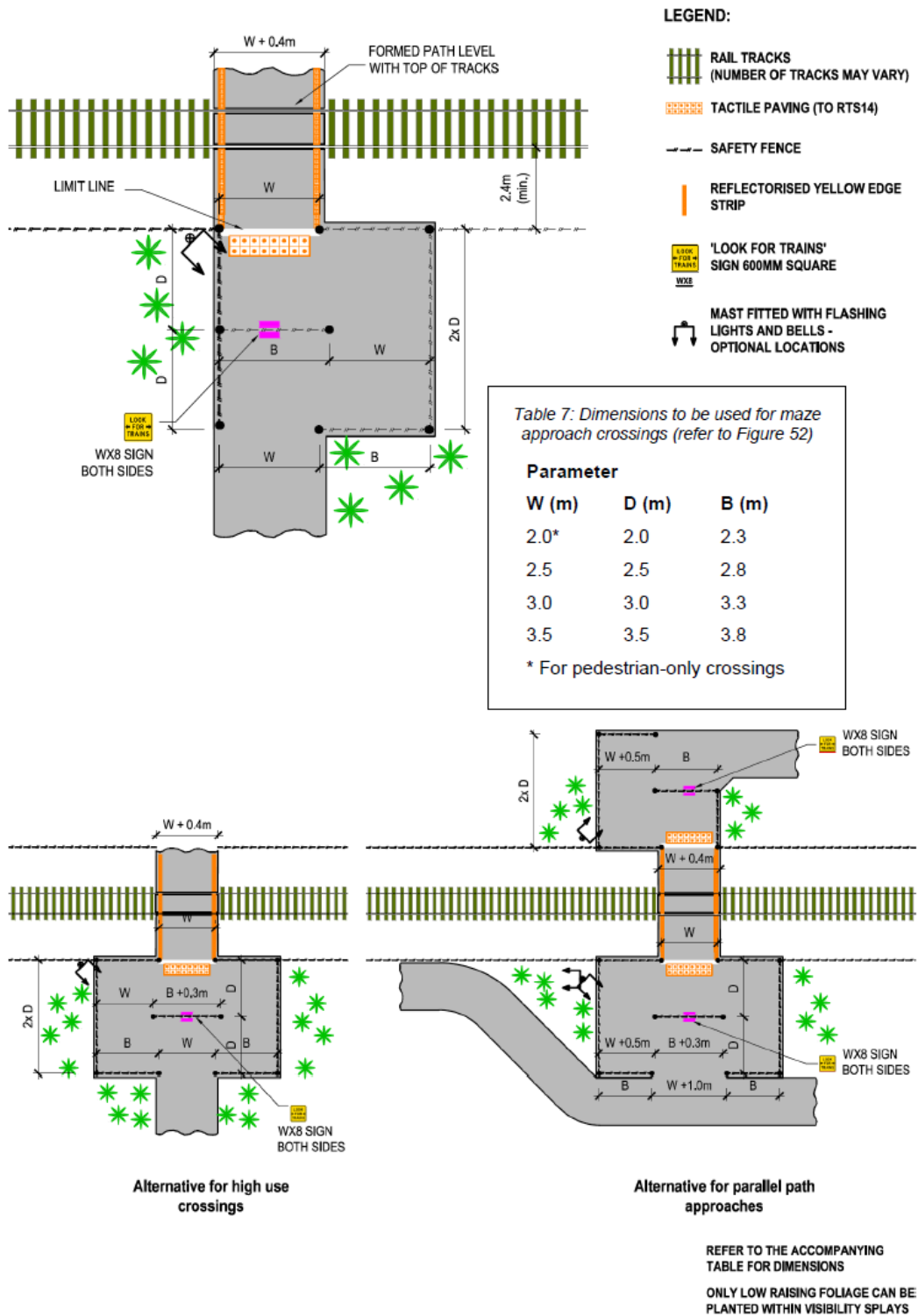
Source: (Koorey, et al., 2017)

**7.3.3 The impact on train drivers**

Apart from the impact to train operations, the psychological impact of pedestrian-rail fatalities requires more attention. With a growing number of pedestrians as trespassers on the tracks, train drivers are increasingly being placed under significant stress. This stress is likely to impact the train driver’s ability to concentrate, make decisions and his general emotional well-being.

The benefit of implementing measures to reduce trespassing and related incidents extends to the well-being of rail staff and the knock-on impact on train operations.

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**Figure 59: Layout plans for maze approaches**

Source: (Koorey, et al., 2017)

# Chapter 8: Conclusions

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This chapter will provide a summary of everything covered by this research report. The key findings are discussed in Section 8.2 along with recommendations, and practical suggestions for implementation. Topics for suggested further research is described in Section 0. The concluding remarks are discussed in Section 8.4, and completes this dissertation.

## 8.1 SUMMARY

The work undertaken as part of this research sought to provide a detailed description of railway trespassing focused on the commuter rail service area in the greater City of Cape Town functional region. Occurrences of pedestrian-rail fatalities as well as incidents of theft and vandalism to rail infrastructure are commonplace and occur with alarming regularity, leading to unnecessary loss of life and crippling the functioning of the rail system.

A detailed literature review was completed to provide a comprehensive overview of current knowledge on all aspects pertaining to railway trespassing as well as the methods and tools that are currently in use for the prevention of such railway trespassing. The literature review highlighted a number of limitations in the current knowledge around which this research was formulated.

This research contributes to the current field of knowledge by:

- presenting the characteristics of railway trespassing in a developing country context in an African city,
- describing the situation not only in the City of Cape Town but also considering all neighbouring municipalities that share the commuter rail service,
- considering all manifestations of trespassing as well as a specific focus on trespass related crime on rail infrastructure, and
- providing an evaluation on the efficacy of a countermeasure currently being implemented with support from empirical evidence on its effectiveness.

The research details the scale of the problem using a mixed-method, sequential exploratory research approach with a quantitative and a lesser, qualitative element. The quantitative analysis focuses on railway mortality and recorded deaths as well as railway safety and railway security incidents data. A specific focus of the analysis was on pedestrian-rail fatalities and injuries as well as occurrences of theft and vandalism to railway infrastructure.

The qualitative element consisted of a multi-pronged approach consisting of a select number of interviews with subject matter experts which was followed up by site visits used to verify and validate the information from the quantitative analysis as well as the expert interviews. The site visits allowed observations to be made whereby the behaviour of trespassers could be witnessed first-hand.

The final element entailed an evaluation of a specific enforcement countermeasure that involved multi-organisation co-operation to respond to the increasing levels of trespass-related crime on the rail network. The pilot project called the Rail Enforcement Unit was evaluated for its efficacy.

The results of the quantitative analysis are presented in iii.) with a full analysis, containing a discussion, interpretation and evaluation of the results of the quantitative analysis. Analysis of the case study evaluation and expert interviews and site visits are discussed at the end of the relevant chapters.

## **8.2 KEY FINDINGS**

### **8.2.1 Key finding 1: Characteristic of the typical pedestrian-rail incident**

The mortality data is the only reliable source of demographic information for deaths attributed to a rail-related trauma. The typical pedestrian-rail incident victim is male, between the ages of 20 and 59 years of age. Incidents are widespread with no clear temporal pattern other than an indication that incidents are more prevalent during the evening peak period, i.e. between 16:00 and 20:00.

### **8.2.2 Key finding 2: Coloured and black townships most at risk**

Analyses of the data confirms that the geographical locations for the highest number of pedestrian-rail occurrences, are where the rail line passes through black

and coloured townships on the Cape Flats. Locations that have high pedestrian-rail occurrences are also likely to have high incidents of theft and vandalism.

### **8.2.3 Key finding 3: Schools close to railway lines must be a focus area**

Railway-related deaths are rare among children. Fatalities increase dramatically from the age of 19 years. The transition from adolescent to adult, is therefore, critical to reinforcing safe behaviour, especially targeting older primary school and high school learners, where schools are located close to the railway.

Learners from schools situated close to the railway are also more accustomed to trespassing, and trespassing behaviour is treated as “normal”.

### **8.2.4 Key finding 4: Intelligent crime responses are required**

Pedestrian-rail occurrences, as well as occurrences of theft and vandalism, display a diffused temporal pattern, i.e. no seasonal or weekly variations exist.

All types of occurrences are more likely to happen in the morning and afternoon peak periods, although they occur regularly throughout the day. Criminals prefer operating under cover of darkness before the morning and after the afternoon peak periods when a reduced train service is operational.

The fact that no clear temporal trend exists is an indication of the rampant nature of occurrences of theft and vandalism on the rail network. Countermeasure strategies which are time-based, such as patrols and enforcement measures, will need to be carefully strategised to vary between high visibility operations and more aggressive surveillance and detection tactics. Longer-term monitoring and surveillance techniques involving CCTV and improved lighting must be considered.

### **8.2.5 Key finding 5: The highest priority rail corridor - The Central Line**

Pedestrian-rail occurrences are likely to increase when a normal train service is resumed on the rail network. This is applicable to urban and township areas where the communities adjacent to railway lines are more densely populated. More trains would mean more opportunities for incidents. This is especially relevant to the Central Line, which currently operates a much-reduced service, and has seen a reduction in the number of pedestrian-rail incidents because of this.

At the time of writing, the Central Line has had its rail service suspended due to theft and vandalism of critical signalling and electrical track equipment. It is planned to restore a reduced service by early 2021.

#### **8.2.6 Key finding 6: Current available data is not fully adequate**

Trespassing is more widespread and commonplace than initially thought. The expert interviews and site inspections confirm that the actual number of people trespassing is unprecedented, and apart from a few very high-traffic locations where pedestrian counts have been carried out, the actual numbers of trespassers across the network is unknown. The occurrence data which only captures an element of trespassing, represents but a fraction of the problem.

#### **8.2.7 Key finding 7: The three manifestations of railway trespassing**

Three main forms of trespassing can be confirmed:

- Informal crossing of the railway (or using a longitudinal path along the tracks), purely as a means of taking a short-cut with no criminal intent.
- Deliberate trespassing onto the non-public side of railway property for criminal intent which includes fare evasion, theft, vandalism and graffiti.
- Deliberate unlawful occupation on railway property for the purpose of setting up an informal shelter or dwelling in the rail reserve. Encroachment in the form of fly-tipping was also witnessed at several trackside locations.

#### **8.2.8 Key finding 8: Fare evasion and revenue protection**

Fare evasion is commonplace and a major cause of trespassing. Fare evaders are commonly encountered at the main destination stations closer to the CBD, but the origin stations should also be targeted for interventions to encourage behavioural change. The platform-ends are commonly used to gain access to the stations and clearly needs to be a focus for the railway operator to secure its station precinct.

#### **8.2.9 Key finding 9: Vegetation management is lacking**

The unchecked growth of track-side vegetation impairs visibility for both trespassers and train drivers and hampers surveillance and detection of criminal activity.

### **8.2.10 Key finding 10: Lack of awareness around the dangers of trespassing**

Trespassers were regularly seen in groups of two or more at several sites. This suggests that the actual behaviour has been reinforced to the degree that it has become second nature and deemed to be acceptable practice. Many pedestrians crossing the railway would not check to see if a train is approaching.

### **8.2.11 Key finding 11: Solutions require a multi-stakeholder approach**

Behavioural and societal issues including unemployment, drug abuse, and gangsterism have been identified as issues that cannot be put down to the railway operator to solve, and needs a coordinated, multi-stakeholder approach. These societal-issues render engineering solutions largely ineffective.

### **8.2.12 Key finding 12: The case for formalising at-grade pedestrian crossings**

Expert interviews and the site visits revealed at least two examples where the formalisation of an at-grade pedestrian crossing would greatly improve conditions for pedestrians and reduce the risks to rail operations. These locations are at the Nomzamo crossing in Strand and the Khayamandi mall crossing in Stellenbosch. Both these locations have thousands of pedestrians crossing the tracks daily. International best practice guidelines exist to enable an effective solution to be developed. An engineering safety management approach to decision making is required to assist the railway operator to meet its legal requirements as well as determine the most appropriate safe and workable solution.

### **8.2.13 Key finding 13: A fence is only as effective as its maintenance regime**

Irrespective of the fence type, it is important that the fence be maintained to an acceptable standard to maintain the effectiveness of the countermeasure.

Fences are also critical to ensure compliant use of existing formal crossings such as subways, pedestrian overbridges and formal pedestrian routes.

Currently the most effective fence installed is the concrete barrier fence installed along sections of the Central Line, which has reduced the number of pedestrian-rail fatalities to zero along the length of the fenced section. The fence however, reinforces community segregation.

#### **8.2.14 Key finding 14: Current hot-spot areas to be monitored**

Analysing the occurrence data identifies six hot-spot areas that can be characterised as follows:

Area 1 – Bonteheuwel to Mutual Stations

Area 2 – Netreg to Stock Road and Lentegeur Stations

Area 3 – Bellville to Kraaifontein Stations

Area 4 – Paarl to Wellington Stations

Area 5 - Cape Town to Salt River and Esplanade Stations

Area 6 - Klapmuts to Muldersvlei Station

#### **8.2.15 Key finding 15: Countermeasure combinations are key**

Countermeasures, when implemented as a basket of measures, has proven to be most effective. Walling, drones, CCTV and enforcement measures have been used to great effect on the Central Line. The Rail Enforcement Unit is an effective short-term countermeasure mainly against railway infrastructure theft and vandalism. Geographic displacement of crime is evident and in accordance with Key finding no.4, deployment tactics should be varied and the possibility of introducing supporting longer-term measures will improve its longer-term sustainability.

#### **8.2.16 Key finding 16: Train driver well-being is vital**

The psychological well-being of train drivers caused by pedestrian-rail incidents as well as near-misses cannot be overlooked. Measures to support this critical resource need to be explored in more detail.

#### **8.2.17 Recommendations**

Based on the research carried out, the following practical recommendations are made:

##### *Focusing on trespassing without criminal intent*

Develop a strategy centred around preventing unlawful station access and encouraging the use of formal crossing opportunities. These include: platform-end ramp treatments, station precincts to be securely fenced, pedestrian subway refurbishments, formalising at-grade pedestrian crossings where warranted and implementing education programmes at schools.

### *Focusing on trespassing with criminal intent*

Develop a strategy centred around increasing the effort of crime, increasing the risk of getting caught and decreasing the reward. These include: target hardening of all high-risk assets, extensive, real-time CCTV monitoring on all high-risk assets and improved tactical response units deployed from satellite stations around the network.

### *Focusing on unlawful occupation*

Develop a strategy centred around a multi-stakeholder partnership approach with provincial and local government, homeless shelters, police, NGOs and social services organisations. A monitoring mechanism is required to detect and report unlawful occupation as early as possible, the use of homeless shelters must be promoted and incentivised, and community-led resettlement action plans must be trialled at key locations.

### *General treatments*

Track-side vegetation clearing, improved lighting and a rigorous fencing and fencing maintenance programme are vital to securing the network. Another key strategy has to be focused on station precinct regeneration; target “broken-window” issues around station precincts, loitering, drug dealing and usage, littering, urinating and other anti-social behaviour.

### *Train driver support*

A comprehensive programme looking into the mitigation of risk factors that can increase the negative effects of pedestrian-rail incidents for train drivers should be developed. Prevention and intervention programs should consider the diversity of reactions from train drivers including: characteristics of the employee, coping mechanisms, the type of incidents, and the support and care received.

It is also recommended that the rail operator embark on targeted identification and training of new train drivers to ensure a sustainable supply of skilled rail staff.

### **8.3 TOPICS RECOMMENDED FOR FURTHER RESEARCH**

#### *Topic 1*

It is a common view held (verified by the expert interviews) that educational and awareness campaigns in a South African context are not an effective trespassing countermeasure. It has been suggested that communication-based measures need to be correctly targeted to ensure its effectiveness. More research is needed where targeted educational campaigns, carried out at schools that are in close proximity to a rail station, are evaluated to determine if the desired outcomes are achieved by decreasing unsafe crossing of the railways.

#### *Topic 2*

More research is needed around uncovering the motives for trespassing from actual trespassers and discovering their opinion on what countermeasures are likely to be effective. Understanding unsafe behaviour and the reasons for the ineffectiveness of engineering controls from those that commonly trespass could provide a new level of information to inform countermeasure strategies.

#### *Topic 3*

Available occurrence data records only safety and security incidents. Little is known of the full extent of illegal occupation or encroachment onto railway property. A multi-stakeholder framework needs to be developed to resolve current hot-spots and adopt a more proactive approach to prevent this phenomenon from increasing.

#### *Topic 4*

It has been suggested that should station-precinct areas be secured, thereby preventing platform-end station access, that this would greatly reduce the rate of trespassing. More research is required on developing and trialling effective countermeasures to prevent platform-end trespassing in a South African context.

#### *Topic 5*

The impact of pedestrian-rail near-misses and fatalities, on the psychological wellbeing of train drivers needs to be explored in greater detail. The effects on rail staff, safe rail operations as well as organisational efficiency of this safety critical role is not researched enough.

## 8.4 CONCLUDING REMARKS

This research provides a comprehensive description of railway trespassing and its main manifestations within the commuter rail network in the City of Cape Town Functional Region.

The research provides evidence in the form of occurrence data analysed to describe the demographic, temporal and spatial characteristics of the main consequences of railway trespassing as it affects railway operations, i.e. pedestrian-rail incidents and occurrences of theft and vandalism to railway infrastructure.

Interviews with subject matter experts and site visits confirms the validity of the data analysed and also reveals three primary motives for trespassing:

- trespassing without criminal intent: pedestrians using the myriad of well-trodden footpaths as short-cuts to reach their destinations,
- trespassing with criminal intent: those seeking to steal and damage rail infrastructure and includes those who travel without paying fares, and
- unlawful occupation on railway property: those who erect shelters inside or encroaching on the railway reserve as well as fly-tipping.

Each motive described above is uniquely different, but all involve the initial act of trespassing. Categorising trespassing in this manner allows for more effective, targeted countermeasure strategies to be developed.

What has become clear, is that the nature of problems experienced on the rail network is essentially not a railway problem. The most affected areas the railway passes through are those that are afflicted with high poverty levels, high unemployment, crime, gangsterism and drug use. The railways, as a socio-technical system has a symbiotic relationship with its environment, and it is only natural that societal issues spill over into the railway environment.

This does not mean that the problems the railways face are insurmountable - rather, in order to develop effective countermeasures, one has to look beyond the typical engineering measures. All environmental and social factors need to be fully considered as part of a systems approach to problem solving. It cannot be expected that the railway operator cure all of society's ills and a multi-organisational approach and effort is required to ensure a safer rail environment.

# Bibliography

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AIBN, 2016. *Investigation of accidents and serious railway incidents at level crossings (presentation)*. Helsinki: Accident Investigation Board Norway.

ANA, 2019. *Western Cape train set numbers improving, says Metrorail*. [Online] Available at: <https://citizen.co.za/news/south-africa/general/2083384/western-cape-train-set-numbers-improving-says-metrorail/>

Anselin, L., 2016. *GeoDa*, Arizona: School of Geographical Sciences and Urban Planning Arizona State University.

Arendse, N., 2010. *Copper theft prevention: An analysis of current strategies in place to address the scourge*. s.l., South African Revenue Protection Association.

Ashby, M. P. & Bowers, K. J., 2015. Concentrations of railway metal theft and the locations of scrap-metal dealers. *Applied Geography*, Volume 63, pp. 283-291.

Boonzaaier, J., 2008. *Tracks across the veld*. ISBN 978-0-620-41711-2 ed. Bela Bela: s.n.

Bosher, S., Smith, M., Koorey, G. & Fowler, M., 2017. *Level crossing risk assessment guidance*, Christchurch: New Zealand Transport Agency and Kiwi Rail.

Botha, J. L., Neighbour, M. K. & Kaur, S., 2014. *An approach for actions to prevent suicides on commuter and metro rail systems in the United States*, San Jose: Mineta Transportation Institute.

Boucher, A. et al., 2008. *A compilation of pedestrian safety devices in use at grade crossings*, s.l.: Office of Safety, Federal Railroad Administration.

Braga, A. A., Papachrisos, A. V. & Hureau, D. M., 2012. *Police programs to prevent crime in hot spot areas No.7 of Crime prevention research review*, Washington D.C.: U.S. Department of Justice, Office of Community Oriented Policing Services.

Bray, R., 2019. *Apartheid Shanty Towns in Cape Town*. [Online]  
Available at: [http://www.capetown.at/heritage/history/apart\\_influx\\_shanty\\_art.htm](http://www.capetown.at/heritage/history/apart_influx_shanty_art.htm)  
[Accessed 29 September 2019].

Burnett, J. & Pang, A. Y.-h., 2004. Design and performance of pedestrian subway lighting systems. *Tunnelling and Underground Space Technology*, 19(2004), pp. 619-628.

Charbonneau, A., 2016. *Managing conflicts in slums within a relocation project (Kibera, Nairobi)*. [Online]  
Available at: <https://mambo.hypotheses.org/941>  
[Accessed 3 July 2019].

Clarke, R. V. & Eck, J. E., 2005. *Crime analysis for problem solvers in 60 small steps*. ISBN: 1-932582-52-5 ed. Washington DC: U.S. Department of justice - Office of Community Oriented Policing Services.

Clark, V. L. P., 2013. *Mixed methods research: A practical introduction for prevention researchers*. San Fransisco, SPR Conference Workshop.

CoCT, 2018. *Comprehensive Integrated Transport Plan 2018-2023*, Cape Town: City of Cape Town.

Cothereau, C. et al., 2004. Professional and medical outcomes for French train drivers after “person under train” accidents: three year follow up study. *Occup Environ Med*, Volume 61, pp. 488 - 494.

Creswell, J. W., 2012. *Educational Research - Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. 4th ed. ed. Lincoln: Pearson Education Inc.

Creswell, J. W., 2014. *Research Design - Qualitative, Quantitative and Mixed Methods Approaches*. 4th ed. ed. Lincoln: SAGE Publications Inc..

Creswell, J. W., Klassen, A. C., Clark, V. L. P. & Smith, K. C., 2010. *Best practices for mixed methods research in the health sciences*, Lincoln: Office of Behavioral and Social Sciences Research (OBSSR).

*Criminal Matters Amendment Act (2015) Republic of South Africa.*

daSilva, M. P., Baron, W. & Carroll, A. A., 2012. *Highway Rail-Grade Crossing Safety Research: Railroad Infrastructure Trespassing Detection Systems Research in Pittsford, New York*, Washington: U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development.

DelMistro, R. & Khanye, T., 2015. *Fare Evasion Survey 2015 Western Cape Region*, Tshwane: Passenger Rail Agency of South Africa (Corporate).

deVilliers, D. W. J., 1986. *Condensed Report of the Study by Dr. W.J. de Villiers regarding the Strategic Planning, management Practices and Systems of the South African Transport Services*, Pretoria: South African Transport Services.

DoT, 2015. *National Rail Policy - Green Paper*, Pretoria: Department of Transport - Republic of South Africa.

DTPW, 2015. *Department of Transport and Public Works - Strategic Plan 2015/16-2019/20*, Cape Town: Western Cape Government.

Eck, J. E. et al., 2005. *Mapping crime: Understanding hot spots*, Washington DC: U.S. Department of Justice - Office of Justice Programs.

Edquist, J., Hughes, B. & Rudin-Brown, C. M., 2011. *Pedestrian non-compliance at level crossing gates*, Perth: Public Transport Authority, Western Australia.

Eurostat, 2018. *Archive: Railway Safety Statistics*. [Online]  
Available at: [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Railway\\_safety\\_statistics&direction=next&oldid=365247](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Railway_safety_statistics&direction=next&oldid=365247)

Fitzpatrick, K. et al., 2015. *Guidebook on pedestrian crossings of public transit rail*. TCRP Report 175 ed. Washington D.C.: National Academies of Sciences, Engineering, and Medicine - The National Academies Press.  
<https://doi.org/10.17226/22183>.

Fox, P., 2019. *Railway Country - 150 Years of Rail in South Africa*. [Online]

Available at: <http://www.transnetfreightrail-tfr.net/Heritage/150years/150YearsRail.pdf>

Freeman, J. & Rakotonirainy, A., 2017. Can rail pedestrian violations be deterred? An investigation into the threat of legal and non-legal sanctions. *Transportation Research*, Part F(45), pp. 102-109.

Gandhiok, J., 2019. *Delhi: Railways won't sit on the fence any longer, starts barricading tracks*. [Online]

Available at: [https://timesofindia.indiatimes.com/city/delhi/railways-wont-sit-on-the-fence-any-longer-starts-barricading-tracks/articleshow/67875683.cms?utm\\_source=contentofinterest&utm\\_medium=text&utm\\_campaign=cppst](https://timesofindia.indiatimes.com/city/delhi/railways-wont-sit-on-the-fence-any-longer-starts-barricading-tracks/articleshow/67875683.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)  
[Accessed 3 July 2019].

Geofabrik, 2019. *Geofabrik GmbH Karlsruhe*, Karlsruhe: s.n.

Georgiannis, D., 2017. *Criminals adapting to copper theft laws - expert*. [Online]

Available at: <http://702.co.za/articles/271598/billions-lost-to-copper-theft-in-sa>  
[Accessed 1 June 2019].

Ghose, A., 1984. Impact of Delhi Anti-Encroachment Bills. *Economic and Political Weekly*, 19(36), pp. 1564-1566.

Gill, C., Vitter, Z. & Weisburd, D., 2015. *Identifying hot spots of juvenile offending - A guide for crime analysts*. ISBN: 978-1-932582-98-7 ed. Washington DC: Office of Community Oriented Policing Services.

GoMetro, 2019. *Metrorail Fares Western Cape*. [Online]

Available at: <https://app.gometro.co.za/#/fares>

GRR, 2018. *Cable theft on UK rail network rises 85 per cent in one year*. [Online]

Available at: <https://www.globalrailwayreview.com/news/75985/cable-theft-uk-rail-rise/>  
[Accessed 1 June 2019].

Harries, K., 1999. *Mapping crime: Principle and practice*, Washington DC: U.S. Department of Justice - Office of Justice Programs.

Hart, T., 2019. *Important Events in Cape Railway History*. [Online]  
Available at: [https://sahris.sahra.org.za/sites/default/files/heritagereports/9-2-110-0075-19980601-ACO\\_0.pdf](https://sahris.sahra.org.za/sites/default/files/heritagereports/9-2-110-0075-19980601-ACO_0.pdf)

Havarneanu, G. M., 2017. Behavioural and organisational interventions to prevent trespass and graffiti vandalism on railway property. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, 213(10), pp. 1078-1087.

Havârneanu, G. M., Bonneau, M.-H. & Colliard, J., 2016. Lessons learned from the collaborative European project RESTRAIL: REduction of suicides and trespasses on RAILway property. *European Transport Research Review*, Volume June.

Havârneanu, G. M., Burkhardt, J.-M. & Paran, F., 2015. A systematic review of the literature on safety measures to prevent railway suicides and trespassing accidents. *Accident Analysis and Prevention*, pp. 30-50.

Havârneanu, G. M., Burkhardt, J.-M. & Silla, A., 2016. Optimizing suicide and trespass prevention on railways: a problem-solving model from the RESTRAIL project. *International Journal of Injury Control and Safety Promotion*, Issue DOI:10.1080/17457300.2016.1232275.

HHO, 2016. *Lotus Park pedestrian bridge investigation feasibility Study*, Cape Town: City of Cape Town.

ICD10, 2019. *2019 ICD-10-CM Diagnosis Code X81.8*. [Online]  
Available at: <https://www.icd10data.com/ICD10CM/Codes/V00-Y99/X71-X83/X81-/X81.8>

InfoMine, 2019. *Historical Copper Prices and Price Chart*. [Online]  
Available at: <http://www.infomine.com/investment/metal-prices/copper/all/>  
[Accessed 1 June 2019].

IOL, 2018. #TrainArson: Significant drop in Metrorail passenger numbers. [Online]  
Available at: <https://www.iol.co.za/capetimes/news/trainarson-significant-drop-in-metrorail-passenger-numbers-16337160>

January, I. R. & Mofokeng, J. T., 2017. *Crime operational aspects of the Rapid Rail Police Unit in the Western Cape rail environment*. Istanbul, ADVED 2017- 3rd International Conference on Advances in Education and Social Sciences.

Kallberg, V. P., Ryan, B., Bruyelle, J. L. & Koursi, E. M. E., 2012. *Method for the evaluation of measures targeted to prevent railway suicides and trespassing accidents - RESTRAIL*, Paris: International Union of Railways (UIC).

Kok, T., 2016. *Nomzamo informal railway crossing Strand area*. Cape Town(Western Cape): City of Cape Town.

Koorey, G., Boshier, S., Smith, M. & Fowler, M., 2017. *Design Guidance for Pedestrian & Cycle Rail Crossings*, Christchurch: NZ Transport Agency and Kiwi Rail.

KUTC, 2015. *Karachi Urban Transport Corporation - Resettlement action plan*.

[Online]

Available at: <http://www.kutckcr.com/resettlementaction.html>

[Accessed 3 July 2019].

Lali, V., 2019. *Railway line occupied as rapid Philippi informal settlement grows*.

[Online]

Available at: <https://www.groundup.org.za/article/railways-occupied-rapid-expansion-philippi-informal-settlement/>

[Accessed 3 July 2019].

Lerer, L. B. & Matzopoulos, R., 1996. Meeting the challenge of railway injury in a South African city. *Public Health Volume 348, Issue 9028*, pp. 664-666.

Levine, D. M., Krehbiel, T. C. & Berenson, M. L., 2010. *Business Statistics - A First Course*. 5th ed. New Jersey: Pearson.

Levine, N., 2013. *CrimeStat IV: A Spatial Statistics Program for the Analysis of Crime Incident Locations (version 4.0)*, Washington DC: Ned Levine & Associates, Houston, TX, and the National Institute of Justice.

Limosin, F. et al., 2005. A prospective study of the psychological effects of "person under train" incidents on drivers. *Journal of Psychiatric Research*, 40(2006), pp. 755-761.

Lobb, B., 2006. Trespassing on the tracks: A review of railway pedestrian safety research. *Journal of Safety Research* 37 (2006), pp. 359-365.

Lobb, B., Harre, N. & Suddendorf, T., 2001. An evaluation of a suburban railway pedestrian crossing safety programme. *Accident Analysis and Prevention*, Volume 33, pp. 157-165.

Lobb, B., Harré, N. & Terry, N., 2003. An evaluation of four types of railway pedestrian crossing safety intervention. *Accident Analysis and Prevention*, Volume 35, pp. 487-494.

Lo, C., 2013. *Railway Technology*. [Online]  
Available at: <https://www.railway-technology.com/features/featurespy-in-the-sky-db-anti-graffiti-campaign/>  
[Accessed 29 June 2019].

Louw, A., 1997. Surviving the Transition: Trends and Perceptions of Crime in South Africa. *Social Indicators Research* 41(1), pp. 137-167.

Matzopoulos, R. & Lerer, L. B., 1998. Hours to hell and back: a social epidemiology of railway injury in a South African city, 1890-1995.. *Social Science & Medicine*, , 47(1), pp. 75-83.

Metrorail, 2010. *Metrorail 2010 Local passenger rail routes of South Africa - Western Cape*. [Online]  
Available at: [http://www.metrorail.co.za/maps/CT\\_RailMap.pdf](http://www.metrorail.co.za/maps/CT_RailMap.pdf)  
[Accessed 20 January 2019].

- Mills, A., 2019. *Trespass - an overview*. [Online]  
Available at: <https://www.rssb.co.uk/Pages/trespass-an-overview.aspx>
- Mills, A., 2019. *Trespass Improvement Programme*. [Online]  
Available at: <https://www.rssb.co.uk/Pages/trespass-improvement-programme.aspx>  
[Accessed 28 June 2019].
- Minn, M., 2019. *MMQGIS*, unknown: <http://michaelminn.com>.
- Mishara, B. L. & Bardon, C., 2015. Systematic review of research on railway and urban transit system suicides. *Journal of Affective Disorders* 193 (2016), pp. 215-226.
- Mishara, B. L. & Bardon, C., 2016. Characteristics of railway suicides in Canada and comparison with accidental railway fatalities: Implications for prevention. *Safety Science* 91 (2017), pp. 251-259.
- Moosa, F., 2014. *Presentation of options for suitable location of proposed NMT facility in Nomzamo*. Cape Town(Western Cape): City of Cape Town.
- Morgan, D. L., 2007. Paradigms lost and pragmatism regained. *Journal of Mixed Methods Research*, 1(1), pp. 48-76.
- Mvinjelwa, P., Kiewiet, S. & Stanbury, J., 2019. *Feasibility studies of pedestrian-rail hotspots in the City of Cape Town*, Cape Town: City of Cape Town.
- NetworkRail, 2019. *Cable theft*. [Online]  
Available at: <https://www.networkrail.co.uk/running-the-railway/looking-after-the-railway/delays-explained/vandalism-and-trespass/cable-theft/>  
[Accessed 1 June 2019].
- Newton, A. D., 2004. Crime on public transport: 'Static' and 'non-static' (moving) crime events. *Western Criminology Review*, 5(3), pp. 25-42.
- Nikolakaki, S. M., 2015. *Spatial and temporal analysis of crime for the discovery of hot spots in road networks: the case of Boston*. Boston, s.n.
- Nominatim, 2019. *Nominatim*. [Online]  
Available at: <https://nominatim.openstreetmap.org/search>  
[Accessed 15 July 2019].

Okabe, A., 2006. *SANET: Spatial Analysis along Networks*, Tokyo: University of Tokyo.

ONRSR, 2017. *Rail safety report 2016 - 2017*, Adelaide: Office of the National Rail Safety Regulator.

OpenStreetMap, 2019. *OpenStreetMap*. [Online]  
Available at: <https://www.openstreetmap.org/#map=14/-33.9465/18.5297&layers=T>  
[Accessed 15 July 2019].

Ozdogan, M. et al., 2006. The epidemiology of the railway related casualties. *Turkish Journal of Trauma & Emergency Surgery*, pp. 235-241.

PAIE, 1998. *Prevention of Illegal Eviction from and Unlawful Occupation of Land Act No.19 of 1998*, Cape Town: Republic of South Africa.

Peck, R., Olsen, C. & Devore, J., 2016. *Introduction to Statistics & Data Analysis*. 5th Edition ed. Boston: Cengage learning.

Peck, R., Olsen, C. & Devore, J. L., 2016. *Introduction to Statistics and Data Analysis*. 5th ed. Boston: Cengage Learning.

Pelletier, A., 1997. Deaths among railroad trespassers: The role of alcohol in fatal injuries. *JAMA The Journal of the American Medical Association* 277(13), pp. 1064-6.

Pirie, G., 2002. Travelling Under Apartheid. In: *The Apartheid City and Beyond - Urbanisation and Social Change in South Africa*. Witwatersrand: Witwatersrand University Press and Routledge, pp. 173-182.

PKP\_Cargo, 2019. *Airborne Drones*. [Online]  
Available at: <https://www.airbornedrones.co/airborne-drones-reports-on-drones-help-catch-train-thieves-in-poland/>  
[Accessed 29 June 2019].

Plaza, J. et al., 2014. *Evaluation of measures, recommendations and guidelines for further implementation*, Paris: International Union of Railways (UIC).

Poya, N. & Mathebula, M., 2013. *The impact of illegally occupied railway land on rail safety in South Africa*. Vancouver, International Railway Safety Conference.

PRASA, 2018. *Annual Report and Financial Statements 2017/18*, Pretoria: Passenger Rail Agency of South Africa.

PRASA, 2018. *PRASA Rescue Plan (Draft)*, Pretoria: Passenger Rail Agency of South Africa.

PRASA, 2019. *2020-2022 MTEF Corporate Plan*, Pretoria: Passenger Rail Agency of South Africa.

PRASA, 2019. *Business mandate*. [Online]  
Available at: <https://www.prasa.com/Business%20Mandate.html>

QGIS, 2019. *QGIS Development Team (2019). QGIS Geographic Information System. Open Source Geospatial Foundation Project.*, s.l.: <http://qgis.osgeo.org>.

Radbo, H. et al., 2012. *Current knowledge of railway suicides and trespassing accidents*, Paris: International Union of Railways (UIC).

Radbo, H. et al., 2012. *Current knowledge of railway suicides and trespassing accidents*, Paris: International Union of Railways (UIC).

Radbo, H., Svedung, I. & Andersson, R., 2005. Suicides and other fatalities from train-person collisions on Swedish railroads: A descriptive epidemiologic analysis as a basis for systems-oriented prevention. *Journal of Safety Research* 36, pp. 423-428.

Rayment, M. R., 1995. *TM-06-96 Spatial and temporal crime analysis techniques*, Vancouver: Centre Canadien De Recherches Policières (CCRP).

RHDHV, 2013. *2012 Rail Census Report Western Cape*, Cape Town: PRASA.

RSA, 2019. *Acts*. [Online]  
Available at:  
<http://www.dpe.gov.za/resourcecentre/Acts/Legal%20Succession%20to%20the%20South%20African%20Transport%20Services%20Act.pdf>

RSR, 2008-2018. *State of Safety Reports for the years 2008 to 2018*, Pretoria: Railway Safety Regulator.

RSR, 2009. *State of Safety Report 2008/09*, Pretoria: Railway Safety Regulator.

RSR, 2010. *State of Safety Report 2009/10*, Pretoria: Railway Safety Regulator.

RSR, 2011. *State of Safety Report 2010/11*, Pretoria: Railway Safety regulator.

RSR, 2012. *State of Safety Report 2011/12*, Pretoria: Railway Safety Regulator.

RSR, 2013. *State of Safety Report 2012/13*, Pretoria: Railway Safety Regulator.

RSR, 2014. *State of Safety Report 2013/14*, Pretoria: Railway Safety Regulator.

RSR, 2015. *State of Safety Report 2014/15*, Pretoria: Railway Safety Regulator.

RSR, 2016. *State of Safety Report 2015/16*, Pretoria: Railway Safety Regulator.

RSR, 2017. *State of Safety Report 2016/17*, Pretoria: Railway Safety Regulator.

RSR, 2018. *State of Safety Report 2017/18*, Pretoria: Railway Safety Regulator.

RSR, 2019. *The RSR Act*. [Online]

Available at: <http://www.rsr.org.za/documents/acts/rsrAct.pdf>

RSSB, 2016. *Drones and the railways (S241)*, London: Rail Safety and Standards Board.

RSSB, 2018. *Controlling Trespass and Access from the Platform End: A Good Practice Guide*, London: Rail Safety and Standards Board.

RSSB, 2018. *Technologies to Tackle Trespassing (S317)*, London: Rail Safety and Standards Board (RSSB).

Rumsey, D. J., 2011. *Statistics for dummies*. 2nd Edition ed. Indiana: Wiley Publishing Inc..

Ryan, B., 2012. *Reducing suicide and trespass in rail*. s.l., RRUKA Annual Conference, 7 November 2012.

Ryan, B. & Kallberg, V. P., 2013. Developing methodology in RESTRAIL for the preliminary evaluation of preventative measures fo rrailway suicide and trespass. *Rail Human Factors: Supporting reliability, safety and cost reduction*, CRC Press(2013), pp. 89-98.

Ryan, B. et al., 2018. Collecting evidence from distributed sources to evaluate railway suicide and trespass prevention measures. *Ergonomics*, Volume DOI:10.1080/00140139.2018.1485970, pp. 1366-5847.

Safe\_Kids\_Canada, 2004. *On the right track for rail safety*, Toronto: Safe Kids Canada.

SAHO, 2019. *A history of Apartheid in South Africa*. [Online] Available at: <https://www.sahistory.org.za/article/history-apartheid-south-africa>

SANS, 2009. *SANS 3000-1:2009 Railway Safety Management\_Edition 2*, Pretoria: SABS Standards Division.

SAPS, 2016. *Rural development and land reform: Section 23 of the extension of Security of Tenure Bill and criminal cases instituted under this act*. unknown: South African Police Service.

SAPS, 2019. *Status: Functioning of rapid Rail Police*. [Online]

Available at: [http://pmg-assets.s3-website-eu-west-1.amazonaws.com/160921Rapid\\_Rail\\_Police.pdf](http://pmg-assets.s3-website-eu-west-1.amazonaws.com/160921Rapid_Rail_Police.pdf)

Savage, I., 2007. Trespassing on the railroad. *Research in Transportation Economics*, Volume 20, pp. 199-224.

Savage, I., 2015. Analysis of fatal train-pedestrian collisions in metropolitan Chicago 2004-2012. *Accident Analysis and Prevention* 86 (2016), pp. 217-228.

*Second Hand Goods Act* (2009) Republic of South Africa.

Sidebottom, A., Ashby, M. & Johnson, S. D., 2014. Copper cable theft: Revisiting the price-theft hypothesis. *Journal of Research in Crime and Delinquency*, 51(5), pp. 684-700.

Sidebottom, A. et al., 2011. Theft in price-volatile markets: On the relationship between copper price and copper theft. *Journal of Research in Crime and Delinquency*, 48(3), pp. 396-418.

Silla, A., 2012. *How to prevent railway suicides and fatalities related to trespassing accidents?*. London, s.n.

Silla, A. & Kallberg, V.-P., 2015. Effect of railway safety education on the safety knowledge and behaviour intention of schoolchildren. *Evaluation and Program Planning* 55 (2016), pp. 9-16.

Silla, A. & Luoma, J., 2008. *Trespassing on Finnish railways: identification of problem sites and characteristics of trespassing behaviour*. s.l., ECTRI, pp. 47-53.

Silla, A. & Luoma, J., 2011. Effect of three countermeasures against the illegal crossing of railway tracks. *Accident Analysis and Prevention*, Volume 43, pp. 1089-1094.

Silla, A. & Luoma, J., 2011. Opinions on railway trespassing of people living close to a railway line. *Safety Science* 50 (2012), pp. 62-67.

Silla, A. & Luoma, J., 2012. Main characteristics of train–pedestrian fatalities on Finnish railroads. *Accident Analysis and Prevention*, pp. 61-66.

Skládaná, P. et al., 2018. Land Use as a Motivation for Railway Trespassing: Experience from the Czech Republic. *Land*, 7(1).

Skládaná, P. et al., 2016. Trespassing railway property – typology of risk localities. *Transportation Research Procedia* 14, pp. 2091-2100.

Srivastava, A. K., 2015. *A challenge for urban development*. [Online]  
Available at: <http://www.csrtimes.com/community-articles/encroachment-a-challenge-for-urban-development/UtyYwduPr>  
[Accessed 3 July 2019].

Taggart, R. C. et al., 1987. *Evaluating grade-separated rail and highway crossing alternatives*, Washington D.C.: Transportation Research Board - National Cooperative Highway Research Programme.

Teddle, C. & Tashakkori, A., 2012. Common "core" characteristics of mixed methods research: A critical review of critical issues and call for greater convergence. *American Behavioral Scientist*, 56(6), pp. 774-788.

Telep, C. W. & Weisburd, D. L., 2012. What is known about the effectiveness of police practices in reducing crime and disorder?. *Police Quarterly*.

Tompson, L., Partridge, H. & Shepherd, N., 2008. *Hot routes: Developing a new methodology for the spatial analysis of crime*. London, 6th National Crime Mapping Conference.

Tranah, T. & Farmer, R. D. T., 1994. Psychological reactions of drivers to railway suicide. *Social Science and Medicine*, 38(3), pp. 459 - 469.

*Trespass Act (1959)* Republic of South Africa.

Turok, I., 1994. Urban planning in the transition from apartheid, Part 1: the legacy of social control. *Town Planning Review*, , 65(3), p. 243.

UDOT, 2013. *UDOT Pedestrian grade crossing manual*, Utah: Utah Department of Transportation.

UIC, 2013. *Metal theft on the railways*, Paris: International Union of Railways.

UK, S. V., 2016. *Valuation of a life*, UK: Social Value UK.

Vanrensburg, R. A. J., 1996. *The History of the Rail Transport Regulatory Environment in South Africa*, Stellenbosch: Stellenbosch University.

Vatshelle, A. & Moen, B. E., 1997. Serious on-the-track accidents experienced by train drivers: Psychological reactions and long-term health effects. *Journal of Psychosomatic Research*, 42(1997), pp. 43 - 52.

Venter, Y. et al., 2014. *Addressing non-motorised transport movement along and across railway lines in the City of Cape Town*. Pretoria, SATC.

Venter, Y. & Shirley, K., 2014. *Proposed research and action plan addressing non-motorised transport (NMT) movements along and across railway lines in the City of Cape Town*, Cape Town: City of Cape Town.

Wang, X., Liu, J., Khattak, A. J. & Clarke, D., 2016. Non-crossing rail-trespassing crashes in the past decade: A spatial approach to analyzing injury severity. *Safety Science* 82, Volume 82, pp. 44-55.

WCG, 2014. *Western Cape Government - Provincial Strategic Plan 2014-2019*, Cape Town: Western Cape Government.

Wilcox, P. & Eck, J. E., 2011. Criminology of the unpopular: Implications for policy aimed at payday lending facilities. *Criminology and Public Policy*, 10(2).

Wilson, A., 2007. *The Gaurdian*. [Online]

Available at: <https://www.theguardian.com/money/2007/jun/08/yourrights.legal>

[Accessed 24 June 2019].

Wilson, R. et al., 2007. The railway as a socio-technical system: human factors at the heart of successful railway engineering. *Proc. IMechE Vol. 221 Part F: J. Rail and Rapid Transit*, pp. 101-115.

Woods, M., 2006. *Improving the content and placement of anti-trespass signs (T555)*. [Online]

Available at: <https://www.rssb.co.uk/library/research-development-and-innovation/research-brief-T555.pdf>

[Accessed 24 June 2019].

Yorke-Smith, L., 2010. *Solving copper theft*. [Online]

Available at:

<https://www.securitysa.com/print.aspx?editorialtype=A&editorialid=5905>

[Accessed 1 June 2019].

You\_vs\_Train, 2019. *You vs. Train*. [Online]

Available at: <https://www.youvstrain.co.uk/>

[Accessed 28 June 2019].

Zhang, M., Khattak, A. J., Liu, J. & Clarke, D., 2018. A comparative study of rail-pedestrian trespassing crash injury severity between highway-rail grade crossings and non-crossings. *Accident Analysis and Prevention* 117 (2018), pp. 427-438.

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# Appendices

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Appendix A – Interview Protocol

Appendix B – Site Inspection Protocol

Appendix C – Case Study Protocol

Appendix D – Incident and Occurrence Maps

Appendix E – Interview Records

Appendix F – Site Inspection Field Notes

Appendix G – EBE Application for Approval of Ethics in Research



## **Investigating Rail Trespassing Occurrences Questionnaire**

### **About the questionnaire**

Hello, my name is Faizel Williams, and I am conducting research towards a Master of Science Degree in Transportation Engineering. I am researching the occurrence of railway trespassing in the Metrorail environment and would like to invite you to participate in the project.

Collision between trains and pedestrians is a leading fatal train-related accident type worldwide and therefore many studies have argued that trespassing is one of the most important railway safety issues. The participants for this survey are selected on the basis of their expert knowledge and experience on the subject matter and has the following objectives:

- i. To identify the most problematic sites for trespassing,
- ii. To learn more about specific trespassing characteristics,
- iii. To seek opinion on the effectiveness of preventive measures and strategies to prevent trespassing.

Participation in the survey is voluntary and anonymous, and in order to participate, all that is required is for you to complete a brief questionnaire.

The data gathered from this exercise will be used to inform my research and could help practitioners, operators and researchers to better understand railway trespassing and could aid in developing effective countermeasures to combat trespassing.

### **What to do with your completed questionnaire**

Please return your completed questionnaire to me as soon as you have completed it, or within 3 weeks of receiving it, to: [wllfai003@myuct.ac.za](mailto:wllfai003@myuct.ac.za) OR in the envelope provided (no stamp needed) to:

F Williams  
4<sup>th</sup> Floor  
11 Leeuwen Street  
Cape Town  
8001

**Thank you very much for your help in  
completing this questionnaire**

## Background Details

1. How long have you worked in your current role in the Western Cape region (to the nearest year)?

2. Which area / corridor / service lines / stations / districts are you primarily assigned to?

## Trespassing

3. How many instances of trespassing in the rail reserve or via platform ends do you believe to occur daily?  
(one person trespassing = one trespassing event)  
Please choose one option.

- |   |                      |  |
|---|----------------------|--|
| 1 | <input type="text"/> | None   |
| 2 | <input type="text"/> | Very little – Less than 10 per day                 |
| 3 | <input type="text"/> | Seldom – More than 10 but less than 30 per day     |
| 4 | <input type="text"/> | Regularly – Between 31 and 70 events per day       |
| 5 | <input type="text"/> | Very regularly – Between 71 and 100 events per day |
| 6 | <input type="text"/> | Too many to count – More than 100 events per day   |

Do you wish to comment specifically about this?

**4. Is there a specific time of day in which trespassing is more prevalent?  
Please tick as appropriate.**

- |   |                          |               |
|---|--------------------------|---------------|
| 1 | <input type="checkbox"/> | 04h30 – 06h00 |
| 2 | <input type="checkbox"/> | 06h00 – 09h00 |
| 3 | <input type="checkbox"/> | 09h00 – 16h00 |
| 4 | <input type="checkbox"/> | 16h00 – 19h00 |
| 5 | <input type="checkbox"/> | 19h00 – 22h00 |

Do you wish to comment specifically about this?

**5. Are trespassers likely to be male or female?**

- |   |                          |                                       |
|---|--------------------------|---------------------------------------|
| 1 | <input type="checkbox"/> | More males                            |
| 2 | <input type="checkbox"/> | More females                          |
| 3 | <input type="checkbox"/> | Both male and female but more males   |
| 4 | <input type="checkbox"/> | Both male and female but more females |
| 5 | <input type="checkbox"/> | Equally both male and female          |

**6. Are trespassers likely to be children, adolescents or adults?**

- |   |                          |             |
|---|--------------------------|-------------|
| 1 | <input type="checkbox"/> | Children    |
| 2 | <input type="checkbox"/> | Adolescents |
| 3 | <input type="checkbox"/> | Adults      |



**8. Please rate what you believe to be the main reasons for trespassing.**

	Strongly agree 1	Agree 2	Neither disagree d or agree 3	Disagree 4	Strongly disagree 5	
Using a shortcut – formal crossing available close-by						A
Using a shortcut – no formal crossing available						B
Formal crossing is deemed unsafe						
Fare evasion						C
Vandalism to rail infrastructure						D
Theft of rail infrastructure						E
Other criminal activity						F
To commit suicide						G
Thrill seeking						H
Socialising						I
Graffiti						J
Encroachment (establishment of an informal dwelling or abode)						K

Would you like to elaborate or provide a reason not listed above?

**9. Rank up to 10 of the worst stations for trespassing incidents from highest to lowest.**

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

**10. Rank up to 10 of the worst line sections (sections between stations) for trespassing incidents from highest to lowest.**

1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

**11. Please rate what in your opinion are the best counter-measures to reducing trespassing.**

	Extremely effective	Effective	Not sure	Not effective	Completely ineffective	
	1	2	3	4	5	
Risk assessments / HazLoc studies						A
Collaboration between organisations						B
Patrols and enforcement						C
Improved police support (crime investigation and intelligence)						D
Effective judicial entities to prosecute trespassers						E
Fencing and barriers						F
Landscaping						G
Detection and surveillance technology						H
Lighting						I
CCTV						J
Signage						K
Awareness and media campaigns						L
Education at schools						M
Thoughtfully designed and located pedestrian overbridges						N
Thoughtfully designed and located pedestrian subways						O
Formalising informal at-grade crossings						P

**12. Do you have any other suggestions for reducing trespassing in the rail environment?**

**13. Are you able to name example sites/locations where counter-measures have successfully been implemented and where you have noticed a marked drop in trespassing?**

1

2

3

4

5

6

7

8

**14. What in your view should be prioritized for immediate response as it affects railway operations? Choose only one option.**

1

Trespassing at and around stations

2

Trespassing along line sections

3

Trespassing at grade-crossings

4

Encroachments

5

Suicides





**Appendix B – Site Inspection Protocol**

Date:	Time:	Location:
Weather:		
Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)		Describe surrounding area (schools, hospitals, residential, shopping etc.)
Define area (station, platform, open line, level crossing, other.)		Count frequency of trespassing / 15-minute interval
Describe specific features of trespassers (gender, age, drunks, homeless etc.)		What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)
What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)		
General notes on location:		Sketch:



*Appendix C – Case Study Protocol*

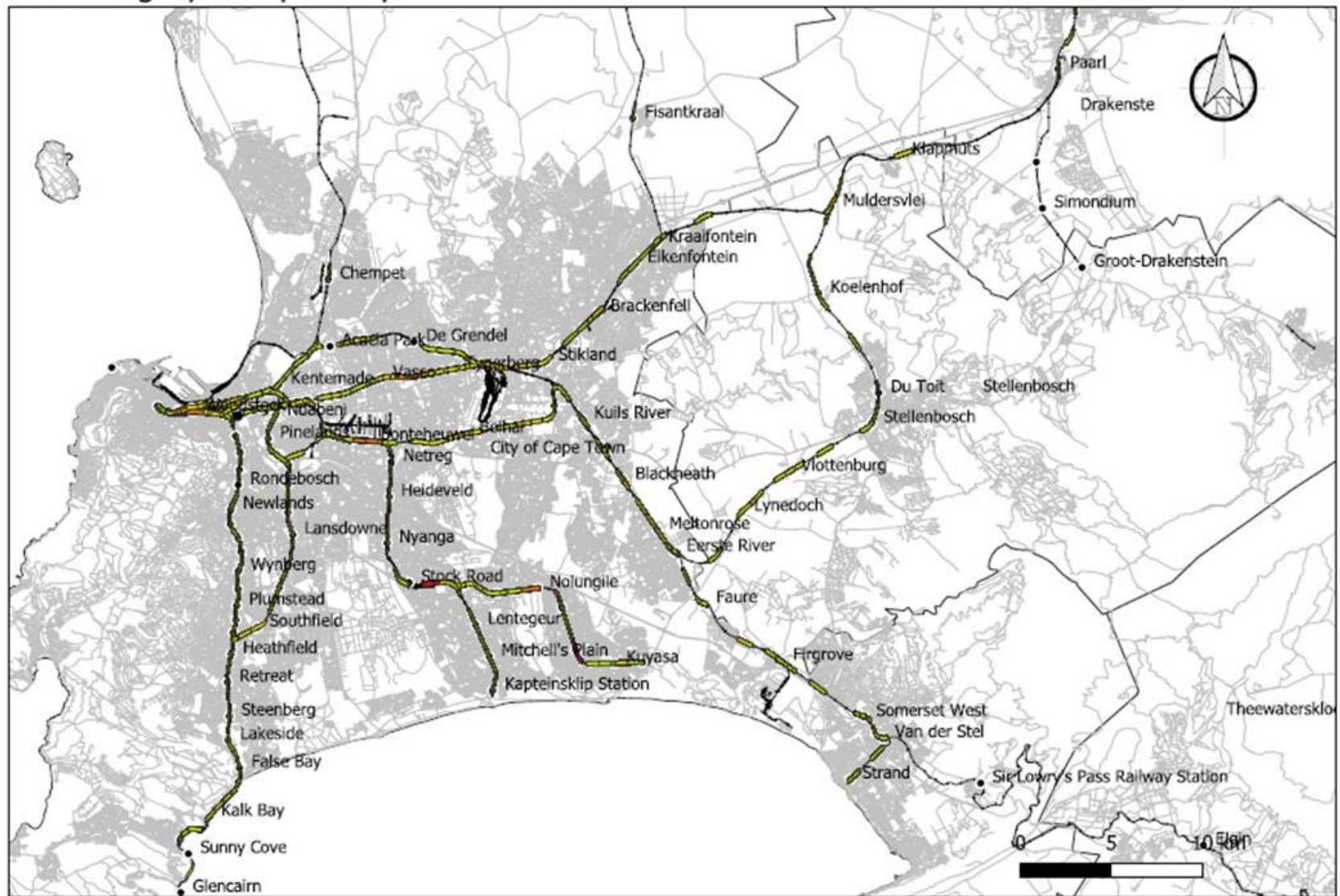
Trespass Countermeasure Evaluation Form																													
<b>Title of measure</b>																													
<b>Locations implemented</b>																													
<p><b>Type of measure</b> Mark 'X' in only one box in each category</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 33%; text-align: center; vertical-align: top;"> <p><b>Type 1</b></p> <table style="border-collapse: collapse;"> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Social</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Physical</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Technical</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Behavioural</td></tr> </table> </td> <td style="width: 33%; text-align: center; vertical-align: top;"> <p><b>Type 2</b></p> <table style="border-collapse: collapse;"> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Primary</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Secondary</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Tertiary</td></tr> </table> </td> <td style="width: 33%; text-align: center; vertical-align: top;"> <p><b>Type 3</b></p> <table style="border-collapse: collapse;"> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Reducing attractiveness</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Obstruct access</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Influence determination</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Early warning</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Reduce impact of collision</td></tr> </table> </td> </tr> </table>			<p><b>Type 1</b></p> <table style="border-collapse: collapse;"> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Social</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Physical</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Technical</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Behavioural</td></tr> </table>		Social		Physical		Technical		Behavioural	<p><b>Type 2</b></p> <table style="border-collapse: collapse;"> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Primary</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Secondary</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Tertiary</td></tr> </table>		Primary		Secondary		Tertiary	<p><b>Type 3</b></p> <table style="border-collapse: collapse;"> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Reducing attractiveness</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Obstruct access</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Influence determination</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Early warning</td></tr> <tr><td style="border: 1px solid black; width: 30px; height: 30px;"></td><td style="padding-left: 5px;">Reduce impact of collision</td></tr> </table>		Reducing attractiveness		Obstruct access		Influence determination		Early warning		Reduce impact of collision
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	Obstruct access																												
	Influence determination																												
	Early warning																												
	Reduce impact of collision																												
<p><b>Description of measure</b> Describe relevant features of the measure: What is done? In what environment? What is the scale of implementation?</p>																													
<p><b>Definition of target incidents</b> Provide brief verbal description of target incidents and consider all relevant categories listed below.</p> <p>.....</p> <p>Suicide / Trespass</p> <p>.....</p> <p>Pre-crash behaviour</p> <p>.....</p> <p>Age of target</p> <p>.....</p> <p>Specific target area</p> <p>.....</p> <p>Time of day</p> <p>.....</p> <p>Urban or rural</p> <p>.....</p>																													
<p><b>Size of the problem</b> Provide baseline incidents or occurrences data in the target group based on the SANS categories in a 1-year period before implementation.</p>																													
<p><b>Effect on incidents and occurrences</b> Provide percentage reduction in the number of target incidents or occurrences data in the target group based on the SANS categories in the period post implementation. State duration of evaluation period.</p>																													

<p><b>Durability of effects</b></p> <p>Estimate if the effects are likely to remain stable, increase or decrease with time, and why. What should be done to maintain the effect over a longer term?</p>
<p><b>Cost and benefits</b></p> <p>If possible, provide estimate of the ratio costs/benefits (C/B) and explain how this estimate was derived (e.g. refer to documented study, list the main types of costs that influence this ratio). Consider implementation, maintenance and organisational costs.</p>
<p><b>Integration with other policy measures</b></p> <p>Consider following issues: How the measure interacts, interfaces or integrates with other preventative measures? Constraints or obstructions for implementation? Preconditions for implementation? How the measure can impact other measures? Does the effectiveness of the measure depend on implementation of other measures - if yes, which? Are there organisational or communication issues that need to be solved?</p>
<p><b>Impact on railway operations</b></p> <p>How does the measure impact on the running of trains (reliability of train service, availability of track)? Is it possible to quantify these impacts? What could or should be done to mitigate any undesired impacts?</p>
<p><b>Impact on people and jobs</b></p> <p>Consider people in and outside railway industry. How would implementation of the measure affect people and their jobs? Consider issues like loss of jobs, training and education, safety and health, number of staff needed, impacts on organisations.</p>
<p><b>Technological issues</b></p> <p>Consider following issues regarding necessary technology: Is it available and reliable? If not, is it likely that the situation will be improved in near future? Is it compatible with current infrastructure design and relevant standards?</p>
<p><b>Environment</b></p> <p>Consider issues like emissions, energy, scenery, wildlife, impacts on people near the track, short and long term effects.</p>
<p><b>Acceptance</b></p> <p>Estimate how relevant groups of people (e.g. staff, passengers, train operators, infrastructure managers, people living near tracks) accept the measure? What are the likely reasons for non-acceptance? Explain the basis of the estimate(s).</p>
<p><b>Transferability issues</b></p> <p>What needs to be considered when applying the measure to another kind of environment (or country) or in different scale? What are the necessary preconditions for successful implementation of the measure in different environments or scale? How could the problems concerning transferability be solved?</p>
<p><b>Additional information</b></p> <p>Describe any other relevant issues concerning successful implementation of the measure that are not mentioned above.</p>

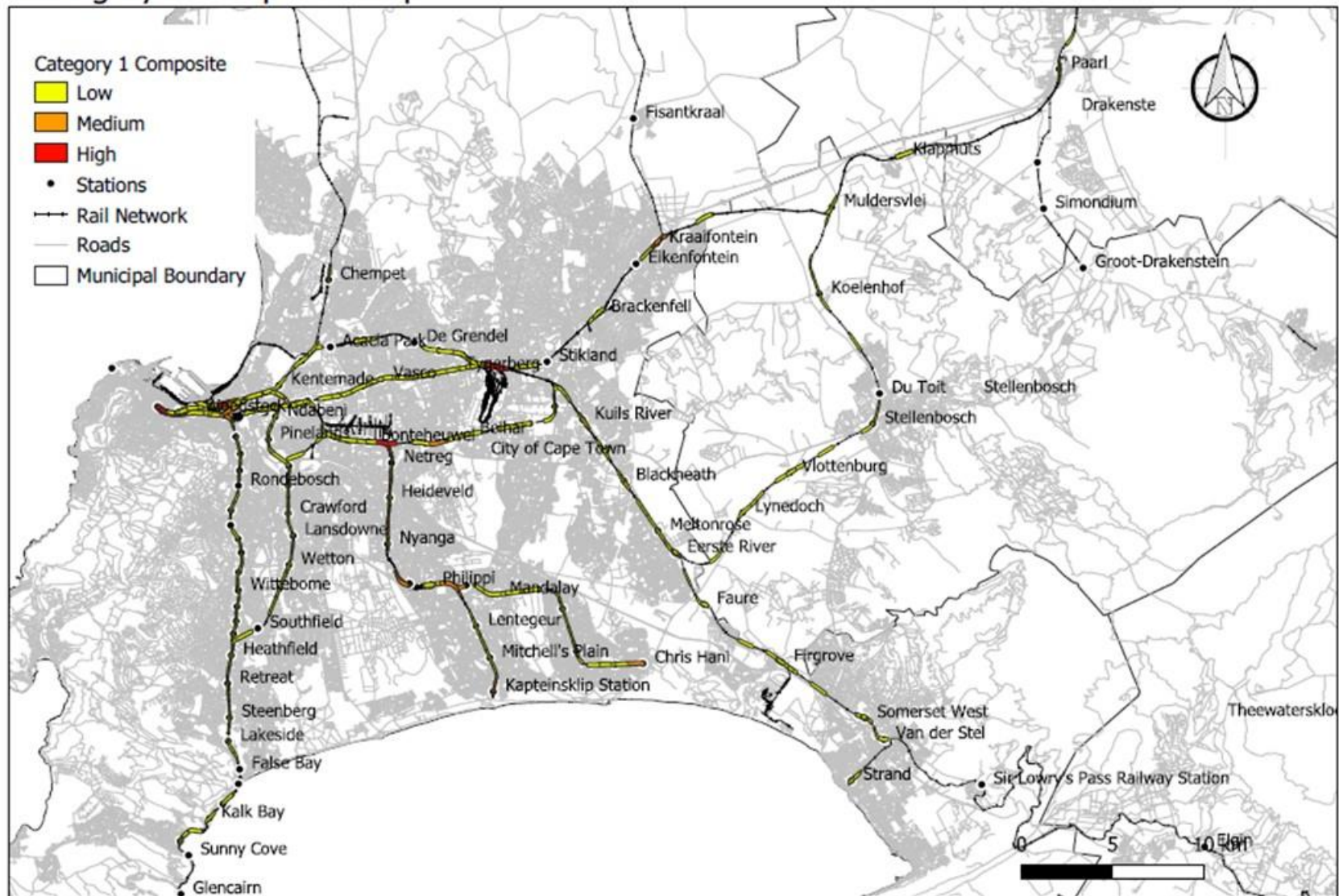
*Appendix D – Incident and Occurrence Maps*

All Category Hot-spot Map Metro
Category 1 Composite – Medium and High Occurrences Hot-spot Map
Category 1-a Occurrences Hot-spot Map
Category 1-b Occurrences Hot-spot Map
Category 1-c Occurrences Hot-spot Map
Category 1-d Occurrences Hot-spot Map
Category 1-e Occurrences Hot-spot Map
Category 1-f Occurrences Hot-spot Map
Category 1-g Occurrences Hot-spot Map
Category 1-h Occurrences Hot-spot Map
Category 1-i Occurrences Hot-spot Map
Category 2 Composite – Medium and High Occurrences Hot-spot Map
Category 2-a Occurrences Hot-spot Map
Category 2-b Occurrences Hot-spot Map
Category 2-c Occurrences Hot-spot Map
Category 2-d Occurrences Hot-spot Map
Category 2-e Occurrences Hot-spot Map
Category 2-f Occurrences Hot-spot Map
Category 2-g Occurrences Hot-spot Map
Category 2-h Occurrences Hot-spot Map
Category 2-i Occurrences Hot-spot Map
Category 1+2 Composite – Medium and High Occurrences Hot-spot Map
Category E-a Occurrences Hot-spot Map
Category E-a Fatalities Hot-spot Map
Category E-a Injuries Hot-spot Map

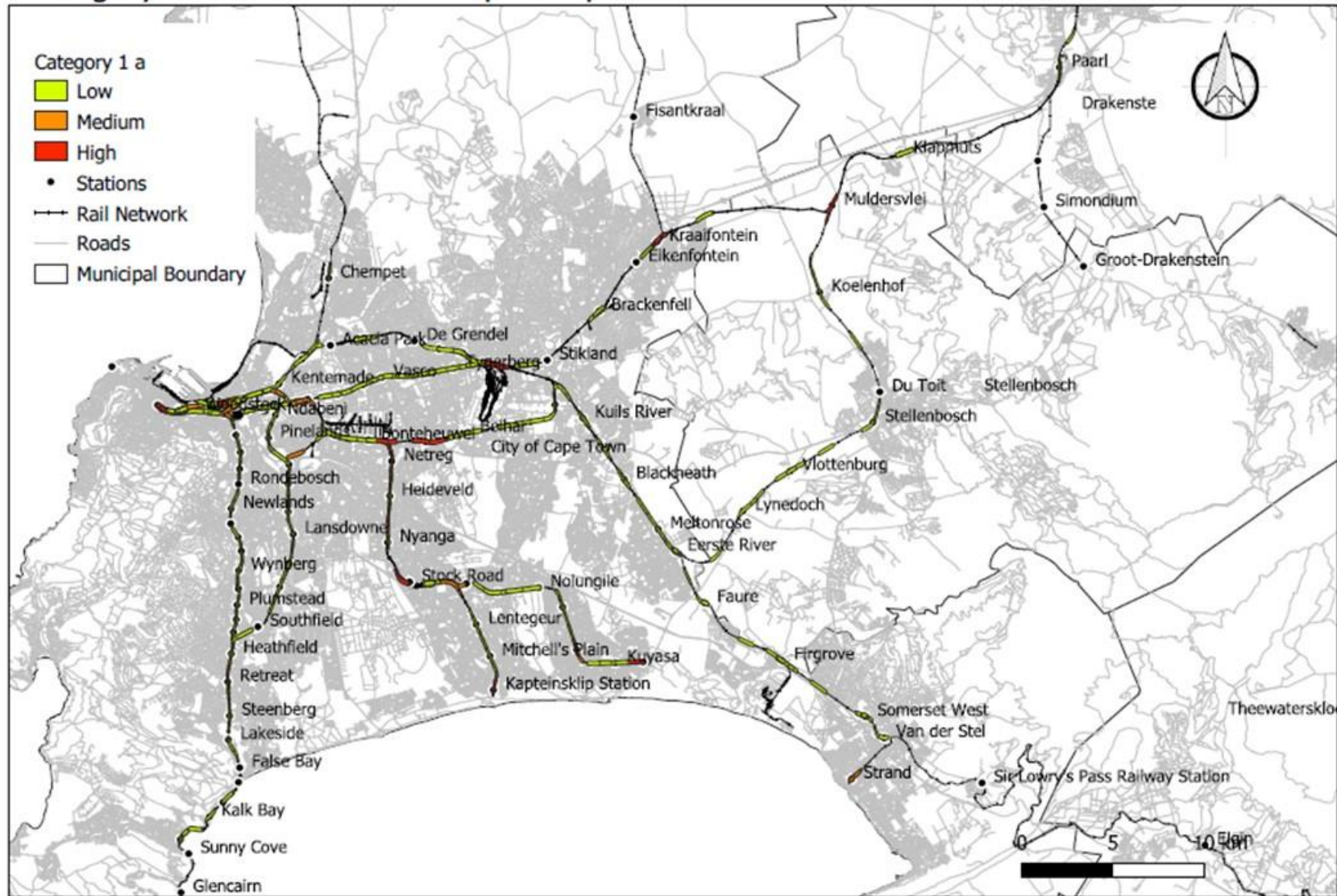
## All Category Hotspot Map



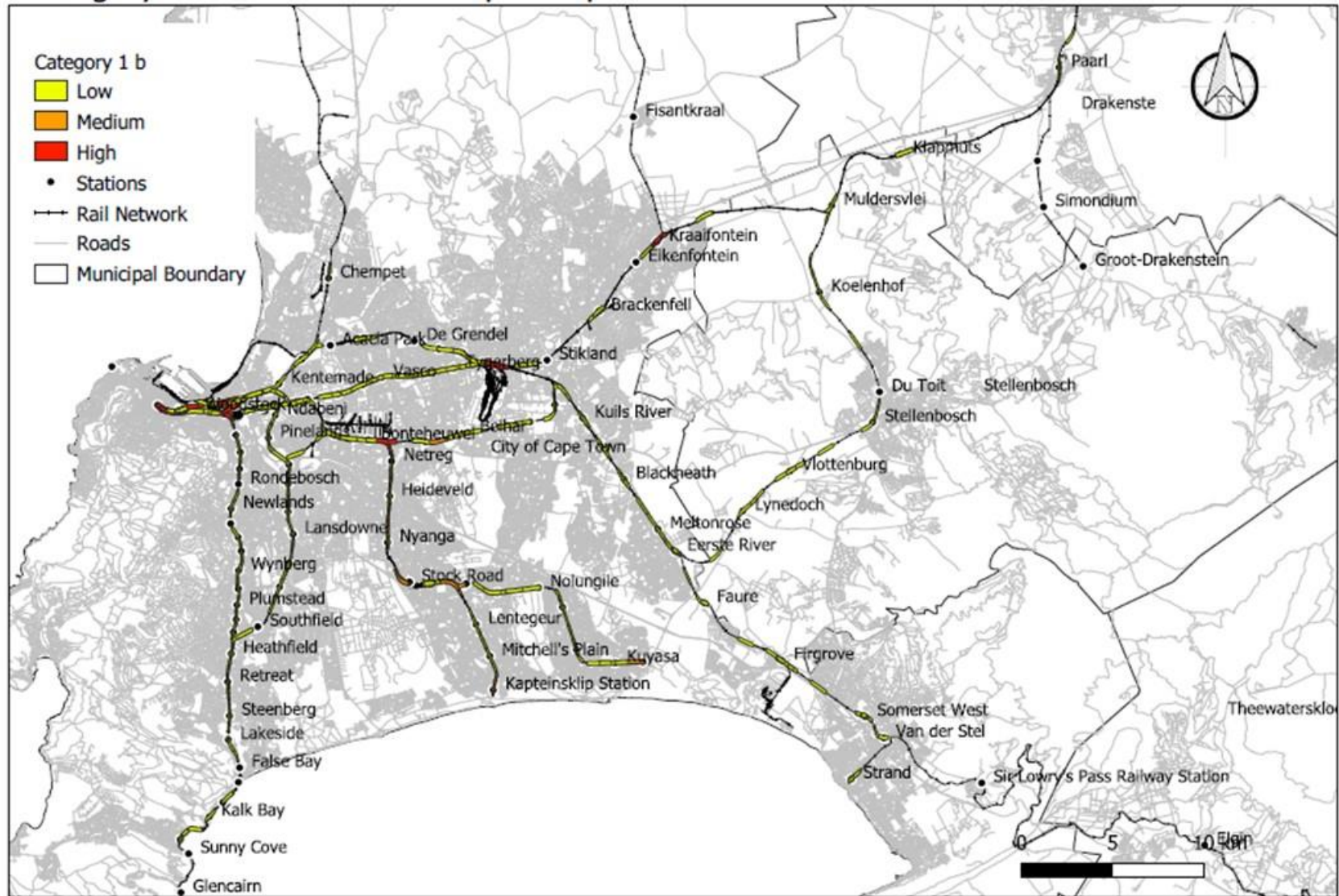
## Category 1 Composite Map



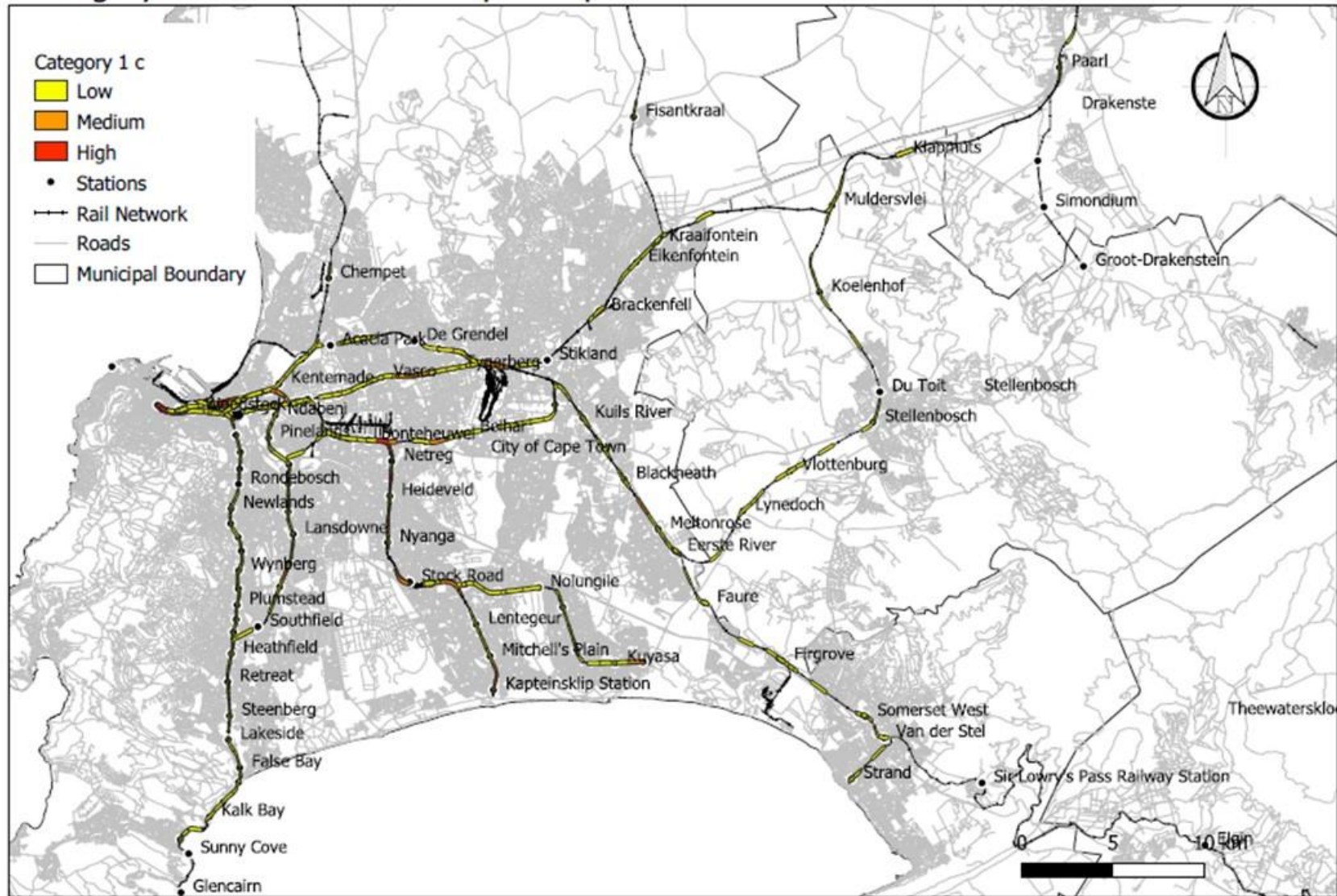
### Category 1-a Occurrences Hotspot Map



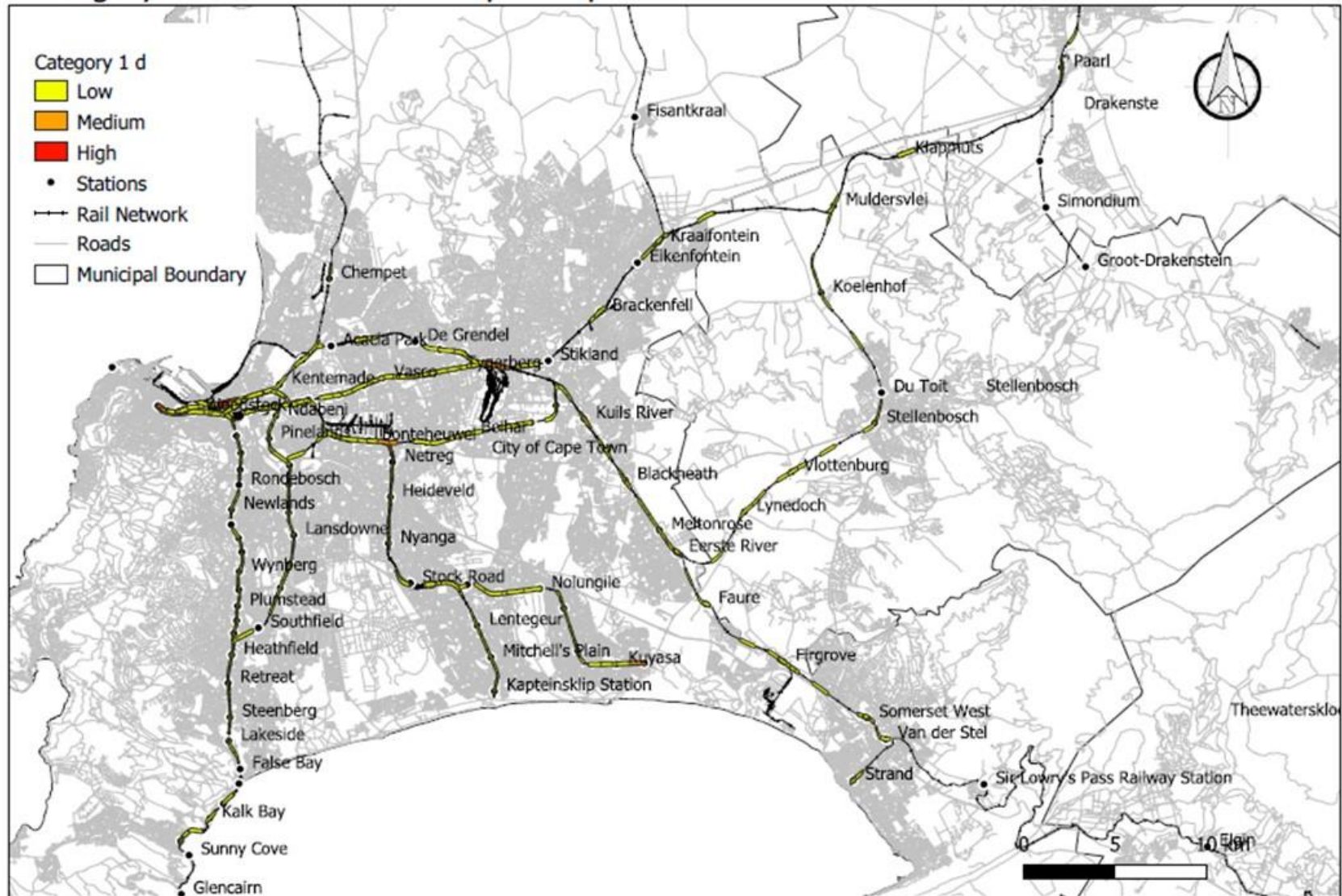
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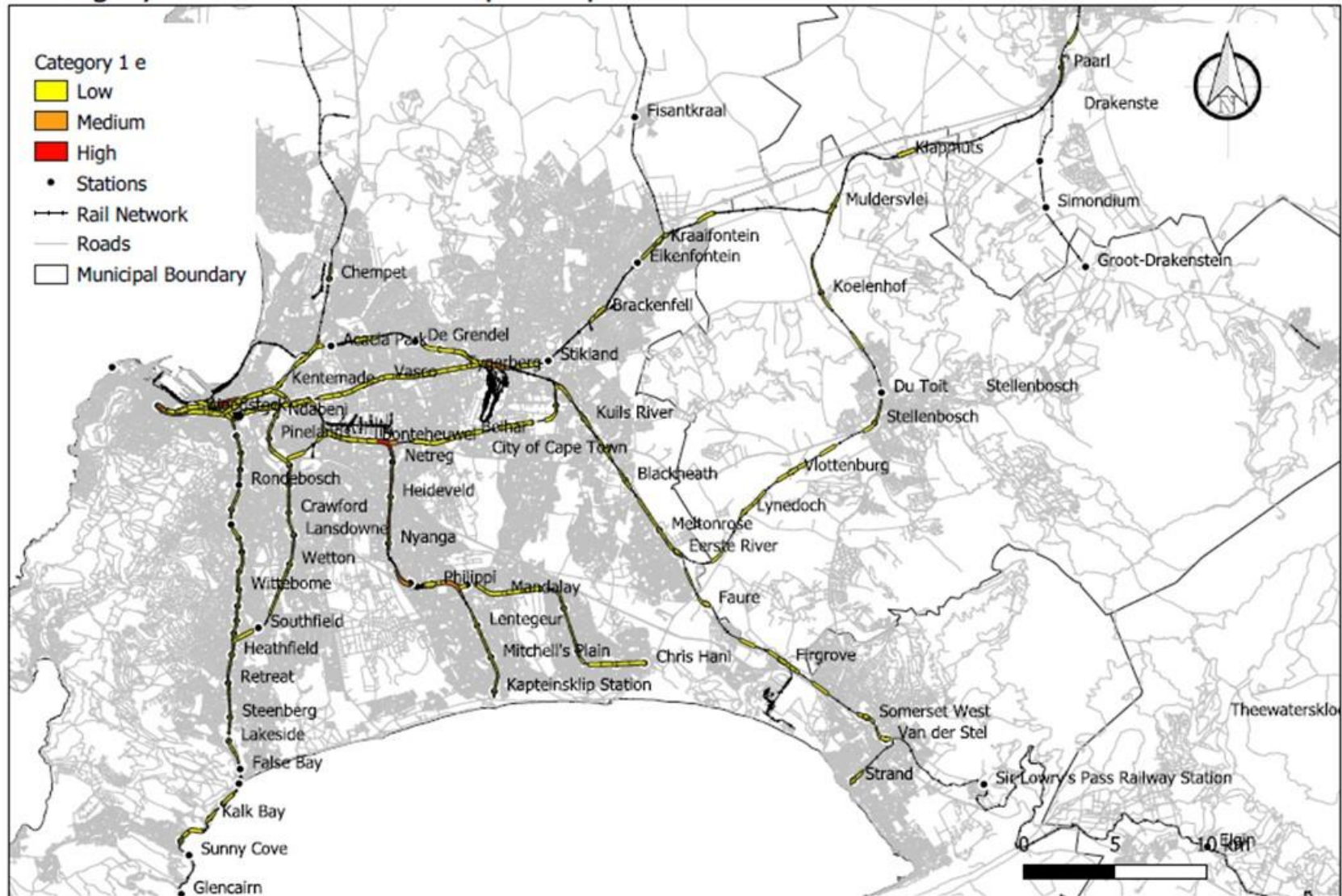
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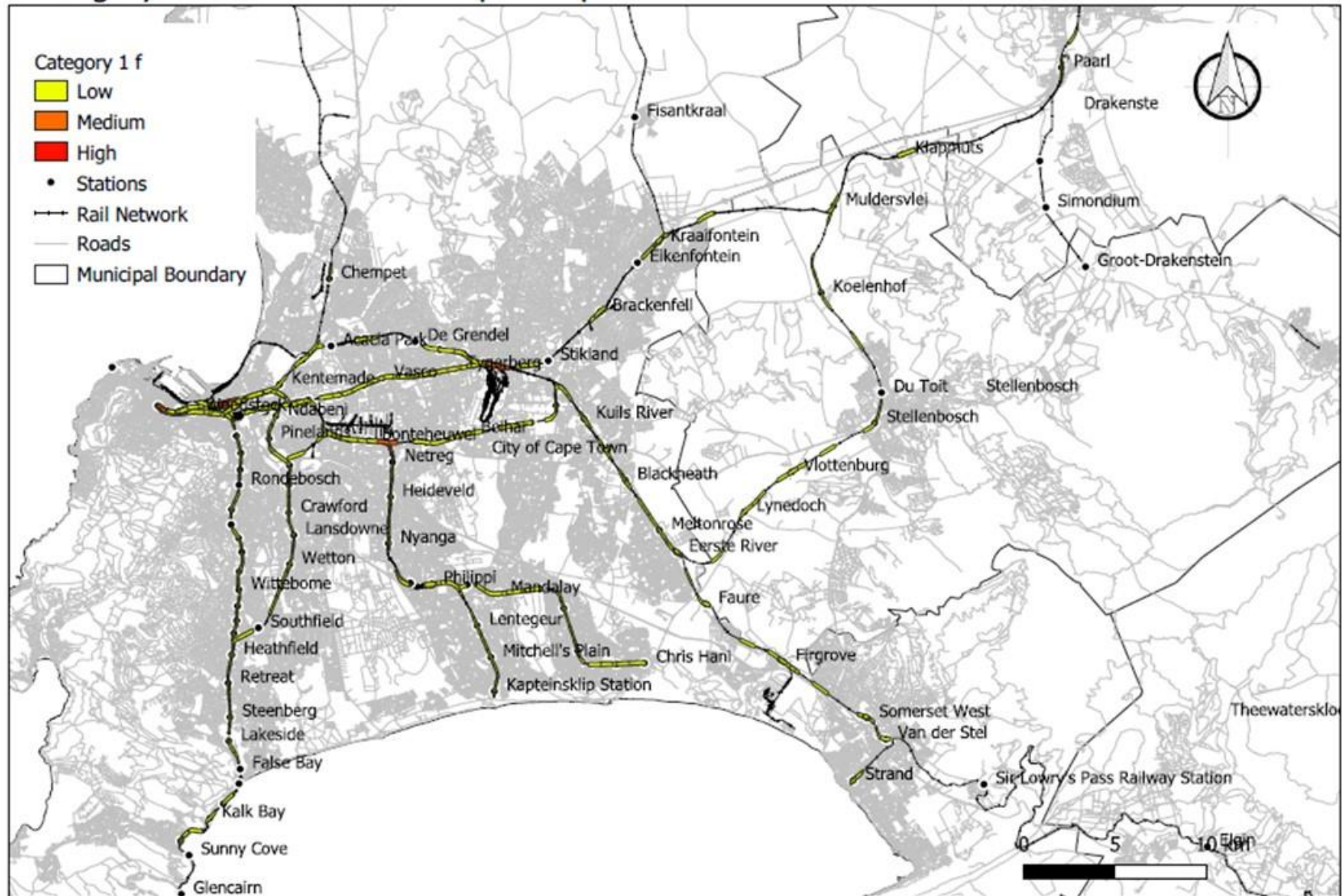
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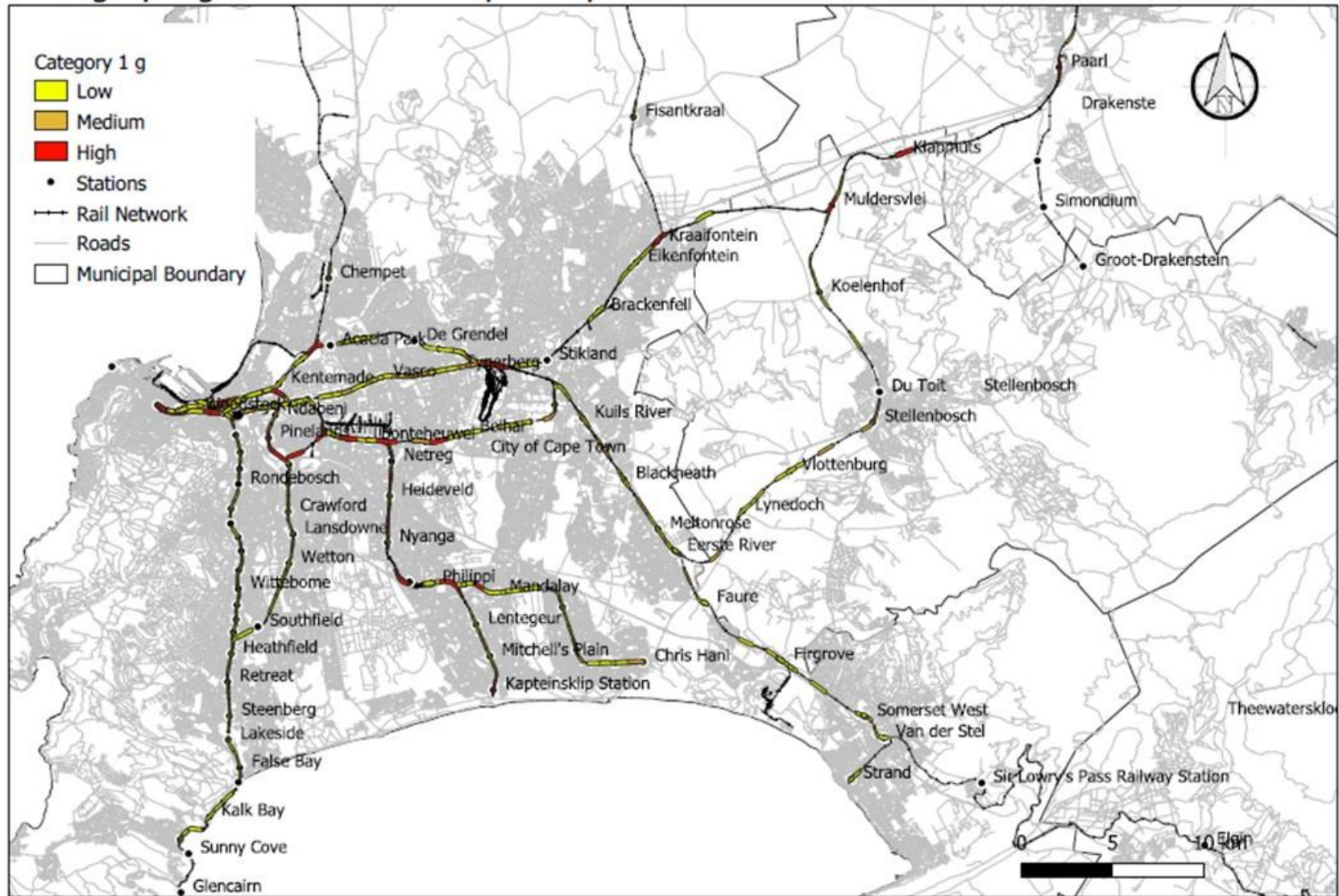
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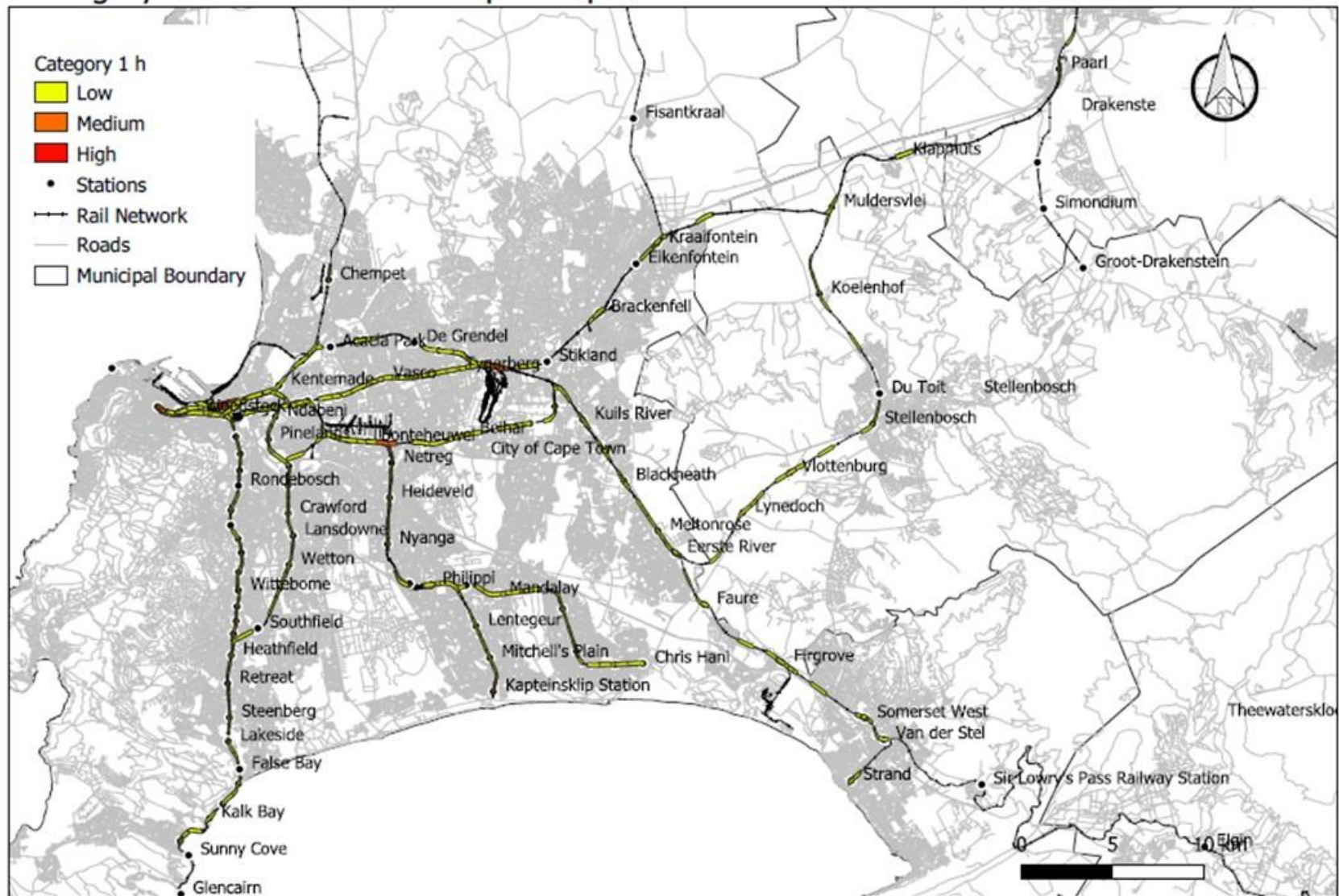
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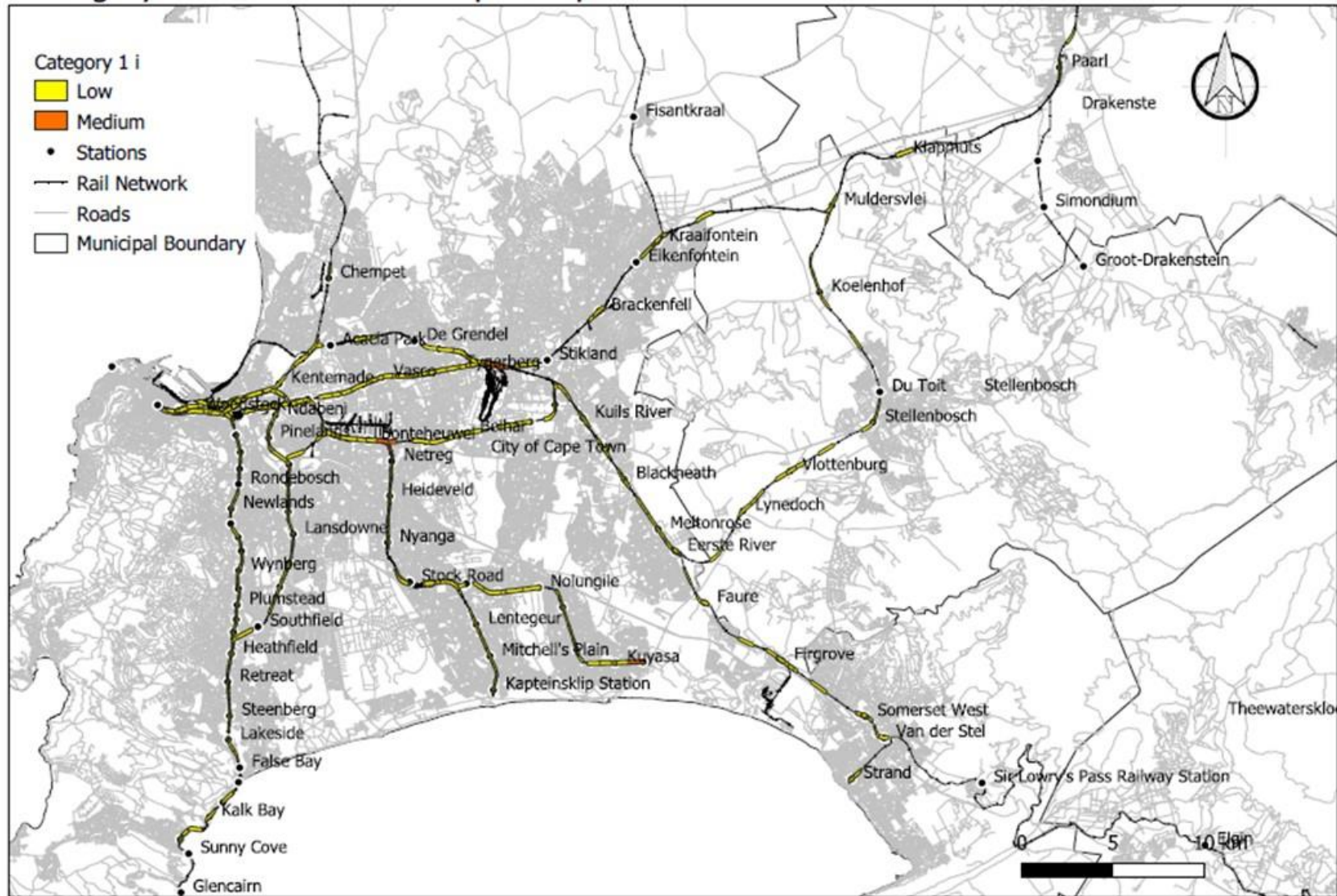
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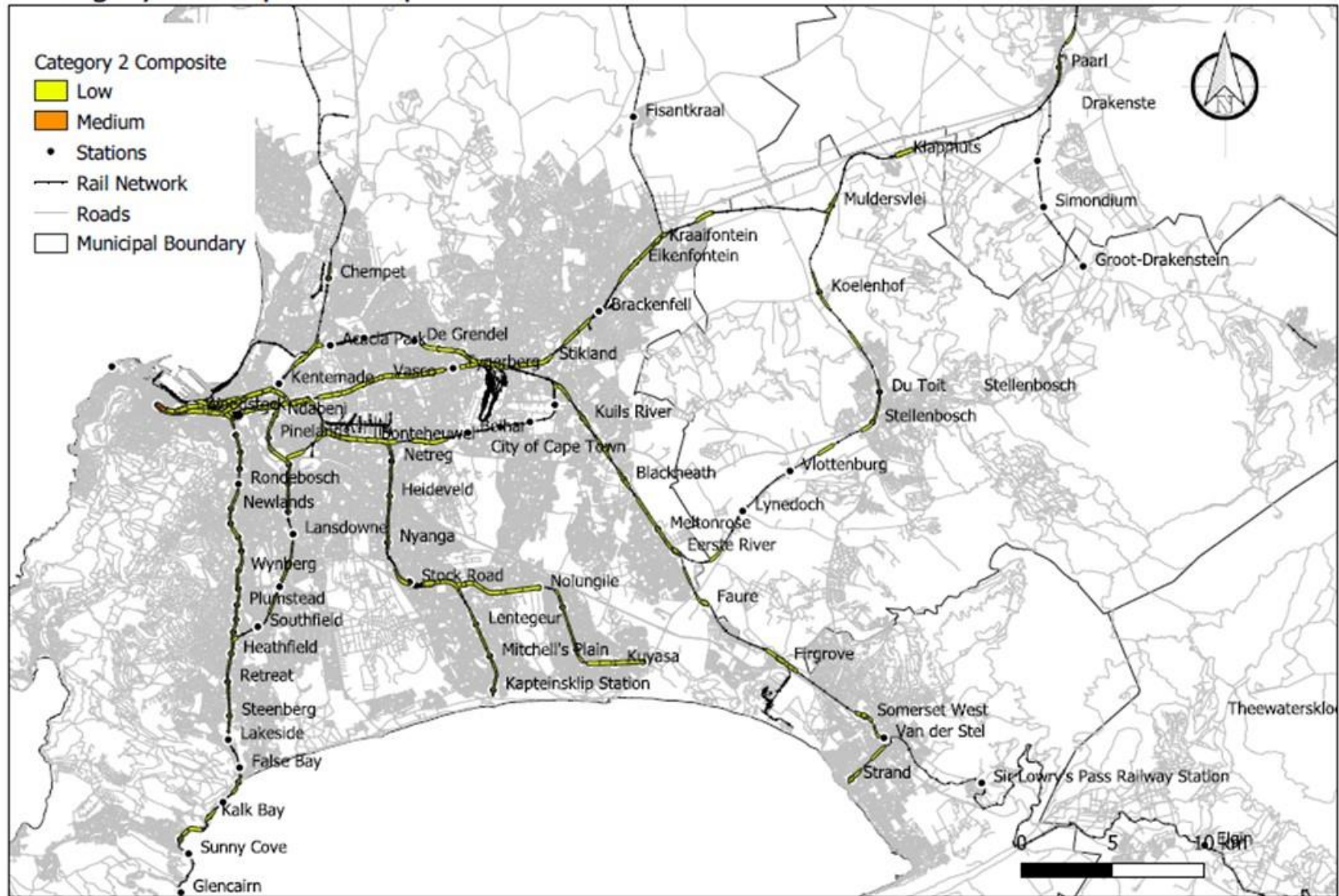
## Category 1-h Occurrences Hotspot Map



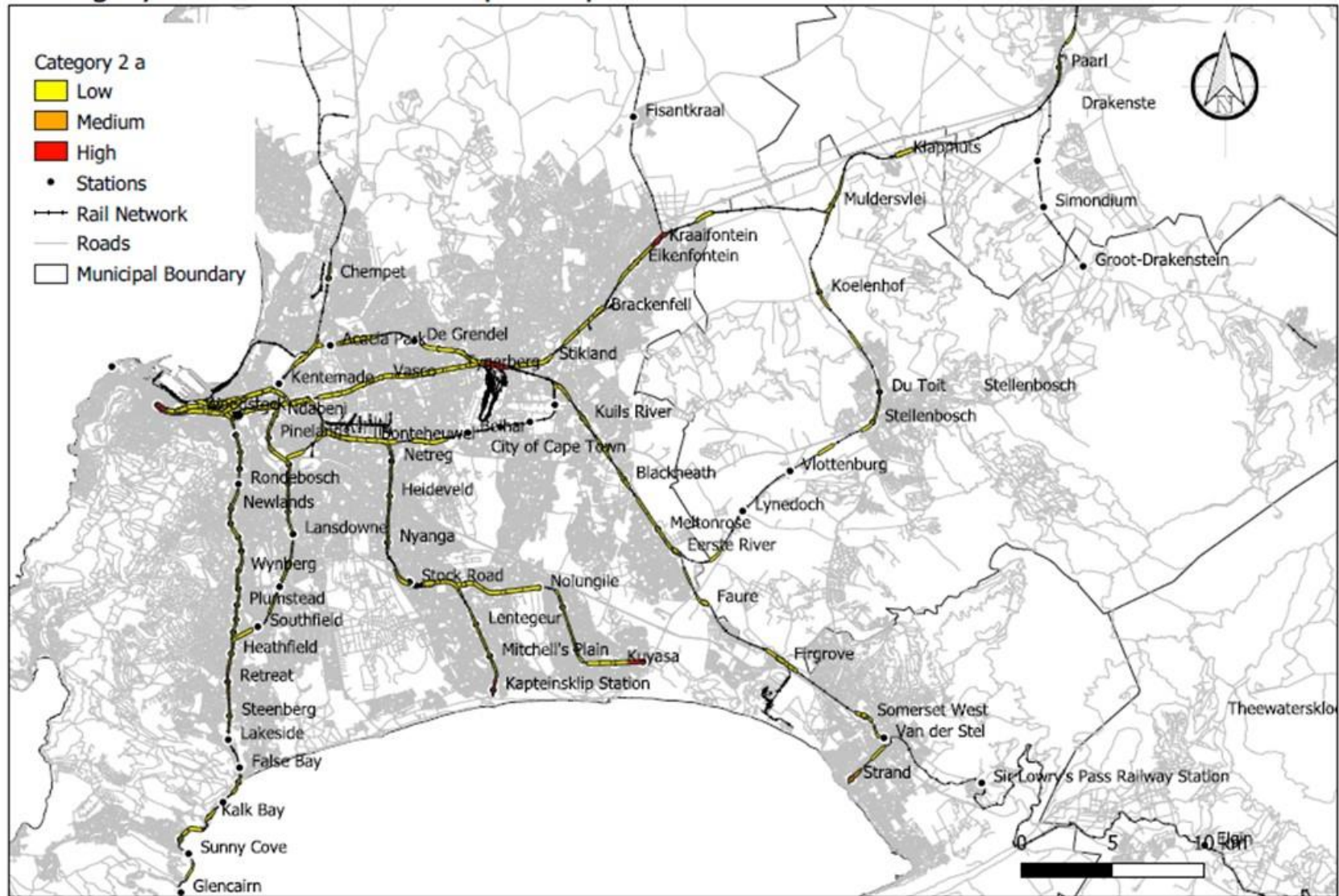
### Category 1-i Occurrences Hotspot Map



## Category 2 Composite Map

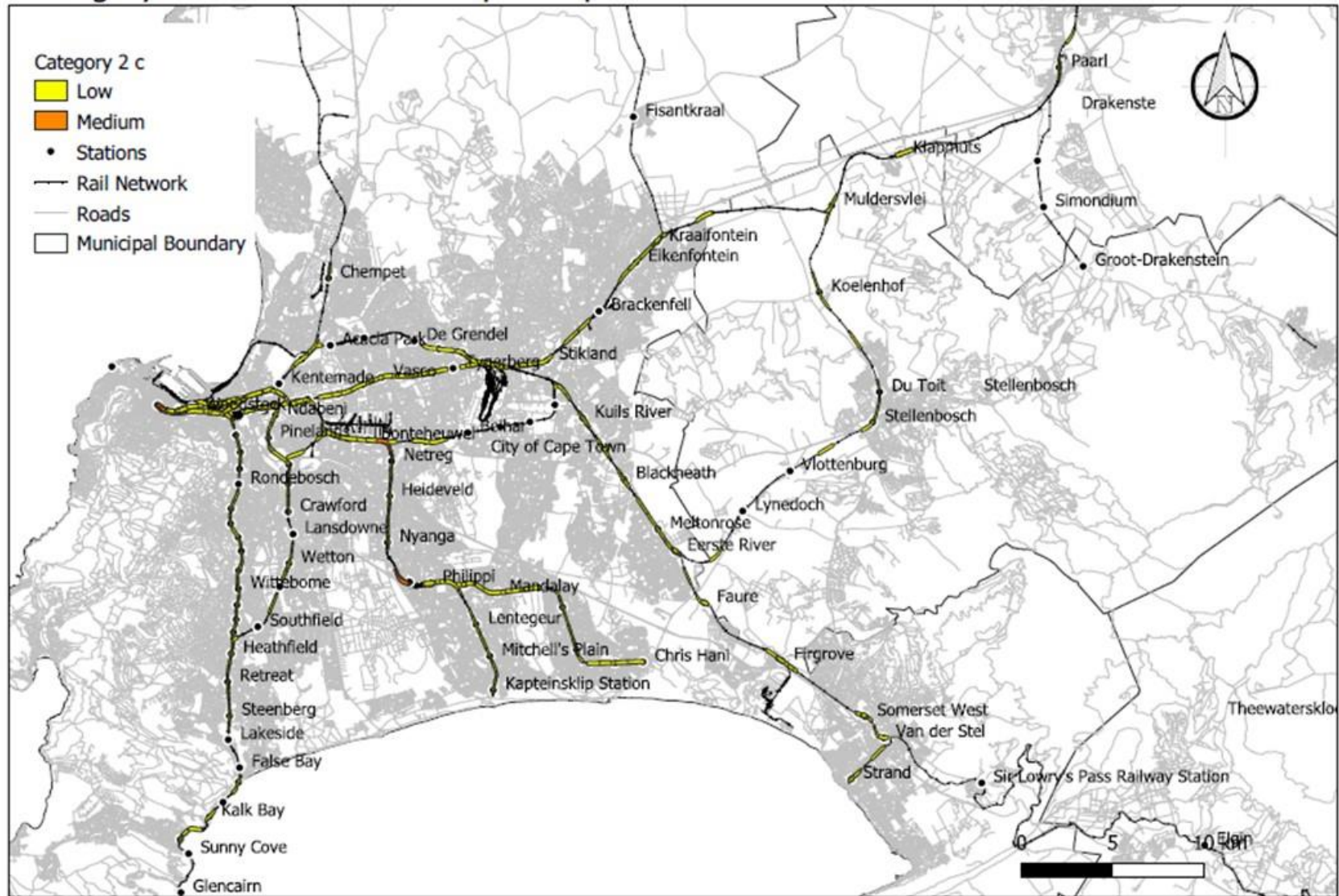


## Category 2-a Occurrences Hotspot Map

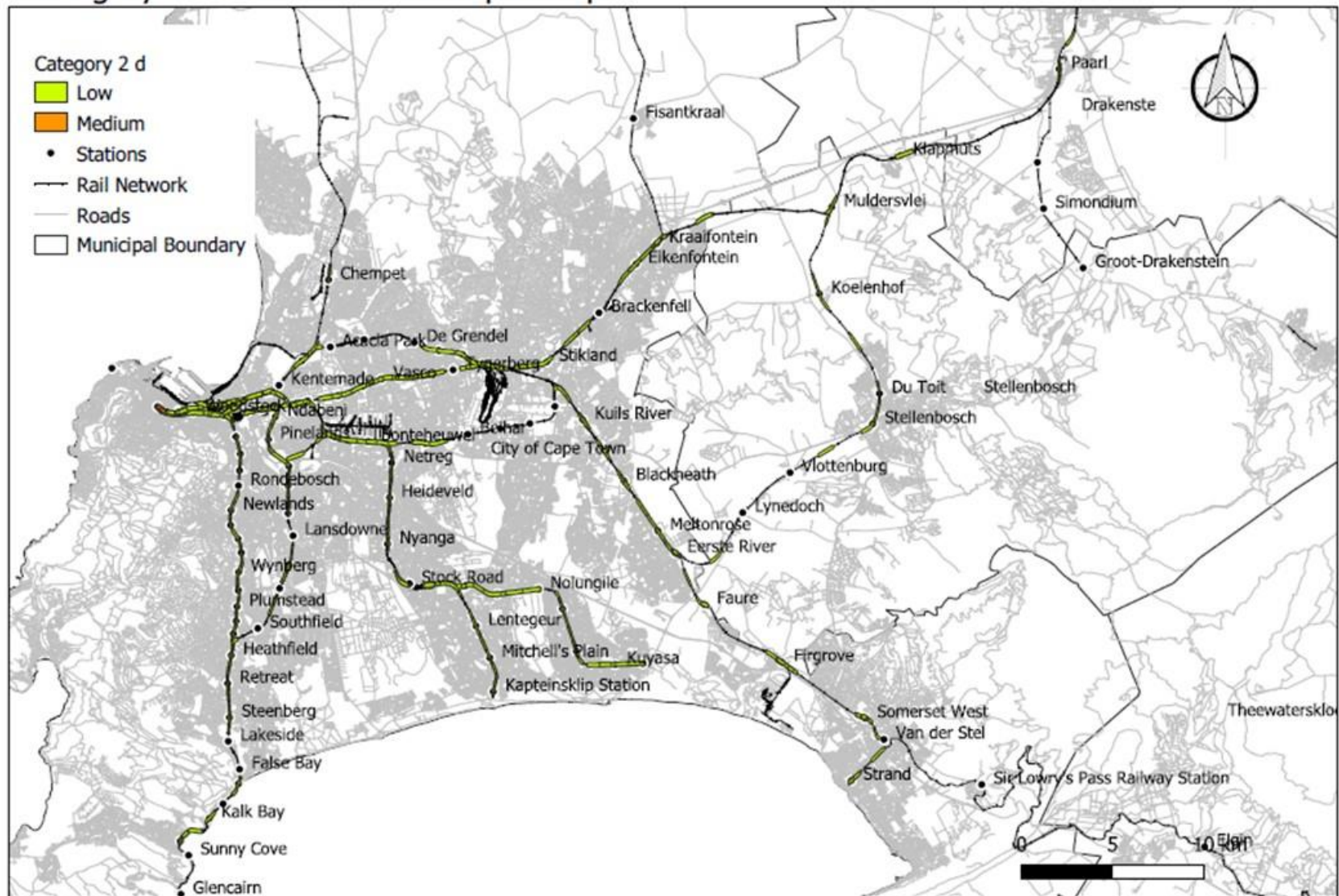




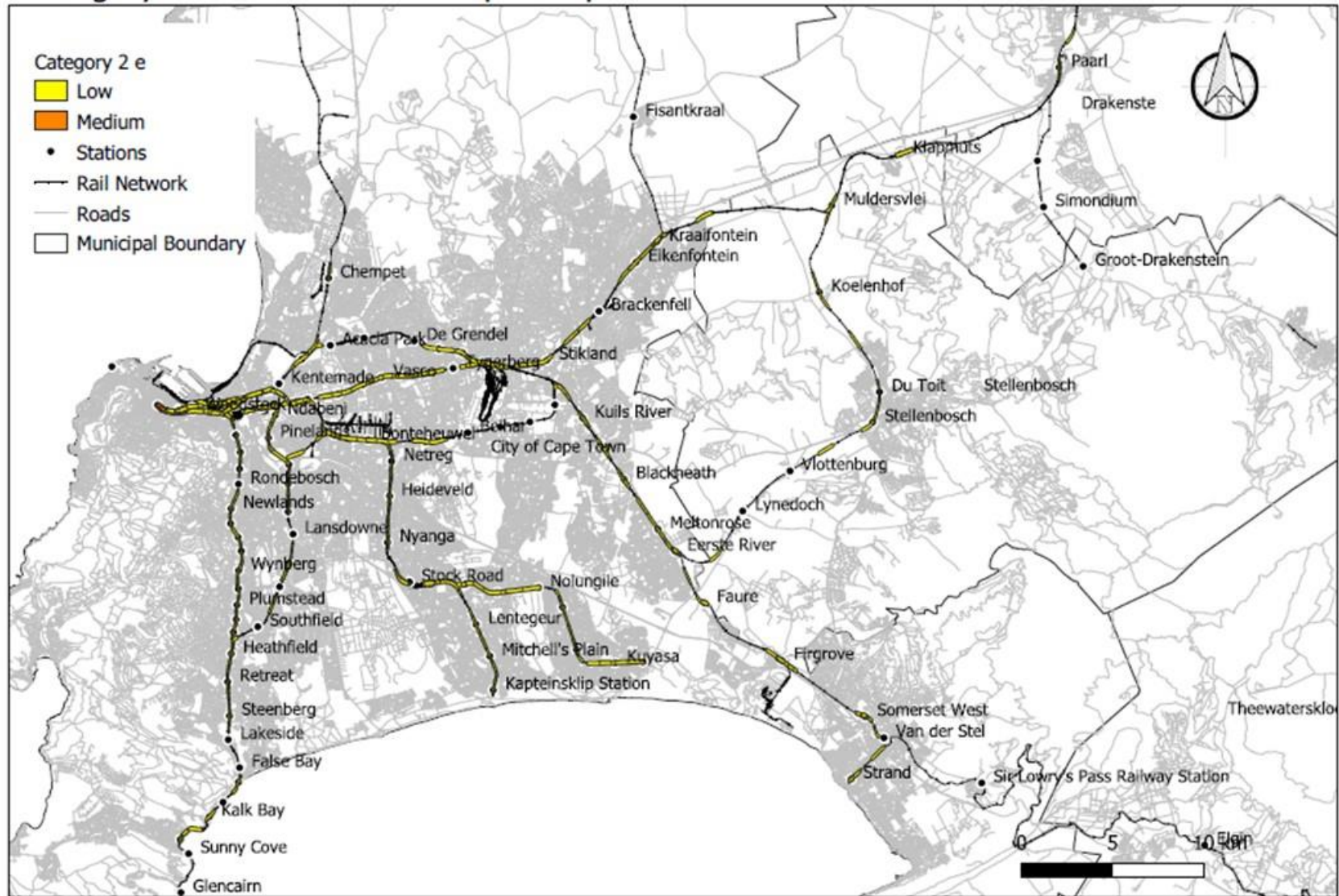
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## Category 2-d Occurrences Hotspot Map



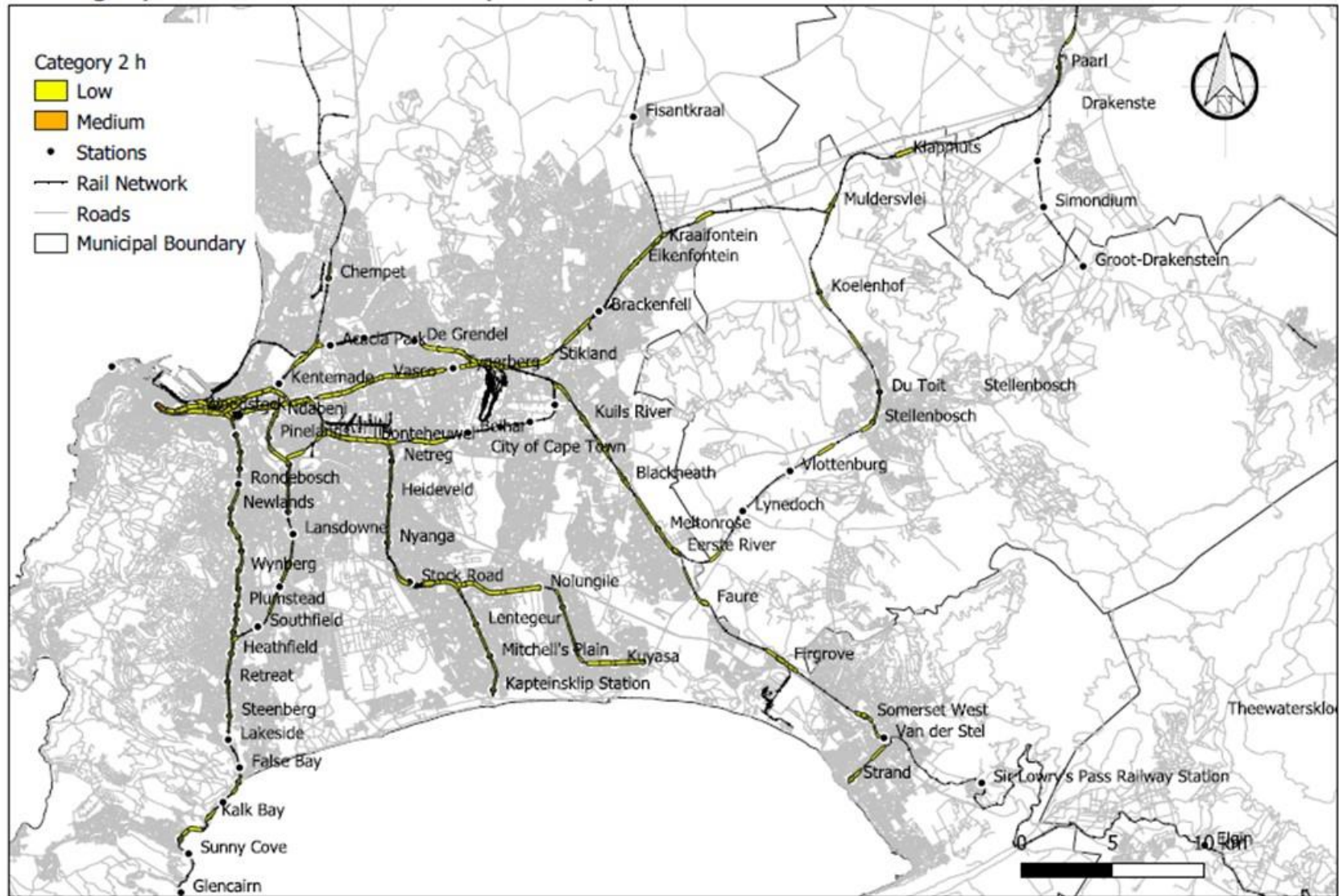
## Category 2-e Occurrences Hotspot Map







## Category 2-h Occurrences Hotspot Map

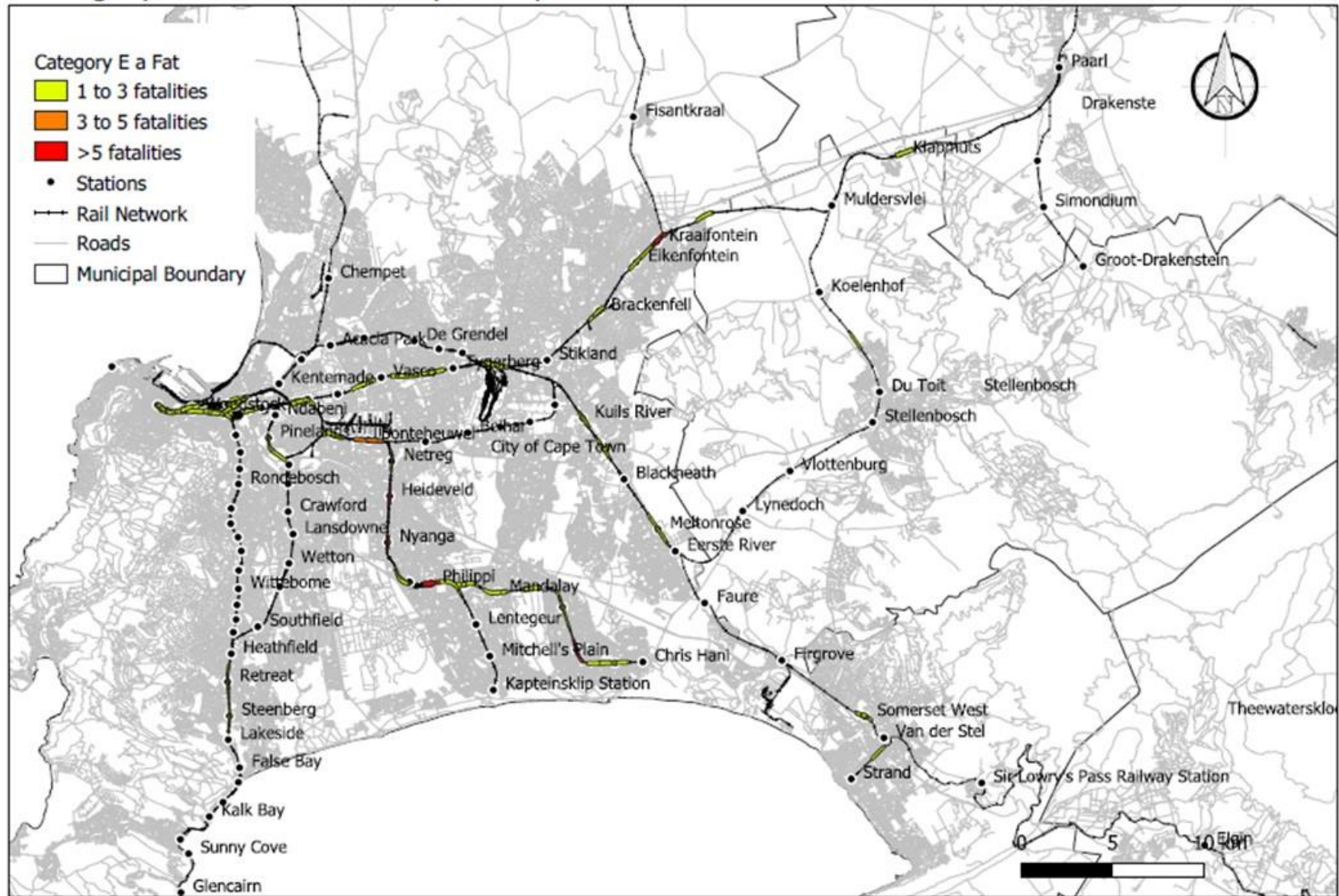




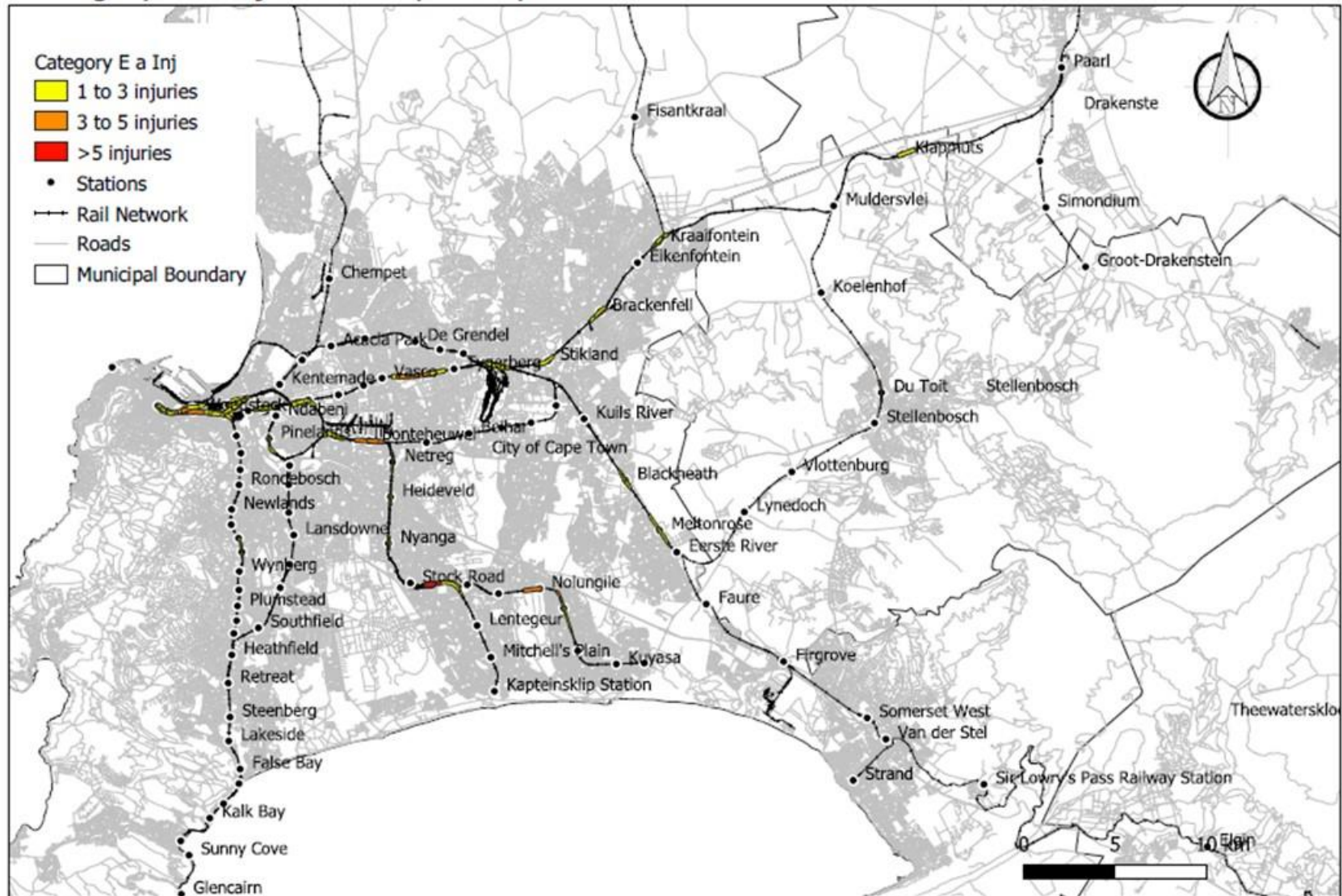




## Category E-a Fatalities Hotspot Map



## Category E-a Injuries Hotspot Map



### *Appendix E – Interview Records*

Interview Record							
No.	Interviewee	Method	Source	Saturation	Format	Length	Recording
I1	Railway operational manager	16/04/2019	Purposefully selected	Yes	Semi-structured	1.5hrs	Notes
I2	Railway safety experts	18/03/2019	Purposefully selected	Yes	Unstructured	1.5hrs	Notes
I3	NMT expert	27/03/2019 18/07/2019	Purposefully selected	No Yes	Information gathering Semi-structured	1.5hrs 2hrs	1st Meeting not recorded. Notes
I4	Railway protective services manager	15/5/2019	Purposefully selected	Yes	Unstructured	2hrs	Notes
I5	Spatial planning expert	2019/09/07	Purposefully selected	Yes	Semi-structured	1.5hrs	Notes
I6	Railway technical manager	No response	Purposefully selected	n/a	n/a	n/a	n/a
I7	Transport enforcement manager	Unable to commit time within research constraints	Purposefully selected	n/a	n/a	n/a	n/a
I8	SAPS RRPV	No response	Purposefully selected	n/a	n/a	n/a	n/a

## Interview 1

1. **Area of expertise.**  
Operations Manager  
Risk Manager

## Trespassing

2. **How many instances of trespassing in the rail reserve or via platform ends do you believe to occur daily?**

Trespassing is an everyday occurrence. The instances of trespassing are too numerous to count.

3. **Is there a specific time of day in which trespassing is more prevalent?**

It depends on the location. It can vary between all day and at peak periods in the morning and afternoon.

Trains move about after the official service ends after 10PM and before the first service starts so this period is when people least expect trains to be about.

4. **Are trespassers likely to be male or female?**

Both male and female but more males.

5. **Are trespassers likely to be children, adolescents or adults?**

Mostly adults. It depends also on the location and if there are schools nearby.

6. **Are there any specific features or trends of trespassers you think should get a mention? E.g. schoolchildren, drunkards, homeless, tourists, drug addicts, graffiti artists, thrill seekers etc.**

Suicides do happen but very seldom. We don't have a huge suicide problem. There is a growing problem of people using the rail reserve to build informal dwellings.

People just don't realise that a train takes a long time to stop.

**7. What you believe to be the main reasons for trespassing.**

Shortcuts

Large numbers trespass to avoid paying fares. Fare evasion is large before big destination stations, e.g. trains coming in to Cape Town, Esplanade is an example of this where people detrain and walk along the tracks to Cape Town.

I don't think people trespass to vandalise specifically. Theft is definitely a big reason to trespass and vandalism is almost as a result of certain actions of theft.

Suicide isn't a huge problem.

Thrill seeking isn't a huge problem.

Socialising is a very strong reason for trespassing. Especially when we talk about access.

Access to recreation, shops, visiting etc.

Graffiti is more of a problem in areas where trains are staged not a big problem on other parts of the network.

Encroachment is an increasing problem. An example of this is at Philippi Station. This area is critical for staging purposes and can hold 32 trains. If we could use this area effectively it would greatly improve operational efficiency. People are building shacks right on the tracks at this location.

**8. Where are the worst stations or line sections for trespassing incidents?**

Nyanga – Philippi

Van der Stel – Strand

Salt River - Woodstock

**9. Please rate what in your opinion are the best counter-measures to reducing trespassing.**

Fencing.

Detection and surveillance technology.

Lighting.

CCTV

Signage not effective.

Awareness campaigns and media campaigns not effective.

Education at schools not effective.

Pedestrian bridges are not effective. People just walk under them.

An example of a formalized at-grade crossing where we have improved conditions can be found at Muizenberg. This was an existing crossing that we relocated slightly to accommodate a municipal project.

**10. Do you have any other suggestions for reducing trespassing in the rail environment?**

Maintenance of rail assets are important. Fences need to be maintained.

**11. Are you able to name example sites/locations where counter-measures have successfully been implemented and where you have noticed a marked drop in trespassing?**

We had a visiting group from the Guardian Angels on how they tackled crime.

**12. What in your view should be prioritized for immediate response as it affects railway operations?**

You need to focus on where you have control. Secondly, there needs to be a focus on securing fare revenue.

Trespassing at and near stations need to be prioritized for these reasons.

**13. Are there any other comments you would like to make?**

The effect of a pedestrian train fatality on train drivers cannot be under-estimated. As well as the knock-on effect of operational planning and driver rostering.

A large portion of train drivers are currently on stand-by, pending a psychological assessment and may or may not return to work. Very few drivers have a clean record where they haven't been involved in a fatality. The current process after a fatal incident needs to be reviewed as the current situation is very difficult for operational planning. Only when a driver is boarded (declared unfit for further duty) can the vacant driver position be filled. The recruit will first have to undergo extensive training before they can be licensed as a train driver. There is a gap between the opening of the vacant position and the filling of the position. We need to be able to fill the positions for stand-by drivers to ensure continuity. Train drivers are too willing to accept being boarded and not return to work and this adds to the delays in the process of concluding the process. It could take months before a position is cleared to be filled and, in the meantime, operational roster planning remains a challenge. Working drivers then are forced to do longer shifts and a lot of over-time, which can cause further stress on drivers.

The situation for drivers is also unsafe and they need to be escorted at certain high-risk locations. Conditions for train drivers are deteriorating.

**14. Personal thoughts**

Trespassing and the act of pedestrians moving from point A to point B is the biggest concern to train drivers. Trespassers are oblivious to the risks involved and their behaviour is a major cause of on-the-job-stress for train drivers.

What came across strongly from this interview was the impact of rail fatalities on train drivers. The well-being of train drivers is often over-looked, and they are expected to carry on with their duties as per normal even under extreme conditions of duress. This poses significant operational risk, as the availability or pool of available drivers are constantly diminishing.

## Interview 2

### 1. Area of expertise

Railway safety manager  
Railway safety inspector  
Railway safety inspector

## Open discussion

### 2. Key Notes

The role of MBT industry as facilitators to unlawful pedestrian behaviour needs to be addressed. They pick up passengers at points along the railway reserve where trespassers frequent, thereby almost legitimising the behaviour. Municipal traffic officials need to do more to police areas within their jurisdiction.

Trespassing is a major issue and railway operator is not capacitated to fully deal with the problems it experiences as part of its day-to-day operations. The railway operator is short on critical staff in several safety critical positions.

Judiciary needs to be educated on the issues facing the rail industry and rail laws. Crime against railway infrastructure is still seen as a minor crime. Dedicated courts would facilitate the prosecution of criminals, which is essential to deter crime on the network.

It is essential that an effective maintenance regime exists to immediately respond to maintenance issues such as vandalised fences, littering etc. Issues around maintenance rights of way between the municipalities and the railway operator need to be resolved so clear accountability is ensured. This is especially relevant with street-to-street grade separated crossings which can go into disrepair because no one takes maintenance responsibility.

The use of modern technology in terms of railway safety and especially rail signalling systems needs to be expedited so that the occurrence and the impacts of signalling theft is reduced. This is the single most concerning issue affecting railway safety and has the biggest knock-on operational effects. Manual authorizing used in the event of the signalling system being disrupted is problematic and has contributed to railway incidents countrywide.

### 3. Personal thoughts

Railway safety inspectors seem exasperated by the lack of a coordinated effort to tackle rail issues. It would seem that the railway operator sees the regulator as an adversary rather than an important stakeholder sharing a common vision.

## Interview 3

### 1. Area of expertise.

Non-motorised transport: pedestrian movements

## Trespassing

### 2. How many instances of trespassing in the rail reserve or via platform ends do you believe to occur daily?

Too many to count.

Based on survey information at Nomzamo in the morning peak period, we have 3000 people crossing in one direction and all-day movements in both directions as well as the afternoon flows.

Rail hot-spot study found approximately 2000 people accessing the station via the platform end at Brackenfell Station, in the morning peak alone. Fencing has been removed or vandalised to allow access to the rail reserve. Includes people going to work and school.

Taxi drop off areas and building contractors pick-up and drop off passengers at these locations.

We call them “informal” crossings.

### 3. Is there a specific time of day in which trespassing is more prevalent?

Morning and afternoon peaks but throughout the day. 6Am to 9AM. Very much location specific depending on where the peak flows are; the further away, the earlier the peak. Areas closer to town will have a later peak. People working close to where they live, will display a later morning peak. School children leaving school in the afternoon will display an early afternoon peak. So, it very much depends on each specific location.

People often cross in areas not very well lit. People will avoid crossing when dark due to the high risk of becoming a victim of crime and may choose a safer alternative.

### 4. Are trespassers likely to be male or female?

Both male and female but more males.

I suspected an increase in female fatalities due to them not being as streetwise or agile.

Areas around Cape Town station for example, there are several lines and high train traffic and it requires a certain amount of dexterity to cross at these locations.

Trespass number have increased significantly of late and I suspect most of them are fare evaders. That specific area maybe has 95% of males due to the physical requirements of trespassing at that location.

Data sets should reflect, gender as well as race. Race is a sensitive subject, but it is important when considering education and communication strategies to ensure that the targeting of those measures is appropriate.

**5. Are trespassers likely to be children, adolescents or adults?**

Majority adults but you will see children as well.

Bonteheuwel: opposite an industrial area, will have mostly adults going to work. It depends largely on the demand for movement, the trip attractors.

I only know of 2 cases where children were involved in rail accidents, i.) Military Road level crossing and the ii.) Pedestrian bridge near Faure/Firgrove. Children don't often become victims of railway incidents. It's a rarity, as most cases movements are internal to townships.

**6. Are there any specific features or trends of trespassers you think should get a mention? E.g. schoolchildren, drunkards, homeless, tourists, drug addicts, graffiti artists, thrill seekers etc.**

If you look at the section of railway in the Southern Suburbs from Salt River to Plumstead, and if you consider the length of the railway and the number of formal crossing opportunities. In this area you have very little informal movement. There are also a number of level crossings on the Southern Line.

In other corridors, the stations are much further apart, with less formal crossing opportunities, less road bridges. People still need to cross and therefore you get a higher rate of informal crossing. Bonteheuwel, again a case in point, people have no criminal intent, they just wish to cross the railway to reach places of work and shops. Nomzamo as well, please just take the shortest route, literally across the railway line. The alternate route is not only a major diversion but is very unsafe for personal safety. People just follow a desire line.

The numbers of people trespassing are not regularly counted or quantified. Part of the work we have done is that we did feasibility studies at 15 hot-spot locations. Of them, pedestrian bridges were only warranted at 7 of the locations. Because of a combination of low pedestrian numbers and in other cases the pedestrian movement is direct platform access. This is a railway operator problem and if addressed would make a significant impact on trespassing. Access control and fencing outside stations need to be addressed.

A large number of people use the rail reserve as a walking corridor with no intention to cross but as a walking path. Informal crossing of railway line becomes a habitual and a behavioural issue. When you see one person cross then it makes it ok for others to cross as well. It is a behaviour which has been perpetuated on a daily basis. People most at risk are new users who aren't as savvy.

No warrants for pedestrian bridges exist at present. A number of case studies have been documented abroad but no formal warrants that indicate the criteria for implementing a pedestrian bridge.

People wearing headphones need to be targeted as they don't hear the approaching train. This has been experienced in road fatalities as well. Train drivers have indicated that in a number of cases they have sounded their siren to warn pedestrians, but they were unable to hear because of the headphones. Bodies were found with earphones. A communication message could be "Don't use headphones when crossing the railway line".

When we started identifying hot-spot locations, rail commuter forum members were questioned as to why people cross the railway, and the answer was as simple as having a need to collect firewood, i.o.w. a very basic need had to be fulfilled.

Trespassing is becoming more commonplace even amongst the so-called middle

class. We are witnessing this behavioural change occurring. It is becoming a common-practice and carried out by people from a middle-income and educated communities. Kuils River is an example. At Eerste River station, people alighting the train, would cross in front of the train before it departs as a quicker route. People become familiar and are experienced train users, there is a certain level of confidence. The behavioural issues are growing, people don't think there is anything wrong with crossing the tracks illegally, or dangerously.

**7. What you believe to be the main reasons for trespassing.**

Short-cuts. No formal crossing nearby or where there is a formal crossing nearby. Heideveld. Pedestrian bridge is an example; people still use a short cut under the bridge. The problem is the fencing has been vandalized and people still cross unsafely. Impenetrable walls are required at locations such as these.

Formal crossing deemed unsafe.

Fare evasion. Some stations have very high fare evasion numbers.

Suicide isn't a major factor. It does occur but is a low percentage of fatalities.

Socialising: At Blackheath Station people would commonly sit on the edge of the platform to rest.

Thrill-seeking. Especially during school holiday.

The challenge with engineering solutions close to pedestrian desire lines, it comes down to the human behaviour issue again, "when I see other people doing something, then I can also do it", behaviour is copied from others. Some may not know it's illegal or that they can be fined. People who purposefully vandalise fencing, clearly know they are doing something wrong. You can't go breaking down fencing. People who follow later can claim they didn't know. Announcements are made at Cape Town Station to warn of the dangers.

The rail reserve is a continuation of the road environment for a pedestrian. Pedestrian compliance with road rules is also deteriorating. Behaviour in road environment spills over into the rail environment. People would perceive the rail environment to be safer than the road environment, so could be willing to take more risks.

Typical hot-spot locations with high fatalities are where the tracks curvature prevents good sight distances for the pedestrians. So, they not able to see the approaching trains.

Levels of risk taking witnessed: Calculated gambles based on a stationary train knowing that it would be a while before the train arrives and calculating the speed and judging the approach distance of a moving train. People also jump into moving trains.

**8. Where are the worst stations or line sections for trespassing incidents?**

Woodstock Station, morning and afternoon peak.

Esplanade Station: increasing amount of people alighting at Esplanade and walking into town along the tracks. Reverse behaviour in the afternoon. Definite fare evasion.

15 hot-spot locations identified in report carried out. Hot-spots are defined as areas with high pedestrian numbers. Each hot-spot was investigated and found to fall into 2 categories: its proximity to a station for platform access and informal street-to-street access.

**9. Please rate what in your opinion are the best counter-measures to reducing trespassing.**

Prosecuting trespassers: this isn't really what we should be doing to pedestrian trespassers. Especially with no criminal intent on the part of the trespasser.

One of the lessons we have learned is that whenever there is an incident, the knee-jerk reaction is to build a pedestrian bridge, which is both costly to build and maintain, apart from the fact that they could become white elephants if not correctly sited. It is important to consider the pedestrian movements at hot-spot locations with a good understanding of what the movements are at each individual location.

Pedestrian movement should guide your interventions.

Successful interventions include patrol and enforcement although this isn't always sustainable due to staffing and capacity issues. As soon as the patrols move off the behaviour returns. Its effective where it is at a point in time but due to the size of the network, you cannot be everywhere all the time. It becomes unsustainable.

Crime investigation and intelligence is critical.

Fencing and barriers. Very effective. Wall south of Nyanga as an example, although not visually very appealing. No visibility. This type of fencing is a last resort scenario.

Fencing no matter what type, needs to be maintained.

Palisade fencing isn't very effective and is easily vandalized. Clear-view fencing more effective. Fencing can be effective but must be considered according to the risk of the area.

Subways are an issue. They will only be accepted by communities if it can be proved that the existing subways on the network can be properly managed. Crime, lighting, littering, drainage issues must be designed.

Elsies River and Bellville subways are awful. Elsie's River subway is especially bad. Bellville is longer but has a lot of people. Elsie's is a quiet subway.

Targeted communication and education campaigns.

**10. Do you have any other suggestions for reducing trespassing in the rail environment?**

Walls and a considered fencing programme.

A guidance on a fencing specification would be useful.

Pedestrian desire lines need to be considered. One must consider that more people will try and save money by walking for certain legs of their journey, especially the last and first mile, especially if it is a walkable distance. People will walk more. Items to consider, desire/need to cross, cost saving, time saving and behavioural decay.

**11. Are you able to name example sites/locations where counter-measures have successfully been implemented and where you have noticed a marked drop in trespassing?**

Nyanga

Access control at Woodstock and Bellville Stations

It's difficult when you are dealing with human behaviour and compliance. We keep on trying to find engineering solutions to social problems.

**12. What in your view should be prioritized for immediate response as it affects railway operations?**

Trespassing at grade crossings show low pedestrian fatalities.

Encroachments are an increasing problem but very complicated to solve.

Suicides prevention programs would be the lowest priority purely because of the low numbers.

The main priority should be to eliminate illegal movements onto stations via the platform ends. If this can be eliminated this will have a knock-on effect on trespassing in section areas.

Platform ends aren't ramped but sometimes they have informal gravel ramps or stepping stones placed by commuters to make access easier.

**13. Are there any other comments you would like to make?**

Pedestrian bridges not always the answer to trespassing.

Fencing is effective but needs to be maintained. Vandalised fencing needs to be repaired before bad behaviour sets in.

Accident locations need to be geolocated as part of accident reports, so the exact locations can be identified.

Accident locations almost always have no relation to trespass numbers. High trespassing locations could have very low or no fatality rates.

Formalising informal at-grade crossings need to be considered as a solution. The rail operator needs to reconsider its policy on this. The technology exists to make it a safe option. Not formalizing crossings such as the one at Nomzamo is even more risky.

We specifically don't call it trespassing but "informal crossing of railway lines".

**14. Personal thoughts**

Very insightful interview. What became apparent to me from this interview was that the solution to trespassing cannot be down to any specific party on its own and needs a coordinated approach. The human behaviour element, again, as with all elements of life in modern day South Africa, is a complicated problem to deal with, which not only affects rail but may be a spill-over from non-compliance generally. We see this in road safety, where road users must be forced to behave in a certain way. Similarly, the only effective engineering measures are the type which forces a certain behaviour. Where people have a choice, they would most likely still choose the risky option.

Another key point from this is the numbers of trespassers counted at the hot-spot sites. The pedestrian numbers are unprecedented. It cannot be acceptable that beurocracy dictate engineering risk when it comes to the proposal to formalize certain at-grade crossings. Risk based decision making must be employed here.

I especially appreciated the fact that the term "trespasser" isn't used to criminalise the pedestrian but rather the term "informal crossing of the railway line."

## Interview 4

### 1. Area of expertise.

Railway security manager

## Open discussion

### 2. Key notes

Better co-working with the RRPU is still lacking. More should be done to foster joint deployment and operations, more visibility on trains and following through on opened criminal dockets. SAPS still only plan their interventions based on reported crime.

Advancements in technology need to be explored with regards to target-hardening. Hi-tech advancements in crime analysis are currently being deployed to provide new intel into crime patterns. Analysis has shown that there is a direct linkage to gang hot-spot areas as well as scrap metal dealers. This is very effective but also very expensive and the current contract with the service provider is nearing its end.

Fencing as the first line of defence must be broadly expanded to secure the network entirely.

Poor service roads and dense trackside vegetation makes responding to incidents difficult and visibility poor.

More target hardening measures need to be implemented on “hot assets”. The same type of assets are targeted repeatedly.

Lighting, especially at hot-spots need to be improved to improve visibility and detection.

With the recent train arson attacks, additional security measures have been put in place at Cape Town Station. Since then, arsonists have now started targeting trains before they come into Cape Town and are now starting to attack the rolling stock at Woodstock Station or even earlier.

### **3. Personal thoughts**

There is currently a lot being done to combat the incidents of crime on the network. The railway operator is using sophisticated crime analysis techniques to provide insight into crime patterns. This information in combination with a dedicated security arm which includes the use of drone surveillance, has proven to be very effective at crime hot-spot locations, leading to a number of arrests and convictions. There is a certain degree of organization to the crime, especially with regards to metal theft.

The information shared at this stage is very confidential and cannot be fully incorporated into the research, and it is worth consideration for further research opportunities.

It is again apparent that you have a railway operator who has become a victim of a larger social problem, but unlike trespassing in general, the intention is to commit a crime which requires a specific intervention. With rail routes passing through gang-infested areas and deprived communities, it will remain a soft-target for potential criminals. Can we expect a rail operator to be crime fighting experts as well?

Continuing organizational issues with the railway operator further complicates matters. I had originally intended to interview the manager for protective services only to learn that the individual had been put on suspension. At the time, I met with the Acting Manager instead, who still is a very capable individual and has expert knowledge on the subject matter.

## Interview 5

- 1. Area of expertise.**  
Spatial and urban planning

## Trespassing

- 2. How many instances of trespassing in the rail reserve or via platform ends do you believe to occur daily?**

Too many to count. We are talking specifically about the type of trespassing where the main reason is to either cross the railway purely to get across or to use the rail reserve as a corridor.

- 3. Is there a specific time of day in which trespassing is more prevalent?**

I have witnessed peak hour flows in the morning and evening, but you will also have all day flows at certain locations. Some stations close to schools also have peaks around school finishing times.

Khayamandi mall crossing has thousands of people crossing all day. The location of an informal taxi rank on the site adjacent to the crossing as well as it being on the main pedestrian route into Stellenbosch, contributes to it being a site that is constantly busy throughout the day.

- 4. Are trespassers likely to be male or female?**

Male and female but more males.

- 5. Are trespassers likely to be children, adolescents or adults?**

Depends on the location. Mostly adults.

If the station is used by nearby schools then you will have a higher ratio of children and teenagers. They will walk in large groups as schoolchildren like to do.

You will also see people crossing the tracks with shopping, walking sticks, bicycles, prams, it really depends on the location.

Effort must be made to study each location on its own merit.

**6. Are there any specific features or trends of trespassers you think should get a mention? E.g. schoolchildren, drunkards, homeless, tourists, drug addicts, graffiti artists, thrill seekers etc.**

There is a growing number of homeless people using the railway reserve to build make-shift shelters. I'm not talking about the type you will see with the encroachment at Philippi, but rather more informal type shelters that are just high enough to crouch in. The rail operator needs to be constantly vigilant to remove these shelters as they quickly mushroom. This obviously not a rail problem, and I don't think it's a housing problem either, these are people living on the fringes of society, who refuse to comply to even homeless shelter rules. You will get people who get a house from the government and then prefer to live in a shack while they rent out their government house.

Station precinct areas: These are areas surrounding train stations. Several station areas have been left to deteriorate and have become little crime infested slums. Combined with growing informal taxi ranking outside some stations, and informal traders these areas have become no-go zones for choice transport users. Local authorities need to do more to tidy up these areas. The area outside Parow station is an example. The area has become a slum.

Cape Town station surrounds is equally bad. People openly sell and use drugs in the square bordering Adderley Street. I have witnessed on a daily basis people smoking tik and using hypodermic needles to inject themselves with heroine, in clear view of passers-by. The station deck area is equally bad. I just mention these 2 but all the major stops and especially those with an interchange, have problems.

**7. What you believe to be the main reasons for trespassing.**

This is not only a railways problem, but it can also be seen on major arterials and highways. The N2, N1, R300 all have people crossing them. The issue will be experienced everywhere a corridor acts as a barrier to the movement of people and formal crossing facilities are inadequate. People need to go to the shops, school, work, or to reach other transport services, clinics and hospitals.

**8. Where are the worst stations or line sections for trespassing incidents?**

Cape Town Station towards Woodstock and Esplanade. I use the MyCiti and witness hordes of people walking longitudinally down the tracks on a daily basis, despite the presence of Metro police. These aren't your Nomzamo's or Khayamandi's, these are purposefully trespassing in order avoid paying fares at Cape Town station. They need to be tackled differently to a pedestrian trying to get from point A to point B.

Any area of the track which runs adjacent to informal settlements is going to have a problem. When you face something day in and day out you become oblivious to the dangers. It becomes part of life.

**9. Please rate what in your opinion are the best counter-measures to reducing trespassing.**

We must be better at how we plan our settlements. Land use and transport planning needs to be carried out more comprehensively with more consideration for NMT users. The Blue Downs Rail link is a case in point. If this is not dealt with correctly it will add to the growing problem.

Education and information strategies need to be reconsidered. Fatality hot-spots need to be properly reviewed and strategies devised around them. It's no use doing a media campaign on the internet for example or at schools, when you should be going into shebeens and taverns instead. There is also a group that won't read or pay attention to any such campaigns. How do you explain the dangers to them? Campaigns must be targeted, and the effectiveness evaluated.

We also need better cross stakeholder involvement. These aren't only rail or transport problems but societal issues. Unemployment, crime, homelessness; these aren't rail issues, but it affects rail.

**10. Do you have any other suggestions for reducing trespassing in the rail environment?**

We must have a minimum standard for the spacing of formal crossing opportunities along transport corridors and provide more crossing opportunities.

**11. Are you able to name example sites/locations where counter-measures have successfully been implemented and where you have noticed a marked drop in trespassing?**

International best practice examples are plenty, especially with respect to pedestrian and vehicle level crossing guidelines. The technical solutions are there. We must consider what will work in our local context considering human behaviour and the growing lack of compliance with basic rules and laws.

**12. What in your view should be prioritized for immediate response as it affects railway operations?**

From an urban land-use perspective, the broken window principal needs to be applied to our station precinct areas. These areas need to be tidied up and become no-go zones not for ordinary people but for drug dealers and criminals. The positive effect of this clean-up will spill over into the rail environment. The same goes for areas along the rail corridor.

From a railway perspective, station access needs to be secured.

**13. Personal thoughts**




As a regular user of public transport, I have witnessed the decline in the state of the areas around major public transport interchanges. Transients, open drug use and litter are common place.

Further confirmation of social problems spilling into the rail environment. The theory that positive changes made outside the rail environment would spill into the rail environment is an interesting one and that is supported by crime analysis.



## *Appendix F – Site Inspection Field Notes*

### **Legend**

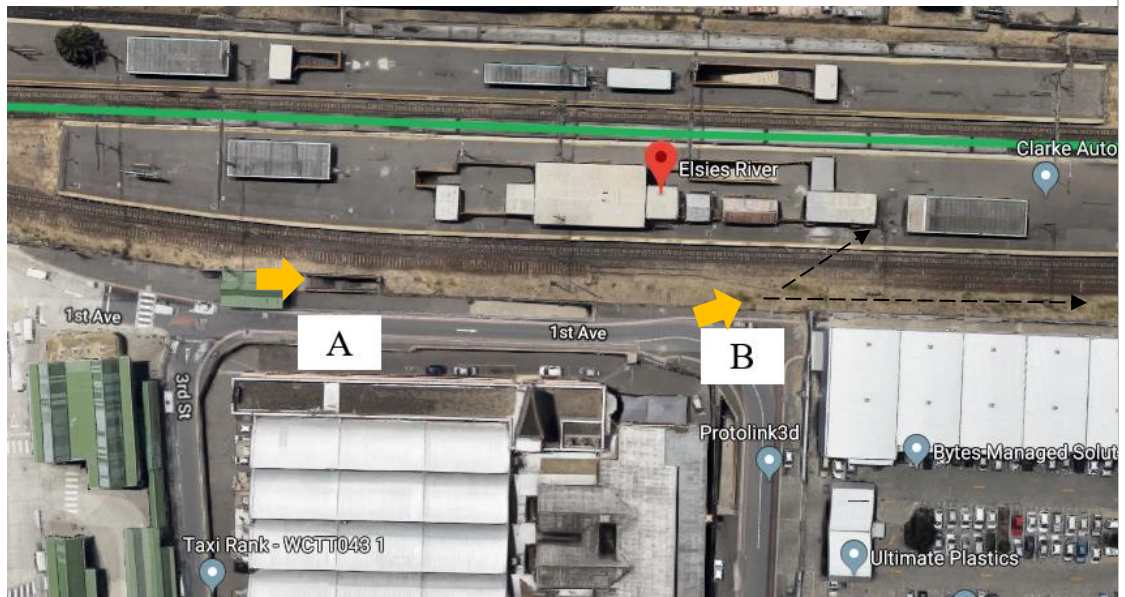
	Pedestrian desire lines
	Encroachment area
	Camera angle

<b>Location</b>	<b>Note</b>
Elsies River Station	SV1
Elsies River Station – Parow Station	SV2
Parow Station – Tygerberg Station	SV3
Parow Station	SV4
Mbekweni Station	SV5
Dal Josafat Station – Mbekweni Station	SV6
Klapmuts Station	SV7, SV8
Du Toit Station – Koelenhof Station	SV9
Strand Station – Van der Stel Station	SV10
Netreg Station – Heideveld Station	SV11
Nyanga Station – Philippi Station	SV12
Bonteheuwel Station	SV13
Kraaifontein Station	SV14

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<b>Date:</b> 23/07/2019	<b>Time:</b> 09h15	<b>Location:</b> Elsie's River Station
<b>Weather:</b> Rain	<b>SV1</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b>  “Unfriendly” subway/underpass Trespassing		<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b>  Industrial area Nearby public transport facility
<b>Define area (station, platform, open line, level crossing, other.)</b>  Subway		<b>Count frequency of trespassing / 15-minute interval</b>  7
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b>  Adult men		<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Subway
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Security presence outside subway entrance but responsible for PT facility.		
<b>General notes on location:</b> Visit during off-peak time. No trains arrived during the time of the visit. Subway very quiet and although lit was found to be dark. (See Fig.1 and 2) No standing water present even though it was raining quit steadily. Very unnerving walking down the subway alone. Only a few homeless people wandering about at street level. At street level I noticed a number of people taking a short-cut at the opposite end of the station where a section of the fence had a hole. Some trespassers sought access to the station platforms via this point while others used it as an entry to walk longitudinally along a path alongside the tracks.		

Google Earth Image



A – Subway entrance  
B – Location of removed fence



Fig.1 View down subway



Fig.2 View down subway entrance at street level



Fig.3 Section of fence removed allowing access to rail reserve and station



Fig.4 Pathway along tracks

<b>Date:</b> 23/07/2019	<b>Time:</b> 9h38	<b>Location:</b> Elsie's River Station – Parow Station
<b>Weather:</b> Rain	SV2	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b>	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b>	
Trespassing	Industrial Residential on opposite side of tracks	
<b>Define area (station, platform, open line, level crossing, other.)</b>	<b>Count frequency of trespassing / 15-minute interval</b>	
Open line section Partly fenced	7	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b>	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b>	
Adult males	None	

**What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)**

Fencing

**General notes on location:**

Trespassers are accessing the tracks at a hole in the fence on the opposite site and walking longitudinally/diagonally across the tracks.  
 Train witnessed while trespassers on tracks. Train did not sound horn.  
 Dense trackside shrubbery and vegetation.  
 Disused track materials spoiled adjacent to tracks.

Google Earth Image





Fig.1 Discarded track materials adjacent to running rails



Fig.2 Entire sections of fencing missing providing unobstructed access to the running rails



Fig.3 Dense vegetation makes visibility poor for surveillance purposes as well as train drivers

<b>Date:</b> 23/07/2019	<b>Time:</b> 10h00	<b>Location:</b> Parow Station – Tygerberg Station
<b>Weather:</b> Rain	<b>SV3</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing Partial encroachment		<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential
<b>Define area (station, platform, open line, level crossing, other.)</b> Line in section		<b>Count frequency of trespassing / 15-minute interval</b> 15
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult males Adult females		<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> None
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing		
<b>General notes on location:</b> Fencing has been vandalized in several places to allow access to the rail reserve. Clear pedestrian desire lines visible, with diagonal paths across the tracks. 20m from the initial position I first witnessed some trespassers, there are a number of informal dwellings along the fence demarcating the railway reserve. Sections of fencing is missing adjacent to these shelters allowing access to cross the tracks. There were no people outside the shelters at the time of my visit.		

Google Earth Image – Location 1





Fig.1 Pedestrian pathway leading to hole in fence



Fig.2 Pedestrian pathway leading to hole in fence and continuing across tracks

Google Earth Image – Location 2

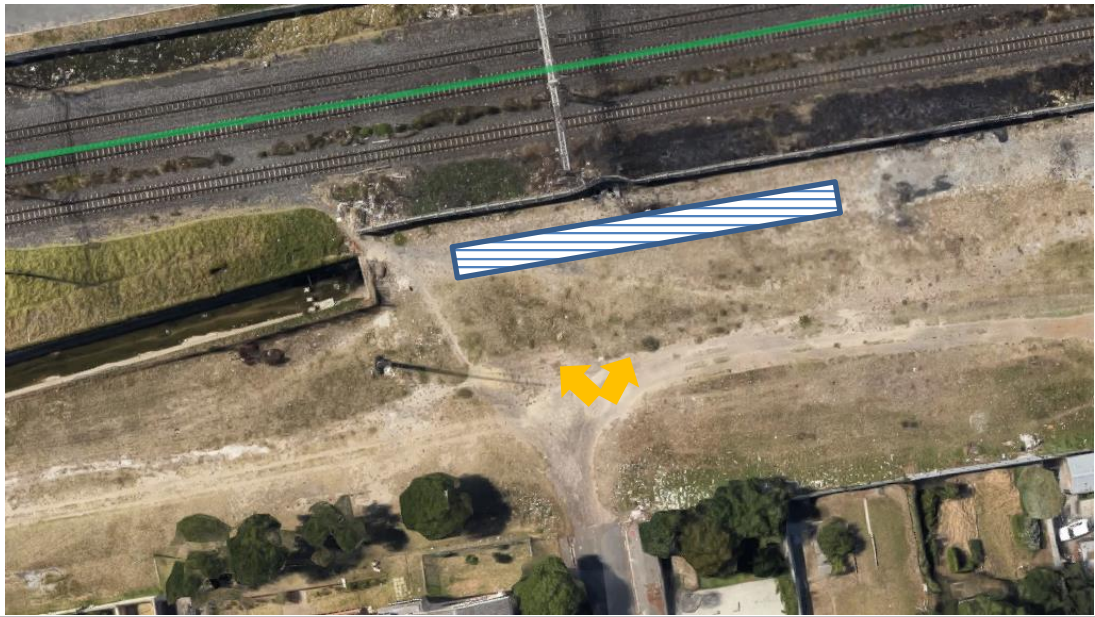


Fig.3 Informal dwellings on railway reserve fence



Fig.4 Informal dwellings on railway reserve fence

<b>Date:</b> 23/07/2019	<b>Time:</b> 10h25	<b>Location:</b> Parow Station
<b>Weather:</b> Rain	<b>SV4</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Encroachment	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential Retail PT facility	
<b>Define area (station, platform, open line, level crossing, other.)</b> Station Looks like a disused platform section	<b>Count frequency of trespassing / 15-minute interval</b> 3 trespassers 3 inhabitants of dwellings	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult males Adult females Homeless	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Overbridge at Parow Station	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing		
<b>General notes on location:</b> There is a fence around the area and an open vehicular gate at the main entrance. The fence immediately adjacent to the shelters has a hole where people pass through. The general station precinct area is filthy and littered with rubbish. There is a MBT rank at the station and the station precinct looks very rundown. Informal shelters built in the doorways of shopfronts. The shelters photographed are within the rail reserve in a “back of platform” area. The shelters look like they have been around for some time and well established.		

Google Earth Image

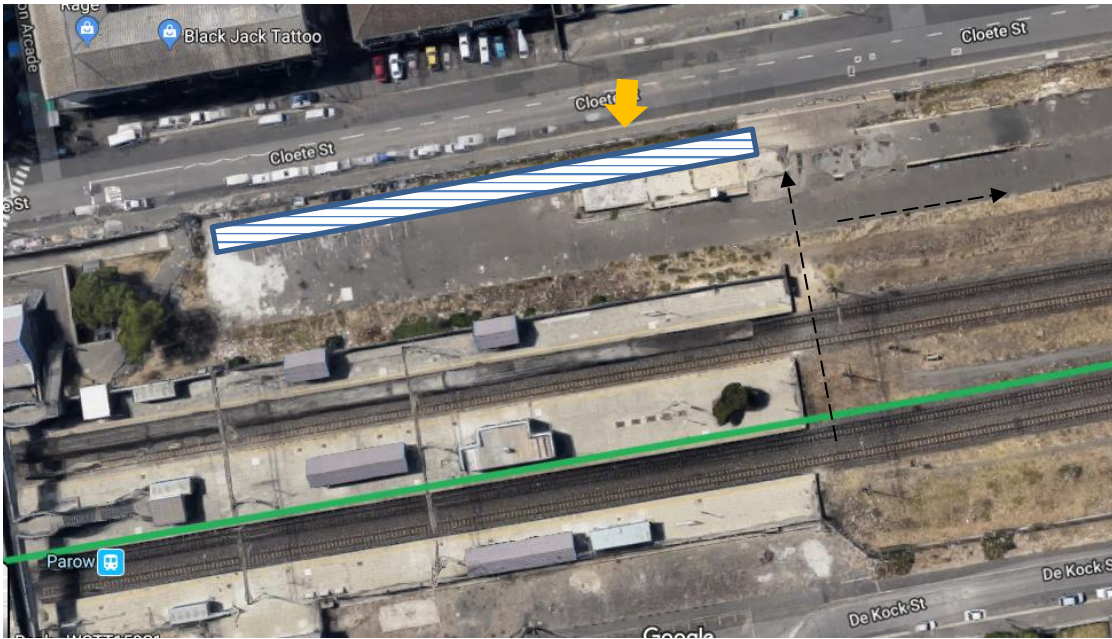


Fig.1 Section of fence removed to allow access to railway area



Fig.2 Row of informal shelters inside the rail reserve

<b>Date:</b> 01/08/2019	<b>Time:</b> 9h30	<b>Location:</b> Mbekweni Station
<b>Weather:</b> Fine	<b>SV5</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Informal settlement Rural	
<b>Define area (station, platform, open line, level crossing, other.)</b> Station Platform-end	<b>Count frequency of trespassing / 15-minute interval</b> 9	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult males Adult females	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Pedestrian overbridge at station	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing		
<b>General notes on location:</b> High pedestrian traffic along Drommedaris Road, typical of informal settlements. Clear desire lines lead up to a “naturally” ramped access to platform end. Fence removed for sections. A number of trespassers were walking longitudinally along the tracks.		

Google Earth Image





Fig.1 Pedestrian pathway leading to platform-end access at station



Fig.2 End of platform providing access to the tracks



Fig. 3 Partial fencing allowing access to the tracks and platform-end



Fig. 4 Pedestrians walking longitudinally along and across the tracks

<b>Date:</b> 01/08/2019	<b>Time:</b> 9h53	<b>Location:</b> Dal Josafat Station – Mbekweni Station
<b>Weather:</b> Fine	<b>SV6</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing Encroachment	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Informal settlement Rural	
<b>Define area (station, platform, open line, level crossing, other.)</b> Line section	<b>Count frequency of trespassing / 15-minute interval</b> 3	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult male Adult female Child	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> None. Vehicular level crossing a bit further south.	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> None		

**General notes on location:**

The line of shacks are to within a few metres from the tracks. Tracks are littered with rubbish and the area smells of human excrement.

Witnessed a woman carrying a little child walking longitudinally along the tracks.

Google Earth Image





Fig.1 Line of shacks encroaching onto the railway reserve



Fig.2 Track area is littered with rubbish and human waste

<b>Date:</b> 01/08/2019	<b>Time:</b> 10h30	<b>Location:</b> Klapmuts Station
<b>Weather:</b> Fine	<b>SV7, SV8</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential Retail on the opposite side	
<b>Define area (station, platform, open line, level crossing, other.)</b> Station Area immediately adjacent to station	<b>Count frequency of trespassing / 15-minute interval</b> 25	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult males Adult females Children Elderly	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Station overbridge Pedestrian underpass	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing Landscaping (rock filled gabions)		
<p><b>General notes on location:</b></p> <p>The Klapmuts rail line separates the residential area from the shopping area, which are on the opposite sides of the tracks. A pedestrian overbridge at the station and an underpass at the other end provide formal pedestrian crossing opportunities. The pedestrian underpass is situated next to a canal and looks a bit treacherous.</p> <p>The fencing is damaged at locations where people can access the station platform.</p> <p>Trespassers cross at well-known footpaths to access the station via the platform ends as well as cross the tracks to reach the shopping center on the opposite side. Some use the station as a thoroughfare to reach the shopping area.</p> <p>High pedestrian numbers were witnessed, including people carrying shopping bags, little children as well as elderly men and women with walking sticks.</p> <p>There is quite a big level difference between the street and track level and the tracks are tricky to traverse having to climb over a gabion then step over a row of cabling to access the tracks. A section of gabion has been removed to allow easier access.</p> <p>On previous occasions during school holidays, I have witnessed children playing on the tracks at this location.</p>		

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Google Earth Image



Fig.1 View showing the level difference between the street and tracks



Fig.2 Pedestrians using the platform-end ramps to gain access to the station



Fig.3 Pedestrians crossing the tracks to reach the opposite side of the station



Fig.4 Section of rock-filled gabion removed to create a pathway



Fig.5 Pedestrian pathway along tracks showing trackside cabling pedestrians need to navigate



Fig.6 An alternate formal crossing point used mainly by pedestrians with baby buggies

<b>Date:</b> 01/08/2019	<b>Time:</b> 11h15	<b>Location:</b> Du Toit Station – Koelenhof Station
<b>Weather:</b> Fine	<b>SV9</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> PT facility Shopping Industrial	
<b>Define area (station, platform, open line, level crossing, other.)</b> Line section Informal at-grade crossing	<b>Count frequency of trespassing / 15-minute interval</b> 303	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult male Adult female Children Elderly Cyclists	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> None	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> None. Informal crossing point has slabs between the tracks to make walking over easier.		
<p><b>General notes on location:</b> Location at Khayamandi Mall. Very high traffic area. More than 300 pedestrians counted in a 15-minute period at almost midday.</p> <p>Very busy shopping area, MBT informal ran as well as informal traders right next to tracks.</p> <p>Majority of pedestrians simply just cross the tracks at this location. Some walk longitudinally along the tracks to access Du Toit station via the platform ends or walk towards Cloetesville. There is also significant loitering on the tracks at this location and a bit further up under the bridge and during the visit an individual was sitting on the tracks defecating.</p> <p>Thick vegetation between tracks at this location.</p> <p>Speaking to one of the traders, he asked in Afrikaans “When are we going to improve this location? It’s very dangerous. Sometimes we don’t even hear the train coming.”</p>		

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Google Earth Image



Fig.1 Informal MBT rank and traders can be seen in the background



Fig.2 Heavily used informal pedestrian crossing showing informal traders active on both sides



Fig.3 Pedestrians walking longitudinally along the tracks to access the station via the platform-ends



Fig.4 Dense trackside vegetation



Fig.5 Loitering on the tracks with one individual using the tracks as a toilet

<b>Date:</b> 01/08/2019	<b>Time:</b> 11h50	<b>Location:</b> Strand Station – Van der Stel Station
<b>Weather:</b> Good	<b>SV10</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing Encroachment	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential Major arterials M153, N2	
<b>Define area (station, platform, open line, level crossing, other.)</b> Line section Informal crossing point	<b>Count frequency of trespassing / 15-minute interval</b> 384	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult males Adult females Children Elderly Cyclists	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Formal pedestrian route nearby.	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing Formal pedestrian route Signage		
<p><b>General notes on location:</b>  Very high pedestrian traffic. Both directions in the middle of the day. Counted 384 pedestrians in a 15-minute period. This is the only site that has warning signage displayed.  Location provides access to the Strand Main Road from the Nomzamo residential area.  A formal pedestrian route does exist but is unused as it not only takes pedestrians on a major diversion but is also very unsafe and strewn with litter. When asked why no one uses the formal route, one pedestrian said, “We get robbed when we walk down there, its unsafe, especially when dark.”  Most pedestrians make a direct crossing at this location and a smaller number walk longitudinally along the tracks to exit the rail reserve through other gaps in the fence further up.  Whilst on site, a rail maintenance crew was inspecting the ballast at this location. Sleepers are used to shore up the ballast as the numbers of pedestrian traffic at this location causes the ballast to become unstable and could pose a further safety risk.  After heavy rains there is a lot of standing water present and the area is strewn with litter. The area next to Strand main Road, is used by taxis to pick-up and drop passengers and there are a number of informal trader’s present. These elements all add to further legitimize the crossing.  A few metres from the crossing towards Van Der Stel Station, there are several informal dwellings erected inside the rail reserve.</p>		

Google Earth Image



Fig.1 Photograph showing fencing removed, no trespassing signage, and ponding water



Fig.2 Informal crossing used by both males and females



Fig.3 Sleepers ineffectively being used to retain the track ballast. Evidence of fly-tipping can also be seen on the right of the photograph.



Fig.4 A cyclist carrying his bicycle across the tracks.



Fig.5 Fencing vandalized to create access points



Fig.6 Informal dwellings erected inside the railway reserve

<b>Date:</b> 01/08/2019	<b>Time:</b> 11h50	<b>Location:</b> Netreg Station – Heideveld Station
<b>Weather:</b> Good	<b>SV11</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing		<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential
<b>Define area (station, platform, open line, level crossing, other.)</b> Line section Formal grade separated pedestrian crossing		<b>Count frequency of trespassing / 15-minute interval</b> 0
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> n/a		<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Location at pedestrian crossing
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing Formal crossing		
<b>General notes on location:</b> Well-designed grade separated pedestrian crossing with universal access. Section of fence on both sides of track removed immediately below the bridge with clear pedestrian desire lines. I didn't witness any trespassing while on site, mainly because it was very quiet at that time of day. 2 female pedestrians were making use of the formal crossing at the time.		

Google Earth Image



Fig.1 Formal pedestrian grade separation



Fig.2 Section of fencing removed under the pedestrian bridge

<b>Date:</b> 01/08/2019	<b>Time:</b> 12h46	<b>Location:</b> Nyanga Station – Philippi Station
<b>Weather:</b> Good	<b>SV12</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential Retail	
<b>Define area (station, platform, open line, level crossing, other.)</b> Line section	<b>Count frequency of trespassing / 15-minute interval</b> 0	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> n/a	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> None. Road overpass further down.	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing		
<p><b>General notes on location:</b></p> <p>The location is a hot-spot for both fatalities and crime occurrences. The countermeasure installed consists of a concrete fence that is used to cordon off the entire length of the corridor along this section.</p> <p>The fence is very robust and seemed free of any defects or damage.</p> <p>The only entry into the rail reserve is via a gated vehicular access. The gate was open at the time of the inspection and it remains so at all times.</p>		

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Google Earth Image

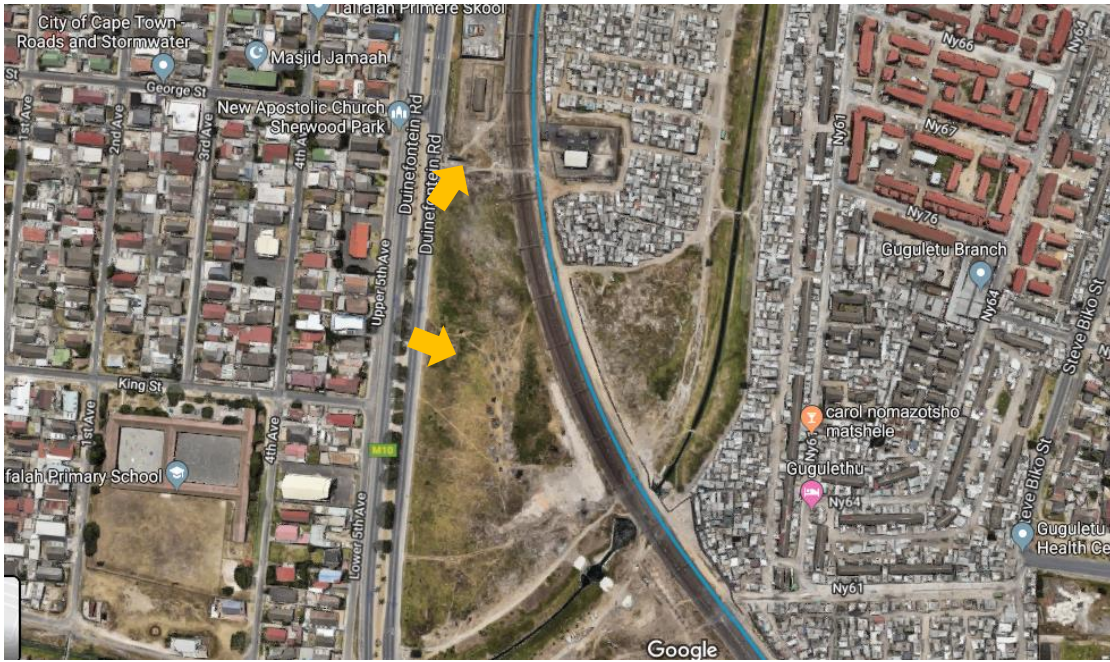


Fig.1 Concrete walling



Fig.2 Entire section of railway corridor with concrete fencing

<b>Date:</b> 01/08/2019	<b>Time:</b> 13h27	<b>Location:</b> Bonteheuwel Station and surrounds
<b>Weather:</b> Good	<b>SV13</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing		<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential Industrial
<b>Define area (station, platform, open line, level crossing, other.)</b> Station Area immediately surrounding station		<b>Count frequency of trespassing / 15-minute interval</b> 12
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult male Adult female Children		<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Station overbridge
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing		
<p><b>General notes on location:</b>  Fencing is broken in several locations with a myriad of pedestrian desire lines across the entire area which can be seen from the aerial photograph.  The main reason is to cross to reach the industrial area at Epping for work and retail opportunities.  During the visit I witnessed pedestrian movement across, diagonally across and longitudinally down the tracks.  Sections along the track has poor drainage and there are areas used as fly-tipping areas, strewn with rubbish. Vegetation is also dense along the track.</p>		

Google Earth Image

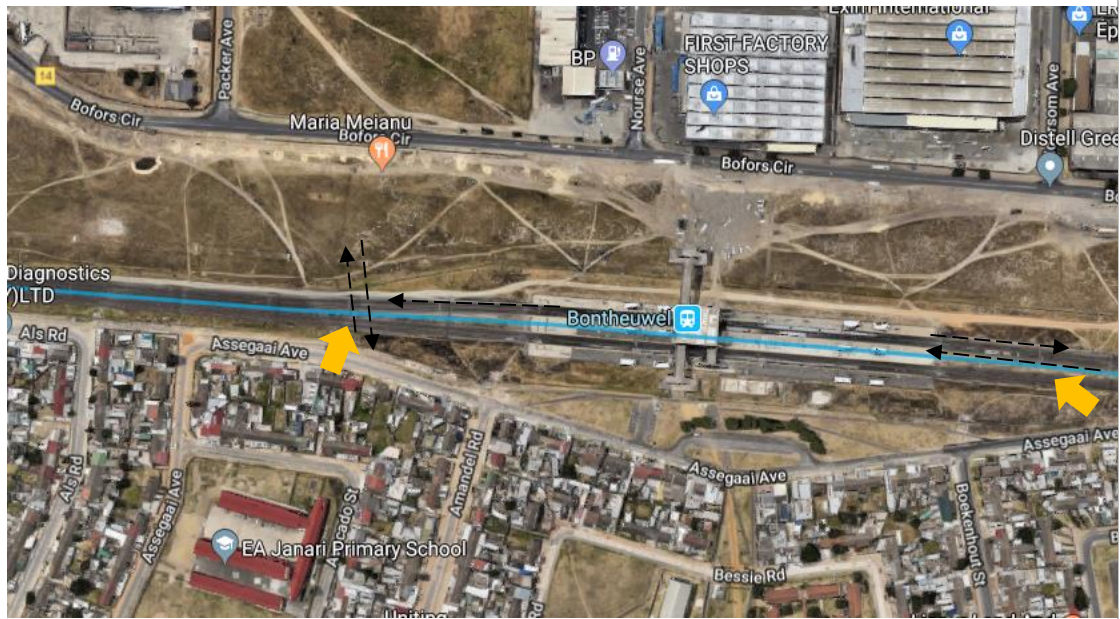


Fig.1 Fly-tipping inside the railway reserve



Fig.2 Fly-tipping and dense vegetation inside the railway reserve



Fig.3 Woman crossing with a toddler using a well-trodden footpath



Fig.4 Extended fencing from platform ends do little to deter trespassing from the platform-ends



Well-trodden pedestrian desire lines leading to the platform end ramps at Kraaifontein Station

<b>Date:</b> 01/08/2019	<b>Time:</b> 14h35	<b>Location:</b> Kraaifontein Station
<b>Weather:</b> Good	<b>SV14</b>	
<b>Describe nature of problem (trespass, suicide, vandalism, theft, leisure etc.)</b> Trespassing	<b>Describe surrounding area (schools, hospitals, residential, shopping etc.)</b> Residential Primary school, high school	
<b>Define area (station, platform, open line, level crossing, other.)</b> Station Area immediately adjacent to station	<b>Count frequency of trespassing / 15-minute interval</b> 21 – north end 33 – south end	
<b>Describe specific features of trespassers (gender, age, drunks, homeless etc.)</b> Adult male Adult female Children (south end – high school children, north side – primary and high school children)	<b>What is the nearest safe crossing place? (underpass, overpass, pedestrian crossing, where is it located)</b> Overbridge at station	
<b>What existing physical measures are in place? (walls, fencing, cameras, security signage, etc.)</b> Fencing		
<p><b>General notes on location:</b></p> <p>I was surprised at the amount of pedestrian traffic through this location at this time.</p> <p>The primary school and high school children right opposite the north end of the station accesses the station via a hole in the fence with a well-used pedestrian desire line.</p> <p>The paths cross the path diagonally to access the station platform ends. There is also a well-trodden foot path longitudinally along the tracks.</p> <p>The South side is equally busy. With a lot of school children accessing the railway reserve by holes in the fence.</p> <p>I suspect that I just missed the peak period for school finishing times. I waited for train but gave up after 20 minutes.</p> <p>There were several individuals loitering in some bushes inside the railway reserve. I couldn't see what they were doing.</p> <p>Very dense vegetation in areas so much so that you cannot see the tracks.</p>		

Google Earth Image



Fig.1 Vandalised fencing



Fig.2 Pedestrian desire lines leading to platform-ends



Fig.3 Pedestrians including school children walking longitudinally along the tracks



Fig.4 Well-trodden pedestrian pathways leading to the station platform-ends



Fig.5 The size of the pedestrian pathway provides an indication of its use

Google Earth Image

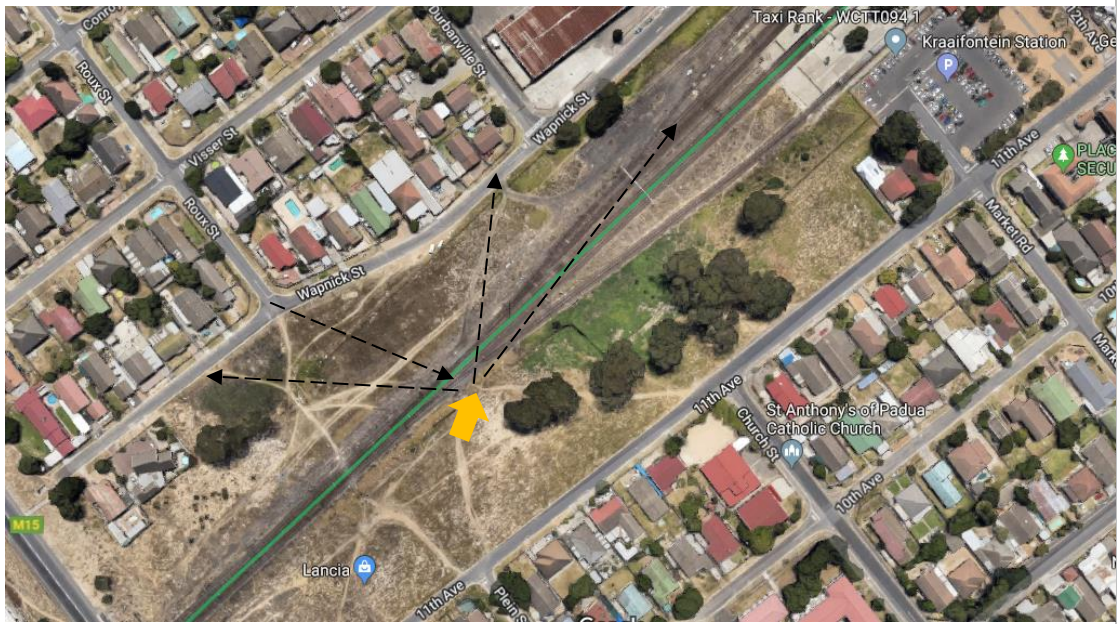


Fig.6 School children accessing the railway reserve through a section of removed fencing to access the station



Fig.7 Pedestrians accessing the station via the platform-ends

## Appendix G – Ethics Clearance

Application for Approval of Ethics in Research (EIR) Projects  
Faculty of Engineering and the Built Environment, University of Cape Town

### APPLICATION FORM

**Please Note:**

Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the EBE Ethics in Research Handbook (available from the UCT EBE, Research Ethics website) prior to completing this application form: <http://www.ebe.uct.ac.za/ebe/research/ethics1>

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant	Faizel Williams	
Department	Engineering and the Built Environment	
Preferred email address of applicant	Wilfa003@myuct.ac.za	
If Student	Your Degree: e.g., MSc, PhD, etc.	MSc
	Credit Value of Research: e.g., 60/120/180/360 etc.	120
	Name of Supervisor (if supervised):	Marianne Vanderschuren
If this is a research contract, indicate the source of funding/sponsorship	n/a	
Project Title	Understanding Railway Trespassing in Cape Town	

**I hereby undertake to carry out my research in such a way that:**

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available, and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

SIGNED BY	Full name	Signature	Date
Principal Researcher/ Student/External applicant	Faizel Williams	Signature Removed	20 Feb 2019

APPLICATION APPROVED BY	Full name	Signature	Date
Supervisor (where applicable)	Marianne Vanderschuren	Signature Removed	Click here to enter a date. 26/2/19
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section 1; and for all Undergraduate research (including Honours).	Click here to enter text.	Signature Removed	Click here to enter a date.
Chair : Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.	R Behrens	Signature Removed	07 March 2019



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