Assessing the constraints to recycling mill scale in a South African Iron and Steel Industry

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DEDICATION

This dissertation is dedicated to my Lord and Saviour Jesus Christ, who is first place in my life and who gives me the strength and wisdom to make all things possible.

I also dedicate this to my dear mother, Marlene Angeline Bezuidenhout who has always been my pillar of strength and provided me with endless support and unfailing love.

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ABSTRACT

The National Environmental Management: Waste Act (NEMWA) (Act No. 59 of 2008) of South Africa regulates waste management in the country. NEMWA (Act No. 59 of 2008) focuses on the goal of zero waste to landfill, however, only 10% of the total waste generated annually is recycled (DEA, 2011). South African industries contribute to a significant percentage of the total waste volume, yet recycles only 4% of its waste (GDACE, 2007). The South African Iron and Steel industry generates high volumes of unique wastes such as mill scale which, although hazardous in nature (Zhang *et al.,* 2016), has a high re-use potential. However, the Gauteng province alone has a backlog of 15000 tons of mill scale (GDACE, 2007). The aim of this study is to assess the constraints to recycling mill scale generated by the Iron and Steel industry in South Africa.

This research begins with a case study which investigates the generation of mill scale at ABC Metals, an Iron and Steel industry in Gauteng. The composition of mill scale, volumes generated and its potential use in an alternative process provide an understanding of its recycling value. Secondly, a review of global waste legislation demonstrates how different regions regulate waste and waste recycling; the effect that waste legislation has on waste recycling in an industry and specifically how legislation influences the recycling of mill scale in South Africa. Lastly, the extent to which industry needs and practicalities are incorporated into the drafting of waste management strategies and waste legislation by the Department of Environmental Affairs (DEA) (the South African custodian of the environment and legislating authority) is evaluated by reviewing the outcomes of the quarterly DEA-Industry Waste Management Forums (DEA-IWMF) which are documented in the minutes of the meetings.

While alternative uses exist for mill scale, South Africa's waste legislation has a strong focus on a controlling-type regulation which obstructs opportunities to recycle industrial waste streams, mainly due to the time and monetary constraints associated with obtaining a requisite recycling licence (Park, 2014). An industry seeking to use a waste stream in its process does not identify itself as a waste manager or waste service provider since its primary function is manufacturing. For this reason, the industry is reluctant to apply for a Waste Management Licence and may retreat to using raw materials in order to remain legally compliant.

Drafting and promulgation of waste legislation should thus take into account the experience and needs of industries. A regular forum between the legislator and industrial stakeholders is an important channel for ensuring that waste management in an industry is sustainable and practical. Such forums should provide a correlation between the operational environment of industries and the lawmakers (Levänen, 2014a). However, analysis of the DEA-IWMF minutes indicates that the legislator does not adequately consider industries' concerns on waste legal matters or provide sufficient feedback on waste management compliance issues.

In South Africa, legislation hinders the amount of recycling that takes place in industries. Instead, the DEA focuses on recycling programmes and providing funding and incentives, in attempt to improve recycling in the country. However, such initiatives are not effective in improving recycling in industries as these do not make provision for the legal constraints of NEMWA (Act No. 59 of 2008).

ACRONYMS

COE	City of Ekurhuleni
DEA	Department of Environmental Affairs
DEA-IWMF	Department of Environmental Affairs-Industrial Waste Management Forum
DEFRA	Department of Environmental, Food and Rural Affairs
DGEEC	Directorate General for Environment in the European Commission
DWAF	Department of Water Affairs and Forestry
EPA	Environmental Protection Agency
GDACE	Gauteng Department of Agriculture, Conservation and Environment
NEMWA	National Environmental Management: Waste Act No. 59 of 2008
NEMWAA	National Environmental Management: Waste Amendment Act No. 26 of 2014
RF	Republic of Finland
RSA	Republic of South Africa
RZ	Republic of Zambia
UK	United Kingdom
UN	United Nations
USA	United States of America
USA RCRA	United States Waste Resource Conservation and Recovery Act 42 USC 6901 of 1976

CONTENTS

Description	Page

LIST OF TABLES

LIST OF FIGURES

LIST OF BOXES

1 RESEARCH BACKGROUND

1.1 INTRODUCTION

The purpose of this Chapter is to provide a synopsis of the research problem which involves an assessment of the constraints to recycling mill scale in a South African Iron and Steel industry. The scope of the research is the case study which is twofold. The first part relates to the generation and management of mill scale at an Iron and Steel industry in the Gauteng province and secondly, the legal requirements for recycling mill scale. The problem statement and the aims and objectives of the research are presented in Section 1.2 and 1.3. Next, the structure and layout of the minor dissertation are outlined and this is followed by the research methodology. The research methodology describes the process for collecting data, including where the data was collected from and the timeframes within which the data was collected. The methodology correlates to the research objectives.

1.1.1 Waste Management in South Africa

Waste statistics report that South Africa only recycles 10% of the 98 million tons of waste it generates per annum (DEA, 2012). Furthermore, this percentage is mainly from recycling undertaken by the packaging industry, which includes the recycling of paper, plastic, glass and metal (Matete and Trois, 2007). The South African government promulgated the National Environmental Management: Waste Act (NEMWA) (Act No. 59 of 2008) in July 2009, to serve as the central piece of legislation to manage and regulate waste issues in the country. The purpose of NEMWA (Act No. 59 of 2008) is to provide laws for the sustainable management of waste as centred on the Waste Hierarchy. The Waste Hierarchy is not a unique concept to South Africa and is a globally used waste management strategy for achieving the goal of zero waste to landfill (Oelofse and Godfrey, 2008). While the central theme of NEMWA (Act No. 59 of 2008) is in line with sustainable waste management, South Africa does not seem to be noticeably increasing the volumes of waste recycled, recovered and reused (DEA, 2011).

The Department of Environmental Affairs (DEA) is the custodian of environmental (including waste) legislation in South Africa and is responsible for the management of the environment and the implementation, monitoring and enforcement of waste law. The onus is, therefore, on the DEA to improve waste management and increase recycling in the country (Taljaard, 2012). Two main approaches are used by the DEA to improve waste management. The first is through waste legislation, regulations and norms and standards. The second is through the development of programmes and the provision of incentives to encourage sustainable waste management (Taljaard, 2012).

1.1.2 Industrial Waste in South Africa

Industries consume copious amounts of raw materials and as a result generate high volumes of hazardous and non-hazardous waste (Zhang *et al.,* 2016). Industrial solid waste management has thus become crucial to the operation of South African industries as well as the sustainable management of waste in the country (Faber, 2000).

The Gauteng Department of Agriculture, Conservation and Environment (now renamed to the Gauteng Department of Agriculture and Rural Development) published a document called the First Generation Integrated Hazardous Waste Management Plan in 2007, which provides information on the types of waste generated by South African industries (GDACE, 2007). This document reported that South African industries recycle only 4% of the total waste generated and that this is mainly for oils, grease and solvents. Other recycled wastes include batteries, metal, plastic and more recently fluorescent tubes. These waste streams have a more prominent recycling structure in place due to the high volumes generated across industries and the homogeneity of the waste stream (GDACE, 2007). However, most industrial waste streams are unique to a specific industry and require research and development to find further uses (Zhang *et al.,* 2016).

Increasing the volumes of waste recycled from the industrial sector would not only help a country meet its projected recycling targets but would also contribute to the conservation of resources, through the substitution of raw materials (Grasso *et al.,* 2009).

1.2 PROBLEM STATEMENT

The harmful effect that waste can have on the natural, social and economic environment has created the need to strictly regulate waste in order to create a sustainable landscape. As such, many countries have robust waste legislation which concentrates on the goal of zero waste. In practice, however, waste generation remains unavoidable especially in less developed countries (Chinwe, 2010). It is, therefore, important to focus on finding alternative uses for waste. Waste streams like paper, glass and oil have become increasingly recycled, while lesser known waste streams such as those unique to an industry, are disposed of. Even in small quantities, the latter can have a significantly adverse effect on the environment (Chinwe, 2010).

Legislation governing recycling, particularly as it applies to industrial waste streams, has been an internationally challenging issue. While the intent of the regulation is to promote zero waste and encourage recycling, it can unintentionally create a barrier to recycling (Gibbs and Deutz, 2007). Countries with high rates of industrial waste recycling such as Finland have allowed for flexible waste legislation which promotes zero waste to landfill through waste recycling and exchange programmes. Legislation in these countries is largely based on negotiations with businesses and industries (Levänen, 2014b). The communication between legislators and industrial role-players are essential for shared learning and informed decision making in the drafting of waste legislation. Waste legislation should, therefore, integrate the experience and continual improvements of industries (Levänen, 2014a).

By contrast, South African waste legislation has a strong focus on a controlling-type regulation which can obstruct opportunities to recycle waste streams due to time and money costs associated with obtaining the requisite recycling permits (Park, 2014).

In South Africa, recycling industrial waste is subject to onerous applications for environmental authorisation and regulations that includes record keeping of waste from cradle to grave, ensuring the use of only permitted or licenced waste management facilities and ensuring that an organisation's on-site waste management operates within the ambit of a permit or prescribed regulation (RSA, 2008). Adherence to the requirements of NEMWA (Act No. 59 of 2008) is mandatory even though waste recycling is not a core function of the industry (Taljaard, 2012). For many industries, waste holds a high reuse value since it can be sold or exchanged with other industries and is thus considered a raw material or by-product. Although alternative uses for industrial waste exists, the legal requirements attached to recycling a waste can be undesirable to both the generator as well as to the entity wanting to utilise it (Park, 2014). Neither party identifies itself as a "waste manager" or to be undertaking a "waste management activity" and, therefore, neither are willing to undergo the rigorous applications or commit to compliance to regulations since recycling does not form part of the organisation's primary functions or operations.

While this study is applicable to various types of industries and associated wastes, a case study has been undertaken on mill scale, which is a hazardous waste generated by ABC Metals in the Gauteng Province. In order to remain compliant, larger industries such as ABC Metals, elect to dispose the waste at a licenced landfill or continue using raw materials in their process (Park, 2014). In this way, legislation creates a barrier to the recycling of industrial wastes (Gibbs and Deutz, 2007).

1.3 AIMS AND OBJECTIVES OF THE STUDY

Industries generate a significant portion of a country's waste, especially hazardous and "unknown" waste (unclassified waste). Unknown wastes result from the various types of raw materials used, production processes and the resultant waste outputs which are unique to a specific industry. These wastes must be analysed before they can be classified as either hazardous or non-hazardous (Zhang *et al.,* 2016). These waste streams can also be highly hazardous to the natural environment and disposal can be deterred by capitalising on their re-use potential. However, industries face challenges when investigating opportunities to recycle industrial waste (Zhang *et al.,* 2016). The aim of this study is to assess the constraints to recycling mill scale generated by the Iron and Steel industry in South Africa by means of a case study. To address the main goal of the case study, the following research objectives have been formulated.

Objective I:
Assess the trends in mill scale waste management in South Africa.

Objective II:
Review international and South African legislation governing the recycling of mill scale.

Objective III:

Assess the problems, challenges, and barriers to effective solid waste management and recycling based on the minutes from public participation forums between regulating authorities and relevant industries, specifically the discussions relating to recycling at an industrial scale.

1.4 RESEARCH SCOPE: CASE STUDY ABC METALS

The Iron and Steel industry is part of South Africa's metallurgic industry and is a major contributor to South Africa's economic development. The Iron and Steel industry employs a significant labour force, while international exports generate foreign exchange and investment for the country (Faber, 2000). The Iron and Steel industry generates high volumes of unique wastes such as slag, foundry sand, furnace dust and mill scale which are mainly hazardous in nature (Zhang *et al.,* 2016). The First Generation Integrated Hazardous Waste Management Plan reported a backlog of potentially reusable waste from the Iron and Steel industry, including filter cake, hexavalent chrome and magnetite (GDACE, 2007).

While various waste streams are generated during the manufacturing process in the Iron and Steel industry, only mill scale, a hazardous waste generated during production, was included in the scope of this research. Mill scale was selected for the case study due to the high volumes that are generated on a monthly basis as well as its high iron content which renders it a useful by-product (Eissa *et al.,* 2015). The case study includes an Iron and Steel manufacturing plant in Johannesburg, which generates mill scale during steel production. Mill scale is generated during the heat treatment, casting and rolling of steel. When solid metal is heated, the surface layer of the metal begins to flake and loosen. These metal flakes are then washed off the steel surface in a cascade of water during a cooling and cleaning process. Similar to metal, the mill scale consists of about 50-75% iron and is thus a very valuable raw material with a number of uses (please refer to Section 2.5) (Wang *et al.,* 2016). For purposes of anonymity, the Iron and Steel manufacturing plant is referred to as ABC Metals.

Globally, around 13.5 million tons of mill scale is generated per annum (Gaballa *et al.,* 2013). Although alternative uses for mill scale do exist in South Africa, none of these have been found to be legally compliant with the requirements of NEMWA (Act No. 59 of 2008). As a result, larger industries such as ABC Metals are forced to dispose (as opposed to recycling) the mill scale in order to remain legally compliant (Park, 2014).

1.5 STRUCTURE OF THE STUDY

Table 1-1 provides an outline of the Chapters of this minor dissertation. Chapter 1 provides the background, relevance and context of the study. The literature review in Chapter 2 contains an overview of waste management in South Africa, the Gauteng province and South African industries. The case study is also introduced in Chapter 2 in order to describe the potential re-use value of mill scale and the current constraints posed by the legal requirements attached to recycling mill scale in South Africa.

The results of this minor dissertation are contained in Chapter 3 and Chapter 4. The case study is presented in Chapter 3, which provides the *status quo* of mill scale generated at ABC Metals and the legal requirements for recycling the mill scale.

The data for the case study was collected from ABC Metals (mill scale generator), as well as a battery manufacturing industry which is a proposed mill scale recycler. Data was collected through on-site observations, discussions with managers and employees. The purpose of the data is to provide information on the nature and characteristics of the mill scale, the volumes generated and the existing waste management practices at ABC Metals. An environmental impact analysis was also undertaken to compare the impacts of disposing of versus recycling the mill scale. International and local legal requirements for the recycling of mill scale were then reviewed. The purpose of the legal framework was to review international legislation to understand how different regions and countries have regulated waste and the requirements for recycling. One region and four countries were selected based on their progress in regulating waste, namely the European Union, Finland, the United States of America, Zambia and South Africa.

Analysis of the minutes from the quarterly Department of Environmental Affairs-Industrial Waste Management Forum (DEA-IWMF) is reviewed in Chapter 4 to understand the relationship between industry and government and how the needs of industry are factored into waste management planning and drafting of waste legislation. Lastly, the results of the study are discussed in Chapter 5, where the key findings are discussed in relation to the objectives of the study.

Table 1-1. Outline of the minor dissertation

Chapter	Title	Description
Chapter 1	Introduction	The Research Background provides the context and relevance of the study, as well as the problem statement and aims and objectives of the study. The research methodology is also outlined in this Chapter and provides a description of the methods that were used to collect, capture and analyse data.
Chapter 2	Literature Review	The literature review includes the review of existing research in support of the objectives of the minor dissertation.
Chapter 3	Case Study: Mill scale waste management and legal requirements	The case study collates and presents the data collected at ABC Metals on the generation, characteristics and management of mill scale. A review of waste legal requirements from five different countries is was undertaken to compare how countries regulate recycling and the effect of waste legislation on recycling mill scale in South Africa.

Chapter	Title	Description
Chapter 4	Analysis of minutes from quarterly forums held between industry and government	Analysis of minutes from a South African government-industry waste management forum was reviewed to understand the relationship between industry and government on waste management issues and drafting waste legislation.
Chapter 5	Discussion and conclusion	Analysis of the results was undertaken in support of the research objectives. A summary of the findings of the research in relation to the objectives is provided as well recommendations for further research.

1.6 RESEARCH METHODOLOGY

The study follows a qualitative research design which focussed on the aims and objectives of the study. This approach provides an in-depth understanding of the subject of enquiry and how this subject has arrived at its *status quo* by using words instead of numbers as a source of data analysis (Hancock *et al.,* 2007). Furthermore, a qualitative design does not necessarily require input or interaction with people, however, it is limited in that the information obtained is not always verifiable (Hancock *et al.,* 2007).

The research methodology was focussed on the collection of data as directly related to meeting the three objectives in Section 1.3. As such, the results from the data collection are presented in Chapter 3 (Objective 1 and Objective 2) and Chapter 4 (Objective 3). The research methodology for collecting this data is outlined below.

1.6.1 Case Study: Mill Scale Generated at ABC Metals (Objective 1)

The first objective of the research relates to the case study which involves the generation and management of mill scale waste at ABC Metals. Table 1-2 provides the list of data that was required for the case study. Research data from three production plants (the Melting Plant; a Rod, Bar and Section Mill and the Forge Plant) within ABC Metals as well as from a battery manufacturing industry (proposed mill scale recycler) was collected during an annual period between June 2015 and May 2016. Both industries fall within the industrially zoned portion of Germiston, Gauteng.

The chemical composition of mill scale was analysed from a 1 kg composite sample from the three production plants at ABC Metals. An accredited laboratory undertook the analysis of the composite mill scale sample in February 2016. The weighbridge data provided in the waste manifest from the waste service provider was used to calculate the tonnages of mill scale removed from the three production plants. The cost to dispose of this mill scale was calculated using the invoices from the waste service providers which were attached to the waste manifest.

Discussions with the plant manager from the battery manufacturing industry, as well as the sites operational procedures and the Air Emission Licence (AEL) issued in terms of the National Environmental Management: Air Quality Act (Act 39 of 2004) was used to derive the data for the potential use of mill scale in battery manufacturing.

Lastly, the environmental impacts associated with the disposal (current practice at ABC Metals) versus recycling (at the battery manufacturing industry) of mill scale were compared using an environmental impact analysis by means of a Leopold matrix and a rating system.

Table 1-2. Research methodology for the collection of data from ABC Metals

Required data	Methodology	Presentation of Data
Identify the generation processes of mill scale	• Observation of onsite process at ABC Metals. • Discussion with plant managers and confirmation of the raw materials, process description and product and waste material generated.	• Process flows by means of an input-output diagram to depict the generation of mill scale.
Identify the composition of mill scale	• Review of laboratory analytical data for mill scale generated at ABC Metals. • Review of mill scale waste classification (SANS 10234) Report.	• Summary of major constituents of mill scale.
Identify the alternative uses of mill scale	• Review of the literature on the global uses of mill scale. • Review of intended use of mill scale by ABC Metals: – Discussion with a battery manufacturer on the process to re-use mill scale in battery manufacturing.	• Overview of uses of mill scale. • Description of intended use of mill scale from ABC Metals.
Verify current waste management practices.	• Observation of onsite storage, handling and transport of mill scale at ABC Metals. • Discussion with foremen responsible for handling mill scale to confirm how it is managed. • Review of existing operational procedures for waste management.	• Overview of existing waste management practices at ABC Metals from generation to disposal.
Identify the tons of mill scale disposed of monthly and annually.	• Safe disposal certificates. • Collection/ Delivery notes. • Weigh Bridge Data.	• Summary of monthly volumes of mill scale generated over an annual period.
• Identify impacts associate with disposal of mill scale.	• Impact analysis for disposal and recycling using a Leopold matrix.	• Summary of main impacts associated with disposal and recycling of mill scale.

Required data	Methodology	Presentation of Data
• Identify impacts associated with recycling of mill scale.		

1.6.1.1 Limitations

Very little literature exists on the generation of mill scale in the specific processes at ABC Metals. Only research from 5 authors (Eissa *et al*., 2015; El-Hussiny *et al*., 2011; Gaballah *et al*., 2013; Sarna, 2014; Wang *et al*., 2016) provided comparable research on the generation of mill scale at ABC Metals. For this reason, the verification of the on-site processes for mill scale generation was highly reliant on discussions with plant personnel and observation of the process.

1.6.2 Legal Framework (Objective 2)

A review of the legal requirements for recycling industrial waste in South Africa is a significant component of the current research. It was therefore important to understand the rationale, intent and effect of South African waste legislation on recycling of mill scale. The second objective relates to the effect of legislation on industrial recycling and more specifically mill scale. The legal framework was presented as part of the case study in Chapter 3. The purpose of the legal framework is to review global legislation to understand how different regions regulate waste and the requirements for recycling. One Region and four countries were selected based on their progress in regulating waste and increasing recycling:

- The European Union;
- Finland;
- The United States of America;
- Zambia; and
- South Africa.

The legal framework outlines important definitions and sections from the respective legislation relating to the recycling of industrial waste. The relevant sections of the legislation were extracted, followed by an explanation of the intent and implication of its meaning (Nahman and Godfrey, 2010). The legal review concluded by summarising the legal requirements attached to the recycling of mill scale.

1.6.3 Analysis of Minutes from Government – Industry Forums (Objective 3)

The Department of Environmental Affairs (DEA) routinely hosts a quarterly forum which serves as a public participation platform for South African industries to provide input and comment into industrial waste management and legislation through discussions with the governing authorities.

The Department of Environmental Affairs-Industry Waste Management Forums (DEA-IWMF) are held at DEA's Head Office (Environment House) in Pretoria and are attended by representatives from DEA, the Gauteng Department of Agriculture and Rural Development, local and district municipalities and various industries throughout South Africa.

These forums serve as an interface between industry and government and were included in this study to determine if DEA considers the commendations, concerns and recommendations from industry. The purpose of reviewing these minutes was to establish whether this input from industry is translated into improving waste management planning in industries and the drafting of waste legislation. The minutes of the forums were used as the main source of information to summarise the concerns and suggestions raised by industries and to track whether this was duly considered by DEA.

Table 1-3 provides the list of minutes and official reference numbers that were reviewed as part of the research. The forum minutes were reviewed over a 2 year period, from February 2015 to October 2016. Although the DEA-IWMF meetings were proposed to be held four times a year (quarterly), only two or three meetings were hosted per annum over the past three years. For the 2015 and 2016 annual periods, a total of five meetings were held.

Table 1-3. List of DEA-IWMF meetings reviewed as part of the study

Date of IWMF Meeting	DEA Reference:
13 February 2015	DEA-IWMF/004/2014/15
9 July 2015	DEA-IWMF/002/2015/16
21 October 2015	DEA-IWMF/003/2015/16
16 February 2016	DEA-IWMF/004/2015/16
11 August 2016	DEA-IWMF/002/2015/16

Only the relevant sections of the minutes which specifically relate to recycling issues or concerns were extracted and are discussed in Chapter 4.

1.6.4 Discussion

The research findings obtained from the case study, legal review and minutes of the forum meetings are discussed and summarised in Chapter 5. A summary of the research results is discussed in relation to the objectives:

- An assessment of the *status quo* of mill scale management in South Africa.
- The effect of legislation on recycling globally and in South Africa.
- An indication of whether or not input received from industries during public participation forums are taken into consideration during in waste management planning and drafting of and promulgation of South African waste legislation.

1.7 CONCLUSION

The bulk of industrial waste generated in South Africa is disposed of at landfills (GDACE, 2007). In order to pave the way for increased recycling in industries, the *status quo* of industrial waste management, specifically for the case study must be understood. This allows for the identification of opportunities to increase recycling of industrial waste such as mill scale.

Furthermore, the effect of South African waste legislation on waste management in industries must be understood to determine how this affects decision making within an industry to dispose or recycle waste (Taljaard, 2012). The following Chapter is comprised of a literature review.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this Chapter is to provide the literature background. The literature review begins with an overview of waste management in South Africa, by firstly ascertaining the vision of the Department of Environmental Affairs for managing the country's waste and then secondly, identifying the *status quo* of waste management in South Africa in terms of the volumes and types of waste generated and the prevailing waste management practices.

Waste management in the Gauteng province is subsequently discussed. The reason for selecting this province for review is because it is the most densely populated South African province, generating the highest volume of waste (DEA, 2012) and also since the case study is located within Gauteng. Industrial waste generation and management in South Africa are reviewed next, with a focus on the Metallurgic sector and more specifically the Iron and Steel industry. This provides the background to the case study, which is the generation and management of mill scale, a typical process waste stream generated by the Iron and Steel industry.

Finally, South African waste legislation is evaluated in terms of its influence on waste management in South Africa as well as its implication on recycling waste generated in an industry.

2.2 WASTE MANAGEMENT IN SOUTH AFRICA

2.2.1 The Goal of Waste Management

Waste Management has been a challenging issue in South Africa, with problems arising in the provision of basic waste management services to the general public, illegal dumping, unsuitably designed landfills, depletion of landfill airspace and a lack of waste reduction and recycling (Muzenda, 2013). In order to regulate and control waste management, the DEA promulgated NEMWA (Act No. 59 of 2008) on 1 July 2009. The overarching goal of NEMWA (Act No. 59 of 2008) is to manage waste in a sustainable manner through the implementation of the Waste Hierarchy, which promotes the notion of zero waste disposal (Oelofse and Godfrey, 2008).

NEMWA (Act No. 59 of 2008) makes provision, amongst others, for:

- The development of Strategies, Norms and Standards for waste management;
- Institutional and planning matters;
- Waste management activities requiring licencing or registration;
- Storage and transport requirements;
- Waste Management Plans;
- Contaminated land; and
- Compliance and enforcement (NEMWA, 2008).

Figure 2-1 depicts the Waste Hierarchy as a strategy to decrease landfilling. The Waste Hierarchy provides an illustrative representation of the ranks of waste management from the most to least desirable option. The inverted pyramid depicts the most favourable option at the top and the least favourable at the bottom. Priority is, therefore, to prevent or avoid the generation of waste. Where this cannot be avoided, waste should then be re-used, followed by recycling, recovery and as the very last resort, disposed of at a landfill site (DEFRA, 2011). It is thus clear that the basic intent of NEMWA (Act No. 59 of 2008) is to reduce waste generation and disposal (NEMWA, 2008). However, waste statistics in South Africa report that over 90% of the total waste generated in South Africa is being landfilled (DEA, 2011).

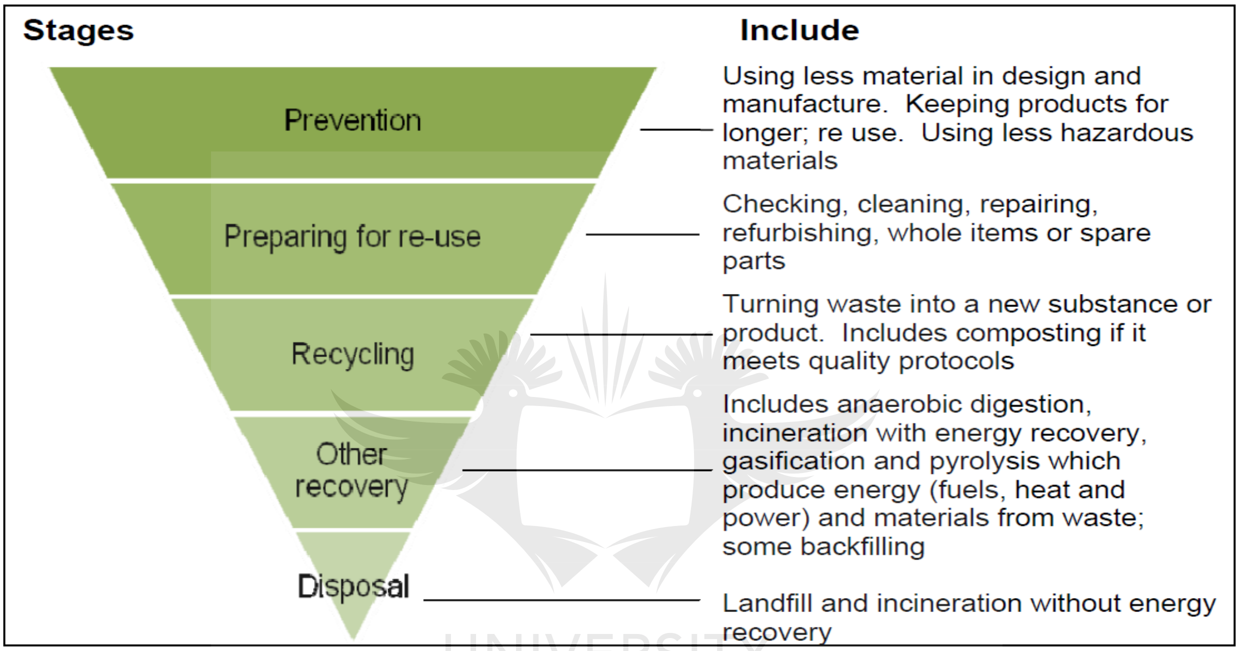

Figure 2-1. Waste Hierarchy representing the tiers of waste management (DEFRA, 2011)

Section 2 of NEMWA (Act No. 59 of 2008) sets out the objectives of the Act, which include (amongst others), is minimising the consumption of raw materials, avoiding waste generation, "reduce, reuse and recycling" of waste and securing sustainable development (RSA, 2008). In order to achieve the objects of NEMWA (Act No. 59 of 2008) and the goal of zero waste to landfill, the South African presidential cabinet approved a National Waste Management Strategy in 2011 as a supporting document which served to drive the implementation of NEMWA (Act No. 59 of 2008). As such, the National Waste Management Strategy included targets for waste avoidance, re-use and recycling of waste in order to measure the success of meeting the goals of NEMWA (Act No. 59 of 2008) (DEA, 2011).

As a starting point, a baseline report was required to determine the *status quo* of waste management in South Africa, against which future data could be monitored and compared (DEA, 2011). The baseline report was initiated in 2011 through the development of the third National Waste Information Baseline study, which built on from waste data collected in previous studies and categorised this under the new classes and definitions contained in NEMWA (Act No. 59 of 2008).

The draft National Waste Information Baseline Report published in 2012 remains the latest available report on waste statistics in South Africa. For purposes of this minor dissertation, the National Waste Information Baseline Report was the main source of information relating to waste statistics (DEA, 2012).

2.2.2 Status Quo of Waste Management in South Africa

2.2.2.1 Generation of waste in South Africa

Although still in draft, the National Waste Information Baseline Report remains the current version of available waste statistics for South Africa. For the 2011 annual period, the National Waste Information Baseline Report stated that a total of 108 million tons of waste was generated in South Africa. Figure 2-2 provides a breakdown of this waste into 3 categories, consisting of 55% general waste, 1% hazardous waste and 44% “unknown” waste. Furthermore, of the total waste generated, only 10% was recycled (DEA, 2012).

The breakdown into 3 waste types in Figure 2-2 reveals that the bulk of waste generated is classified as general waste which consists of organic waste, paper, plastic, metal, glass and rubble (DEA, 2012). The second highest generated waste is referred to as “unknown waste”, is mainly generated by industries as a result of the diverse input raw materials, including chemicals and natural resources and the different processes that these materials are subjected to. Unknown waste must undergo an analysis and waste classification process to determine whether the waste is hazardous or non-hazardous (DWAF, 1998). Hazardous waste makes up only 1% of the total waste generated and is defined as “*any waste that contains organic or inorganic compounds that may, owing to the inherent physical, chemical or toxicological characteristic of the waste, have a detrimental impact on health and the environment*” (DEA, 2012, p 3). According to the National Waste Information Baseline Report, the known portion of hazardous waste is comprised mainly of inorganic waste, tarry and bituminous waste (DEA, 2012).

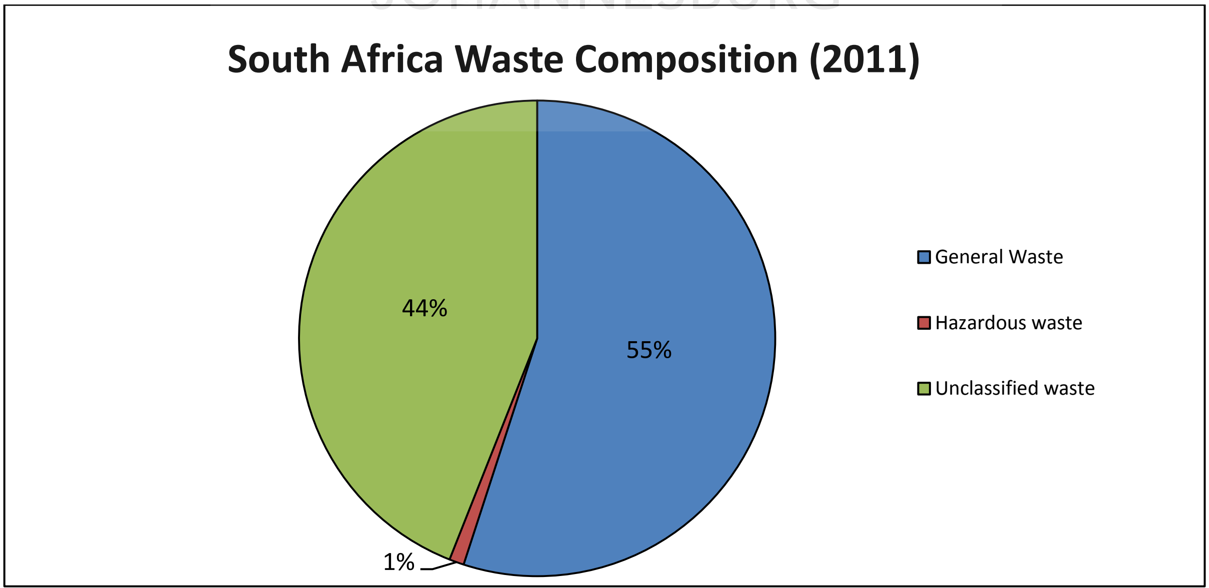

Figure 2-2. Waste composition as percentage of total waste generated in South Africa (DEA, 2012)

2.2.2.2 Management of waste in South Africa

According to the National Waste Information Baseline Report, the bulk of waste generated in South Africa is landfilled. The available statistics indicate that 90.1% of the total generated waste was landfilled, while only 9.9% was recycled (DEA, 2012).

Most of South Africa's recycling is undertaken by the packaging industry which includes paper and cardboard, plastics, glass and metals. These waste streams fall within the general waste category. Figure 2-3 illustrates the percentage of the total waste generated that was recycled for each respective waste streams from 1991 to 2000. An increase in recycling is noted between 1991 and 2000 (Matete and Trois, 2007). The percentage of paper and board recycled tripled from 1991 (28.4%) to 2000 (89%) and remains the most recycled waste stream in South Africa, followed by tins (mainly cold drink cans), plastic and glass. These initiatives are mainly undertaken by private industries such as Mondi (paper), Consol and Nampak (glass) and Reclam (tin). The statistics presented in Figure 2-3 are expected to continue to slowly increase over time on account of an increasing market for these recyclables (Matete and Trois, 2007).

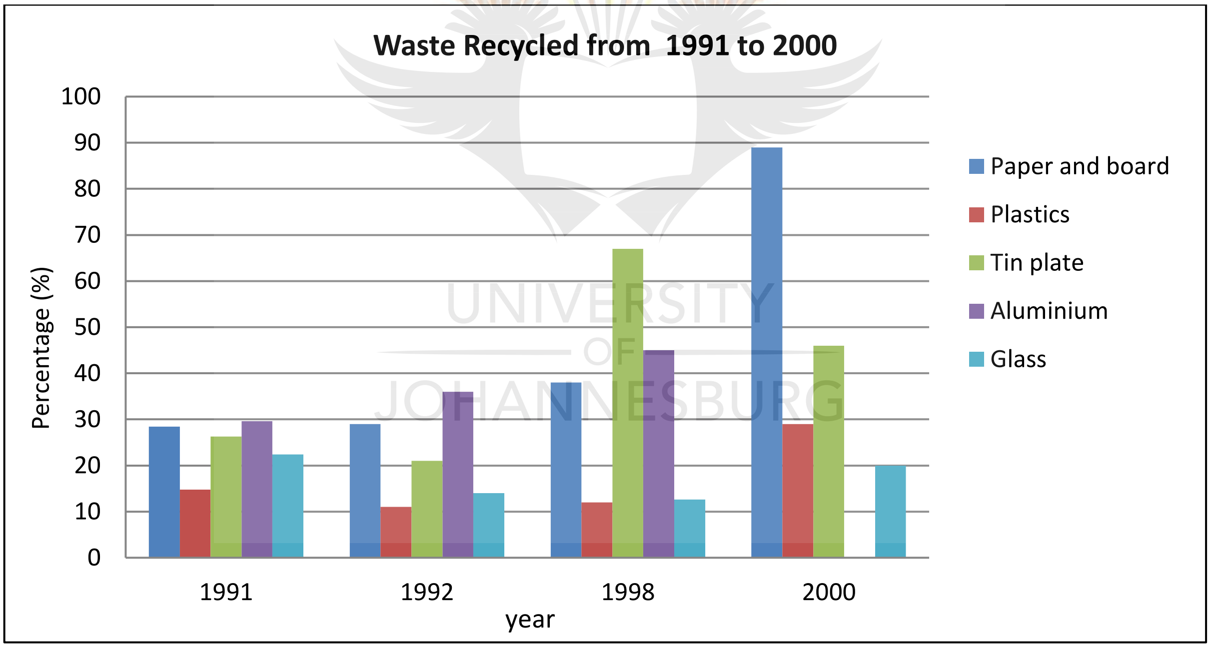

Figure 2-3. Recycling in South Africa from 1991 to 2000 (Matete and Trois, 2007)

Hazardous waste streams like oil, batteries, e-waste and fluorescent tubes have also become increasingly recycled. However, the "unknown" waste streams, particularly those generated by industry are predominantly disposed of (Chinwe, 2010).

2.3 WASTE MANAGEMENT IN GAUTENG

2.3.1 Generation of Waste in Gauteng

According to the National Waste Information Baseline Report, the Gauteng province generated the highest volume of waste in South Africa for the reporting period. Gauteng accounted for 45% of the total generated waste, with 761 kg generated per capita (DEA, 2012).

The composition of the waste generated in Gauteng is represented in Figure 2-4. The provincial statistics provided in the National Waste Information Baseline Report is based on information supplied by municipalities and industry. Since very limited waste analysis is available in South African municipalities, the provincial waste was categorised into four broad waste types. The bulk of the waste generated in Gauteng is classified as non-recyclable waste and accounts for 40% of the total waste generated; this is followed by mainline recyclable waste (paper, plastic, glass, tins and tyres) which comprises 25% of the waste reported; rubble comprised 20% of the total; and organics which include food and garden waste accounts for 15% (DEA, 2012).

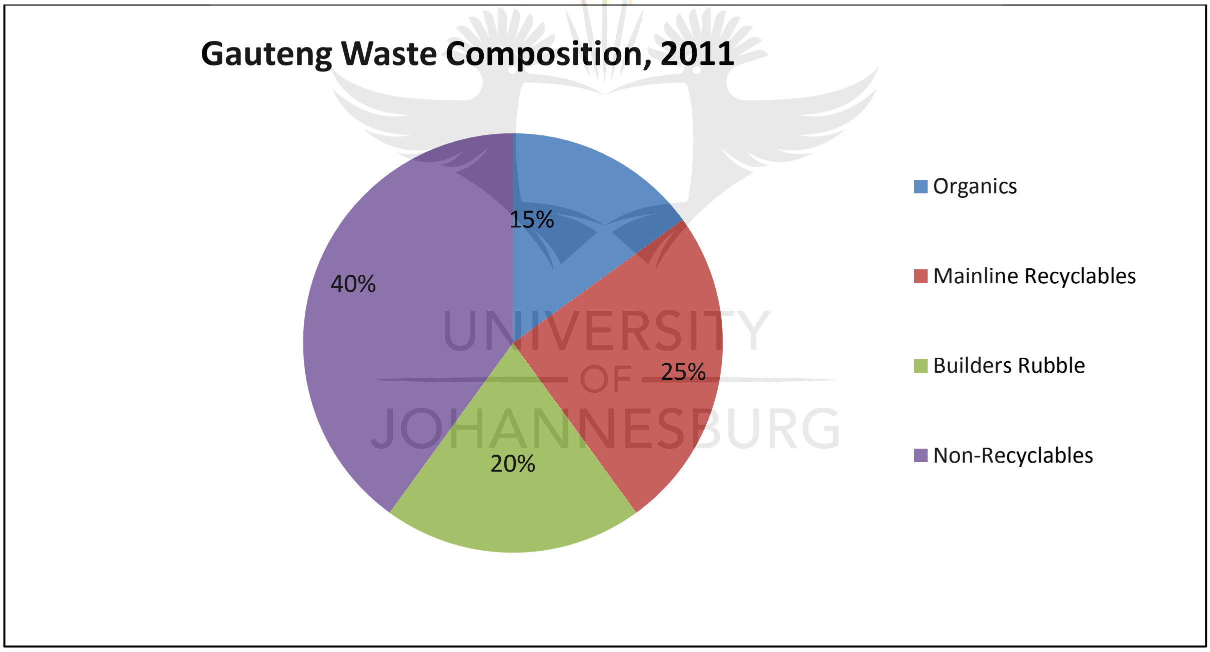

Figure 2-4. Gauteng waste composition (DEA, 2012)

The National Waste Information Baseline Report does not provide specific information on the hazardous portion of waste that is generated in Gauteng (DEA, 2012). However, hazardous waste data is available in the First Generation Integrated Hazardous Waste Management Plan which was developed in 2007 by the Gauteng Department of Agriculture, Conservation and Environment. The purpose of the First Generation Integrated Hazardous Waste Management Plan was to provide a hazardous waste management plan for Gauteng and to include a strategy for implementing the Waste Hierarchy (GDACE, 2007).

According to the First Generation Integrated Hazardous Waste Management Plan a total of 446 200 tons of hazardous waste was generated in the Gauteng Province for the annual reporting period. Five sectors were identified to account for 95% of the hazardous waste generated namely the metallurgy, chemicals, pulp and paper, mining and manufacturing industries. The report further stated that most of the waste generated was disposed of at landfills and recommended that government should provide assistance in the promotion and coordination of a waste exchange programme between industries (GDACE, 2007).

2.3.2 Management of Waste in Gauteng

Figure 2-5 provides the tonnages of waste disposed of and recycled in Gauteng from 2009 to 2011. An increase in waste generation of 2.5% is noted from 2009 to 2010 while waste generation remains almost constant from 2010 to 2011 (at a variation of -0.1%) (Muzenda, 2012). Disposal remained the predominant waste management practice in Gauteng, with over 80% of the generated waste disposed of at landfills from 2009 to 2011 (Muzenda, 2012).

Although recycling of waste for the 2 year period was less than 20% of the total waste generated, recycling gradually increased from year to year. Recycling increased by 5.7% from 2009 to 2010 and by 1.2% from 2010 to 2011. The recycled wastes shown in Figure 2-5 are limited to the "Mainline Recyclables" which include paper, plastic, glass and metal (Muzenda, 2012).

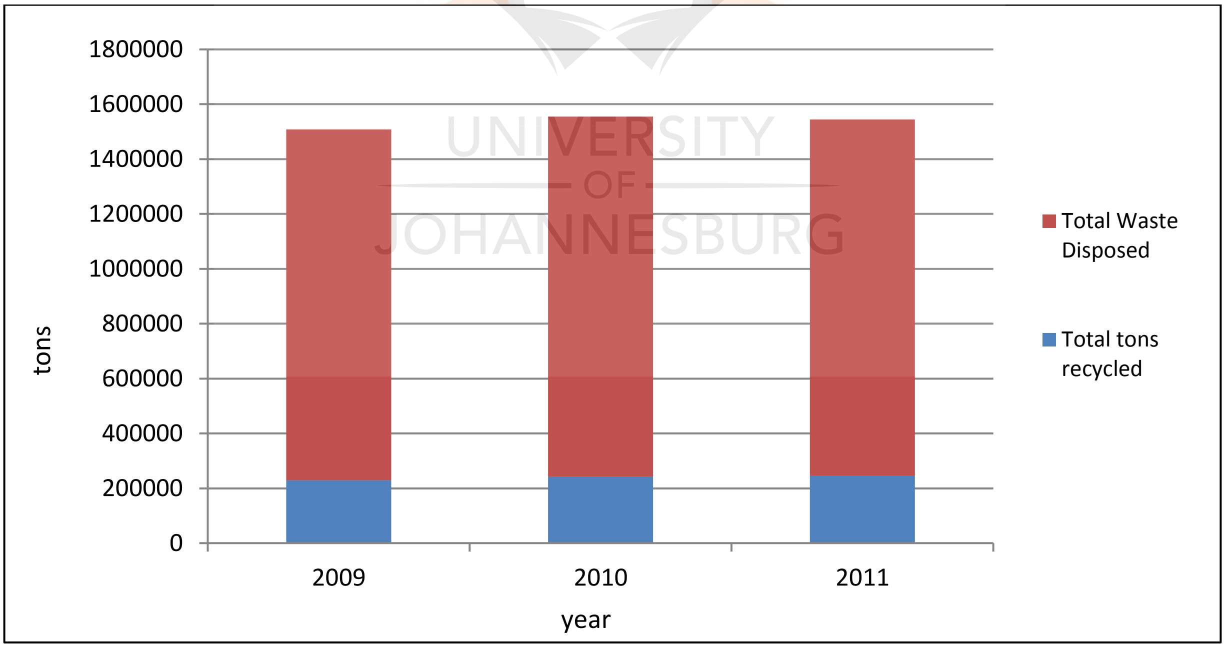

Figure 2-5. Recycling survey for Gauteng from 2009 to 2011 (Muzenda, 2012)

In Gauteng, recycling initiatives are coordinated by local government and industries. Local government has provided drop off centres where workers undertake waste separation of household waste received. These centres separate paper, glass, tins and other waste and direct the waste streams to private recyclers (Muzenda, 2012).

The City of Tshwane also provided training and support to informal waste recyclers, enabling them to form waste cooperatives which undertake formal an informal recycling. In the City of Johannesburg, the municipalities appointed waste service provider PIKITUP, also initiated e-waste drop off centres and buy back centres in Johannesburg where the public can drop off electronic waste such as old phones, computers and batteries in exchange for monetary or other incentives. The collected e-waste is sorted into its various components (separating plastic) and sent to private recyclers (Muzenda, 2012).

2.4 INDUSTRIAL WASTE

Industries, in general, consume high amounts of raw materials and as a result generate high volumes of waste, including hazardous and non-hazardous waste (Zhang *et al.,* 2016). Unlike general waste, hazardous waste is not readily degradable and persists in the environment. Hazardous waste poses a serious negative threat to the environment and natural resources, especially when not disposed of at an appropriately designed landfill (Grasso *et al.,* 2009).

A volume of 9.2 billion tons of waste was generated at a global scale in 2011, of which 1.74 was from industry. Industrial waste evidently constitutes a significant portion of global waste output at a reported 20% of the global waste output in 2011 (Song and Zeng, 2015). Industrial solid waste management is crucial to the sustainable operation of South African Industries. Sustainable waste management in industries provides financial benefits while promoting environmental conservation and social advantages (Faber, 2000). The Brundtland Report describes the most widely accepted definition of sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987, p 37). The pillars of sustainable development are the balance between environmental, economic and social needs or a "triple bottom line" (Xu *et al.,* 2014). With a growing global emphasis on sustainable development especially with regard to industrial waste management, governing authorities have introduced and are advancing environmental waste legislation to regulate and manage waste (Faber, 2000).

The most sustainable waste management practice in an industry is to ultimately avoid or reduce waste generation by modification of the process design, technologies and/ or input raw materials. However, due to the high costs involved with introducing such technologies, many South African industries seek opportunities to reuse or recycle waste streams by using this as a raw material in alternative processes. This not only decreases the amount of waste disposed of but also saves costs for an industry in terms of eliminating the disposal fee at a landfill, as well as the remuneration from the sale of the waste stream (Grasso *et al.*, 2009).

Recycling or re-use of waste material is essential to waste management, notably, after waste avoidance is unachievable. Recycling contributes to a decrease in raw material usage by substituting mineral ores or natural resources.

Furthermore, using material which has already been processed to some degree requires less energy usage to achieve the end product (Chingono and Mbohwa, 2016).

It is also important to take cognisance of the depletion of natural resources. Globally the use of natural resources is estimated to be 120-130 billion tons per year from which approximately 3.4 to 4 billion tons of waste is generated (Song and Zeng, 2015).

2.4.1 Benefits of Recycling Industrial Waste

Recycling has been promoted internationally in industries on account of the associated benefits, including:

- Reducing the amount of waste to landfill;
- Reducing the depletion of natural resources (iron ore), through substitution;
- Reducing costs associated with purchasing iron ore;
- Reducing costs associated with disposal; and
- Providing remuneration through sale of waste streams (El-Hussiny *et al.*, 2011).

2.4.1.1 Environmental benefits

The Waste Hierarchy is implemented by identifying ways to reduce waste generation and where this is not possible, to prevent the amount of waste being landfilled. Recycling of industrial waste supports the Waste Hierarchy by reducing the amount of waste to landfill and in doing so, prevent potential impact on soil and groundwater as well as increase the life of the landfill. Additionally, the re-use of industrial waste streams can reduce the consumption of raw materials (Eissa *et al.,* 2015).

2.4.1.2 Economic benefits

Recovery of industrial waste results in higher financial rewards. For the generator, cost savings occur from the sale of this waste stream which generates an additional source of revenue as opposed to the waste disposal costs for sending this waste stream to landfill. The generator would benefit from a reduced annual expenditure on waste disposal, which by contrast, can become a source of income (Rostik, 1996).

The entity purchasing the waste stream, for use as a raw material also benefits from this interaction since the waste stream is usually sold at a substantially lower cost than the purchasing of a raw material (El-Hussiny *et al.*, 2011).

2.4.1.3 Social benefits

Benefits to the social environment include minimising hazardous or nuisances to the surrounding community as a result of landfilling (Giannakopoulos, 2013).The image of both the generator and purchaser would benefit from the introduction of "green projects". Such projects are attractive to international investors and provide improved client satisfaction for both organisations through the introduction of environmentally friendly and efficient ways of reducing waste (Rostik, 1996).

2.4.2 Waste from the Iron and Steel Industry

The Iron and Steel industry falls within the Metallurgic Sector and is a secondary industry, which produces a variety of steel products (Chand *et al.,* 2016). Steel is an iron alloy produced from raw materials that mainly include iron ore (reduced), scrap and fluxing agents (purifying) as well as energy and intensive labour. The outputs of the steel making process are sellable steel products and wastes in gaseous, liquid and solid form (Chand *et al.,* 2016). The Iron and Steel industry is a major contributor to the infrastructural and overall economic development of a country. Steel is an important global commodity and has extensive applications in the mining, construction and transport sector, as well as for downstream industries (Wang *et al.,* 2009). The production of steel has substantially increased since the 1950's, from a global output of 189 million tons to 1244 million tons in 2006 (Wang *et al.,* 2009). In South Africa, the Iron and Steel industry is an important economic contributor and employs a significant labour force. The international exports further generate foreign exchange and investment for the country (Faber, 2000).

The First Generation Integrated Hazardous Waste Management Plan provides information on the waste from the metallurgical industry, which includes the Iron and Steel industry. Figure 2-6 provides a breakdown of the types of waste generated in the metallurgic industry (GDACE, 2007). A significant portion of the hazardous waste generated by the metallurgic industry is classified as poisonous, toxic and infectious substances. A hazard rating undertaken on the waste streams indicates that they present a moderate to high risk, which is pertinent to the facility used for disposal (GDACE, 2007). Of the total waste generated, only 4% is recycled and this is mainly for oils and grease as well as solvents. First Generation Integrated Hazardous Waste Management Plan also reported a backlog of potentially reusable waste, including filter cake, hexavalent chrome and magnetite (GDACE, 2007).

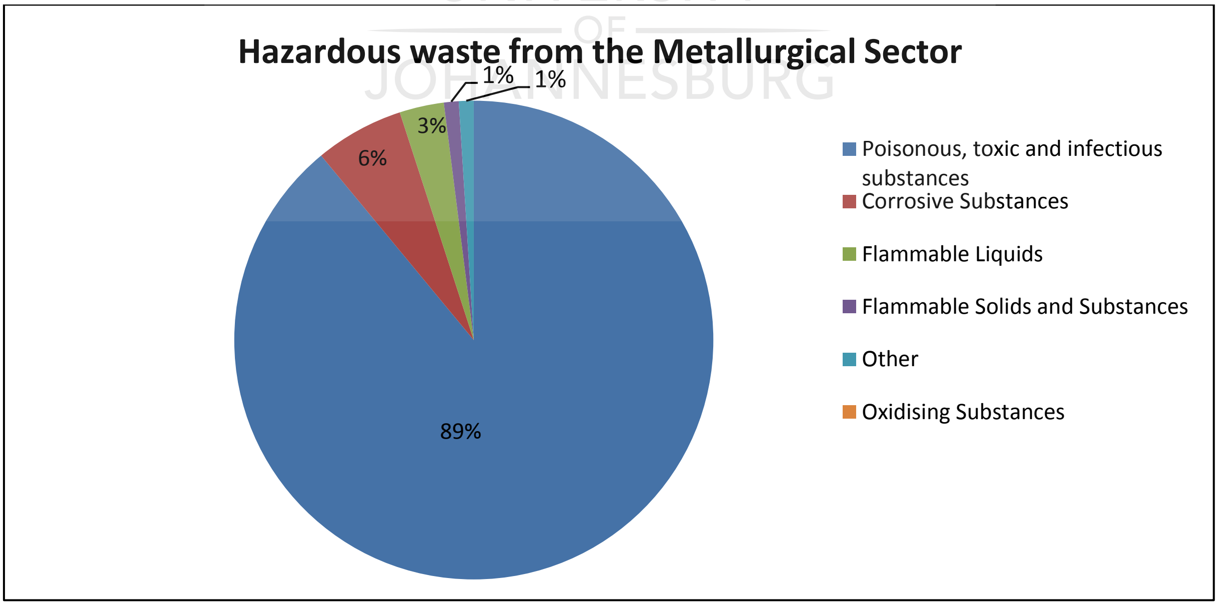

Figure 2-6. Hazardous waste composition in Gauteng: metallurgical industries (GDACE, 2007)

2.5 MILL SCALE

Mill scale is a typical production waste generated from the Iron and Steel industry and is generated when solid steel is heat treated, continuously cast or rolled as part of the steel during the steel making process. During these processes, mill scale develops as iron oxides on the surface of steel in a flaky or scale-like form and washes off the surface of the steel in a flume and deposited for collection (Wang *et al.,* 2016). Since mill scale is the flaky exterior of steel, it contains 50-75% iron in the form of FeO or Fe_2O_3 or FeO_4 and is thus a valuable raw material as it can be used in various applications due to its high iron content (Wang *et al.,* 2016). Due to its high iron content, mill scale can substitute the use of iron ores and can contribute to conserving natural resources as well as reducing waste to landfill (Wang *et al.,* 2016). Globally, around 13.5 m tons of mill scale is generated per annum (Gaballah *et al.,* 2013) and the Gauteng province alone recorded a backlog of 16 000 tons, which can be reduced by selling this for use in various applications (GDACE, 2007). Currently, waste legislation in South Africa requires mill scale to be disposed of since no companies meet the legal requirements in terms of NEMWA (Act No. 59 of 2008) for re-using this waste stream.

2.5.1 Alternative Uses for Mill scale

2.5.1.1 Fluxing agent

i. Battery Manufacturing

Mill scale can be used in the manufacturing of alkaline batteries. Mill scale and copper are combined during rolling and forging which produces the negative electrode. Mill scale is also used as a fluxing agent in the manufacture of lead batteries. Mill scale is added directly to the furnace to absorb impurities in the slag (Eissa *et al.,* 2015).

ii. Direct Reducing of Iron Ore

This process involves the reduction of iron ore using a fluxing agent and coal. In this state, the iron can be fed directly into a furnace for further processing. Mill scale can be used as a fluxing agent in this process and is a good substitute as it yields high-grade sinter, reduces the amount of slag generated and can provide a significant cost saving (Wang *et al.,* 2016).

iii. Ferro-alloy refinement

The addition of mill scale during the production of ferroalloys improves the absorption of impurities from the alloys. These impurities rise to the surface of the molten alloys and collect in the slag which is disposed of (El-Hussiny *et al.,* 2011).

2.5.1.2 Heat conservation in furnaces

Adding mill scale to the furnace can regulate the temperature and conserve energy. This is achieved by the removal of volatile metals and impurities which allows for heat conservation in the furnace (Eissa *et al.,* 2015).

2.5.1.3 Cement manufacturing

Mill scale has two valuable uses during cement making. The first is the use of mill scale directly with other raw materials. Secondly, during the manufacturing of cement, high-risk emissions (hydrocarbons) are released into the atmosphere. Adding mill scale during the combustion process of cement making can convert these gases into less volatile products. Mill scale can also be used in the manufacturing of heavy concrete by mixing with feedstock (El-Hussiny *et al.,* 2011).

2.5.1.4 Counterweights in machinery

Counterweights are used in machinery or equipment to create an even mass. Mill scale can be used to substitute concrete as a filling material in machineries, such as a washing machine (El-Hussiny *et al.,* 2011).

2.5.1.5 Iron feedstock

Since mill scale is mainly comprised of iron, it can be combined with other materials to produce an iron feedstock which can be further processed by techniques such as leaching or roasting (El-Hussiny *et al.,* 2011).

2.5.1.6 Agriculture

Mill scale can be used in agriculture to improve the efficiency and effectiveness of mixed fertilisers. The magnetic properties of mill scale assist in the carrying of nutrients to the crops. Additionally, mill scale can be used during the production of phosphate fertiliser to remove silicon (El-Hussiny *et al.,* 2011).

2.5.2 Benefits of Mill Scale Recycling

Although generated as a waste from the steel making process, mill scale is a valuable secondary material or by-product due to high iron, low impurities and chemical stability (El-Hussiny *et al.*, 2011).

Recycling of mill scale supports the Waste Hierarchy by reducing the amount of waste to landfill and in doing so, prevents potential impact on soil and groundwater as well as increase the life of the landfill (Oelofse and Godfrey, 2008). Additionally, the re-use of mill scale reduces the consumption of raw materials. For example, mill scale can be used as a substitute for iron ore (Eissa *et al.,* 2015). Recovery of mill scale results in cost savings from the sale of the waste stream which generates an additional source of revenue as opposed to the waste disposal costs. Further benefits include minimising hazards or nuisances to the surrounding community as a result of landfilling (Rostik, 1996).

2.6 REGULATING WASTE

The harmful effect that waste can have on the natural, social and economic environment has created the need to strictly regulate waste and create a sustainable landscape (Chinwe, 2010).

As such, many countries introduced waste legislation primarily centred on preventing negative environmental impact, with a shift in focus to promoting resource conservation as the legislation progresses (Chinwe, 2010).

A country’s legal connotation of waste influences the volumes and types of waste recycled (Levänen, 2014b). In South Africa recycling of waste, especially industrial waste, is subject to onerous applications and regulations that include record keeping of waste from cradle to grave, ensuring the use of only permitted or licenced waste management facilities and that an organisation’s on-site waste management operates within the ambit of a permit or prescribed regulation (Taljaard, 2012). Recycling as a waste management option can thus become undesirable to the industry (Levänen, 2014b).

Although alternative uses exist, the waste legal requirements attached to recycling mill scale can be undesirable to both the generator as well as to the entity wanting to utilise it. Companies that seek to buy mill scale for use as a raw material do not view mill scale as a waste (Taljaard, 2012). A common question that arises within industries is whether a material generated from processes and which is suitable for reuse or application in an alternative process is a by-product or a waste (Taljaard, 2012).

This would allow the material to be exempt from waste legal requirements, which present time and cost barriers and would further extend the life cycle and end volume of waste produced (Taljaard, 2012). The DEA has, however, removed the term “by-product” from NEMWA (Act No. 59 of 2008) in the NEMWAA (Act No. 26 of 2014) in June 2014 and has not legislated an alternative approach for managing these waste streams for the past 3 years (RSA, 2014a).

This leads to the question of whether compliance with South African waste legislation is practical and suitable for the recycling of waste in the industrial sector (Sentime, 2014). Various industries have expressed their concern through government forums on the challenges experienced when exploring opportunities to recycle hazardous waste streams (Papu-Zamxaka, 2010).

2.6.1 Public Participation in Waste Regulation

Principle 10 the Rio Declaration on Environment and Development in 1992 emphasises the importance of public participation in environmental legislation. Principle 10 highlights two important rights, namely the right of access to information and the right to public participation on issues affecting a person’s community, including decision-making processes (Keating, 1993). A review of the literature on the effectiveness of policy highlights the importance of the feedback and interaction between the formal legislature and the industrial role players directly involved and experienced in an applicable operation (Gera, 2014). In South Africa, there is robust legislation that obliges public participation in environmental issues. In terms of waste management within industries, the DEA hosts quarterly forums between government institutions and privately owned industry to discuss waste management matters that arise in industries and provide an opportunity for industries to comment on legislation (DEA, 2015).

A regular forum between the legislator or authority and industrial stakeholders is an important channel for collective learning, a broader participation and more informed decision making into the drafting waste legislation. Waste legislation should focus on the experience and continual improvements of industries (Levänen, 2014a).

2.7 CONCLUSION

The Department of Environmental Affairs promulgated the NEMWA (Act No. 59 of 2008) in an effort to improve and manage waste in South Africa. A central theme of NEMWA (Act No. 59 of 2008) is to reduce the amount of waste disposed of (RSA, 2008). However, waste statistics indicate that over 90% of the waste generated in the country is being landfilled and the 10% that is being recycled is largely waste from the packaging industry including paper, plastic, glass and metals (DEA, 2012).

Industries generate a significant portion of hazardous and unknown waste, however, the Iron and Steel industry recycles only 4% of its waste (GDACE, 2007). For many industries, waste holds a high reuse value and is thus viewed as a by-product or a raw material. Mill scale is one such example of a waste generated by the Iron and Steel industry, which due to its high iron content is a valuable raw material (Maritz, 2011). However, although alternative uses exist, the waste legal requirements attached to recycling mill scale can be undesirable to both the generator as well as to the entity wanting to utilise it (Taljaard, 2012). As a result and in order to remain compliant, industries elect to dispose the mill scale at a landfill (Park, 2014).

The next Chapter focuses on the case study, which is the generation and management of mill scale at ABC Metals and the legal requirements for waste management of mill scale.

3 CASE STUDY: MILL SCALE WASTE MANAGEMENT AT ABC METALS

3.1 INTRODUCTION

This Chapter provides the results of the case study, which is the generation and management of mill scale waste at ABC Metals as well as a review of the legal requirements for the recycling of mill scale. The assessment includes a review of how mill scale is generated; its composition and characteristics; the quantities generated and waste management methods. This information was required to find alternative uses for mill scale and identify the applicable waste legal requirements under NEMWA (Act No. 59 of 2008) and NEMWAA (Act No. 26 of 2014) for recycling. The case study also includes an analysis of the impacts associated with the disposal of mill scale (existing practice by ABC Metals) which was compared with the impacts associated with recycling (at a battery manufacturing industry). These impacts were analysed using a Leopold matrix.

In South Africa, the definition of waste as per Section 1 (i)(a) of the National Environmental Management: Waste Amendment Act (NEMWAA) (Act No. 26 of 2014) is "*any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered*" (RSA, 2014a, p 4). Even though an alternative use exists for mill scale and it can be sold as a by-product, it still fits the definition of a waste since it is "*unwanted.. by the holder…whether or not it can be recycled*" and must, therefore, comply with the requirements of NEMWA (Act No. 26 of 2014). NEMWA (Act No. 59 of 2008) requires that a mill scale recycler must be in possession of a valid Waste Management Licence before it can accept and recycle the mill scale.

The legal requirements for the management of mill scale are also reviewed as part of this Chapter to understand how different regions and countries have regulated waste and the requirements for recycling. One region and four countries were selected based on their progress in regulating waste management, namely the European Union, Finland, the United States of America, Zambia and South Africa (SA). Important definitions and sections of the respective legislation relating to recycling or re-use of industrial waste are discussed in terms of the intent and implication of its meaning. The definition of waste is of utmost importance in interpreting waste legislation as it delivers meaning and characteristic to the subject matter. The definition should be carefully written to ensure that the intent of the author is clear and that no ambiguities exist, which could allow for an alternate interpretation. However, the definition of waste in different countries has proved to be a complex matter (Pongrácz and Pohjola, 2004).

3.2 PROCESS OF GENERATING MILL SCALE

ABC Metals generates mill scale at 3 production plants. The first is a melting facility known as the Melting Plant, which melts scrap steel to produce billets, which are longitudinal square shaped metal (refer to Figure 3-1).

The second is a grinding media facility called the Forge Plant, which uses the billets produced by the

Melting Plant to produce steel balls which are used mainly in the mining industry for grinding and crushing large sized solid mineral ore (refer to Figure 3-2). The third facility is the Rod, Bar and Section Mill which also uses billets produced by the Melting Plant to produced steel frames or structures according to client specifications (refer to Figure 3-3).

Figure 3-1. Billets (JSJ Metal Recycling, 2017)

Figure 3-2. Grinding Media (Everychina, 2017)

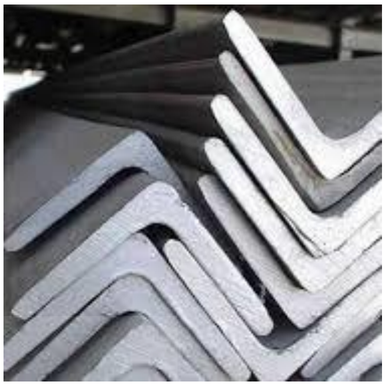

Figure 3-3. Rods and Bars (USSE, 2014)

The generation of mill scale is depicted using Input-Output Diagrams for the Melting Plant, the Forge Plant and the Rod, Bar and Section Mill in Figures 3-4 to 3-8. These diagrams allow for easy identification of the raw materials used in production and the resultant outputs. Substances indicated in red are solids, those in blue are liquate and gaseous substances are shown in green in the diagrams. Inputs or outputs which do not fit either of these categories are shown in black, for example, electricity.

3.2.1 Melting Plant

Pre-graded, sorted and shredded scrap metal is off-loaded at the Melting Plant. The scrap metal is charged by magnet cranes and fed into an Electric Arc Furnace to form a furnace charge. This is then melted, tapped into a ladle and sent to the ladle furnace for final preparation. Steel is placed on a butterfly type turret and square billets are produced through a continuous casting machine. These billets can be supplied directly to customers or despatched to the Rod, Bar and Section Mill or Forge plant for further processing.

Figure 3-4 illustrates the inputs and outputs of the Melting Plant‘s continuous casting process. It is during the continuous casting process that mill scale is formed. The process involves the casting of liquid steel into billets. As the billet cools a thin layer of scale forms on the surface and peels off on the cooling bed. The scale is then washed away into the flume water which also serves to cool the billet and deposited in a hydrocyclone which is a sump collecting water from the process.

From here the mill scale is placed in a skip. Due to the oils used in the continuous casting machine, mill scale formed from this process is hydrocarbon contaminated. As noted in Figure 3-4, the slag, oil and water are recycled. Notably, ABC Metals recycled slag on site. Due to the high volumes of slag generated during melting of steel, ABC metals recycles slag mainly into road aggregate in terms of a valid Waste Management Licence.

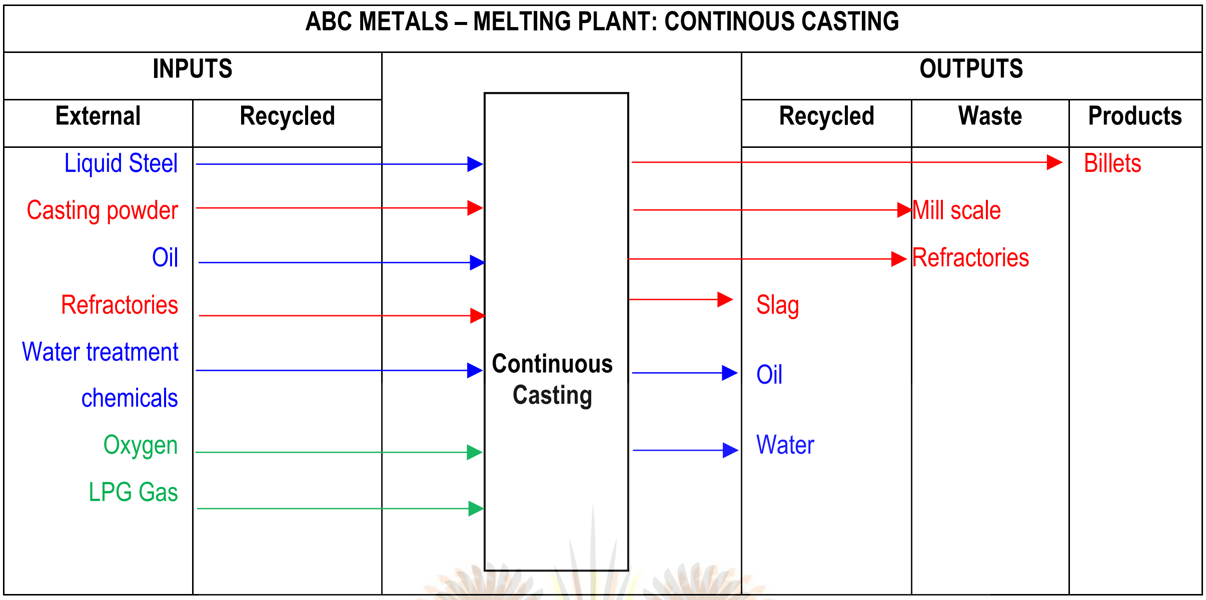

Figure 3-4. Input-output diagram showing the process of continuous casting at the Melting Plant (Grimard *et al*., 2016)

3.2.2 Rod, Bar and Section Mill

The Rod, Bar and Section Mill is a rolling mill which receives billets from the Melting Plant. The billets received are reheated and rolled to form round bar, coiled rod and sections. Mill scale is generated during two processes at the Rod, Bar and Section Mill, namely during the reheating of the billets in the reheat furnace and in the rolling of steel.

3.2.2.1 Heating of billets

Figure 3-5 illustrates the generation of mill scale at the Rod, Bar and Section Mill during the reheating of a billet in the furnace. Mill scale forms on the exterior surface of metal billets during reheating in the furnace. The mill scale is deposited at the discharge point of the reheat furnace, from where a shovel is used to load the mill scale into a waste skip.

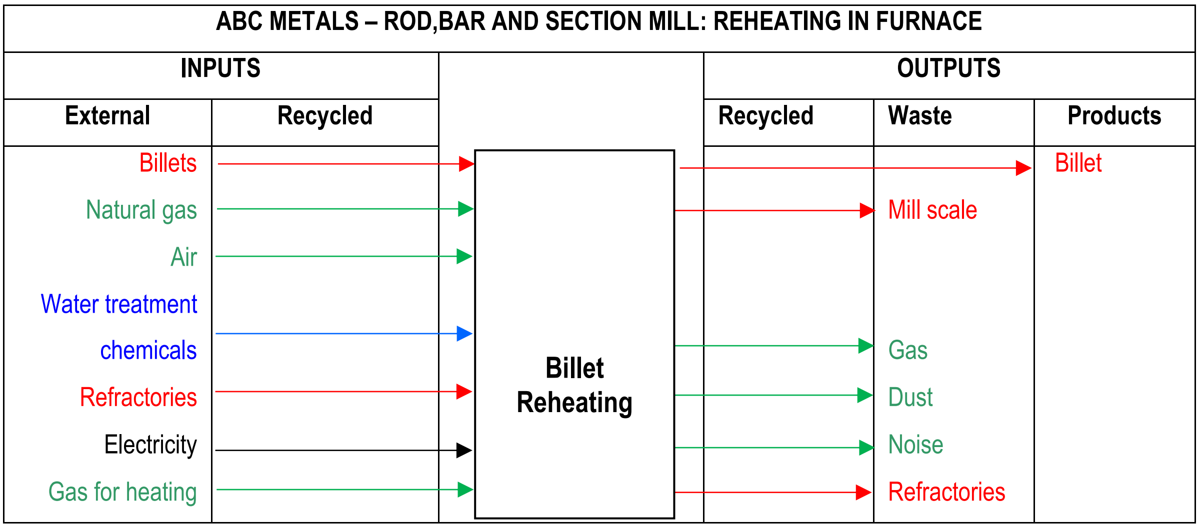

Figure 3-5. Input-output diagram showing billet reheating at the Rod, Bar and Section Mill (Grimard *et al*., 2016)

3.2.2.2 Rolling of heated billets

Mill scale is also generated during the rolling of the heated billet during which thickness and shape of the heated billet is altered. Figure 3-6 displays the inputs and outputs of for the process of rolling steel. Mill scale continues to form on the surface of the bullet and cooling water is used to strip and remove the scale from the bars. This flume water then transfers the scale to a water plant from where the scale is deposited into skips.

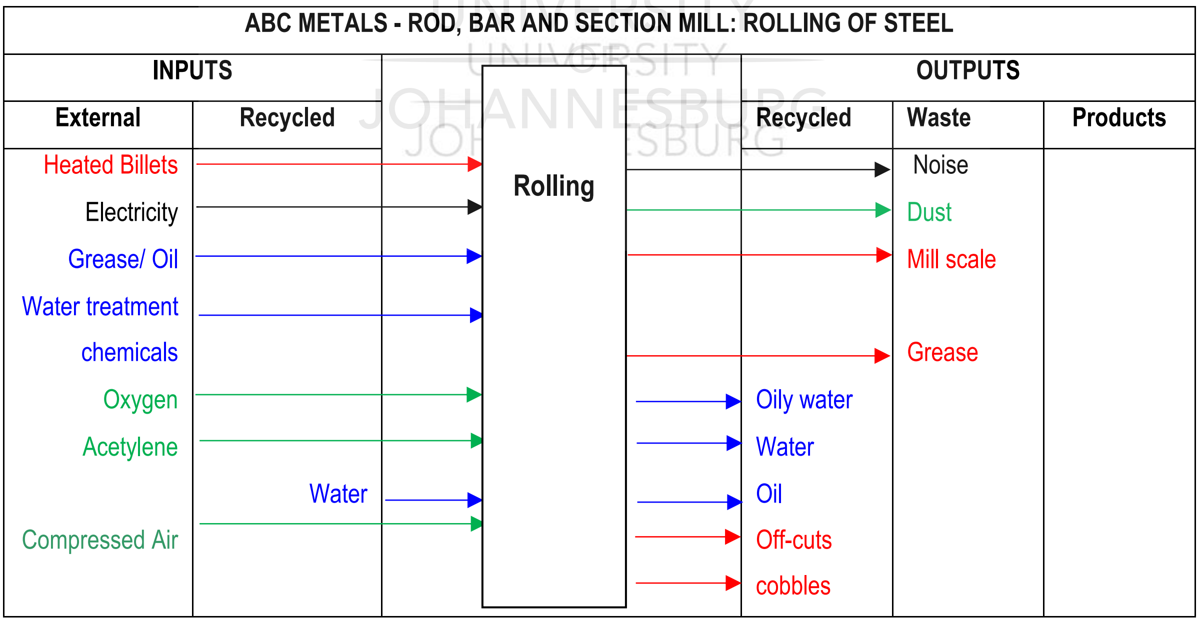

Figure 3-6. Input-output diagram showing steel rolling at the Rod, Bar and Section Mill (Grimard *et al*., 2016)

3.2.3 The Forge Plant

The Forge plant also uses the billets produced by the Melting Plant. Similar to the Rod, Bar and Section Mill, the mill scale forms during two processes, namely the reheating of the billet and the forging process.

Figure 3-7 indicates the process of reheating the billet. As described in the Rod, Bar and Section Mill, reheating causes the billet surface to flake and peel off. The mill scale is deposited at the discharge point of the reheat surface, from where it is removed with a spade. The hydraulic oil used in this processes can create an oil residue which results in hydrocarbons contaminating the mill scale.

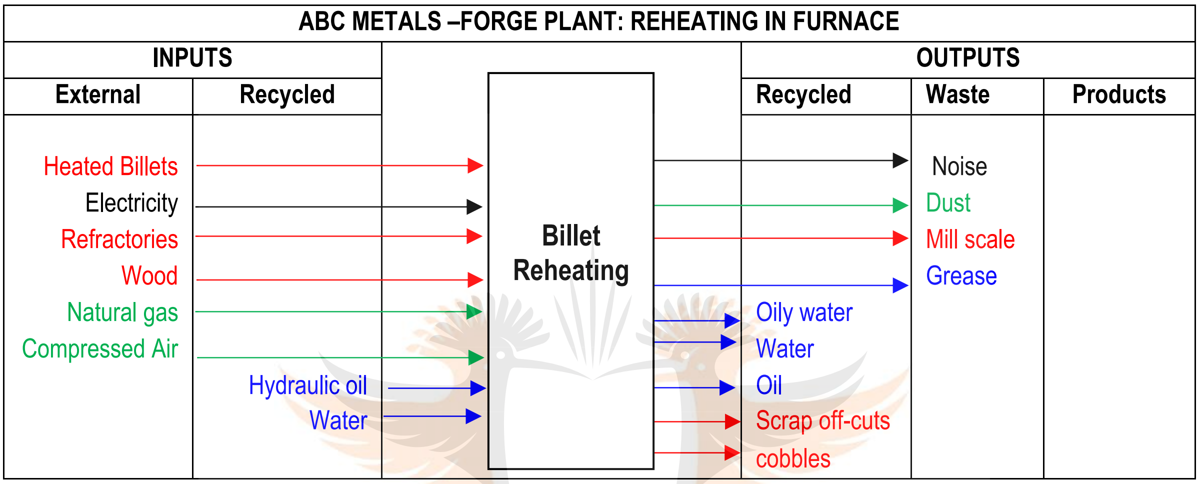

Figure 3-7. Input-output diagram showing the process of reheating at the Forge Plant (Grimard *et al*., 2016)

Figure 3-8 depicts the forging process. After the billets are reheated, forging transforms the billets into balls. The mill scale which develops on the steel surface during this process washed away by flume water and is collected in skips.

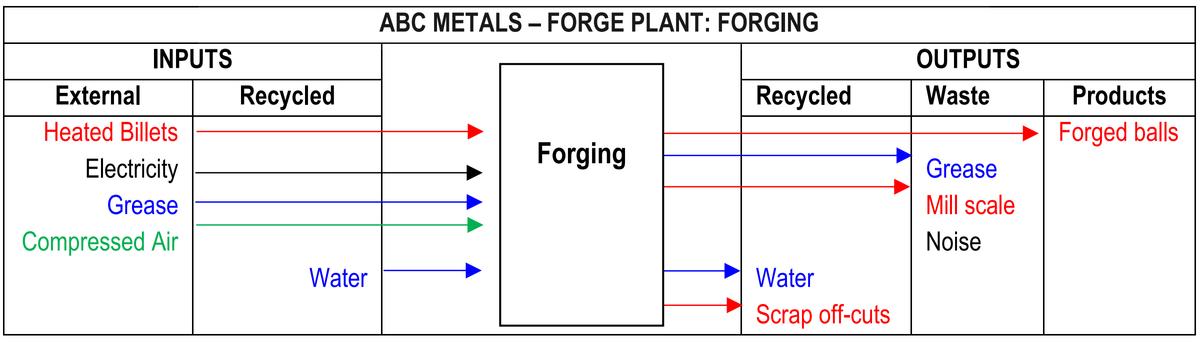

Figure 3-8. Input-output diagram showing the process of forging at the Forge Plant (Grimard *et al*., 2016)

3.3 PHYSICAL AND CHEMICAL CHARACTERISTICS OF MILL SCALE

On visual inspection, mill scale appears as a black metallic powder comprised of fine particles mixed with chips or flakes (see Figure 3-9 and Figure 3-10). Mill scale is bluish black in colour and the size varies from fine-grained dust-sized particles to 6 mm. Mill scale forms from the steel surface during heat treatment, rolling or forging and thus has no discernible odour (Sarna, 2014).

Figure 3-9. Mill scale (NHRTC, 2017)

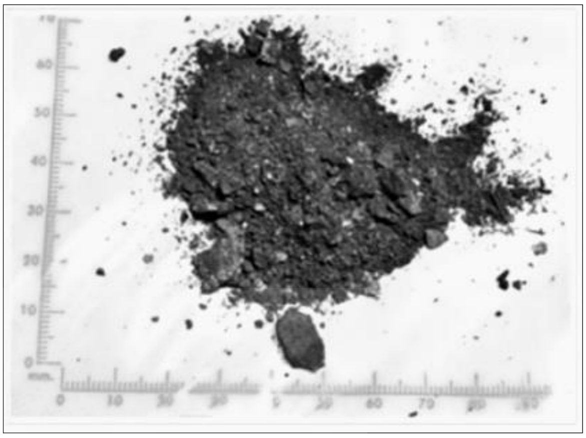

Figure 3-10. Mill scale size (Sarna, 2014)

The chemical properties of mill scale are similar to iron. The significance of this is that mill scale can be used as an iron substitute. Chemical properties of raw materials are important in industrial processes and the manufacturing process (Sarna, 2014). The specific gravity (density of a substance compared to the density of water) of mill scale ranges between of 5.7 to 6.2, whereas cast iron is approximately 7. Mill scale has a melting point in the order of 1370 °C and a boiling point of around 2760 °C, similar to that of iron, which is 1538 °C and 2862 °C respectively (Sarna, 2014). As with iron, mill scale is insoluble in water but dissolves in strong acidic solutions. Mill scale contains 50 - 75% iron in the form of FeO or Fe_2O_3 or FeO_4 and is thus an iron-rich source with minimum impurities (Sarna, 2014). The chemical properties indicate that mill scale is very similar to iron and can thus be substituted for iron in a variety of applications provided that do not contain any hydrocarbons (Sarna, 2014).

3.3.1 Sampling and Analysis of Mill Scale at ABC Metals

Mill scale is generated at the Rod, Bar and Section Mill, Forge Plant and the Melting Plant. A sample of mill scale was collected from each plant (1 kg) and combined into a single composite sample. This composite sample was then analysed and classified in terms of the SANS 10234 Standard (RSA, 2013a). Mill scale was classified as a hazardous material due to the diesel range organics (RSA, 2013a).

Table 3-1 provides a summary of the major constituents of the mill scale. The analysis of the mill scale sample was undertaken in February 2016 by an accredited laboratory.
Mill scale taken as a composite sample from the Melting Plant, Rod, Bar and Section Mill and Forge Plant contains 62.7% Iron and trace metals of manganese (0.7%) and zinc (0.5%). The mill scale further contains notable levels of total petroleum hydrocarbon (0.5%) and mineral oils at (0.3%) respectively.

Table 3-1. Chemical composition of mill scale

Component	Mill scale	
	mg/ kg	%
Iron	627000	62.7
Manganese	7360	0.7
Zinc	5230	0.5
TPH >C6-C40	4840	0.5
TPH >C16-40	4820	0.5
Mineral Oil >C10-C40	2730	0.3
Chromium	1190	0.1
Copper	907	0.09
Calcium	638	0.06
Nickel	403	0.04
Aluminium	169	0.01
Sodium	81.1	0.008

[nd]levels not detected

Note: all other chemicals occur as trace elements.

These results indicated that the mill scale itself serves as a good substitute for iron ore. However, the presence of the hydrocarbons may require that the oily residue is removed prior to use. There are, however, certain applications that can use this mill scale as per its analysis in Table 3-1.

3.4 QUANTITIES OF WASTE GENERATED AT ABC METALS

The tonnages of mill scale generated at the Melting Plant, Rod, Bar and Section Mill and Forge Plant are depicted in Figure 3-11. These tonnages are based on the weighbridge data in the Waste Manifest received from the Waste Service Provider disposing the mill scale. The volumes were recorded over a 12 month period, from June 2015 to May 2016. The lowest volumes were generated in December (168.98 tons) and January (302.94 tons) and are as a result of the shutdown period in December during which production is stopped and the start-up period in January. The average monthly generation of mill scale at ABC Metals is 425 tons per month.

Most of the mill scale is generated by the Rod, Bar and Section Mill and this is both due to the higher production rates as well as the reheating and rolling process which produce more mill scale. While the Melting Facility also has a high production rate, similar to the Rod, Bar and Section Mill, it is only after the molten metal has been cast and is in process of cooling, during which a thin layer of mill scale forms on the surface of the mill scale. The Forge Plant has a much lower production rate, and this attributes to the low amounts of mill scale formed. The Rod, Bar and Section Mill generates on average 391 tons of mill scale per month, while the Forge Plant and Melting Plant both generate on average 17-18 tons of mill scale per month.

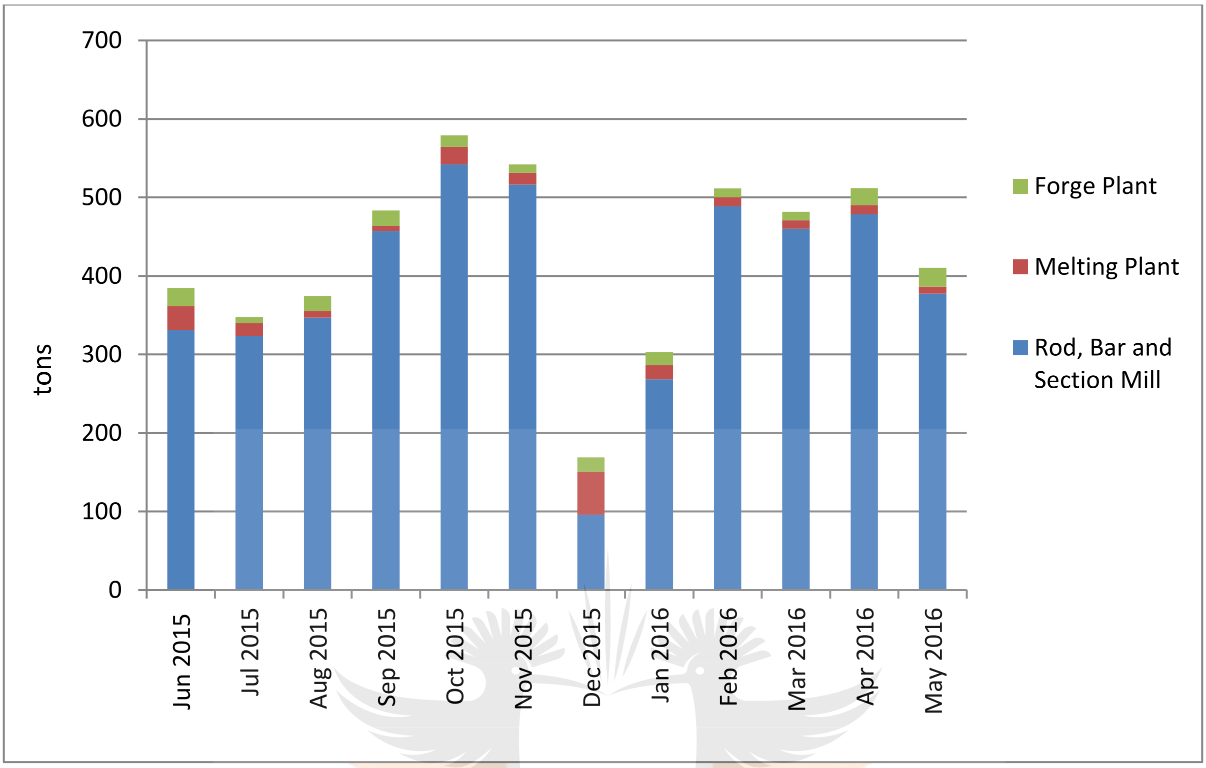

Figure 3-11. Mill scale generated at ABC Metals from June 2015 to May 2016

Figure 3-12 provides the total mill scale generated by ABC Metals for an annual period from June 2015 to May 2016 by the Rod, Bar and Section Mill, the Melting Plant and the Forge Plant. The Rod, Bar and Section Mill is the predominant generator of mill scale. The Forge Plant generated 198.52 tons of mill scale for the reporting period; the Rod, Bar and Section Mill generated 4686.6 tons and the Melting Plant 215.18 tons of mill scale per annum. The total volume of mill scale generated at ABC Metals is 5100.3 tons per annum (June 2015 to May 2016). The monthly average of mill scale generated is approximately 425 tons.

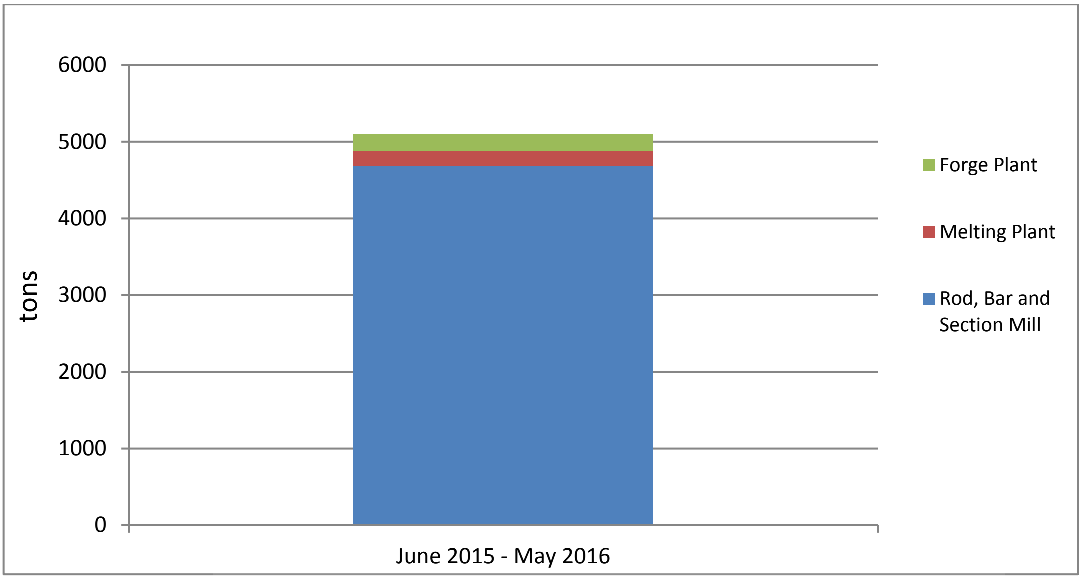

Figure 3-12. Annual tons of mill scale generated ABC Metals

The invoices supplied by the waste service provider indicate that the cost of disposal of mill scale generated by ABC Metals between June 2015 and May 2016 at the Rietfontein disposal site amounted to approximately R942 000 per annum. ABC Metals would benefit from a reduced annual expenditure on waste disposal (Rostik, 1996). The battery manufacturing industry would also benefit from this interaction, since the mill scale is provided at a substantially lower cost than purchasing an alternative fluxing agent (El-Hussiny *et al.*, 2011).

3.5 EXISTING WASTE MANAGEMENT PRACTICE AT ABC METALS

All mill scale generated by ABC Metals is currently landfilled, since no licenced service provider exists to recycle the mill scale. The following handling, storage, transport and disposal practice is set up at ABC Metals.

1. Mill scale is stored in 6 m^3 skips.
2. Once the skip is full, the waste service provider is contacted to remove the skip.
3. The waste contractor enters ABC Metals and the truck is weighed upon entry.
4. The waste service provider removes the onsite skip and replaces it with a clean, empty skip.
5. At the point of collection of the mill scale skip, the waste service provider provides ABC personnel with a signed delivery note indicating the date, time, area where waste was collected, the type of waste and waste receptacle that was removed. This is signed by the waste service provider and ABC representative.
6. The truck is weighed before it leaves the premises and the net difference is used to calculate the weight of mill scale removed.

7. The service provider is issued with a weighbridge slip from ABC Metals to indicate the volumes removed.
8. Mill scale is removed for disposal at Rietfontein Landfill.
9. As the truck enters the landfill, it is weighed upon entry.
10. After the mill scale has been offloaded, the truck is weighed before it leaves the landfill and the net difference is used to calculate the weight of mill scale disposed of.
11. A copy of the waste manifest, weighbridge slips and an invoice are sent to ABC Metals for payment and record keeping.

3.6 POSSIBLE RECYCLING OF MILL SCALE IN BATTERY MANUFACTURING

This section deals with the recycling of mill scale at a battery manufacturing industry. The purpose of this section is to provide a short description how mill scale would be used as a raw material, including the waste that would be generated. This information is required to undertake the environmental impact analysis in Section 3.7.3.

A lead battery manufacturing industry is able to use mill scale as a fluxing agent in its internal processes. Mill scale can be used in a process by adding it directly to the furnaces to absorb impurities in the slag and constitutes a maximum of 3% of the total furnace charge/load. This process can use up to 240 tons of mill scale per month and can thus divert up to 60% of the mill scale generated by ABC Metals from being landfilled.

3.6.1 Raw Materials

Table 3-2 includes a list of the existing raw materials used during lead battery manufacturing. Note that although mill scale is listed in Table 3-2 it is not currently being used, however, has been included to provide information on the predicted quantities required. The process involves the recovery of lead and polypropylene fractions from spent lead-acid batteries. The lead compounds are separated from the battery and smelted in rotary furnaces using reducing agent and fluxes (soda ash and Sasol coke). Mill scale can be used in this process to remove condition the slag. The lead is then refined or alloyed before it is cast into ingots.

Table 3-2. Raw materials used in battery manufacturing

Raw Material	Quantity used t/ month
Spent Lead-acid batteries	5000
Lead Scrap, Battery Plates	1958
Lead Drosses	179
Fluxes: Soda Ash	450
Fluxes: Sasol Coke	320
Fluxes: Mill scale*	240

***Estimated volumes based on existing information**
(Source: COE, 2014)

3.6.2 Pre-Treatment Activities

No pre-treatment activities are required as part of the process. Mill scale would be placed directly into the furnace. The only preparation in the overall process relates to the dismantling of batteries to render the lead and polypropylene for charging of the furnaces.

3.6.3 Mill scale Recycling Process Description

The overall process involves the following steps:

1. Mill scale received from ABC Metals would be stored in bunkers on an impermeable concrete surface.
2. The mill scale would be transferred directly to the furnace by front-end loader.
3. The mill scale would be charged into the furnace and heated to approximately 1000 °C, at which point the mill scale melts and form part of the slag (the purpose of slag is to absorb impurities and clean the bullion which is subsequently tapped).
4. After tapping the bullion, the slag would be tapped, cooled and tipped into a slag bunker which has a concrete surface.

3.6.4 Waste Generated from the Recycling Mill scale

A list of waste streams generated from the process of recycling mill scale is provided in Table 3-3, including the classification and volumes generated per month. The waste generated from the addition of fluxing agents including mill scale are contained in the slag. The slag generated from this process is cooled and stored in a bunker on an impermeable concrete surface. A waste service provider collects the slag when bunkers are full and removes this to a licenced hazardous waste facility.

Table 3-3. Waste streams that would be generated from the recycling of mill scale

Component	Classification	Quantities
	SANS10234:2008	tons/ month
Slag	Hazardous	820

(Source: COE, 2014)

3.7 IMPACT ANALYSIS FOR THE MANAGEMENT OF MILL SCALE

The purpose of the impact analysis was to compare the impacts of waste disposal with the impacts of recycling mill scale. Since both ABC Metals and the battery manufacturing plants are existing business located in the same industrial area, impacts are only considered during the operational phase. No additional facilities or infrastructure are required to be constructed to recycle the mill scale.

Two environmental impact analyses were undertaken. The first was undertaken to assess the impacts of disposal of mill scale generated at ABC Metal's site:

- storage and handling of mill scale at ABC Metals;
- transport of mill scale from ABC Metals to Rietfontein landfill; and
- disposal of mill scale at Rietfontein landfill.

The second impact analysis assessed the impacts related to recycling the mill scale at the battery manufacturer:

- storage and handling of mill scale at ABC Metals[1];
- transport of mill scale from ABC Metals to the battery manufacturer;
- storage and handling of mill scale at the battery manufacturer;
- Recycling process for mill scale; and
- Waste outputs from the recycling process.

The methodology used to rate the impacts are described below. The impacts were rated using a Leopold Matrix to identify and prioritise the most significant impacts. The Leopold matrix was developed by Dr Luna Leopold is a widely used tool to undertake environmental impact analyses. The format consists of an elaborate open-cell matrix with rating criteria along the horizontal axis and activities, environmental aspects and impacts on the vertical axis. Each environmental impact identified is then risk rated to determine which impacts represent negligible, moderate or significant risks, from which opportunities to mitigate the significant risks can be (Aucamp, 2009).

Note that the rating of impacts in the matrices in Section 3.7.2 and Section 3.7.3 did not consider any existing controls or preventative measures. The controls are discussed in each section and include post-mitigation for only those impacts which were rated as significant. Although not all controls were discussed for the impacts, this does not mean that no controls exist. This impact analysis identifies all impacts, however, only those impacts considered to be significant are discussed further.

3.7.1 Methodology of Assessing Impacts

The rating system shown below was used to analyse the environmental impacts identified in Section 3.7.2 and Section 3.7.3. Three criteria were used to rate an impact, namely probability, severity and detection. These ratings do not consider any existing controls. Controls were only considered when assessing the outcome of the impact analysis. The rating system is described below.

[1] Note that this was only be included in the first impact analysis (disposal) to prevent repetition. However, it is discussed when summarizing the findings from both impact analysis (disposal and recycling impact analysis).

3.7.1.1 Probability (PROB)

The Probability describes the likelihood of the impact to occur on account of the activity or in other words, how likely is it for this impact to occur. The rating system is shown in Table 3-4, where 1 is highly unlikely and 5 occurs regularly. This rating should consider how often this impact has occurred in the past.

Table 3-4. Probability rating matrix

Weight Number	1	2	3	4	5
Evaluation description	Almost impossible	Unlikely	possible	likely	Highly likely

(Source: Mitre, 2017)

3.7.1.2 Severity (SEV)

The Severity describes the magnitude or degree of the effect or impact that the activity may have on the environment or how intense is the impact based on the damage it can cause. The rating for severity is provided in Table 3-5, where 1 is that the impact causes insignificant or negligible damage and where 5 causes a disastrous or extremely harmful damage.

Table 3-5.Severity rating matrix

Weight Number	1	2	3	4	5
Evaluation description	Insignificant	Potentially harmful	Slightly harmful	Harmful	Disastrous

(Source: Mitre, 2017)

3.7.1.3 Detection (DET)

Detection describes the degree to which the impact can be detected. For example, an underground oil or diesel leak is not very easy to detect and can results in disastrous consequence if this is not detected early. The rating for detection is shown in Table 3-6 and is rated from 1 to 5, where 1 is easy to detect, such as a strong odour or visible fumes and where 5 is nearly impossible to detect.

Table 3-6. Detection rating matrix

Weight Number	1	2	3	4	5
Evaluation description	Very Easy to detect	Fairly easy to detect	50/ 50 chance of detection	Difficult to detect	Impossible to detect

(Source: Mitre, 2017)

3.7.1.4 Significance

Once the rating of the impact is done, the significance of the impact is calculated as:

Significance = Severity x Probability x Detection

Table 3-7 provides the classification for the significance rating of an impact. The highest score an impact can have is 125 without controls. A rating below 25 is considered as a low impact. A rating between 29 and 45 is considered to have a medium impact on the environment and a rating above 45 is considered to have a high or significant impact.

Table 3-7. Significance rating classification

Rating Value	Significance
0-19	Low impact (L)
20-45	Medium impact (M)
> 45	Significant Impact (H)

(Source: Mitre, 2017)

Once the final significance rating is calculated, only the significant impacts are considered further.

3.7.2 Environmental Impact Analysis for the Disposal of Mill Scale

The impact assessment in Table 3-9 was undertaken without considering the existing controls to reduce or prevent the impact. The impacts were considered from the point of generation at ABC Metals, to the collection by the waste service provider and to the disposal at the landfill. Since this is not a new activity, ABC has a current procedure for storing mill scale.

3.7.2.1 Negative impacts

i. Stormwater, Groundwater and Soil Contamination from Mill Scale Residue

Mill scale may enter stormwater drains through spillage or windblown particles if not contained properly. The major constituents of concern of mill scale are the high iron content and oil content of mill scale. The City of Ekurhuleni (COE) wastewater management by-laws (MI 197/2001 of 2001) requires in Section 33(5) that all persons in its jurisdiction must ensure that stormwater is kept clean (RSA, 2002). Since there are no stormwater quality guidelines from the COE, ABC Metals should comply with the Klip River Catchment Water Quality limits since stormwater in the site flows into this Catchment. The Klip River Catchment Water Quality limit for Iron is 1mg/l. However, the Klip River Catchment Water Quality does not provide concentration limits for Soap, Oil and Grease. For this reason the General Limit published by the Department of Water and Sanitation is applicable, which is contained within 21 (f) and 21 (h) the Generational Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 of 1998) (GN No 665 of September 2013) (RSA, 2013b).

The 21(f) and 21(h) water uses relate to the discharging of water and provide a limit of 2.5mg/l for Soaps, Oils and Grease (RSA, 2013b). The leachable concentrations of the mill scale are shown in Table 3-8 and indicate high levels of iron (627g/l) and lower although significant levels of total petroleum hydrocarbon (2.7 – 4.8 g/l). Mill scale must, therefore, not be allowed to enter any stormwater drains or natural water resources.

Table 3-8. Leachable concentration for major constituents of mill scale

Component	**Mill scale**
	mg/l
Iron (Fe)	627000
Mineral Oil >C10-C40	2730
Total Petroleum Hydrocarbon >C6-C40	4840
Total Petroleum Hydrocarbon >C16-40	4820

Note: all other chemicals occur as trace elements.

ii. Depletion of Landfill Space

ABC Metals generates approximately 425 tons of mill scale waste per month and 5100 tons per year. The mill scale is landfilled at the Rietfontein landfill which is located in the City of Ekurhuleni (COE). Rietfontein is a GLB+ landfill site and is licenced for co-disposal and to accept delisted waste streams. The landfill accepts approximately 950 tons of waste per day and has a life expectancy of 17 years (Giannakopoulos, 2013).

Table 3-9. Environmental impact analysis for the disposal of mill scale from ABC metals

Activities	Aspect	Environmental, Health or Safety Impact	Impact	Nature of Impact	Risk			Rating	
					Prob	Sev	Det	Value	Category
Storage of mill scale	Spillage of mill scale	Environmental	Soil and groundwater contamination	Negative	4	4	3	**48**	**H**
		Environmental	Stormwater pollution	Negative	4	4	3	**48**	**H**
	Dust generation	Environmental	Air Pollution	Negative	3	2	3	**18**	**L**
		Health	Inhalation leading to respiratory infections	Negative	3	2	3	**18**	**L**
Transport of Mill scale	Generation of Dust	Environmental	Air Pollution	Negative	4	2	4	**32**	**M**
		Health	Inhalation leading to respiratory infections	Negative	3	2	4	**24**	**M**
	Spillage of mill scale	Environmental	Soil and groundwater contamination	Negative	3	4	4	**48**	**H**
		Environmental	Stormwater pollution	Negative	3	4	4	**48**	**H**
	Exhaust emissions	Environmental	Air Pollution	Negative	3	1	4	**12**	**L**
	Vehicle Oil leaks	Environmental	Soil and groundwater contamination	Negative	3	1	3	**9**	**L**
Disposal of mill scale	Disposal of mill scale	Environmental	Depletion of landfill space	Negative	5	3	3	**45**	**H**
			Soil and groundwater contamination	Negative	3	2	3	**18**	**L**

3.7.2.2 Mitigation measures

The significant impacts identified in the impact analysis did not take into account any controls such as preventative and reactive measures that are in place. Two significant impacts were identified and which are shown in Table 3-10 below, where a post-mitigation rating is undertaken to evaluate these impacts by including the existing controls in the rating.

i. Stormwater, groundwater and soil contamination from mill scale residue

Table 3-10 indicates the mitigation measures or controls which are currently in place and effectively reduce the probability of the spillage of mill scale. At ABC Metals, mill scale is stored in 6m3 skips on a paved and impermeable surface. The skips are not stored near stormwater drains and are wetted to prevent dust generation. Furthermore, a waste management procedure and training is provided to employees for direction on the safe management of mill scale waste and to prevent spillages. Once the skips are full, the waste service provider is contacted to remove the mill scale. The waste service provider's vehicle is weighed on arrival and upon exiting ABC Metals to determine the weight of mill scale removed. The waste service provider then issues a collection note. The waste service provider additionally weighs the truck as it enters and exits Rietfontein landfill. A waste manifest is issued, which ensures that the tonnages of mill scale removed from ABC Metals are the same as the tonnages received at Rietfontein landfill. These controls are effective in lowering the impact of ground and water pollution. No mitigation measures exist to prevent depletion of landfill space.

ii. Depletion of Landfill Space

No mitigation measures are in place to prevent the disposal of mill scale at Rietfontein landfill. Table 3-10 indicates that the rating, therefore, does not change.

Table 3-10. Re-rating of significant negative impacts with controls (disposal)

Activities/ Aspect and Impact	Nature of Impact	Control (mitigation measures)	Risk			Rating	
			Prob	Sev	Det	Value	Category
Spillage of mill scale during storage, handling and transport, resulting in Soil and groundwater contamination.	Neg	• Storage on paved surface, away from stormwater drains • Storage in 6 m^3 skips • Wetting of mill scale • ABC Metals Waste Procedure • Training on waste procedure • SHE toolbox talks on Stormwater drains; waste management. • Collection of mill scale by tarpaulin trucks.	**2**	**4**	**3**	**24**	**L**
Depletion of Landfill Space	Neg	• None	5	2	3	**50**	**H**

3.7.2.3 Positive impacts

No positive environmental impacts are associated with the disposal of mill scale waste.

3.7.3 Environmental Impact Analysis for the Recycling of Mill scale

The impact assessment in Table 3-11 has been undertaken without considering the existing controls that reduce or prevent the impact. Only the most significant impacts is discussed below. The impacts for the recycling of mill scale are considered from the point of collection of mill scale at ABC Metals, the use of mill scale in battery manufacturing and the disposal of waste that arise from the use of mill scale. The significant impacts include spillages of mill scale during storage, transport as well as the generation of fumes during the process.

3.7.3.1 Negative impacts

i. Stormwater, Groundwater and Soil Contamination from Mill Scale Residue

Mill scale may enter stormwater drains through spillage or windblown if not contained properly. The major constituents were shown in Table 3-8.

ii. Air Pollution during Operation of the Furnace

The generation of fumes during the operation of furnace results in the introduction of pollutants into the atmosphere.

Table 3-11. Environmental impact analysis for recycling mill scale in battery manufacturing

Activities	Aspect	Environmental, health or Safety Impact	Impact	Nature of Impact	Risk			Rating	
					Prob	Sev	Det	Value	Category
Receipt of mill scale and Storage of Mill scale at the battery manufacturer	Spillage of mill scale	Environmental	Soil and groundwater contamination	Negative	4	4	3	**48**	**H**
		Environmental	Stormwater Pollution	Negative	4	4	3	**48**	**H**
	Dust generation	Environmental	Air Pollution	Negative	3	2	3	**18**	**L**
		Health	Inhalation leading to respiratory infections	Negative	3	2	3	**18**	**L**
Operation of Furnace	Generation of air emissions	Environmental	Air Pollution	Negative	4	4	3	**36**	**H**
		Health	Inhalation leading to respiratory infections	Negative	4	3	3	**36**	**M**
	Spillage of mill scale	Environmental	Soil and groundwater contamination	Negative	3	3	3	**27**	**M**
Waste Generation	Recycling of mill scale	Environmental	Conservation of natural resources (iron ore)	Positive	4	3	5	**60**	**H**
			Conservation of landfill space	Positive	4	3	5	**60**	**H**
Storage of slag	Spillage of mill scale	Environmental	Soil and groundwater contamination	Negative	4	4	3	**48**	**H**
		Environmental	Stormwater pollution	Negative	4	4	3	**48**	**H**
Transport of Slag	Generation of Dust	Environmental	Air Pollution	Negative	2	2	3	**12**	**L**
		Health	Inhalation leading to respiratory infections	Negative	2	2	3	**12**	**L**
Disposal of Slag waste	Disposal of Slag	Environmental	Depletion of landfill space	Negative	3	3	3	**27**	**M**
		Environmental	Soil and groundwater contamination	Negative	3	3	3	**27**	**M**

3.7.3.2 Mitigation measures

Table 3-12 indicates the re-evaluation of the significant impacts inclusive of controls or mitigation measures.

i. Stormwater, groundwater and soil contamination from Mill scale residue

During the transport of mill scale from ABC Metals to the battery manufacturer's premises, the mill scale would be collected by tipper trucks covered in tarpaulin. The trucks would load the mill scale directly into the raw material bunkers. The raw material bunkers are located in a sheeted building. The area is paved and not located near stormwater drains. Where mill scale consists of fine material, this would be wetted to prevent the generation of dust.

It is thus not expected that mill scale would result in contamination, as it would be contained during transport and stored in bunkers and on concreted areas. Furthermore, the battery manufacturer is located in an industrially zoned area and impact on the natural environment is thus minimal. Table 3-12 indicates that the impact of mill scale spillages can be effectively mitigated.

ii. Air pollution during operation of the Furnace

The battery manufacturing industry operates in accordance with the AEL (Air Emission Licence), issued in terms of the National Environmental Management: Air Quality Act (Act 39 of 2004). Monitoring must be undertaken according to the requirements of an AEL in order to ensure that emissions are within the acceptable limits stipulated by the licencing authority in the AEL. While the use of mill scale does not increase the capacity of the operation, the AEL must be amended to include mill scale as a new raw material.

During the melting process, the fumes are cooled and go through a baghouse with polyester needle felt bags. Provided this abatement equipment works effectively, the impact of fumes can thus be effectively mitigated. Monitoring must be undertaken according to the requirements of an AEL in order to ensure that emissions are within the acceptable limits. Table 3-12 indicates that the impact of fumes can be effectively mitigated.

Table 3-12. Re-rating of significant negative impacts with controls (mill scale recycling)

Activities/ Aspect and Impact	Nature of Impact	Control (mitigation measures)	Risk			Rating	
			Prob	Sev	Det	Value	Category
Spillage of mill scale during storage, handling and transport, resulting in Soil and groundwater contamination.	Neg	• Storage in bunkers, on paved surface and away from stormwater drains • Training on waste procedure provided to employees • SHE toolbox talks on Stormwater drains; waste management. • Collection of mill scale in tarpaulin trucks.	**2**	**4**	**3**	**24**	**L**
Operation of fumes resulting emissions and air pollution	Neg	• Abatement equipment (baghouse and polyester needle felt bags) • Operation in accordance with the AEL. • Monitoring of emissions.	**2**	**4**	**3**	**24**	**L**

3.7.3.3 Positive Impact

Recycling mill scale has a positive impact on the environment. Currently, the bulk of mill scale generated is landfilled. By recycling mill scale, this waste can be diverted away from landfill and in doing so, prevent potential impact on soil and groundwater as well as increase the life of the landfill (Eissa *et al.,* 2015). Additionally, the re-use of mill scale in battery manufacturing contributes to reducing consumption of raw materials, such as iron ore. Recycling of mill scale results in cost savings from the disposal rates as revenue generation from the rebate received from the sale of this waste stream (Grasso *et al.,* 2009). As per Table 3-13, no mitigation measures are required to be applied to a positive impact as these are not required to be lowered (Aucamp, 2009).

Table 3-13. Re-Rating of significant positive impacts with controls (recycling)

Activities/ Aspect and Impact	Nature of Impact	Control (mitigation measures)	Risk			Rating	
			Prob	Sev	Det	Value	Category
Recycling of Mill scale	Pos	Conservation of natural resources (iron ore)	4	3	5	**60**	**H**
		Conservation of landfill space	4	3	5	**60**	**H**

High volumes of mill scale are generated by ABC Metals on a monthly basis. The chemical properties of the mill scale are similar to iron and this makes mill scale a suitable candidate for iron substitution. A potential alternative use for mill scale exists in the battery manufacturing industry. The impact analysis comparing the impacts associated with landfilling and recycling demonstrated that the recycling of mill scale poses a lesser environmental impact as opposed to landfilling. Other advantages include a conservation of natural resources or iron ore as well as financial savings to the generator and recycler.

However, the mill scale cannot simply be provided to a recycler due to the legal requirements associated with the processing or recycling of waste. This process entails an application for a Waste Management Licence amongst other requirements.

3.8 LEGAL FRAMEWORK FOR RECYCLING

When the overall goal of waste management is the Waste Hierarchy, it would be expected that the definition of waste supports waste avoidance, re-use, recycling and recovery. However, it appears that at the onset of promulgating waste legislation, countries prioritise the minimisation of negative environmental impacts associated with waste disposal and only through the trial and error of implementation, does the focus shift towards waste avoidance, resource recovery and cleaner production. It is thus important to note that countries with later promulgated waste legislation lag behind in this rationale (Pongrácz and Pohjola, 2004).

3.8.1 The European Union

The European Union published the Council Directive (75/442/EEC of 15 July 1975) to regulate waste management for its member states. After various amendments, this Directive was codified (organisation of all prior amendments into a new Directive) in 2006 into the Waste Framework Directive (Directive 2006/12/EC). The European Waste Framework Directive (2008/98/EC) was revised again in 2008 (the current version) and came into effect on 12 December 2010 and orientates waste policy to its associated states within the European Union (Corvellec, 2016).

The goal of the European Waste Framework Directive (2008/98/EC) is to unify waste management policies amongst its member states and ensure that the management of waste poses minimal impact on the environment by providing instructions for implementing and enforcing key priorities in accordance with the European environmental policy (Levänen, 2014b).

The definition of waste in the European Waste Framework Directive (2008/98/EC) has been a challenging issue and has thus been numerously brought before the European Court of Justice by various industries since as early as the 1990's (Taljaard, 2012). Chapter 1, Article 3 (1) of the European Waste Framework Directive (2008/98/EC) defines waste as "*any substance or object which the holder discards or intends or is required to discard*" (EU, 2008, p 9).

The definition of waste as per the European Waste Framework Directive (2008/98/EC) is explained in a guideline published by the Directorate General for Environment in the European Commission (DGEEC). The guideline describes waste as any item which is thrown away or transferred to a waste management service provider ("*holder discards*"); is planned for disposal, such as decommissioning and rehabilitation plans ("intends to discard") or under any other provision which requires the disposal of an item in terms of a specific law ("required to discard") (DGEEC, 2012).

The definition of waste led to numerous disputes where criminal prosecutions resulted in a court argument of whether a material constitutes a waste or is exempt (Taljaard, 2012). A pioneer ruling on the definition of waste as per the Council Directive (1975) emanated from the Vessoso and Zanetti case (joined cases C-206/88 and C-207/88 of 28 March 1990) (Voermans *et al.,* 2000). The defendant argued that if a waste has a potential re-use value, it cannot fit the definition of a waste, whether or not the holder intends to dispose of it (Voermans *et al.,* 2000). The European Court of Justice, however, ruled that neither the re-use value of the waste nor the intention of the holder has any bearing on the definition of a waste. Furthermore, the court ruled that member states of the European Union are acting in violation of the European Waste Framework Directive (2008/98/EC) where they exclude any materials from the definition of a waste, simply because it has a potential re-use value (Voermans *et al.,* 2000).

The European Court of Justice upheld its ruling in the Tombesi and Savini case (joined cases C-304/94, C-330/94, C-342/94 and C-224/95 of 25 June 1997). The European Court of Justice stated that the definition of waste includes all waste which the holder disposes, whether or not it has a commercial value and was initially intended for re-use or recycling. In the same year, in the Inter-Environment Wallonie case (Case C-129/96 of 18 December 1997), the European Court of Justice ruled that the term 'to dispose of' in terms of the European Waste Framework Directive (2008/98/EC) encompasses both disposal and recovery and added that using a waste in an industrial process, does not immediately disqualify it from the definition of a waste (Voermans *et al.,* 2000).

The final case providing direction on the European Waste Framework Directive (2008/98/EC) definition of a waste is the ARCO Chemie Nederland Ltd. (hereafter, ARCO) and Dorpsbelang Hees (joined Cases C-418/97 and C-419/97 of 15 June 2000), which raised the question of whether a waste which is subject to the Recovery Act in Annexe II of the WDF, can be excluded from the definition of a waste. The European Court of Justice stated that the definition of a waste must focus on the words "dispose of" and that the impact on the environment must be taken into consideration. Furthermore, even where a waste is subjected to recovery, it must still be regarded as a waste. However, ARCO appealed the court's decision, arguing that when a substance can be recovered in a manner that does not impact on the environment and without any significant treatment, this cannot constitute a waste (Voermans *et al.,* 2000).

These cases, however, still left uncertainty on the definition of waste and as a result, these issues were dealt with on a case by case basis. It is clear that uncertainty existed in the definition of waste in the European Union and the distinction between recovery and when a material ceases to be a waste. This is especially concerning where holders of waste are required to apply for permits under Article 11 of the European Waste Framework Directive (2008/98/EC), where holders are to be subjected or excluded from the definition of a waste.

Subsequent to these cases, the European Waste Framework Directive (2008/98/EC) included the provision for a by-product to distinguish between a waste and a material which had a further use. The intention was to promote the re-use of waste streams, which were previously being challenged by the definition of waste (Levänen, 2014a). Chapter 1, Article 5 (1) of the European Waste Framework Directive (2008/98/EC) defines a by-product as "*a substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste"* (EU, 2008, p 11). The definition further requires states that in order to qualify as a by-product that there must be a certain use for the waste; it must be used in its raw form without any processing or treatment; it must directly form part of a production process; and the reuse thereof, must not incur any negative environmental or health impact (Husgafvel *et al.,* 2016). The inclusion of a by-product in the European Waste Framework Directive (2008/98/EC) thus allowed for industrial wastes which have a further re-use value to be excluded from the definition of a waste and thus not be subjected to permitting requirements (Taljaard, 2012).

3.8.2 Finland

The European Union orientates policies and laws for its member states throughout Europe. Member states must align with the policies of the European Union, which thus provides the European Union with a significant bearing on all European legislation. Finland is a member state of the European Union and is an example of a country well guided by waste legislation in promoting waste efficiency (Levänen, 2014a).

Finland became a member state of the European Union in 1995 and followed suit in aligning the Finnish Waste Act (646/2011) to the European Waste Framework Directive (2008/98/EC). The Finnish Waste Act (646/2011) promotes sustainable development by placing emphasis on cleaner production, waste recycling and use of bio-based resources (Husgafvel *et al.,* 2016). The Finnish Waste Act (646/2011) moved away from the focus on waste prevention and toward the promotion of material efficiency. Industries in particular experience difficulties in practising waste prevention or reduction and often opt for re-use, recycling and recovery opportunities (Lilja, 2009). Additionally, Finland municipalities provide advisory services for implementing the Waste Hierarchy, at no cost to the generator (these costs are recuperated from waste collection fees) (Lilja, 2009).

Waste is defined in Chapter 1, Section 5 (1) of the Finnish Waste Act (646/2011) and is identical to the definition of waste in the European Union Waste Framework Directive (2008/98/EC).

These definitions were based on the view that waste is a potential hazard to the environment and should, therefore, be effectively managed so as not to harm the environment (RF, 2011). Waste was thus not initially prioritised as a reusable or potential resource. Instead, the focus was centred on environmental protection through safe handling and disposal techniques as opposed to promoting resource efficiency through recovery and reuse initiatives (Pongrácz and Pohjola, 2004). An application for a Waste Permit in terms of the Finnish Environmental Protection Act (86/2000) was required for waste recovery, re-use or in excess of 5000 tons (RF, 2000). The application for a waste permit is a costly exercise which requires onerous information such as the characteristics, composition and properties of the waste, the technical background of the process of generation and recovery process, as well as a detailed assessment of the environmental and safety impacts (Mroueh and Wahlström, 2002). Furthermore, such an application takes a minimum of at least four months before the permit is issued. The requirement for a permit, thus largely hindered industries from undertaken waste recovery, re-use or recycling initiatives unless these were clearly lucrative (Mroueh and Wahlström, 2002).

The term by-product was introduced in 2012 in the Finnish Waste Act (646/2011) and allowed for waste which was intended for recovery, re-use or recycling to be exempt from the definition of a waste and was thus not subjected to the relevant waste requirements of the Finnish Waste Act (646/2011). Similar to the European Union Waste Framework Directive (2008/98/EC), a requirement for re-use of the waste is to ensure that it does not pose a negative environmental impact (Mroueh and Wahlström, 2002). The inclusion of the by-product criteria allows industries to consider a further use for their waste streams. If an industry is able to reuse its waste without first treating it or causing negative environmental impacts, the legal status can be changed from a waste to a by-product (Levänon, 2015).

The Finnish Waste Act (646/2011) also included "end of waste criteria" in Chapter 1: Section 5 (4). This allowed for a material to no longer be considered a waste once it has undergone recovery, is used in an alternate process or a market exists for the material. Similar to the requirements of a by-product, the process must not incur any negative impact on the environment (Mroueh and Wahlström, 2002).

3.8.3 United States

The United States of America's Waste Law has been included, also based on the maturity of waste regulation and the high rates of recycling. The United States of America's Resource Conservation and Recovery Act (USA RCRA) (42 USC 6901 of 1976) was published by the US Congress in 1976 to provide a framework for managing non-hazardous (or solid waste) and hazardous waste.

In order to promote recycling, the USA Environmental Protection Agency (EPA) allows for certain wastes to be excluded from the definition of a solid waste or hazardous waste provided they fit into a specified category or meet certain conditions. These exclusions are contained in Title 40: Section 261.4 of the Code of Federal Regulation. Materials that meet the criteria for exclusion are not subjected to the regulations for a solid or hazardous waste (EPA, 2014a). Section 261.4 (a) provides twenty seven categories of materials which are excluded from the definition of solid waste and Section 261.4 (b) provides eighteen categories for the exclusion of certain materials from the definition of a hazardous waste. The generation, recovery and sale of a waste stream would thus not be subjected to regulations of the USA RCRA (42 USC 6901 of 1976) and an application for a permit is not required. The generator of the waste, however, is expected to demonstrate compliance with the conditions listed in Section S261.4 (a) (USA, 1976).

3.8.4 Zambia

Zambia has less progressive waste legislation and focuses on environmental protection and safe disposal (UN, 2010). Zambia does not have a standalone Waste Act to regulate waste management in the country. The Zambian Environmental Management Act (Act No. 12 of 2011) regulates the management of all aspects of the environment and is monitored and enforced by the Zambian Environmental Management Agency. Waste Management is contained in Part IV Division 4 of the Zambian Environmental Management Act (Act No. 12 of 2011) (RZ, 2011). The Zambian Environmental Management Act (Act No. 12 of 2011) defines waste in Part IV: Division 4 as "*garbage, refuse, sludge's and other discarded substances resulting from industrial and commercial operations and domestic of community activities, but does not include wastewater as defined in the definition of "effluent" in Division 2"* (RZ, 2011, p 134).

The Zambian definition of waste strongly focuses on preventing negative impacts on the environment and implies that any substance which is discarded, whether generated in an industry, commercially or in a household is regarded as waste. Emphasis is placed on discarding or throwing away (UN, 2010). While the definition is similar to that of the European Union, unlike the European Union and its member states, no provision is made for exceptions such as by-products or "end of waste criteria". Section 55 of the Zambian Environmental Management Act (Act No. 12 of 2011) requires that a Waste Licence must be obtained before commencing with recovery and recycling initiatives (RZ, 2011).

The Environmental Management (Licencing) Regulations (Zambian Licencing Regulations)(S.I. No 112 of 2013) were published by the Zambian Environmental Management Agency in 2013 as a statutory instrument of the Zambian Environmental Management Act (Act No. 12 of 2011). The Zambian Licencing Regulations (S.I. No 112 of 2013) provided more specific direction to the Waste Licence application process specifically relating to recycling, re-use or recovery of a waste (RZ, 2013). The application requires the submission of an Environmental Impact Assessment which comprises the bulk of the submission (RZ, 2013).

3.8.5 South Africa

NEMWA (Act No. 59 of 2008) is the principal piece of legislation that deals with how waste must be managed in South Africa. NEMWA (Act No. 59 of 2008) was promulgated on 1 July 2009 and is applicable to government departments, state-owned enterprises, private institutions, industries and individuals

(Oelofse and Godfrey, 2008).

The intention of NEMWA (Act No. 59 of 2008) is to manage waste in a sustainable manner and to support sustainable development, as described in the preamble which is the very first paragraph of NEMWA (Act No. 59 of 2008).

The objects in Section 2 of NEMWA (Act No. 59 of 2008) provide the overall intention the Act and waste management in South Africa (RSA, 2008). The objects stated above clearly indicate the goal of the waste hierarchy as the central theme. The objects favour waste avoidance followed by reducing, re-using recycling and least favourably disposal of waste. Pollution prevention and sustainable development are also highlighted (RSA, 2008).

The definition of waste in (Act No. 59 of 2008) was revised in 2014 in NEMWAA (Act No. 26 of 2014). Additionally, this amendment removed the definition of a by-product (RSA, 2014a). The definition of waste is provided in Chapter 1, Section 1(i) of NEMWAA (Act No. 26 of 2014) as "*any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be reused, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act*" (RSA, 2014a, p 4).

The reference to the "*unwanted, rejected, abandoned, discarded or disposed*" and "*whether or not such substance, material or object can be reused, recycled or recovered*" prevents the exclusion of any waste stream from the provisions of NEMWA (Act No. 59 of 2008, p 4). This reference also reiterates the European Court of Justice ruling, that whether a waste is recovered or recycled, has no bearing on the definition of a waste (Voermans *et al.,* 2000). While no clarity has been provided as to why the provision of a by-product was removed in NEMWAA (Act No. 26 of 2014), this decision would have repercussions in terms of the DEA's intent to increase recycling volumes, specifically for recycling of hazardous waste streams (Taljaard, 2012).

After the promulgation of NEMWAA (Act No. 26 of 2014) in July 2014, the DEA published the draft Regulations to Exclude a Waste Stream or a Portion of a Waste Stream from the Definition of Waste (Waste Exclusion Regulations) (GN No. 38210 of 14 November 2014) in November 2014. The regulations would provide an application process to exclude a waste stream from the definition of waste, in which case it would not be subjected to the requirements of NEMWA (Act No. 59 of 2008). However, after 3 years, these regulations are still in draft.

The recycling and recovery of waste material is regulated in Section 17, 18 and Section 19 of NEMWA (Act No. 59 of 2008). In Section 19 of the Act, the minister published a list of waste management activities which include waste recycling and recovery (RSA, 2008). Such activities require either an application for a Waste Management Licence and Environmental Authorisation or compliance to published Standards prescribed by the Department (RSA, 2008).

3.8.5.1. Legal requirements for recycling mill scale in South Africa

According to the definition of a waste, mill scale which is generated by ABC Metals is an "*unwanted*" product and must, therefore, be treated as such "*whether or not such substance, material or object can be re-used, recycled or recovered*" (RSA, 2014a, p 4). Mill scale is thus subject to all waste requirements in terms of NEMWA (Act No. 59 of 2008). The current list of waste management activities are contained in the List of Waste Management Activities that have or are likely to have, a Detrimental Effect on the Environment (Government Notice No. 921 of 29 November 2013, as amended by GN No 332 of 2 May 2014; GN No. R633 of 24 July 2015 and GN No. 1094 of 11 October 2017). Waste Management Activities are divided into 2 categories, Category A and Category B (RSA, 2013c).

Activities in Category A require an application for Environmental Authorisation in terms of a Basic Assessment, while activities in Category B require that a full Scoping and Environmental Impact Assessment process be undertaken. Both Categories include the requirement to apply for a Waste Management Licence (RSA, 2013c). As per Table 3-14, since mill scale is classified as a hazardous waste (due to the hydrocarbon content), recycling mill scale triggers a Category B activity which requires a Scoping and Environmental Impact Assessment and an application for a Waste Management Licence. Furthermore, as per the case study, it is projected that up to 8 tons of mill scale can be recycled per day.

Table 3-14. Waste management listed activities for the recovery of mill scale

Legal Reference	Description	Explanation
Regulations for the List of waste management activities that have or are likely to have, a detrimental effect on the environment. **Government Notice (GN) No. 921 of 29 November 2013:**	Category B: Reuse, Recycling or recovery of waste Activity (2) *"The reuse or recycling of hazardous waste excess of 1 ton per day, excluding reuse or recycling that takes place as an integral part of internal manufacturing within the same premises"* (RSA, 2013c, p 6).	Since it is then established that mill scale is a waste (hazardous), the recycling of this waste stream triggers Category B (2) if it is to be recycled. "Recycle" is defined in NEM:WA (Act No. 59 of 2008) Section 1 (definitions) as *"a process where waste is reclaimed for further use, which process involves the separation of waste form a waste stream for further use and the processing of that separated material as a product or raw material" (RSA, 2008, p 16).* The Mill scale would be used as a fluxing agent during the manufacturing of lead batteries and will thus constitute the term "*recycle*" in the above definition. Furthermore, it is envisaged that 8 tons of mill scale would be used per day. Lastly the recycling of mill scale would be undertaken by an external company and, therefore, it does not form part of ABC's internal manufacturing in processes.

3.8.6 Summary of Legal Requirements

Table 3-18 provides a summary of the legal requirements, specifically focussing on the definition of waste and how this relates to the licencing/ permit requirements for the recycling of mill scale in each country.

Table 3-15. Summary of Legal Requirements

Country / Region	Legal Reference:	Requirements for recycling mill scale	Permit/ Licence Required to recycle Mill scale
The European Union	**The European Waste Framework Directive (2008/98/EC)** Chapter 1, Article 3: Definition of Waste Chapter 1, Article 5: By-products	The inclusion of a by-product in the European Waste Framework Directive (2008/98/EC) allows for industrial wastes which have a further re-use value to be excluded from the definition of a waste and thus not be subjected to permitting requirements (Taljaard, 2012).	**NO**
Finland	**Finnish Waste Act (646/2011)** Chapter 1, Section 5 (1): Definition of waste Chapter 1, Section 5 (2): Definition of a By-Product	The inclusion of the by-product criteria allows industries to consider a further use for their waste streams. If an industry is able to reuse its waste and complies with (1)-(4), the legal status can be changed from a waste to a by-product (Levänon, 2015). The Finnish Waste Act (646/2011) included "end of waste criteria", which allowed for a material to no longer be considered a waste once it has undergone recovery, is used in an alternate process or a market exists for the material. Similar to the requirements of a by-product, the process must not incur any negative effect on the environment (Mroueh and Wahlström, 2002).	**NO**
United States	**United States Waste Resource Conservation and Recovery Act (42 USC 6901 et seq of 1976)** Code of Federal Regulation Section S261.4 (a), category 24: exclusion of a hazardous waste	The Environmental Protection Agency (EPA) allows for certain materials to be excluded from the definition of solid waste or hazardous waste; or alternatively exempting a waste from regulation when it is being recycled (EPA, 2014a). • If the material is directly used as an ingredient in a production process without first being reclaimed, then that material is not a solid waste. • If the material is being directly used as an effective substitute for a commercial product (without first being reclaimed) it is exempt from the definition of a solid waste (EPA, 2014a).	**NO**
Zambia	**The Environmental Management Act (Act No. 12 of 2011)** Part IV, Division 4, Section 53-63: Waste Management Licences	A Waste Licence is required for any activity which involves recycling or recovery. (RZ, 2011). It is clear that health issues are prioritised over environmental issues and this is due to the health epidemics that commonly arise during rainy seasons where unhygienic living areas and overcrowding lead to the spread diseases like cholera. As a result, government spending becomes focussed on combating epidemics and cleaning areas and waste management is not prioritised (UN, 2010).	**YES**
South Africa	**National Environmental Management: Waste Act Amendment (Act No. 26 of 2014)** Section 1 (i):Definition of waste	According to the definition of a waste, mill scale which is generated by ABC Metals is an "*unwanted*" product and must, therefore, be treated as such "*whether or not such substance, material or object can be reused, recycled or recovered"* (RSA, 2014a, p 4). Mill scale is thus subject to all waste requirements in terms of NEMWA (Act No. 59 of 2008) as well as the applicable Regulations, Norms and Standards. A list of all the relevant legal requirements for mill scale as a waste and the recycling of this waste in South Africa are outlined below.	**YES**

3.9 CONCLUSION

Waste legislation from the reviewed countries, apart from South Africa and Zambia, show a progression from the initial focus on preventing waste pollution to a focus on sustainable waste management and cleaner production.

Waste Legislation from the European Union and the United States of America provide less stringent legislation on recycling in order to promote and increase recycling. Waste legislation here allows for waste to be classified as a by-product or exemptions from the waste legal requirements by demonstrating that the particular waste recycling activity does not result in a negative impact on the environment. South Africa, however, has currently removed the allowance for a by-product and recycling initiatives thus require a Waste Management Licence and compliance to waste management regulations in order to recycle waste. Zambia has shown very little to no progression in waste management law, which is due a prioritisation of health issues over environmental issues as a result of health epidemics (UN, 2010). These findings are discussed in detail in Chapter 5.

The following Chapter assesses the public participation forums between the DEA and Industries. The minutes of these meetings were reviewed to identify the recommendation received from industrial role players in terms of recycling issues and whether these have been duly considered by the legislator.

4 ANALYSIS OF THE MINUTES FROM DEA-INDUSTRY WASTE MANAGEMENT FORUMS

4.1 INTRODUCTION

The Department of Environmental Affairs – Industrial Waste Management Forum (DEA-IWMF) commenced at the beginning of 2014 as a point of communication on waste management matters between government and industries. The purpose of this Chapter is to analyse the minutes of the DEA-IWMF in order to identify concerns and recommendations raised by industry and to ascertain whether the DEA provides consideration to these inputs or uses this industrial knowledge in legislation and policy making.

The minutes from the meetings held in 2015 and 2016 are included in the analysis. Although DEA-IWMF meetings are intended to take place on a quarterly basis, only 3 meetings were held in 2015 (February, July and October) and 2 meetings in 2016 (February and August). Only the relevant sections of the minutes, which pertain to waste recycling, recovery and/ or re-use issues, form part of the review. Please note that Box 4-1 to Box 4-9 shown in the sections below are taken verbatim from relevant sections of the minutes and follow an explanation of what was said in the respective meeting. The purpose of including the Boxes is for ease of reference to the minutes.

4.2 MINUTES OF THE DEA-IWMF MEETING ON 13 FEBRUARY 2015
(Reference: DEA-IWMF/004/2014/15)

The first quarterly IWMF meeting of 2015 was held on 13 February 2015. Item 1.4.1 of the minutes as shown in Box 4-1 below, records a discussion on the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014).

As discussed in Chapter 3, the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) was published for public comment 5 months after the promulgation of the NEMWAA (Act No. 26 of 2014) which removed the provision for a by-product and redefined waste (RSA, 2014b). The Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) were also published to satisfy part (b)(iv) of the definition of waste, as redefined in the NEMWAA (Act No. 26 of 2014). The intent of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) was to provide a list of predetermined waste streams which are excluded from the definition of waste or to allow an application process for a waste holder to apply for a certain waste to be excluded from the definition of a waste, by providing a motivation, the intended further use and assessing the impacts of that use (RSA, 2014b). This was required since the provision for a by-product had now been removed from NEMWA (Act No. 59 of 2008) in NEMWAA (Act No. 26 of 2014) and all generated waste was thus subjected to the requirements of NEMWA (Act No. 59 of 2008). Alternatively, Section 74 of NEMWA (Act No. 59 of 2008), as referred to in (b)(iii) of the definition of waste allows for an application for exemption from a provision of the Act and this may be used to apply for an exemption from the definition of a waste.

Item 1.4. of the minutes in Box 4-1 refers to of the DEA-IWMF meeting held on 13 February 2015 and reports that subsequent to the promulgation of NEMWAA (Act No. 26 of 2014) and prior to publication of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) for comment in November 2014, industries had embarked on “Beneficial Use Applications” to deal with waste management activity exemptions. These applications were provided for in Section 9 of the Waste Management and Classification Regulations (GN. No R634 of August 2013) for listing waste management activities which do not require a Waste Management Licence. The intent of the Beneficial Use Application was for an industry to obtain approval to recover, reuse or recycle a waste stream, by demonstrating that this process provided environmental, social and economic benefits with little environmental impact.

However, once the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) was published in November 2014, the DEA indicated at the meeting held in February 2015 that it may or may not proceed with the beneficial use applications which were submitted, but may instead await the finalisation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014). The DEA indicated that a decision would be communicated within 2 weeks of the date of the meeting.

Box 4-1. Item 1.4. from the minutes of the DEA-IWMF meeting held on 13 February 2015

1.4. Matters arising from the minutes (issues not forming part of the agenda items)

1.4.1 With reference to the beneficial use applications that have already been submitted to the Department, regarding whether the applicants should proceed with the application or wait for the finalisation of the Exclusion Regulations, it was concluded that a decision will be taken in two weeks' time and such a decision will be communicated to the affected parties.

In Item 2.1 in Box 4-2 of the minutes of the same meeting, the DEA stated that a high number of comments were received during the commenting period for the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014). The DEA expressed that the review of the comments had resulted in a delay in finalising the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) and that this was now expected to be finalised by 31 March 2015 (i.e. within three and a half months).

Box 4-2. Item 2.1. from the minutes of the DEA-IWMF meeting held on 13 February 2015

2.1. Implementation Guideline for the Amendment Act

Progress report in relation to the development of the Waste Act Implementation Guideline:

- *A huge number of comments and inputs on the Exclusion Regulations were received and this might delay the finalisation of these regulations – which were expected to be finalised by the end of the current financial year (31 March 2015).*

Box 4-3 refers to Item 3.2., also of same the meeting. The DEA reiterated that while the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) are expected to be finalised by 31 March 2015, there may be further delays as the list of excluded wastes has not yet been published for public comment.

Box 4-3. Item 3.2. from the minutes of the DEA-IWMF meeting held on 13 February 2015

3.2. Waste Exclusion Regulations

- *Feedback was provided on the Exclusion Regulations.*
- *The Regulations were published for public comment on the 14th of November 2014.*
- *The List (of waste streams to be excluded) was however not published with the Regulations. It will be published separately for comment, following internal consultations with the Legal Reform Chief Directorate.*
- *Public comments have been received and DEA is currently assessing or reviewing and responding to the issues raised or inputs provided.*
- *The expected date for the finalisation of the Regulations is 31 March 2015. However, due to a large number of comments received and the fact that the List is not yet published, there is a high possibility that the deadline will not be met.*

4.3 MINUTES OF THE DEA-IWMF MEETING ON 09 JULY 2015

(Reference: DEA-IWMF/002/2015/16)

Item 3.2. of the Minutes as shown in Box 4-4, of the DEA-IWMF of 9 July 2015 report an update on the progress made on the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) since the last meeting, 5 months prior. Note that the deadline for finalising the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) by 31 March 2015 had not been met.

The DEA official advised that a response document had been drafted for all comments received on the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) and that this was undergoing an internal review. The DEA also identified its own shortcomings in the draft regulations. One of the shortcomings related to the draft checklist of information required as part of the application for exclusion which was not comprehensive enough to make an informed decision. Furthermore, the DEA reported that some of the shortcomings and related challenges would require a legal opinion and that this process is likely to further delay the finalisation of the regulations. The following questions were raised by members of the forum in response to these statements made by the DEA official:

4.3.1 Review of Question 1

An attendee of the meeting (industrial role player) requested clarity on whether the list of predetermined waste streams which are excluded from the definition of waste (and which should have been published with draft the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014), has been reviewed as yet. The attendee further questioned whether this list of waste streams forms part of the challenges described by the DEA official.

The DEA official did not address this question in its entirety. Either the DEA representative did not correctly hear or understand the question, or the minutes were incorrectly recorded. The DEA official referred to Schedule 3 of NEMWAA (Act No. 26 of 2014) which contains pre-classified hazardous (Category A) and general (Category B) waste streams. The DEA official stated that the Schedule 3 list was included in the legal review process and that this list of waste streams would be dealt with in terms of Section 4 of the National Environmental Management Laws Amendment Act (Act No. 25 of 2014) which allows for an application for exemption from a provision of the National Environmental Management Act (Act 107 of 1998), however, except for environmental authorisations. This implies that no exclusion or exemption is permissible for waste listed in Category A and Category B of the Schedule 3 of the NEMWAA (Act No. 26 of 2014). While this does provide direction on pre-classified waste streams, it does not address the question that was posed with regard to the draft list of predetermined waste streams which were to be published with the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014).

4.3.2 Review of Question 2

The second question related to whether the DEA enforcement and compliance department were aware that the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) are currently under a legal review and questioned how this would impact on compliance notices and directives which have already been issued in this regard. While no information is provided detailing the specific compliance issue, it is likely that the industry had undertaken recovery or recycling of its waste stream without applying for a Waste Management Licence. The likely motivation for doing this may either have been that the organisation believed the waste was, in fact, a by-product under NEMWA (Act No. 59 of 2008); or undertook a Beneficial Use Application; or that it would await the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) in terms of NEMWAA (Act No. 26 of 2014).

The DEA responded that each case would be dealt with on an individual basis, according to the facts presented and the relevant legal requirements. The DEA advised that it would consult the compliance enforcement department on this issue and provide feedback at the next forum. The DEA further advised that the Department of Water and Sanitation would be invited to the next meeting as they play a role in waste licencing**.**

Box 4-4. Item 3.2. from the minutes of the IWMF meeting held on 9 July 2015

3.2. Waste Exclusion Regulations

DEA Comment

DEA would like to extend gratitude to the Forum members for the comments provided. A lot comments were received and were considered. A Comment and Response Document has been drafted for internal consultation. A number of unintended consequences, mainly due to rushing the processes, were identified with regard to this document, which came to our attention after publishing the document for comment. These included:

- *The modified checklist which was sent out with the draft regulation, which limited the amount of information that could be provided.*
- *Some of the challenges encountered would require the document to be subjected to legal review in order to get some legal opinion and guidance and way forward – this is a process that could be lengthy. Nevertheless, problems need to be resolved before further progress on the document could be realised.*

<u>Questions from the IWMF members:</u>

Question 1*: *Do these challenges also include the list of waste to be excluded?

DEA Answer: *The pre-classified list is part of this legal review process. Schedule 3 issues will be dealt with as part of NEMLA 4 Amendments, which takes into consideration the issues industry raised through the comments that have been submitted.*

***Question 2*:** *Have these issues or challenges been raised and discussed with the Compliance and Enforcement, while a legal review process is still being considered and how will non-compliance issues be dealt with?*

***DEA Answer*:** *The law still needs to be complied with and there is no guarantee that those that fail to abide by the law will not be prosecuted. However, each case will be dealt with in its merit and the merit of each case will determine what sort of recourse that needs to be undertaken. This matter will be taken to DEA Compliance Enforcement Forum for deliberation and the outcome of this will be reported at the next DEA-Industry Waste Management Forum meeting. There was also a request that the Department of Water and Sanitation be invited at the DEA Compliance Enforcement meeting since they play a role in relation to this matter, particularly the licencing part.*

4.4 MINUTES OF THE DEA-IWMF MEETING ON 21 OCTOBER 2015

(Reference: DEA-IWMF/003/2015/16)

Box 4-5 reflects Item 3.1. of the Minutes of the DEA-IWMF of 21 October 2015. The DEA reiterates what was said in the previous DEA-IWMF meeting, that a large number of comments were received on the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) and that this has now resulted in substantial changes. For this reason, the DEA advised that the regulations would be published for public comment again.

The DEA also provided waste streams which had been excluded from the definition of waste, including fly ash, gypsum (only from pulp, paper and cardboard production) and biomass. The DEA advised that a presentation on the draft regulations would be circulated to forum members.

Box 4-5. Item 3.1. from the minutes of the IWMF meeting held on 21 October 2015

3.1. Waste Exclusion Regulations

- *The first draft regulations were published on the 14th of November 2014 and DEA received lots of comments which necessitated the draft regulations to be amended drastically.*

- *Hence the draft regulations are very different from the once published. These regulations still need to be published because of substantial changes.*
- *The following waste streams are excluded from the definition of waste slag from ferrochrome metallurgy*
    - *Ash from combustion plants*
    - *Gypsum from pulp, paper and cardboard production and processing*
    - *Biomass (bark, offcuts, sawdust) from pulp, paper and cardboard production and processing.*

Action:

Secretariat to circulate the draft regulations presentations to the forum members.

4.5 MINUTES OF THE DEA-IWMF MEETING ON 16 FEBRUARY 2016
(Reference: DEA-IWMF/004/2015/16)

Box 4-6 outlines item 1.4 from the minutes of the meeting held on 16 February 2016. The DEA advised that it had not yet consulted with its enforcement and compliance department regarding the compliance notices and directives which were issued relating to waste licencing and the Exclusion Regulations (GN No. 38210 of 14 November 2014). The DEA also stated that it would invite the Department of Water and Sanitation to the next meeting as they are involved in waste licencing.

Note that this was raised by forum members at the meeting held on 9 July 2015 and no action had since been taken up to February 2016.

Box 4-6. Item 1.4. from the minutes of the IWMF meeting held on 16 February 2016

1.4. Matters (Follow-up actions) arising from the minutes of the meeting of the 21st of October 2015

- *DEA to discuss compliance issues on the Waste Exclusion Regulations at the next Compliance Enforcement Forum meeting and also to invite Department of Water Affairs to attend the next Compliance Enforcement meeting: discussion not done and feedback will be given in the next Forum meeting.*

Item 3.7 of the minutes of the same meeting, reports that the DEA introduced the Recycling Enterprise Development Programme. This programme was developed and funded by the DEA as an intervention to increase recycling in South Africa and stating that this initiative would create employment. The programme would support two recycling enterprises per province and host national waste management awareness and educational workshops, provide guidelines and funding to prospective persons involved in waste management.

Box 4-7. Item 3.7. from the minutes of the IWMF meeting held on 16 February 2016

> ***3.7. Recycling Enterprise Development Programme (REDP)***
>
> - *Why establish new recycling companies?*
> - *90% of waste generated end up in landfill sites.*
> - *The regulatory framework requires us to apply vigilantly the waste management hierarchy.*
> - *Government intention is to create as many jobs as possible in the recycling economy.*
> - *The intention of REDP is to identify, support and promote enterprises in the waste recycling space (two per province); it's a joint initiative of the National government and provinces.*
>
> - *Future actions include:*
>   - *Coordinating national workshops*
>   - *Finalising provincial concepts documents*
>   - *Establishment of the project steering committee.*
>   - *Further engagement with project sponsors and potential funders.*
>   - *Developing and submitting funding proposals*
>   - *To host national waste public awareness and educational session*
>   - *Solicit proposal from interested individuals and companies*
>   - *Identification and engagement with initial candidates.*

Item 5.1 of the minutes of the same meeting relate to the Environmental Performance Assessment for waste management in South Africa. Importantly and relevant to this minor dissertation, the DEA identified the disposal of recyclable material as a challenge.

Box 4-8. Item 5.1. from the minutes of the IWMF meeting held on 16 February 2016

> ***5.1 Environmental Performance Assessment***
>
> - *Industry support sub directorate function is to assist industry in implementing and complying with Waste policies and legislation.*
> - *Support mechanisms include training/workshops, forums and environmental performance assessments.*
> - *The forum mandate is to create a conducive platform for dialogue between industry and government and this will improve compliance with the Waste Act.*
> - *Environmental Performance Assessments Objectives:*
>   - *The focus is on waste management*
>   - *Site visit and audits conducted.*
>   - *Identify waste management challenges and best practice at a company level*
>   - *Improve compliance with Waste Act.*

- *Common challenges associated with Environmental Performance Assessments:*
    - *Lack of trust on the assessment.*
    - *Lack of understanding of Waste classification regulations.*
    - *Non-functional monitoring committees*
    - *Waste manifest documents not readily available.*
    - *Disposal of recyclable material*
    - *Noncompliance with waste storage norms and standards.*

4.6 MINUTES OF THE DEA-IWMF MEETING ON 11 AUGUST 2016

Reference: DEA-IWMF/002/2015/16

Only two DEA-IWMF meetings were held in 2016. The second and last was hosted on 11 August 2016. Item 1.4 of the minutes reported that the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014), together with Schedule 3 of NEMWAA (Act No. 26 of 2014) had been submitted for approval by the minister. The DEA also confirmed the four wastes (ash, gypsum, biomass and slag) which had been identified in the list for waste excluded from the definition of a waste. Note that the list of predetermined waste to be excluded from the definition of waste had still not been published for public comment.

Box 4-9. Item 1.4. from the minutes of the IWMF meeting held on 11 August 2016

1.4 Matters (Follow-up actions) arising from the minutes of the meeting of the 16th of February 2016

- *Draft Exclusions Regulations and Schedule 3 – the draft regulations has been sent for minister approval.*
- *Four waste streams have been identified on the Exclusion Regulations for exclusion, namely; Ash, Gypsum, Biomass and Slag.*

4.7 SUMMARY OF THE DEA-IWMF MEETING FROM 2015-2016

Table 4-1 serves to track the actions and summaries the progress of the issues raised in the DEA-IWMF meeting the over a 2 year period (2015-2016). This allows for ease of interpreting the successes and failures of the DEA-IWMF meetings which are discussed in Chapter 5.

Table 4-1. Summary of the minutes from the five DEA-IWMF meetings

13 February 2015	9 July 2015	21 October 2015	16 February 2017	11 August 2016
Beneficial use applications:				
• DEA will provide feedback to all affected persons that have applied for a beneficial use application and advise whether these applications will continue being considered for approval or whether the applicants should apply in terms of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014).	No feedback provided on the applications submitted for beneficial use.	No feedback provided on the applications submitted for beneficial use.	No feedback provided on the applications submitted for beneficial use.	No feedback provided on the applications submitted for beneficial use.
Waste Exclusion Regulations (GN No. 38210 of 14 November 2014)				
• Expected date for publishing the final Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) are 31 March 2015. • The list of waste streams to be excluded will be published for comment, however, the date was not confirmed.	• Expected date for publishing the final Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) on 31 March 2015 was not met. No new date is set for the finalisation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014). • Comments have been responded to and a draft response document is being reviewed internally. • Challenges from the draft regulations include the draft checklist of information required to be insufficient for collecting adequate information to make an informed decision.	• No expected date for publishing the final Waste Exclusion Regulations. • Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) will be published again for public comment and a presentation on the draft regulations will be circulated. • DEA advised that certain waste streams are already included in the list for exclusion from the definition of a waste.	No update on the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014).	• The Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) and list of waste to be excluded have been submitted to the minister of the DEA for approval. • Four waste streams have been included in the list of waste streams excluded from the definition of waste.
Enforcement and Compliance				
N/A	• Compliance notices and directives that have been issued in spite of the finalisation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) will be dealt with on a case to case basis and will take into consideration the relevant facts and the legal requirements. • DEA will consult with the enforcement and compliance and provide feedback at next meeting. • The DEA will also invite the Department of Water and Sanitation to next meeting as they are involved in waste licencing.	• The DEA has not consulted the enforcement and compliance department as yet. • The DEA has not yet invited the Department of Water and Sanitation to attend the DEA-IWMF meeting.	• No feedback on consultation with the Enforcement and Compliance Department. • No feedback on whether the DEA invited the Department of Water and Sanitation to next meeting.	• No feedback on consultation with the Enforcement and Compliance Department. • No feedback on whether the DEA invited the Department of Water and Sanitation to next meeting.
Recycling Enterprise Development Programme				
N/A	N/A	N/A	• The Recycling Enterprise Development Programme was created to increase recycling in South Africa and will support two recycling enterprises per province • The programme would host waste management educational workshops, guidelines and funding to prospective waste management companies.	• National Concept document on Recycling Economy has been developed. • Request for waste management proposal was published. • 185 interested parties applied for the programme. • Proposals were mainly on waste collection and recycling and waste to energy projects.

4.8 CONCLUSIONS

Communication between the legislator and industrial stakeholders is important for shared learning, a wider participation and informed decision making into the drafting of waste legislation (Levänen, 2014a). The DEA hosts quarterly forums to facilitate the interaction between government and industries and to provide an opportunity to industries to raise queries and suggestions into industrial waste management in South Africa. The minutes of these meetings were reviewed over a 2 year period, to determine whether it has served as an effective channel for industries to participate in the drafting of South African waste legislation. The specific findings and outcomes of these meetings as reviewed in this Chapter are discussed in Section 5.1.3.

5 DISCUSSION AND CONCLUSIONS

5.1 INTRODUCTION

The purpose of this Chapter is to discuss the findings of the research in relation to meeting the objectives which were outlined in Chapter 1. In line with the first objective, the results of the case study were provided in Chapter 3 and discussed in terms of the generation and characteristics of mill scale as well as the suitability and impacts of using mill scale in alternative industrial processes. The results relating to the second objective was also discussed in Chapter 3 and involved a review of the legal requirements attached to the recycling of mill scale internationally and locally South Africa. Lastly, the results for meeting the third objective which was presented in Chapter 4 assessed using the minutes of the DEA-IWMF's meetings to determine the level of inclusion of public input and opinion into the drafting of waste legislation.

5.2 KEY FINDINGS

5.2.1 Objective 1: Assessment of Trends in Mill Scale Waste Management

The case study presented in Chapter 3, reviewed the generation and management of mill scale generated at ABC Metals. The review included the composition, characteristics, volumes of mill scale produced and the existing waste management practices. Additionally, a comparison of the impacts associated with the disposal versus recycling (in battery manufacturing) of mill scale was undertaken by means of an environmental impact analysis.

The chemical and physical properties of mill scale presented in Section 3.3, indicates that mill scale is very similar in nature to iron, containing over 60% iron and including trace metals such as chromium, copper and nickel. The chemical properties such as boiling and melting points, specific gravity and solubility are also similar, indicating that mill scale is a suitable substitute for iron as a raw material in industrial processes (Sarna, 2014). ABC Metals generates approximately 425 tons of mill scale per month, which is disposed of at the Rietfontein landfill and costs ABC metals around R 942 000.00 per annum. The environmental impact analysis in Section 3.7 compared the impacts of landfilling mill scale (current practice) with the impacts of recycling mill scale in battery manufacturing (potential process). During recycling, mill scale would be used in its existing form by adding it directly to the furnace to serve as a fluxing agent. Since ABC Metals and the battery manufacturer are existing operations and located in an industrially zoned area, no operational, process or infrastructure changes are required at both plants.

The results of the environmental impact analysis for the disposal of mill scale showed that the depletion of landfill space is the most significant adverse impact since the Rietfontein landfill has a life expectancy of only 17 years and accepts approximately 950 tons of waste per day (Giannakopoulos, 2013).
Additionally, the results indicated that mill scale contains a considerable amount of hydrocarbons and land pollution may result from soil contaminated with oil. No positive impacts result from landfilling. In terms of recycling mill scale at a battery manufacturer, the results demonstrate that no significant

negative impacts exist once controls are considered. Although the spillage of mill scale and contamination of soil and water is a potentially significant negative impact due to the hazardous nature of mill scale, this impact can be effectively mitigated through proper storage on an impermeable surface and transport in closed waste receptacles. Two positive environmental impacts result from recycling of mill scale at a battery manufacturer, the conservation of natural resources (iron ore) and the conservation of landfill space at the Rietfontein landfill.

The purpose of the impact analysis was to determine whether the recycling of mill scale poses any adverse impacts on the environment. Where legislation makes provision for a by-product (which would allow for the exemption of mill scale from the requirements of a waste on account of its further use), this is only possible provided that no negative environmental impacts result from the process of recycling (EU, 2008). Furthermore, waste recycling should prevent pollution and increase resource conservation (Husgafvel *et al.,* 2016). According to the environmental impact analysis, the recycling of mill scale in battery manufacturer provides both environmental and economic rewards as opposed to disposal.

5.2.2 Objective 2: Review Legislation Governing Recycling of Mill Scale

The progression on the definition of waste was reviewed in the European Union Waste Framework Directive (2008/ 98/ EC), the Finnish Waste Act (646/2011), the United States Resource Conservation and Recovery Act (42 USC 6901 et seq of 1976), the Zambian Environmental Management Act (Act No. 12 of 2011) and NEMWA (Act No. 59 of 2008), as discussed in Chapter 3. From these pieces of waste legislation, it is clear that initially, the definition of waste focused on the prevention of pollution (Pongrácz and Pohjola, 2004).

The initial definition of waste from the European Union led to a number of court proceedings throughout Europe, where industries began to challenge the requirement to obtain a Waste Permit to undertake activities relating to recovery, recycling and re-use (Voermans, *et al.,* 2000). The mandate of the European Court of Justice was to hand down a ruling based on a legal interpretation or in other words, a direct interpretation of the definition of waste. The court ruled that whether a waste is intended to be discarded, reused or recovered would have no bearing on the definition. It thus became largely conceded that the definition of waste presented a hindrance to industries wanting to undertake recycling, recovery or re-use of industrial waste streams (Voermans, *et al.,* 2000).

In 2008, the European Union revised the Waste Framework Directive (2008/ 98/ EC) and introduced the terms “by-products”. This allowed for industries to apply for waste to be a by-product (and exempted from being a waste) by demonstrating its further value and explaining the re-use or recycling process, whilst ensuring that this does not harm the environment (Levänen, 2014a).

The provision for a by-product in waste legislation allows for the regulation of residual material generated from a manufacturing process, without this simply being regarded and treated as waste (Levänen, 2014a). Member states of the European Union followed suit in revising their waste legislation. Finland is an example of a country with well-written waste legislation and this is evident in the increase in material and energy recovery. Finland disposed of almost 1.5 m tons per year of waste in 2003 and by 2015 waste disposal dropped to 300 000 tons (due to recovery), even though the amount of waste generated had steadily increased over this period (RF, 2017). Likewise, the United States of America has advanced waste regulation and associated high rates of recycling. Waste recovery and recycling figures published by the USA Environmental Protection Agency (EPA) reported that the United States of America generated approximately 258 m tons of waste in 2014, of which 35% was recycled and energy was recovered from 12% of the total volume generated (EPA, 2014b).

On the other hand, legislation from countries with lower rates of recycling and recovery such as South Africa and Zambia have less progressive and a controlling-type waste legislation which focuses on environmental protection, pollution prevention and safe disposal. Very little information exists on recycling statistics in Zambia. Statistics from 2010 indicate that Zambia only recycled about 6% of the total waste generated (UN, 2010). South Africa reportedly only recycles about 10% of the total volume of waste generated (DEA, 2012).

When the DEA published NEMWA (Act 59 of 2008) in July 2009, the term “by-product” was included in the Act. However, the NEMWAA (Act No. 26 of 2014) published in June 2014, provided a new definition of waste and removed the provision for a by-product (RSA, 2014a). Instead, the DEA proposed to publish the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) which would provide a list of predetermined waste streams which are excluded from the definition of a waste or alternatively provide an application process for industries to apply for certain waste stream to be excluded from the definition of waste (RSA, 2014b). These Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) have been in draft for the past 3 years and in the interim, all waste is subjected to the requirements of NEMWA (Act 59 of 2008) with no exclusions or exemptions. Mill scale is thus subject to all waste requirements in terms of NEMWA (Act No. 59 of 2008) as well as the applicable Regulations, Norms and Standards.

As the waste legislation currently stands in South Africa, the recycling of mill scale in battery manufacturing would require the battery manufacturer (the recycler or waste manager) to obtain a Waste Management Licence before it can receive and recycle mill scale from ABC Metals (RSA, 2008). The resistance from the battery manufacturer to obtain a Waste Management Licence is twofold. Firstly, since the mill scale would be used as a raw material and is not considered as a waste, the battery manufacturer does not identify itself a waste manager and, therefore, does not believe a Waste Management Licence is fitting for their type of operation and associated manufacturing activities. Furthermore, the battery manufacturer is not obliged to use mill scale and can continue operating optimally without mill scale.

Secondly, appointing an external consultant to undertake an Environmental Impact Assessment and Waste Management Licence application carries a high time and costs expenditure. Since the battery manufacturer is thus not in possession of a valid Waste Management Licence for recycling, ABC Metals is, therefore, required to dispose mill scale at a licenced landfill in order to remain compliant (RSA, 2008).

5.2.3 Objective 3: Assessment of Minutes from Public Participation Forums

A regular forum between the legislator or authority and industrial stakeholders is an important channel for collective learning, a broader participation and more informed decision making into the drafting of waste legislation. Waste legislation should largely be centred on the experience and continual improvements of industries. Optimally, these forums should provide a correlation between the operational environment of industries and the lawmakers (Levänen, 2014a). A review of minutes from the DEA-IWMF meetings in Chapter 4 only included the items relevant to waste recycling, recovery and reuse matters in an industry. These included:

- Beneficial Use Applications;
- Enforcement and compliance;
- Waste Exclusion Regulations (GN No. 38210 of 14 November 2014); and
- Recycling Enterprise Development Programme.

5.2.3.1. Beneficial use applications

The purpose of the Beneficial Use Applications was to allow for a waste holder to obtain an exemption from the requirement of a Waste Management Licence to recover, reuse or recycle a waste stream, by demonstrating that this process provided environmental, social and economic benefits with little to no negative environmental impact. Many industries had submitted beneficial use applications to the DEA subsequent to the removal of a “by-product” in NEMWAA (Act No. 26 of 2014). In the meeting held on 9 February 2015, concern was raised by industries that had submitted Beneficial Use Applications and whether these applications would still proceed for approval. The DEA advised that it would provide feedback to all affected persons that have applied for a Beneficial Use Applications and advise whether these applications would continue being considered for approval or whether the applicants should apply in terms of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014).

No further feedback was provided by the DEA on the Beneficial Use Applications and no approvals were granted to those industries who had applied. The DEA now requests industries to apply in terms of Section 9 of the Waste Management and Classification Regulations (GN No. R634 of 23 August 2013) for listed waste management activities which do not require a Waste Management Licence yet informs the applicant that an approval of the application would be as a result of the pending finalisation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) (RSA, 2013a). The analysis of the DEA-IWMF forums indicated that these forums do not assist industries in waste legal issues and concerns that have been raised.

Organisations that undertook Beneficial Use Applications, as guided by the DEA also did not receive further feedback or support from the DEA and were advised to await the promulgation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014).

5.2.3.2. Enforcement and compliance

A concern was raised by an industrial role-player at the DEA-IWMF meeting held in July 2015, regarding the fate of compliance notices and directives issued for waste activities requiring a Waste Management Licence. Compliance notices and Directives were being issued after the provision for a by-product was removed, to those industries that were selling or exchanging waste without a Waste Management Licence. The DEA advised that each case would be dealt with according to its merits and the applicable legal requirements. The DEA also stated that it would consult the compliance enforcement department and provide feedback at the next forum. No feedback was provided on how industries should handle enforcement and compliance issues during the transitional period of the promulgation of NEMWAA (Act No. 26 of 2014). The removal of a by-product from NEMWA (Act No. 59 of 2008) in NEMWAA (Act No. 14 of 2014) left many industries unaware of their legal requirements for the recycling of residual wastes. Although this was referenced in the DEA-IWMF meetings over a two year period, no progress was made or direction provided to those industries who had received directives.

5.2.3.3. Waste Exclusion Regulations (GN No. 38210 of 14 November 2014)

The Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) is an important piece of legislation that deals with exclusions of certain waste stream from the requirements of NEMWA (Act No. 59 of 2008) and was published in November 2014, five months after the removal of a by-product in NEMWAA (Act No. 26 of 2014). At the DEA-IWMF meeting held in February 2015, the DEA advised the attendees that many comments were received during the commenting period and that this had delayed in finalisation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) which were expected to be finalised by 31 March 2015. This deadline was not met. At the DEA-IWMF meeting held on 9 July 2015, the DEA advised that a response document on comments received was under internal review, together with additional challenges identified by the department. The DEA also stated that a legal review was required for the challenges identified and comments reviewed and that the legal review would include the list of pre- waste streams in Schedule 3 of the NEMWAA (Act No. 26 of 2014). In the subsequent DEA-IWMF meeting held in October 2015, the DEA provided the list of 4 waste streams which had been included in the list of wastes to be excluded from the definition of waste, however, reiterated that the finalisation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) was delayed. In August 2015, the DEA reported that the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014), together with Schedule 3 of NEMWAA (Act No. 26 of 2014) had been submitted for approval by the minister. The DEA also confirmed the four wastes which had been identified in the list for waste excluded from the definition of a waste.

The second draft of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) was only published for comment on 2 June 2017 and now includes a specific list of waste streams excluded from the definition of waste. The list includes waste streams related to the construction, agriculture and rail industry (RSA, 2017).

Since these regulations have not been finalised since 2014 and no material can be excluded from the definition of a waste, this has largely hindered industries from participating in waste recovery, recycling or exchange programmes for the past 3 years. The Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) should have ideally been published together with NEMWAA (Act No. 26 of 2014), in order to provide for the removal of a by-product. However, 3 years have now passed and industries continue to dispose of industrial waste while awaiting the finalisation of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014). Thereafter, it is uncertain whether the requirements set out in the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) will promote or create additional barriers to industrial waste recycling. The DEA-IWMF meetings are thus not a useful tool in providing industries with an opportunity to provide input and first-hand experience into waste legislation.

5.2.3.4. Recycling Enterprise Development Programme

The DEA introduced the Recycling Enterprise Development Programme at the DEA-IWMF meeting held on 16 February 2016. The purpose of the programme was to increase recycling in South Africa, which was stated to be only 10% of the total waste generated (DEA, 2011). The programme included the funding of two recycling enterprises per province and undertaking national waste management awareness and training campaigns workshops. It is clear that government recognises the low levels of recycling in South Africa. However, the Recycling Enterprise Development Programme is a more reactive approach than proactive to improving waste management in South Africa. The DEA swiftly implemented the Recycling Enterprise Development Programme as indicated in the meeting held in August 2015, in which much progress had been made.

The DEA has developed numerous campaigns, programmes and provided funding for recycling and other waste management initiatives and cooperatives throughout South Africa. The Recycling Enterprise Development Programme is one of the many programmes implemented by the DEA to increase recycling. As mentioned, there are two ways a governing authority enforces the Waste Hierarchy. Firstly by programmes such as the Recycling Enterprise Development Programme, waste exchange, funding cooperatives and informal waste recyclers, training and awareness (Taljaard, 2012). South Africa is certainly not short of these initiatives which have increased steadily since the promulgation of NEMWA (Act No. 59 of 2008) in 2009. However, these programmes mainly focus on the non-industrial sectors, especially informal recyclers and the recycling of mainline recyclable waste such as glass, paper, plastics and organic waste. The DEA did, however, in conjunction with the Council for Scientific and Industrial Research implement the Waste Exchange Programme to find alternative uses for industrial waste and facilitate the exchange of these wastes between industries.
However, the Waste Exchange Programme does not exempt an industry from the requirement to obtain a Waste Management Licence before a waste can be recycled, recovered or reused in another industry (DEA, 2005).

It is clear from this research that legislation hinders recycling in South African industries. Industries are proactive in finding alternative uses for their waste streams and do not necessarily require government assistance in this regard. It is, in fact, the legal requirements for waste recycling that is largely hindering recycling from taking place within and across industries.

5.3 RECOMMENDATIONS FOR FURTHER RESEARCH

5.3.1 The effectiveness of the Waste Exclusion Regulations in improving recycling in South African Industries

- Once the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) are published, the success of these regulations should be evaluated against its effect on improving recycling of industrial waste.

5.3.2 An Assessment of Whether Input Received during the Public Commenting Periods are Taken into Consideration during the Drafting of and Promulgation of South African Waste Legislation

- Public comments received during the commenting period of the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) should be reviewed to verify whether or not this is an effective public participation tool.
- This can be achieved by requesting the summary of comments on the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) from the DEA and reviewing the response from DEA and its legal team. The Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) should then be compared to the final Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) to determine whether these issues were considered.
-

5.3.3 Update of Waste Statistics in South Africa

- The latest available document of waste statistics in South Africa is dated 2011. Six years have passed and no update of waste statistics has been developed. It is recommended that further research is undertaken to update waste statistics in South Africa.
- The DEA developed South African Waste Information System for online reporting and this serves as a valuable source of information for providing waste statistics on disposal and recycling volumes.

5.3.4 The Effectiveness of Government Initiatives, Programmes and Funding to Improving Waste Recycling

- This minor dissertation focussed on the effect of waste legislation on recycling in an industry, however, the DEA also implements programmes and provides funding for waste management initiatives to improve waste management in South Africa.
- It is recommended that further research is done to determine the success of such programmes in improving waste recycling in South Africa.

5.4 CONCLUSIONS

The industrial sector generates approximately 20% of the global waste output and is thus a significant contributor to a country achieving the goal of zero waste to landfill (Song and Zeng, 2015). In South Africa, industries are the major source of hazardous and unknown waste, however, only 4% of the industrial waste generated is recycled (DEA, 2011).

The South African Iron and Steel industry generates mainly poisonous, toxic and infectious substances including waste such as slags, sludges, foundry sand, dust and mill scale. Mill scale waste is generated during the heat treatment of steel and has a high re-use potential as it consists mainly of iron. However, a backlog of 15000 tons of mill scale was reported in South Africa (GDACE, 2007). ABC Metals is an Iron and Steel industry located in Johannesburg that generates high volumes of mill scale (Gaballa *et al.,* 2013). Although alternative uses of mill scale do exist in South Africa, few of these have been found to be legally compliant with the requirement of NEMWA (Act No. 59 of 2008). As a result, larger industries, such as ABC Metals opt for waste disposal (as opposed to recycling) of mill scale in order to remain legally compliant.

The DEA enforces waste management through legislation and through programmes providing incentives to encourage sustainable waste management (Taljaard, 2012). The programmes have not proved to be a useful approach for increasing recycling in industries. The Waste Exchange Programme, for example, was a DEA initiative implemented by Council for Scientific and Industrial Research to identify industrial waste streams which had further use and then encourage the exchange of these wastes between industries (DEA, 2005). The Waste Exchange Programme did not, however, take into consideration the legal requirements for recycling waste and the requirement of a Waste Management Licence which was the main hindering factor to recycling in industries. Industries do not necessarily require assistance in finding alternative uses for their waste streams, as this is usually done internally by engineers and technicians. ABC Metals found an alternative use for mill scale which could be used in battery manufacturing, however, this transaction is hindered by waste legal requirements.

For industries, the legal requirements attached to waste management largely influences the volumes and types of waste recycled. While the intent of waste regulation is to encourage recycling of waste, it can unintentionally create a barrier (Gibbs and Deutz, 2007). In South Africa waste management, especially industrial waste, is subject to onerous application and regulations that include record keeping of waste from cradle to grave, ensuring that only permitted or licenced waste management facilities are used and ensuring that an organisation's on-site waste management operates within the ambit of a Waste Management Licence or prescribed regulation (Taljaard, 2012). These processes present high costs which are not feasible for many industries (Levänen, 2014b).

The drafting of legislation should thus take into account the experience and needs of the industry during decision making. Countries with higher rates of recycling allow for flexible waste legislation which promotes zero waste to landfill through waste recycling and exchange programmes. Legislation in these countries has largely been based on negotiations with businesses and industries (Levänen, 2014b). By contrast, South African waste legislation can be described as a controlling-type regulation which can obstruct opportunities to recycle waste streams due to time and money costs associated with obtaining the requisite recycling permits (Park, 2014). Based on the waste legislation history and framework in the United States of America and the European Union, the provision of a by-product was an important advancement in waste legislation that encouraged industrial waste recycling. A by-product in legislation allows for industrial wastes generated during the manufacturing a primary product which can be re-used or recycled in an alternate process, to be excluded from the definition of a waste and not to comply with the licencing requirements (Taljaard, 2012).

South Africa published its first piece of waste legislation in 2009, NEMWA (Act No. 59 of 2008) which closely resembled the European Waste Framework Directive (2008/98/EC), with a similar definition of waste and a by-product. It is unclear why by-product was later removed from NEMWA (Act No. 59 of 2008) in the NEMWAA (Act No. 26 of 2014) published in June 2014. However, the DEA intended to publish the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) to close this gap. The Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) should have ideally been published at the same time as NEMWAA (Act No. 26 of 2014) in order to compensate for the removal of a by-product. The delay in finalising the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014) has resulted in a standstill on recycling in industries for over 3 years and will continue until these regulations are finalised and published by the Minister of the DEA. Furthermore, it is unclear whether the Waste Exclusion Regulations (GN No. 38210 of 14 November 2014), when promulgated, will be effective in improving recycling in the country.

Incorporating the experience of the industrial sector also allows for knowledge sharing and wider consideration in the drafting of legislation (Levänen, 2014a). The DEA hosts quarterly forums which serve to allow industry and government to work together to implement NEMWA (Act 59 of 2008)" (DEA, 2015). However, analysis of the DEA-IWMF forums indicates that these forums did not assist industries in waste legal issues and the concerns that were raised industry members were met with inadequate feedback and guidance. Another public participation tool used by the DEA is the thirty day public commenting period on draft regulations. Although this was not reviewed as part of this research, it should be evaluated in terms of whether comments from industries are duly considered by DEA and whether this is a more effective platform to engage industries. If legislation considers the operational requirements of industries, amendments to legislation would enable continual improvement in waste management in industries.

6 REFERENCES

Aucamp, P.J. 2009: *Environmental impact assessment: A practical guide for the discerning practitioner* (1st Edition.). Van Schaik Publishers: Pretoria.

Brundtland, G. 1987: *Our Common Future*. The world commission on environment and development. Oxford University Press: New York.

Chand, S., B. Paul and M. Kumar. 2016: Sustainable approaches for LD slag waste management in steel industries: a review. *Metallurgist*, 60(1-2): 116-128.

Chingono, T. and C. Mbohwa. 2016: Waste management for sustainable development in industrial parks. A case study of Wadesville industrial area, Johannesburg. Proceedings of the 2016 international conference on industrial engineering and operations management. 8-10 March 2016. IEOM Society International: Kuala Lumpur.

Chinwe, N.W. 2010: Legal framework for the regulation of waste in Nigeria. *African Research Review*, 4(2): 491-501.

City of Ekurhuleni. 2014: Atmospheric Emission License as Contemplated in Section 43 of the National Environmental Management: Air Quality Act, 2004, (Act No 39. Of 2004) as amended by Act 20 of 19 May 2014 issued to Fry's Metals a Division of Zimco Group (Pty) Ltd. Unpublished Air Emission Licence. City of Ekurhuleni: Johannesburg.

COE see City of Ekurhuleni.

Corvellec, H. 2016: A performative definition of waste prevention. *Waste Management*, 52: 3-13.

DEA see Environmental Affairs.

DEFRA see Department of Environmental, Food and Rural Affairs.

Department of Environmental Affairs. 2005: *Review of industrial waste exchange*. [ONLINE] Available from: http://sawic.environment.gov.za/ [Accessed 18 January 2017].

Department of Environmental Affairs. 2011: *National waste management strategy*. [ONLINE] Available from: http://sawic.environment.gov.za/ [Accessed 18 January 2017].

Department of Environmental Affairs. 2012: *National waste information baseline report*. [ONLINE] Available from: http://sawic.environment.gov.za/ [Accessed 18 January 2017].

Department of Environmental Affairs. 2015: Minister Edna Molewa's keynote address during the National Waste Management Summit. 9-11 March 2015. [ONLINE] Available from: https://www.environment.gov.za/speech/molewa_onnationalwastemanagementsummit [Accessed 2 June 2017].

Department of Environmental, Food and Rural Affairs. 2011: *Guidance on applying the waste hierarchy* [ONLINE] Available from: https://www.gov.uk/government/publications/guidance-on-applying-the-waste-hierarchy [Accessed 2 March 2017].

Department of Water Affairs and Forestry. 1998: *Waste management series: Minimum requirements for the handling, classification and disposal of hazardous waste*. (2nd Edition.). [ONLINE] Available from: http://sawic.environment.gov.za/ [Accessed 18 January 2017].

DGEEC see Directorate General for Environment in the European Commission.

Directorate General for Environment in the European Commission. 2012: *Guidelines on the interpretation of key provisions of Directive 2008/98/EC on waste*. [ONLINE] Available from: http://ec.europa.eu/environment/waste/framework/ [Accessed 2 March 2017].

DWAF see Department of Water Affairs and Forestry.

Eissa, M., A. Ahmed and M. El-Fawkhry. 2015: Conversion of mill scale waste into valuable products via carbothermic reduction. *Journal of Metallurgy*, 2015: 1-9.

El-Hussiny, N.A., F.M. Mohamed and M.E.H. Shalabi. 2011: Recycling of mill scale in the sintering process. *Science of Sintering*, 43: 21-31.

Environmental Protection Agency. 2014a: *RCRA orientation manual*. [ONLINE] Available from: https://www.epa.gov/hwgenerators/resource-conservation-and-recovery-act-rcra-orientation-manual [Accessed 2 March 2017].

Environmental Protection Agency. 2014b: *Advancing sustainable materials management: facts and figures.* [ONLINE] Available from: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management [Accessed 2 March 2017].

EPA see Environmental Protection Agency.

EU see European Union.

European Union. 2008: European Waste Framework Directive (2008/98/EC). [ONLINE] Available from: http://ec.europa.eu/environment/waste/framework/ [Accessed 2 March 2017].

Everychina. 2017: *Forging steel balls Cr15 grinding media high chrome casting ball*. [ONLINE] Available from: http://ballmillliners.sell.everychina.com/p-93928138-forging-steel-balls-cr15-grinding-media-high-chrome-casting-ball.html [Accessed 6 June 2017].

Faber, T. 2000: *The environmental management requirements associated with slag deposition in the Iron and Steel Industry*. Unpublished Msc dissertation. University of Johannesburg: Johannesburg.

Gaballah, N. M., A. F. Zikry, M. G. Khalifa, A. B. Farag, N. A. El-Hussiny and M. E. H. Shalabi. 2013: Production of iron from mill scale industrial waste via hydrogen. *Open Journal of Inorganic Non-Metallic Materials*, 3: 23-28.

Gauteng Department of Agriculture, Conservation and Environment. 2007: *First generation integrated hazardous waste management plan for Gauteng* (G/DACE07/2006). [ONLINE] Available from: http://sawic.environment.gov.za/ [Accessed 18 January 2017].

Gera, W. 2014: Public participation in environmental governance in the Philippines: the challenge of consolidation in engaging the state. *Land Use Policy*, 52 (2016): 501–510.

GDACE see Gauteng Department of Agriculture, Conservation and Environment.

Giannakopoulos, K. 2013: *Illegal Dumping a Problem*. [ONLINE] Available from: https://springsadvertiser.co.za/9535/illegal-dumping [Accessed 7 June 2017].

Gibbs, D. and P. Deutz, 2007: Reflections on implementing industrial ecology through eco-industrial park development. *Journal of Cleaner Production*, 15 (2007): 1683-1695.

Grasso, D., T. Vogel and B. Smets (Eds). 2009: *Hazardous Waste Management*. Encyclopedia of life support systems. Eolss Publishers Co Ltd: Oxford.

Grimard, J., L. Dewasme, and A.V. Wouwer. 2016: A review of dynamic models of hot-melt extrusion. *Processes*, 4: 12-19.

Hancock, B., E. Ockleford and K Windridge. 2007: *An introduction to qualitative research.* The NIHR Research Design Service for the East Midlands and Yorkshire & the Humber: Sheffield.

Husgafvel, R., E. Karjalainen, L. Linkosalmi, and O. Dahl. 2016: Recycling industrial residue streams into a potential new symbiosis product. The case of soil amelioration granules. *Journal of Cleaner Production*, 135 (90-96).

JSJ Metal Recycling. 2017: *Surplus/Reusables*. [ONLINE] Available from: http://jsjmetalrecycling.com/our-products/surplusreusable [Accessed 6 June 2017].

Keating, M. 1993: *Agenda for change: a plain language version of agenda 21 and other Rio agreements*. Centre for Our Common Future: Switzerland.

Levänen, J. 2014a: Ending waste by law: institutions and collective learning in the development of industrial recycling in Finland. *Journal of Cleaner Production*, 87: 542-549.

Levänen, J. 2014b: Policy deliberation and the trading zone metaphor: evaluating expert participation in the reform of Finnish waste policy. *Environmental Policy and Governance*, 24: 364–376.

Lilja, R. 2009: From waste prevention to promotion of material efficiency: change of discourse in the waste policy of Finland. *Journal of Cleaner Production*, 17: 129-136.

Maritz, S.J. 2011: *Waste generation in steel production* (*Legal opinion*). [ONLINE] Available from: http://citeseerx.ist.psu.edu/ [Accessed 15 January 2017].

Matete, N. and C. Trois. 2007: Towards zero waste in emerging countries – a South African experience. *Waste Management*, 28: 1480-1492.

Mitre. 2017: *Risk Impact Assessment and Prioritization*. [ONLINE] Available from: https://www.mitre.org/publications/systems-engineering-guide/acquisition-systems-engineering/risk-management/risk-impact-assessment-and-prioritization [Accessed 3 March 2017].

Mroueh, U. and M. Wahlström. 2002: By-products and recycled materials in earth construction in Finland – an assessment of applicability. *Resources, Conservation and Recycling*, 35: 117-129.

Muzenda, E. 2012: Gauteng's waste outlook: a reflection. *International Journal of Environmental, Earth Science and Engineering*, 6(8): 153-158.

Muzenda, E. 2013: Recycling situation in South Africa: a discussion. *International Journal of Biological, Ecological and Environmental Sciences*, 2(4): 2277-4394.

Nahman, A. and L. Godfrey. 2010: Economic instruments for solid waste management in South Africa: opportunities and constraints. *Resources, Conservation and Recycling*, 54: 521-531.

New Hope Resources Training Company Ltd. 2017: *Mill scale*. [ONLINE] Available from: http://www.newhopert.com/products4.asp [Accessed 7 June 2017].

NHRTC see New Hope Resources Training Company Ltd.

Oelofse, S.H. and L. Godfrey. 2008: Defining waste in South Africa: moving beyond the age of "waste". *South African Journal of Science*, 104: 7-8.

Papu-Zamxaka, V., T. Harpham and A. Mathee, 2010: Environmental legislation and contamination: the gap between theory and reality in South Africa. *Journal of Environmental Management*, 91: 2275-2280.

Park, J.Y. 2014: Assessing determinants of industrial waste reuse: the case of coal ash in the United States. *Resources, Conservation and Recycling*, 92: 116–127.

Pongrácz, E. and V.J. Pohjola. 2004: Re-defining waste, the concept of ownership and the role of waste management. *Resources, Conservation and Recycling*, 40: 141–153.

Republic of Finland. 2000: Environmental Protection Act (86/2000). [ONLINE] Available from: https://www.finlex.fi/fi/laki/alkup/2014/20140527 [Accessed 3 March 2017].

Republic of Finland. 2011: Finnish Waste Act (646/2011). [ONLINE] Available from: https://www.finlex.fi/fi/laki/alkup/2011/20110646 [Accessed 6 March 2017].

Republic of Finland. 2017: *Finland waste statistics*. [ONLINE] Available from: http://www.stat.fi/til/jate/index_en.html [Accessed 6 April 2017].

Republic of South Africa. City of Ekurhuleni. 2002: Ekurhuleni Metropolitan Municipality Wastewater Management By-Laws (MI 197/2001 dated 29 November 2001). [ONLINE] Available from: https://www.ekurhuleni.gov.za/ekurhuleni-by-laws-1/ [Accessed 8 May 2017].

Republic of South Africa. 2008: National Environmental Management: Waste Act No. 59 of 2008. Government Printer: Pretoria.

Republic of South Africa. Department of Environmental Affairs. 2013a: Waste management and classification regulations (GN No. R634 of 23 August 2013). Government Printer: Pretoria.

Republic of South Africa. Department of Water Affairs. 2013b: Revision of General Authorisations in terms of section 39 of the National Water Act No. 36 of 1998 (GN No 665 of September 2013). Government Printer: Pretoria.

Republic of South Africa. Department of Environmental Affairs. 2013c: Waste management activities that have or are likely to have, a detrimental effect on the environment (Government Notice No. 921 of 29 November 2013). Government Printer: Pretoria.

Republic of South Africa. 2014a: National Environmental Management: Waste Amendment Act 26 of 2014. Government Printer: Pretoria.

Republic of South Africa. Department of Environmental Affairs. 2014b: Proposed regulations to exclude a waste stream or a portion of a waste stream from the definition of waste (GN No. 38210 of 14 November 2014). Government Printer: Pretoria.

Republic of South Africa. Department of Environmental Affairs. 2017: Proposed regulations to exclude waste streams from the definition of waste (GN No. R528 of 02 June 2017). Government Printer: Pretoria.

Republic of Zambia. 2011: Zambian Environmental Management Act No. 12 of 2011. Government Printer: Lusaka.

Republic of Zambia. Zambian Environmental Management Agency. 2013: The Environmental Management (Licensing) Regulations (S.I. No 112 of 2013). [ONLINE] Available from: www.zambialaws.com [Accessed 21 October 2016].

RF see Republic of Finland.

Rostik, L.F. 1996: Zero waste electric arc furnace (EAF) steelmaking Chaparral steel company target. Waste Minimization/Pollution Prevention Technical Conference. 4-7 February 1996. EPA Region III: Philadelphia.

RSA see Republic of South Africa.

RZ see Republic of Zambia.

Sarna, K.S. 2014: *Generation Transport and uses of Mill Scale*. [ONLINE] Available from: http://ispatguru.com/generation-transport-and-uses-of-mill-scale [Accessed 7 June 2017].

Sentime, K. 2014: The impact of legislative framework governing waste management and collection in South Africa. *African Geographical Review*, 33(1): 81-93.

Song, Q., J. Li and X. Zeng. 2015: Minimizing the increasing solid waste through zero waste strategy. *Journal of Cleaner Production*, 104: 199-210.

Taljaard, A. C. 2012: *Critical perspectives on the definition of waste in South Africa – experiences within* *the steelmaking industry*. Unpublished Msc dissertation. North-West University: Potchefstroom.

UN see United Nations.

United Nations. 2010: *Solid waste management in the world's cities*. [ONLINE] Available from: https://unhabitat.org/books/solid-waste-management-in-the-worlds-cities-water-and-sanitation-in-the-worlds-cities-2010-2/ [Accessed 2 March 2017].

United States of America. 1976: Waste Resource Conservation and Recovery Act 42 USC 6901 of 1976. [ONLINE] Available from: https://www.epa.gov/rcra [Accessed 2 March 2017].

USA see United States of America.

USSE see Universal Standard Steel Engineering.

Universal Standard Steel Engineering. 2014: *Products Catalogue* [ONLINE] Available from: http://www.universalstainlesssteel.com.my/ [Accessed 6 April 2017].

Voermans, W., P. Eijlander, R. van Gestel, I. de Leeuw, A.D. de Moor-van Vugt and S. Prechal. 2000: *Quality, Implementation And Enforcement: A study into the quality of EC rules and the impact on the implementation and enforcement within the Netherlands*. Catholic University of Brabant: Netherlands.

Wang, L. K., N.K. Shammas and Y. Hung. 2009: *Waste treatment in the metal manufacturing, forming, coating and finishing industries*. Taylor & Francis Group: New York.

Wang, Z., D. Pinson, S. Chew, B.J. Monaghan, M.I. Pownceby, N.A.S. Webster and H. Rogers. 2016: Effect of addition of mill scale on sintering of iron ores. *Metallurgic and Materials Transactions*, 47B: 2848-2860.

Xu, L., D. Marinova and X. Guo. 2014: Resilience thinking: a renewed system approach for sustainability science. *Sustainability Science,* 10:123-138.

Zhang, M., Y. Wang, Y. Song, T. Zhang and J. Wang. 2016: Manifest system for management of non-hazardous solid wastes: results from Tianjin industrial park. *Journal of Cleaner Production*, 133: 252-261.