AN INVESTIGATION INTO FACTORS INCREASING CONTAMINATION RISK POSED BY FUEL STORAGE FACILITIES AND CONCOMITANT METHODS TO MITIGATE THESE RISKS

by

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ABSTRACT

Light Non-Aqueous Phase Liquids (LNAPLs) are used throughout the world for numerous applications, the most well-known being automotive fuels, such as petrol and diesel. The widespread production, distribution, storage and use of LNAPLs results in the ubiquitous occurrence of spillage to ground (Geller *et al*, 2000). Considering the hazardous nature of most LNAPLs due to their explosive and toxic characteristics, releases of LNAPLs to ground have well documented human health and ecological consequences.

The occurrence of leaking underground and above-ground storage tanks at service stations and consumer installations is a common cause of contamination; and is described in literature for various countries of the world (Dietz et. al., 1986; Moschini *et al*, 2005; Mulroy and Ou, 1997; Harris, 1989; The Institute of Petroleum, 2002).

Little failure data are however available for the South African context. In addition to this, data concerning the location and characteristics of sites storing LNAPLs in South Africa is similarly scarce.

The study analysed data from three sources, namely the eThekwini Fire and Emergency Services data, GIS data and data from a local consultancy, in order to determine whether certain factors increased contamination risk posed by these facilities. The results indicated that contamination may be a result of numerous factors, but primarily line and tank failure. The type of installation was also found to have a significant influence on whether a site would be contaminated or not.

In addition to the above, the results indicated that certain circumstances increase the severity of loss.

The results indicated the need for more investigation to be performed into contamination as a result of LNAPL loss to ground, and the need for protective measures to be implemented for high risk sites where the likelihood and severity of a potential loss is high. Focus should then be centred on the probability of failure of non-ferrous pipework and GRP tanks to ensure adequate protective mechanisms are in place in the event of a failure of this newer infrastructure.

In addition, a review of regulatory control of LNAPL storage in South Africa and the eThekwini Municipality, with reference to the international context, indicated the need for a specific department within the local government structure that manages LNAPLs with the objective of reducing contamination incidents.

The continued use of underground storage of LNAPLs will always present a risk of failure/contamination due to the unseen nature of the installations and related infrastructure. It is this risk that requires regulatory management. Details of contaminated sites in South Africa should be within the public domain.

Every day is a holiday.

Rodney Harbour

DECLARATION

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CONTENTS

ABBREVIATIONS

AST	Above-ground storage tank
ATG	Automatic tank gauging
BDL	Below detection limit
BGL	Below ground level
BTEXN	Benzene, toluene, ethylbenzene, xylenes and naphthalene
COR	Certificate of registration
DEAT	Department of Environmental Affairs and Tourism
DRO	Diesel range organics
DWA	Department of Water Affairs and Forestry
FMEA	Failure mode and effect analysis
FPP	Free phase product
GC MS	Gas chromatography mass spectroscopy
GIS	Geographical information system
GRO	Gasoline range organics
GRP	Glass fibre reinforced polyester (tank)
HSEQ	Health, safety, environment and quality
HSI	Habitat suitability index
HAZOP	Hazard and operability studies
IARC	International Agency for Research on Cancer
LNAPL	Light non-aqueous phase liquid
LP	Leaded petrol
LRP	Lead replacement petrol

MSDS	Material data safety sheet
MTBE	Methyl tertiary butyl ether
NEMA	National Environmental Management Act
PAH	Polycyclic aromatic hydrocarbon
PID	Photo ionisation detector
PVC	Poly vinyl chloride
ROI	Radius of influence
SANS	South African National Standards
SAPIA	South African Petroleum Industry Association
Sg	Specific gravity
SVS	Soil vapour survey
TAME	Tertiary amyl methyl ether
ULP	Unleaded petrol
UST	Underground storage tank
USA EPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
WRC	Water Research Commission

GLOSSARY

Alluvium	The detrital materials that are eroded, transported, and deposited by streams.
Aromatic hydrocarbon	A compound of hydrogen and carbon where the carbon atoms are arranged in a benzene ring structure with alternating double and single bonds.
Apparent thickness	The thickness of an LNAPL in a monitoring well typically exceeds the thickness of LNAPL in the subsurface by a factor estimated to range between 2 and 10. Due to this difference, the LNAPL thickness measured in a monitoring well is commonly referred to as the "apparent thickness" and is not an accurate measurement of the LNAPL thickness in the subsurface. The difference in LNAPL thickness is primarily caused by LNAPL floating on the capillary fringe (water held above the water table in soil pore spaces by capillary forces), which is not present in the monitoring well. The absence of the capillary fringe in the monitoring well causes the well to act as a low point into which LNAPL will drain. When LNAPL accumulates in the well, the weight of the LNAPL will depress the water table in the well resulting in additional LNAPL drainage into the well.
Bidim	A porous woven geotextile used to wrap monitoring wells thus preventing ingress of fines and blocking of the monitoring well slots.
Capillary fringe	A lower portion of the zone of aeration immediately above the water table, in which interstices are filled with water. Although the water is at less than the atmospheric pressure, being part of the water below the water table, it is held above that level by surface tension.
Clay	A detrital mineral particle of any composition having a diameter less than 0.002 mm.
Commercial installation	Facility for the storage of automotive fuel (or other) for own use.
Darcy’s Law	A law stating that the flow rate of a fluid through a porous material varies directly with the products of the pressure gradient causing the flow and the permeability of the material.
Dual phase extraction	A method employed to remove free phase product from the ground that incorporates the removal of both groundwater and product simultaneously.

Flash point	The lowest temperature at atmospheric pressure that a liquid will give off sufficient volatiles to ignite provided sufficient oxygen is present and an ignition source is present.
Free phase product	One of the four phases of an LNAPL, and refers to the liquid phase. Other forms are the dissolved phase, vapour phase and sorbed phase.
Hand auger	Field instrument for soil excavation comprising a T handle, extension rods and a cutting devise and bucket designed to remove a cylindrical volume of soil in an incremental manner with vertical advancement.
Hydraulic gradient	The ratio between the difference of elevation and the horizontal distance between two points. The rate and direction of water movement in an aquifer are determined by the permeability and the hydraulic gradient.
Lithology	The description of the characteristics of rocks, as seen in hand specimens and outcrops on the basis of colour, grain size and composition.
Perched aquifer	A local water table above an impermeable layer of very limited extent, such as a lens of clay within a sandstone bed.
Porosity	The ratio of the collected volume of interstices in a soil or rock to the total volume, usually stated as a percentage.
Primary aquifer	Aquifer in which groundwater is contained in the void spaces between particles.
Sand	A detrital particle larger than a silt grain and smaller than a granule, having a diameter in the range of 0.05 mm to 2 mm.
Secondary aquifer	Aquifer in which the groundwater is contained in the discontinuities, such as joints, fractures and bedding planes, and fractured and weathered horizons.
Service station	Facility for storage and sale of automotive fuels to the public (occasionally include storage and sale of paraffin).
Silt	A detrital particle finer than very fine sand and coarser than clay in the range 0.002 mm and 0.05 mm.
Soil permeability	The measure of the ability of the earth materials to transmit a fluid. It depends largely upon the size of pore spaces and their connectedness, it is less dependent on the actual porosity.

Thiem Equation	Equation commonly used to estimate aquifer properties, particularly hydraulic conductivity or transmissivity.
Vadose zone	The sub-surface sediment above the water table containing air and water. Also known as unsaturated zone and zone of aeration.

CHAPTER 1. INTRODUCTION

Light Non-Aqueous Phase Liquids (LNAPLs) is a broad term referring to organic liquids that are both immiscible in water, and less dense than water. Included in this definition are automotive fuels, such as petrol and diesel. These essential fuels are typically extracted from the ground as crude, manufactured into useable products at oil refineries, stored, distributed by road, rail and pipeline and finally consumed globally. Due to their acute toxicity (IARC, 1987) however, spillage to ground can have significant consequences for ecological wellbeing (O'Halloran and Booth, 2000) and human health at any stage in the lifetime of the pre-refined and refined product. The impact of spillage on these receptors can range from nuisance effects to death and loss of sound functioning ecosystems.

Significant resources are therefore invested to ensure loss to ground is prevented, however loss to ground does occur. Substantial research has been invested in determining causes of spillage, impacts of spillage and remediation of spillage.

Control of LNAPLs by organs of state and regulations pertaining to the manufacture, storage and handling of the products varies significantly from country to country. South African regulations pertaining to LNAPLs are contained within National legislation; Codes of Practise; as well as local municipal by-laws. These regulations pertain to specifications for the design, construction and decommissioning of fuel infrastructure; as well as requirements in the event of spillage to ground; and remediation.

Failure of underground and aboveground fuel storage tanks and associated pipework and infrastructure is described in literature by numerous authors including Dietz *et al* (1986), Moschini *et al* (2005), Harris (1989) and the United States Environmental Protection Agency (1997 – 2007), and has been reviewed. Failure of this infrastructure will be investigated within this dissertation with reference to the South African context. Specific focus will be placed on the underlying causes of contamination and mechanisms of failure at retail service stations and commercial (not for sale to the public) facilities.

CHAPTER 2. AIM AND STRUCTURE OF THE STUDY

The aim of the study is therefore to determine the mechanisms of LNAPL spillage from commercial and retail fuel facilities within the South African context, with specific reference to the eThekwini Municipality. In order to achieve the above aims, the study has been structured as follows:

1. Define LNAPLs (Chapter 3).
2. Define petrol and diesel automotive fuels (Chapter 3 and 4).
3. Determine the nature and extent of the problem (Chapter 5).
4. Review current local and international regulations (Chapter 6).
5. Perform a literature review for available data on fuel storage tank and infrastructure failures (Chapter 7).
6. Collate data on storage tanks in KwaZulu-Natal region and the eThekwini municipality (Chapter 8).
7. Analyse data to determine causes of failure, and their related severity (Chapter 9).
8. Provide results and conclusions of data analysis (Chapter 10).
9. Provide recommendations to reduce the frequency and severity of failure (Chapter 10).
10. Propose additional measures and frameworks to manage and reduce the incident of LNAPL contamination (Chapter 10).

The study excludes pathways of contamination migration, potential receptors of contamination and assessment of contamination impacts. The study also excludes consideration for soil types and geology.

CHAPTER 3. LIGHT NON-AQUEOUS PHASE LIQUIDS

Mayer and Massanizadeh (2000) describe an LNAPL as having the following characteristics:

- *Density less than water;*
- *Float on water and move along the top of the saturated groundwater zone;*
- *Hazardous organic liquid; and*
- *Low solubility.*

Rubin *et al* (1998) describes an LNAPL as being:

- *Petroleum hydrocarbon; and*
- *Classified as either paraffins, olefins, naphthenes or aromatics.*

3.1 LNAPLs defined

LNAPLs are defined as follows:

L: Light i.e. having a specific gravity (sg) of <1. Lead replacement petrol and unleaded petrol have an sg of 0.783 g/cm^3 at 20°C, while diesel has an sg of 0.8450 g/cm^3 at 20°C (Engen Product Safety Advisor, 2006 and 2007)

NAP: Non-aqueous phase i.e. being **relatively** immiscible in water. The term relative is used due to the fact that a small fraction of petrol and diesel are in fact soluble in water, and are referred to as a *dissolved phase* component / contaminant (as opposed to *free phase* contamination - referring to an LNAPL that floats on a water surface or occurs in the soil matrix). The Engen MSDSs (Engen Product Safety Advisor, 2006 and 2007) refer to the aromatic hydrocarbon components of petrol and diesel as being '*more water soluble than other components'*; while the Chevron MSDSs for leaded and unleaded petrol refer to the solubility of these products in water to be '*slight'* (van der Heyden, J.A.L., 1997). Note some MSDSs, such as the Sasol MSDSs for petrol and diesel, state the water solubility of the product to be immiscible (Sohan, A., 2005 and Motlatsi, M.S., 2007).

L: Liquid. Petrol and diesel are liquids at ambient temperature. The Sasol MSDSs indicate the boiling ranges for petrol and diesel to be 38.05°C to 200.05°C, and 160°C to 380°C respectively. Freezing points are typically not quoted on MSDSs as solidification in petrols and diesels is not common and therefore of little use. Petroleum products can however be classified according to either freezing point, congealing point, cloud point and pour point; and will become a plastic solid at sufficiently low temperatures (Speight, J.G., 1988).

3.2 Importance of LNAPL solubility

The American Society for Testing and Materials (ASTM, 1995) provide the following generalisations with respect to increasing carbon chain lengths of hydrocarbons:

- A decreasing volatility (vapour pressure);
- A decreasing (water) solubility;
- A decreasing mobility;
- An increasing boiling point;
- An increasing viscosity; and
- An increasing sg.

The American Petroleum Institute indicates aqueous solubility of petroleum hydrocarbons to be primarily an inverse function of their molecular size (as cited in Nadim, 2000). To demonstrate this, a mixture was prepared consisting of one part petrol and ten parts deionised water and agitated for 96 hours. Results were as follows:

Table 3.1. Solubility of petrol constituents (as cited in Nadim, 2000)

Compound	Chemical Formula	Dissolved Phase Concentration in Water (mg/L)
Benzene	C_6H_6	51.4
Toluene	C_7H_8	29.2
Ethylbenzene	C_8H_{10}	3.8

The results demonstrate the greater solubility of the lighter fraction (benzene) compounds.

Irwin (1997) reports the following (maximum) water solubilities for benzene, toluene, ethylbenzene, xylene (BTEX) and methyl tertiary butyl ether (MTBE):

Table 3.2. Solubility of petrol constituents and MTBE (Irwin, 1997)

Compound	Maximum Water Solubility (mg/L)
Benzene	1 780
Toluene	535
Ethylbenzene	152
Xylene (C_8H_{10})	175
MTBE ($C_5H_{12}O$)	43 000

Aromatic hydrocarbons account for approximately 87 – 95% of the water soluble fraction of petrol.

Grunwald *et al* (2000) reported petrol to have an approximate water solubility of 92 mg/L. The addition of the MTBE additive at a 7% concentration significantly increased the overall petrol solubility to 782 mg/L. Nadim *et al* (2000) indicates the high solubility of MTBE to be as a result of the presence of the oxygen atom in its structure.

The implication therefore of a soluble fraction of hydrocarbons within automotive fuel is that in the event of spillage, remedial measures required are not limited to recovery of the fuel itself, but frequently require the remediation of groundwater or surface water impacted by dissolved phase contamination.

Furthermore, on-site drainage separation of water and automotive fuels with increased fuel water solubility by conventional sand, oil and grease traps / over-under weir separators is not possible without contaminating the sewer discharge with the dissolved phase constituents. This dissolved phase fraction therefore frequently gets discharged to sewer reticulation, or worst case, stormwater.

The inability of sewage waste water treatment plants to treat organic pollutants is well documented (Rosell *et al*, 2006) with the consequent discharge of compounds such as MTBE and its primary product of degradation *tert*-Butyl alcohol to coastal waters.

The characteristics of automotive fuels are therefore important in the understanding of contamination risk and are therefore discussed further in Chapter 4.

CHAPTER 4. LNAPL PRODUCTION AND CHARACTERISTICS

The origin of most synthetic LNAPLs is from crude oil. Crude (also referred to as petroleum) is a term used to describe a widely varying mixture of hydrocarbons and other compounds containing different amounts of sulphur, oxygen and nitrogen. Crude has variable chemical properties, including colour, viscosity, volatility and specific gravity, as well as varying degrees of metals, such as nickel and vanadium. Crude occurs naturally underground in reservoirs, and was formed as a result of the degradation of vast quantities of organic matter under conditions of pressure and temperature millions of years ago (Speight, 1988).

The primary constituents of crude are hydrocarbons, compounds of carbon and hydrogen. Hydrocarbons are typically classified into:

- *Straight chain and branched chain hydrocarbons, of which paraffins are the most common (also referred to as aliphatics); and*
- *Hydrocarbons with carbon ring structures, known as naphthenes, of which benzene (an aromatic) is the most common.*

Crude oil, in the broadest sense, is refined by processes of distillation whereby different products are recovered according to their volatility. Further processing occurs by cracking (separation of heavier constituents into smaller, lighter fractions) and reforming (conversion of straight chain hydrocarbons / paraffins to ringed hydrocarbons / aromatics).

Products of the refining process include petrol (referred to as gasoline in the USA) and diesel; and are used in internal combustion engines and compression ignition engines respectively.

4.1 Petrol

Petrol is a volatile organic hydrocarbon liquid. Schwerko (1994) reports petrol to consist predominantly of $C_6 – C_{10}$ compounds, while Speight (1998) and Irwin (1997) indicate petrol to include compounds from C_4 - C_{12}. The distinction is likely to be attributed to Schwerko's (1994) context being soil and groundwater contamination related while Speight (1998) and Irwin's (1997) reference is strictly to petrol itself. Typically the C_4 and C_5 components occur only as vapour phase, while the C_{11} and C_{12} compounds occur in proportionally very small quantities.

The following characteristics further describe petrol:

- *It is highly flammable and thus has a high energy of combustion (flash point < -40°C, Engen Product Safety Advisor, 2006);*
- *Has a low boiling point; and*

- *It mixes readily with air and is thus suitable for internal combustion engines.*

Literature (Irwin, 1997) indicates that petrol comprises three chief constituents: paraffins (typically 66%), aromatics (typically 25%), as well as olefins (remainder), a hydrocarbon with carbon to carbon double or triple bonds. Irwin (1997) indicates that other literature reports the above composition to be at different proportions.

These constituents make up over 200 compounds found in petrol, including the BTEXN compounds.

The characteristics of petrol include its quality. The quality of petrol is typically determined by the octane number. The octane number is determined by the 'lightness' of the product and is a function of the inverse of the sg (Speight, 1998). Typically the higher the octane number, the less the fuel is likely to cause an engine to knock / ping i.e. experience premature ignition. It was found that the greater the proportion of light fraction hydrocarbons in petrol, the less the knocking and the greater the engine efficiency.

Quality enhancements therefore comprise the addition of additives to increase the octane number. Historically tetraethyl lead ($Pb(CH_3)_4$) was added to petrol for this purpose. Leaded petrol (LP), as it was known, was the only automotive fuel available for over 50 years since its introduction in 1923. LP had however been phased out in the USA by 1980 (Mulroy and Ou, 1998), and in 2006 in South Africa due to its toxicity. Current fuel additives to increase the octane number include the oxygenate MTBE which can occur in petrol up to 15% volume (Grunwald, 2000 and Ahmed, 2001). MTBE acts to both increase the octane number of fuel as well as to reduce exhaust pollution by reducing carbon monoxide emissions.

An alternative additive to MTBE is the oxygenate tertiary amyl methyl ether (TAME), with chemical formula $C_6H_{14}O$.

Various types of petrol therefore occur and differ according to their:

- *Octane rating;*
- *Additive content; and*
- *BTEXN concentrations (Irwin, 1997).*

The proportions of BTEXN compounds in petrol are reported by Irwin (1997) to be as follows: benzene 2 – 3%, toluene 4 – 7%, ethylbenzene unreported, xylenes 6 – 8% and naphthalene 0.09 – 0.49% (all weight percentages).

A petrol fingerprint analysis can be performed to determine the relative concentrations of the above compounds whereby the product is subjected to gas chromatography mass spectography (GC MS) analysis. The GC MS analysis allows for constituent identification as well as providing an indication of the degree of weathering and loss of volatiles the product has undergone (Irwin, 1997). Typically, laboratory analysis for petrol by method EPA 8015 commences with the elution of MTBE and terminates

with the elution of naphthalene. This method is commonly referred to as a Gasoline Range Organics (GRO) analysis. An example is attached as Appendix A: Gas Chromatograph of Petrol.

It should be noted that petrol contains trace polycyclic aromatic hydocarbons (PAHs). This will be discussed in more detail in Section 4.2.

4.2 Diesel

Diesel is a semi-volatile petroleum hydrocarbon with predominantly $C_{10} - C_{24 - 28}$ compounds (Schwerko, 1994). Diesel comprises paraffins, cycloparaffins / cycloalkanes / naphthenes (saturated hydrocarbons containing one or more rings, each of which may have one or more paraffinic side chains, Speight, 1988), aromatics and olefins. Diesel is used in compression ignition engines in automotive passenger and commercial vehicles, boats, industrial engines and railway locomotives. For the purposes of this study, only automotive diesel will be referred to. Irwin (1997) reports a carbon range of $C_9 - C_{20}$ for automotive diesel, and can be described as having the following additional characteristics:

- *Flash point of $>55^0$ C, closed cup method, (Motlatsi, 2007);*
- *Higher boiling point than petrol (referred to as middle distillates);*
- *Semi-volatile and having greater density than petrol. Diesel therefore has a greater energy per unit volume than petrol (Irwin, 1997); and*
- *Moderate (water) solubility (Irwin, 1997).*

Diesel contains PAHs at low concentrations. PAHs in soil and groundwater are less readily degraded by processes of microbial action compared with BTEX compounds (Irwin, 1997). The following list provides PAHs typically reported by laboratories during analysis of soil or groundwater:

- Naphthalene
- Acenaphthene
- Anthracene
- Fluoranthene
- Fluorene
- Pyrene
- Acenaphthylene
- Phenanthrene
- Benzo(a)anthracene

- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Chrysene

Although diesel is referred to as having carbon compounds greater than C_9, BTEX compounds (lighter than C_9) can also be found in diesel at trace concentrations.

Diesel fuel has a higher viscosity than petrol and therefore typically migrates through porous media such as sub-surface soils at a slower rate.

4.3 Product Classes

LNAPLs are classed according to their flash points in order to classify risks and to prescribe appropriate storage and handling infrastructure. Table 4.1 summarises Class 1, Class 2 and Class 3 products:

Table 4.1. Types of products according to flash point (Institute Petroleum, 2003)

Product	Closed Cup Flash Point (°C)	Product Types
Class 1	<21°C	Unleaded petrol Lead replacement petrol
Class 2	≥21°C <55°C	Paraffin
Class 3	>55°C	Diesel

CHAPTER 5. RISKS ASSOCIATED WITH LNAPLs

Soil and groundwater contamination by LNAPLs is well documented in literature, particularly reference works such as Nathanail and Bardos '*Reclamation of Contaminated Land*' (2004); Mayer and Hassanizadeh '*Soil and Groundwater Contamination: Non-Aqueous Phase Liquids*' (2005) and Rubin *et al*. '*Soil and Aquifer Pollution: Non-Aqueous Phase Liquids – Contamination and Reclamation*' (1998).

This contamination has significant consequences due to a number of contributing risk factors, as described in Sections 5.1 to 5.14.

5.1 Increasing oil production

Seiferlein (2007) reports that global crude oil production has increased from approximately 20 million barrels per day in 1960 to 73 million barrels in 2006, while Kwiatkowski (2008) reports that the International Energy Agency has indicated that in order for oil production to keep up with oil consumption, an additional 64 million barrels per day will be required by the year 2030, a quantity equal in volume to the current Kuwaiti oil fields. This vast increase has resulted in both an increase in fuel consumption as well as an increase in fuel storage and distribution facilities such as fuel depots, pipelines and service stations.

5.2 Widespread LNAPL distribution and transportation

An increase in fuel storage, distribution and consumption has resulted in an increase in incidents. Nathaniel and Bardos (2004) cite the Netherlands as an example where in 1981, records indicated 350 sites to be contaminated, while in 1995, this figure was 300 000. (It should be noted that better detection, record keeping and awareness could have had a bearing on the figures quoted).

Geller *et al* (2000) describe contamination by hydrocarbon fuels to be ubiquitous simply due to their widespread production and use. Ligthelm (2002) reported that 20.1 billion litres of liquid petroleum fuels were sold in South Africa in 2001, with 16% of this being in KwaZulu-Natal. Data from the South African Petroleum Industry Association (SAPIA) Annual Report for 2006 (SAPIA, 2006) indicates that this figure had escalated to 32 billion litres per year by 2006 (including export trade and non-fuel hydrocarbon products).

The Department of Minerals and Energy reports approximately 4 600 retail service stations in South Africa (Department of Minerals and Energy, 2006). If each service station stored 69 000 litres (3 standard 23 000 litre tanks), this equates to more than 317 million L. This figure excludes all other LNAPL storage, such as bulk fuel depots and commercial (non-retail) sites.

If 53% (sample size 206) of South African service stations have a leak history, (Holt, 1997), loss to ground can be potentially significant. The potential risk is further increased due to automotive fuels having a multiple-stage handling factor, as described below:

- Off-loading at harbours or off-shore moorings (crude);
- Transport of fuels by rail and bulk pipeline;
- Bulk storage at approximately 200 depots (Department of Minerals and Energy, 2006);
- Off-loading and loading at bulk depots;
- Bulk tanker loading (road, rail);
- Delivery of fuels to service stations via road;
- Delivery of fuels at service stations typically via flexible hose to the USTs using remote filler points;
- Dispensing of fuels via underground lines to the forecourt pumps, typically under pressure; and
- Sale of fuel via dispensing mechanisms[1].

Contamination associated with LNAPL transportation is also well documented. Goven (2005) found petroleum to be the primary dangerous goods transported by road in the South Durban region. In an assessment of a single road intersection, it was reported that a heavy vehicle accident rate of 99/year occurred; with a deterministic dangerous goods release rate of 1 per year; and the likelihood of a petroleum release at this intersection being once every 2.74 years. No data on actual LNAPL releases as a result of vehicular accidents in South Africa was found.

Risks associated with transport of LNAPLs by pipeline are related to pipeline rupture and release to the sub-surface. Within the South African context, pipelines are used to transport LNAPLs between five provinces, namely KwaZulu-Natal, Free State, Gauteng, North West and Mpumalanga.

5.3 LNAPL toxicity and flammability

Exhaustive studies on the health and environmental effects of the components of petrol and diesel have been performed. Risk posed by petrol is most commonly assessed by the determination of BTEXN and MTBE concentrations in soil and groundwater; and similarly the determination of PAH concentrations in the case of diesel contamination.

Carcinogenicity studies, and particularly work undertaken by the International Agency for Research on Cancer (IARC), have confirmed benzene to be carcinogenic (IARC, 1987, and Nadim *et al*, 2000). This has been known as long ago as 1975 when benzene was suspected to have a causal relationship with the development of leukaemia in humans if exposed for sufficient periods of time (Hancock, 1975).

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[1] The above data excludes approximately 100 000 commercial sites where fuel is stored and dispensed for customer own use, and not resale (Department of Minerals and Energy, 2006).

Inhalation exposure to BTEXN compounds also poses potential health hazards to human organ function, including the heart, lungs and kidneys; while impacts on general biota are widespread and include physical damage as well as impacts on reproductivity, organ damage etc. Exposure routes, concentrations and length of exposure vary depending on the circumstances.

Similarly, human and general biotic exposure to PAHs can result in both short term chronic toxicological effects as well as long term impacts (Irwin, 1997).

Hydrocarbon LNAPLs are flammable, particularly 'lighter' products, such as petrol. Entry of these flammable products into confined spaces following accidental release can also result in the creation of an explosive atmosphere (United States Environmental Protection Agency, 1996), given the correct ignition, oxygen and hydrocarbon vapour concentration conditions. Risks can therefore occur in the working environment as a result of the potential presence of a flammable substance and explosive atmospheres.

5.4 Groundwater vulnerability

Most service station storage tanks occur below ground level and in the event of a product loss to ground, contamination of soil and more importantly groundwater, can go undetected for some time prior to action being taken, if at all. Frequently, considering the often heterogeneous nature of the sub-surface, contamination migration is difficult to determine and plume delineation is not always absolute.

Groundwater is an important potable water source worldwide, however it is significantly threatened by increasing contamination by organic pollutants (Langendijk *et al*, 1998). Israel for example sources approximately 60% of its water resource from underground aquifers (Rubin *et al* (1), 1998). Nixon and Saphores (2007) quote that at least 50% of the American population is to some extent reliant on groundwater for domestic purposes. The South African Department of Water Affairs and Forestry (DWAF) estimate that 65% of South African domestic water supply is groundwater sourced (Department of Water Affairs and Forestry, 2000).

Nadim *et al* (2000) indicates 1 L of petrol has the potential of contaminating 2 million m^3 of groundwater. This is concurred by Mayer (2000) who indicates that small amounts of LNAPL components can dissolve in large quantities of water and at very slow rates resulting in potential long term threats to groundwater.

KwaZulu-Natal is experiencing increasing domestic and industrial water demand. Studies have shown that unless increased water resources are secured for KwaZulu-Natal, a future shortfall will occur. As a result, the Department of Water Affairs (DWA) are currently investigating future water requirements of KwaZulu-Natal through the initiation of the project entitled 'Development of a Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas' (Van Rooyen, 2007).

Economic and industrial growth in SA, underpinned by government policy and initiatives, imply increased fuel usage. The most accurate indicator of future fuel needs is the number of registered motor

vehicles, as dictated by economic activity. The trend was reported to be consistent over the 24 year study period (1970 – 1993), and resilient to oil crises (Department of Minerals and Energy, 2002)[2]. Consumption of petroleum products by the transport sector was reported to increase by 31% between 1992 and 2001 (Department of Minerals and Energy, 2006).

An increase in the distribution and use of fuel poses an increased risk of groundwater contamination. Similarly, increased industrialisation, urbanisation, agriculture and development poses a risk to over-abstraction and contamination of groundwater (DWAF, 2000).

In the event that growth in demand continues and surface water supplies are limited, it is likely that domestic and industrial consumers will make greater utilisation of groundwater, particularly in urban areas. Abstraction of urban groundwater may expose LNAPL contaminated aquifers.

Professor Cawthorn indicated this threat likely to be greater than that posed by global warming (Creamer, 2011).

The presence of MTBE in South African soils was reported by McKune (2009), and the author pointed to the absence of legislation controlling its use. Arey and Gschwend (2004) indicated that use of oxyegenates would cause widespread contamination problems if preventative measures were not implemented and these additives were not biodegradable.

5.5 Costs of cleanup

Metzger (1989) reported that clean-up of a UST release (in the USA) can range from $20 000 if the release is limited to the site boundaries; or to up to $11 million if significant off-site damage occurs.

Nixon and Saphores (2007) performed research into the costs associated with cleanup of leaking USTs and runoff from freeways. It was estimated that between $0.8 billion and $2.1 billion was spent on clean-up of leaking USTs during 2005 in the USA. Cost comparisons cited indicate the unnecessary expense required for reactive clean-up as compared with lower pre-emptive detection and monitoring costs. The authors cite a 47-fold difference in annual tank administrative compliance costs between a non-leaking UST and a leaking UST.

Since 2005, oil companies have had to fund alternative water supplies to Santa Monica, California, at a cost of $3 million per year. This is as a result of MTBE contamination of 80% of this area's local water supply (Nixon and Saphores, 2007 and Nadim *et al*, 2001).

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[2] The increase in number of registered motor vehicles is not quoted for the study period.

More recent literature by a Los Angeles Times columnist J. Wilson (2008) reported that oil companies had agreed to pay $423 million in settlement as a result of MTBE contamination of groundwater in twenty states in the USA.

Comparatively, the collective cost of LNAPL contamination remediation that is incurred by oil companies in South Africa is not in the public domain. Costs incurred during disposal of contaminated soils include tipping rates to low hazardous (H:h) landfill sites, and the related over-excavation and transport costs.

5.6 Limits to absolute remediation

Remediation of LNAPL contaminated soil or groundwater to conditions prior to contamination are practically impossible, without excessive cost implications (DWAF, 2000, and Nadim *et al* 2000). This is due to a number of reasons, but primarily due to complexities associated with the fate and transport of an LNAPL within soil, groundwater and bedrock (Carberry, 1998 and Novak *et al*, 1998). An LNAPL will differentiate into the free phase, dissolved phase, gaseous phase and residual/sorbed phase[3], and spread according to preferential pathways. In cases where a perched water table occurs and intercepts the contaminant, recovery can be relatively simple, however where heterogeneous sub-surface conditions occur, such as within fractured rock aquifers, plume delineation can be remarkably difficult and remediation similarly challenging.

LNAPLs can travel vast distances (Geller *et al*, 2000), particularly in urban environments where the contaminant enters a conduit for migration, such as stormwater reticulation, phone cable ducting etc. Resultant widespread contamination is practically impossible to remediate to pre-incident conditions.

Mulroy and Ou (1998) indicate the behaviour of fuels during bioremediation in their paper on the degradation of tetraethyl lead in soil. Complete bioremediation to below detection level (BDL) is not possible due to the inability of microbial action to access hydrocarbons sorbed to the soil or trapped in the soil matrices, particularly aged hydrocarbons. Geller *et al* (2000) similarly points out the shortcomings of remedial techniques in recovering contaminants from rock matrix pore spaces; while Rubin *et al* (2) (1998) describes the difficulty of removing LNAPLs trapped in soil pores by conventional remedial techniques.

Furthermore free phase product recovery rates are typically good in the initial stages of the project, however drop asymptotically resulting in a disproportionate time period to recover the second half of the available product. Available product for recovery typically approximates 20 – 50% of the loss volume (USA EPA, 1996). Mayer and Hassanizadeh (2000) cite values of 64-83% of product was not recovered in a study of 8 product recovery sites.

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[3] Product adsorbed onto soil particles

Typically, residual LNAPL remediation following simple pump and treat operations requires greater technical bioremediation, soil vapour extraction or the addition of surfactants and oxidising agents.

Frequently, the presence of residual LNAPLs in soil and groundwater acts as a secondary source of persistent and lengthy contamination affecting hydrologically downgradient receptors. Recovery is often hampered by product smearing whereby LNAPLs become trapped within soil pore spaces as a result of seasonal fluctuations of the water table and floating product (Huntley and Beckett, 2002).

5.7 Ecological impacts

Contamination risk assessments are primarily based on carcinogenic and non-carcinogenic health effects to human health, with token regard for impacts to ecological receptors (O'Halloran and Booth, 2000), particularly microflora and fauna. The establishment of ecological risk assessment frameworks are mostly in the development stages, such as the American Society for Testing and Materials Standard: WK3365 New Standard Guide for Estimating Wildlife Exposure Using Habitat Suitability Index (HSI) Values (reference not available).

This notion is supported by predominantly Australian research such as Humphreys (2000), where assessment of the value of groundwater ecosystems was undertaken. Results demonstrate that these ecosystems can be as diverse as some complex terrestrial and surface water ecosystems, with habitation by endemic stygofauna, microbes and protozoa.

Currently, the functioning of these complex ecosystems is poorly understood and impacts by LNAPLs unquantified.

5.8 Inadvertent spreading of contamination

Assessment and implementation of remedial measures at LNAPL contaminated sites frequently results in some degree of contamination spreading. In cases where leaking tanks and / or product lines occur, this infrastructure requires removal. As a result, excavations are left open on site. In cases where rainfall occurs during this period when the excavations are open on site, entry of rainwater occurs into these excavations. As a result, soil contamination can be entrained vertically downwards, while dissolved phase or free phase product in or on the groundwater can be spread hydrologically downgradient as a result of the movement of the rainwater within the subsurface.

Similarly, LNAPL contaminants within stockpiled material can be leached out by rainfall and discharged off site unless care is taken to cover the stockpile with an impermeable liner, and the integrity of the liner is maintained until the stockpile is removed.

Drilling of either monitoring wells and / or product recovery wells can result in the spreading of contamination. Frequently, LNAPL contamination movement is restricted by a confining layer, such as clay lenses within sub-surface soils. If during installation of wells this confining clay layer is punctured, vertical spreading of contamination can result.

Installation of wells frequently requires the use of either drilling mud, or in the case of water jetted wells, large quantities of water (up to $4m^3$). The introduction of water during these well installation processes can spread contamination, particularly in cases where a steep hydraulic gradient occurs. The dissipation of the additional water in the subsurface can entrain contaminants hydraulically downgradient.

5.9 Human error and the inability to prevent all contamination

Even with the most sophisticated engineering, the introduction of the human element during production and distribution of LNAPLs equates to the potential for a certain degree of error being introduced.

By way of example, in his 1970 essay entitled 'Alaska – The Ecology of Oil', Weisberg (as cited in Love and Love, 1970) warned of a likely ecological crisis in Alaska following the discovery of the Prudhoe Bay oil field based on the likelihood of a spillage incident.

In March 2006, the crude oil transfer line from the Alaskan Prudhoe Bay oil field ruptured resulting in loss of product and contamination of the environment (Robert, undated). The cause was cited as a lack of sufficient maintenance.

5.10 Absence of legislation for dated equipment

Currently, no legislation in South Africa stipulates that dated equipment of inferior quality (e.g. mild steel tanks and pipework), must be removed within a defined time period.

5.11 Absence of definitive clean-up guideline values

Generally in developed countries, regulatory agencies publish soil and groundwater assessment guideline values. These values can then be used by remediation assessment practitioners to determine remedial requirements. For example, the USA Environmental Protection Agency has published Gasoline Range Organics (GRO), Diesel Range Organics (DRO), BTEXN and PAH guideline values. Where concentrations exceed these values, further assessment and possible remediation is required. Bell *et al* (1991) however pointed to the inconsistency of these levels from state to state, and the absence of rigid clean-up requirements.

No such enforceable guidelines applicable to the products handled by service stations are published by South African regulatory agencies, and as such, contamination assessment practitioners in South Africa rely on the interpretation of these internationally available guidelines for implementation at local level. As a result, interpretation of risk by various practitioners vary and clean-up targets are inconsistently applied.

Guidelines have however recently been published by the South African National Department of Environmental Affairs, and are entitled Framework for the Management of Contaminated Land (WSP Environment and Energy, 2010). These guidelines define 'Soil Screening Values' for contaminated land. The values are generic in nature and can be used as conservative clean-up targets. The values provide a

basis for assessment and determining whether an unacceptable risk is posed to human health. The guidelines recommend the values are used in conjunction with a site specific risk assessment if deemed necessary.

5.12 Absence of motivation for preventative measures

In cases of large contamination events where the cost of clean-up exceeds an excess value, this expense is frequently incurred by the insuring party. The cost of clean-up can therefore be limited to the excess value and the cost of unaccounted for product.

The Environment Conservation Act (Republic of South Africa, 1989) historically made provision for fines to be imposed on polluters, with the maximum penalty being R100 000 (Sampson, 2001). The relative absence of enforcement resulted in a perception that no financial deterrent existed and a lack of implementation of pollution prevention mechanisms. Current NEMA (Republic of South Africa, 1998) legislation now allows for up to R5 million penalty to be imposed in the context of the '*polluter pays'* principle.

5.13 Availability of data

The absence of data in the public domain of South Africa regarding LNAPL contamination and LNAPL incidents is synonymous with a high risk activity. The custodians of groundwater, the National Department of Water Affairs, does not maintain a database of incidents in KwaZulu-Natal, while the National Department of Water Affairs would not release information from an '*internal database*' (pers comm. DWAF, July 2008), and indicated that no service stations appear on the database.

Similarly, the only state record of underground storage tanks (USTs) in the eThekwini Municipality is held by the Fire and Emergency Services department and is inaccessible to the public.

A literature survey revealed the absence of journal published literature regarding leak rates of fuel storage tanks in South Africa (refer to Chapter 7 for further details).

5.14 Identifying a source

Considering the underground nature of most LNAPL releases, identifying the source with certainty can be difficult. This notion is compounded by the following factors:

- Products may be produced by the same refinery but branded differently;
- A product may differ in composition consistency, although originating from the same refinery;
- Products do not often contain unique additives that allow for ease of identification; and
- Products occurring in the ground are frequently weathered thus making comparison of the contaminant chromatograph with a suspected source chromatograph difficult.

Although cluster analysis can be performed, the results frequently have a large degree of uncertainty (Potter, 1989 and Ebrahimi and Hibbert, 2008).

The above factors indicate the risks associated with the production, distribution, storage and dispensing of LNAPLs and present a risk to the ecological wellbeing, human health and future water needs of KwaZulu-Natal and the eThekwini Municipality.

CHAPTER 6. REGULATORY REVIEW

Chapter 6 provides a review of international and local legislation governing LNAPLs.

6.1 United Kingdom

The definitive reference for the design and construction of service station is the '*Guidance for the Design, Construction, Modification and Maintenance of Petrol Filling Stations*', and is known as the Blue Book, and is published by the British based Energy Institute (The Institute of Petroleum, 1999[4]). This reference provides the full specification for service station planning requirements prior to construction; tankage and pipework details; dispensers and forecourt drainage; maintenance and monitoring; repair and decommissioning.

The document is a guidance only and serves to provide methodologies for control over adverse health effects, pollution and safety.

The document highlights two important items, as detailed below:

6.1.1 Tanks

The use of single wall underground tanks presents a contamination risk due to the fact that a loss will only be confirmed after contamination has occurred. The use of corrosion protection is therefore recommended, particularly for unprotected mild steel tanks.

6.1.2 Lines

Similarly, product will be lost to ground prior to leak detection at sites utilising single containment pipework and submersible pumps with leak detectors. Consequently, the Institute of Petroleum recommends referral to the USA EPA Code of Federal Regulations (CFR). CFR 40 Protection of the Environment Part 280 specifies: *Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks* (2011). Section 6.2 provides further details.

6.2 United States of America

State specific regulations for USTs are numerous however the most comprehensive and user friendly (available in the public domain) are those published by the United States Environmental Protection Agency, and termed '*Musts for USTs: A Summary of Federal Regulations for Underground Storage Tank Systems*' (USA Environmental Protection Agency, 1995). The document details specific requirements for

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[4] The 2005 revision is referred to as Guidance for the Design, Construction, Modification, Maintenance and Decommissioning of Filing Stations, while the draft of the Third Edition is entitled Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations, dated June 2010

owners of USTs as stipulated in the above Code 40 CFR Part 280. Requirements are dependent on the date of installation, and are outlined in more detail in the following sections.

6.2.1 Installation

Tanks and dispensing equipment (lines and pumps) must be installed by a qualified installer according to the relevant industry codes. The installer must demonstrate that the installation has complied with the codes.

6.2.2 Leak Detection

All USTs must by law have leak detection by a single method or a combination of methods. The cornerstone of leak detection is inventory control whereby product purchased and sold is reconciled daily. Various mechanisms are available for this and include manual tank dipping and Automatic Tank Gauging. Data retrieved from either of these systems can be utilised for Statistical Inventory Reconciliation whereby the determination of loss is established by statistical data analysis.

On pressurised systems, where product is delivered to the bowser by a submersible pump housed in the tank manhole, line leak detectors are required to ensure system shutdown in the event of a leak in the dispensing lines.

Annual testing of leak detectors on submersible pumps is required. The detection limit needs to be less than 3 gallons per hour at 10 psi [Subpart D, Item 280.44 (a)].

Leak detection may also be performed by having monitoring wells on the corners of the USTs. The monitoring wells are installed to the base of the excavation and intercept the perched water table. The monitoring wells must be inspected routinely for the presence of floating free phase product. This method is only suitable where a perched groundwater table occurs at a depth of less than approximately 3 metres below ground level.

Where dual containment tanks are installed, monitoring of the interstitial space can be performed.

The USA EPA requires that USTs greater than 10 years old are tightness tested every 5 years. Various techniques can be employed for this and include simple pressure testing, vacusonic testing or MassTech testing.

Specific leak detection requirements are contained in USA EPA document '*Straight talk on tanks: Leak detection methods for petroleum underground storage tanks and piping*' (undated), and includes annual line tightness testing on pressurised lines or one of four monthly monitoring tests.

6.2.3 Spill Prevention Infrastructure

All UST systems are required to have impermeable containment sumps beneath the filler point. The filler points are either located directly above the tank or located remotely whereby product is 'dropped' into the tank via a filler line. Typically remote fillers are positioned together.

6.2.4 Overfill Protection

The USA EPA requires product drops to be performed according to a specific procedure. Human error however can result in the overfilling of a UST. In order to mitigate against this, the USA EPA requires the installation of an overfill protection device on all USTs. The device is installed on the filler line and prevents the tank from being overfilled by means of a float device that is activated when product nears the top of the tank.

6.2.5 Corrosion Protection

Corrosion protection is required on USTs and pipework, including infrastructure that is partly steel and partly a non-ferrous material, such as a GRP tank. In cases employing cathodic protection, monitoring of the cathodic protection is required. Systems that do not require cathodic protection must be manufactured entirely of non-ferrous materials, including USTs and all pipework.

Corrosion protection can be performed by a variety of suitable means, including the option of certification by a corrosion expert that the surrounding environment is not corrosive [Subpart B, Item 280.20 (b) (2)].

6.2.6 Other

The regulations stipulate the necessity for record keeping, as well as procedures to follow in the event of a suspected leak and a confirmed leak. In the event of closure of USTs, procedures are to be similarly followed.

6.3 South Africa

The South African legislation incorporates national, provincial and local governing structures, as well as The South African National Standards (SANS) which are applied to the commercial and industrial sectors.

6.3.1 National government

Various national acts are applied to activities in South Africa that may have a detrimental impact on the environment.

6.3.1.1 National Environmental Management Act, 1998

Broad based protection is afforded to South Africans and the environment by means of the **National Environmental Management Act, 1998 (Act No. 107 of 1998)**, commonly referred to as NEMA. The Act allows for:

Persons to live in an environment that is not harmful to their health;
Promotion of sustainable development;
Protection of ecological functioning; and
Prevention of pollution and environmental degradation.

Pollution is similarly broadly defined as changes caused to the environment as a result of the introduction of an extraneous material, be it solid, liquid, gaseous, radioactive, heat or noise.

The Act stipulates that in the case of pollution occurring, the responsible party is liable to assess the degree of pollution and implement measures to prevent further pollution and remediate the areas impacted (Chapter 7, Section 28.3). The Act does not require the notification of authorities by the responsible party in the event of pollution being caused, unless the pollution is classed an incident, where an incident is defined as:

> *'"incident" means an unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed'.*

In such a case, the Act requires the responsible person to notify a 'relevant authority' within 14 days of the incident taking place. The relevant authority is defined as either the municipality in which the incident took place; a provincial official or Head of Department of the Department of Environmental Affairs and Tourism; or the Director General of the Department of Environmental Affairs and Tourism.

The Act draws no reference to specific standards with respect to the degree of pollution.

In the event of failure of the responsible party to perform the necessary remedial measures, recourse can be implemented by the State whereby the affected property is expropriated and cost of implementing remedial measures recovered from the responsible party (Section 28.6 – 28.8).

Similarly, in the event of an emergency incident whereby the incident is not reported to the relevant authority and / or where remedial measures are not taken by the responsible party, the State can implement recourse action against the responsible party.

The interpretation of an 'incident' could therefore preclude the reporting of a tank failure.

6.3.1.2 National Environmental Management: Waste Act, 2008

The **National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)** came into effect on the 1st July 2009 and regulates the generation, handling and disposal of waste in South Africa. In addition the Act includes the control of contaminated land in Part 8. Notably the Act is retrospective whereby contamination that occurred prior to the commencement of the Act is also regulated by the Act. The Act specifies the methodology for reporting contamination and remediation requirements. The Act defines contamination as follows:

> *'the presence in or under any land, site, buildings or structures of a substance or micro-organism above the concentration that is normally present in or under that land,*

which substance or micro-organism directly or indirectly affects or may affect the quality of soil or the environment adversely'.

The act does not however specify concentrations of contaminants that may affect the environment adversely. The Department of Environmental Affairs has however published the Framework for the Management of Contaminated Land in March 2008, as discussed previously. The document proposes Soil Screening Values for application during the assessment of contaminated land. The values are therefore not contained within the Waste Act mentioned above.

The amended Waste Act (Department of Environmental Affairs, 2010) indicates that a person who wishes to remediate contaminated land (Category A Activity, Item 11), is required to perform a Basic Assessment in pursuance of a Waste Licence.

6.3.1.3 National Environmental Management Act, 1998

Similarly, the **National Environmental Management Act, 1998 (Environmental Impact Assessment Regulations, 2010)** (Department of Environmental Affairs, 2010) specifies that a Basic Assessment is required prior to decommissioning a facility where the facility or the land on which the facility is located is contaminated (Listing Activity No. 27 iv). Decommissioned is defined by the regulation.

In addition this acts makes provision for a Basic Assessment to be performed prior to the construction of facilities for the storage of dangerous goods for capacities greater than $80m^3$ (Listing Activity No. 13). This document typically details the nature of the activity; the potential impacts that the proposed activity may pose to the receiving environment; and whether mitigatory measures are sufficient to reduce any impacts to acceptable levels. Typically in the case of LNAPL storage, South African National Standards are quoted as mitigation.

6.3.1.4 The Environmental Conservation Act, 1989

The **Environmental Conservation Act, 1989 (Act No. 73 of 1989)** (Republic of South Africa, 1989) provided broad based environmental protection against environmental harm as per Part IV: Control of Environmental Pollution. Similarly Part V: Control of Activities Which May Have a Detrimental Effect on the Environment, provides a non-exhaustive list of activities that have the potential to cause contamination. The activities do not include the operation of service stations. The Act has however mostly been repealed

6.3.1.5 The National Water Act, 1998

The **National Water Act, 1998 (Act No. 36 of 1998)** (Republic of South Africa, 1998) provides the legal framework for the protection of water resources in South Africa. The Act defines water resources and users within South Africa, and Chapter 14 allows for the provision of access to information by water users and the general public, as follows:

'Part 2 requires the Minister, as soon as it is practically possible to do so, to establish National Information Systems, each covering a different aspect of water resources, such

> *as a national register of water use authorisations, or an information system on the quantity and quality of all water resources. The minister may require any person to provide the department with information prescribed by the minister in regulations. In addition to its use by the department and water management institutions, and subject to any limitations imposed by law, information in the national systems should be generally accessible for use by water users and the general public'* .

The Act further reiterates the above right access to information in Section 145, as follows:

> *'A water management institution must, at its own expense, make information at its disposal available to the public in an appropriate manner, in respect of any risk posed by the quality of any water to life, health or property'.*

DWAF are generally accepted as the custodians of groundwater and groundwater quality despite the above exclusive reference to DEAT (and municipal structures) within NEMA. DWA is the implementing agent of the National Water Act through various mechanisms, guided by the Policy and Strategy for Groundwater Quality Management in South Africa (DWAF, 2000). The document defines the policy for the protection and controlled utilisation of water resources in South Africa, and provides guiding principles for the management of groundwater contamination, including and not limited to 'hydrocarbon storage tanks' (Section 4.1.4).

Communication with the Durban DWAF in 2008 has indicated that the department handles reported incidents of contamination on an ad hoc basis and no database is kept regarding contaminated sites.

It is noted that both the National Environmental Management Act and the National Water Act make provision for the recovery of costs incurred in pursuing responsible parties with respect to contamination incidents. These costs can include investigation and prosecution expenses incurred during and after pollution incidents (Sampson, 2001).

6.3.1.6 The Petroleum Product Act, 1977

The **Petroleum Product Act, 1977** (Department of Minerals and Energy, 2006) regulates storage of petroleum products at retail sites by means of Government Notice No. 286. The act details requirements including preventative mechanisms, management mechanisms and remediation requirements in the event of an incident or closure.

6.3.2 Provincial government

Provincial structures are in place to manage the upgrading and construction of new service stations. The Gauteng Province has published a guideline (*'Guideline for the construction and upgrade of filling stations and associated tank installations')* for:

- Minimum distances between service stations in residential areas;

- Minimum distances between service stations in non-residential areas; and
- Minimum distances from land uses including schools and hospitals.

In addition to the above requirements, applicants are required to detail the nature of the surrounding land use, the proximity of boreholes and the cumulative impact of all the service stations in the vicinity of the proposed development (Gauteng Department of Agriculture, Conservation, Environment, and Land Affairs, 2002).

6.3.3 eThekwini Municipality structures and regulations

eThekwini Municipality Pollution Department is tasked with the management of environmental pollution. Operational activities are mostly management of failure and contamination of stormwater and sewer reticulation.

The Development Planning, Environment and Management Unit of the eThekwini Municipality is tasked with facilitating environmentally sustainable development in the Metro, as well as reviewing Environmental Impact Assessments.

The Municipal Fire Department are responsible for reacting to fire events, as well as being responsible for ensuring preventative measures are carried out, as per the Interim Code Relating to Fire Prevention and Flammable Liquids and Substances (eThekwini Municipality, 2007). The code provides regulatory powers to the Fire Department to perform, amongst others, the following functions:

Fire prevention;
Control of fire fighting equipment;
Inspection of flammable liquid and substance storage;
Inspection of storage tanks, pumps and containers; and
Inspection of bulk storage depots.

The Code stipulates that persons storing flammable liquids in excess of 200 litres (of a Class 1 Flammable Liquid with Flash Point <21°C) are required to obtain a Certificate of Registration for the products from the Chief Fire Officer.

The Certificate of Registration stipulates the volume and type of products stored, as well as various conditions of Registration, as follows:

- The provision of a Site Plan with the Application for Certificate of Registration;
- Compliance with SANS 10089 Code of Practise of the Petroleum Industry Part 1: the Handling Storage and Distribution of Petroleum Products;
- 2 Fire extinguishers are required per UST [Section 46 1. (a)], and are to be tested by a competent person once a year;
- Tank owners are to ensure USTs and pipework are free of leakage [Section 63 (d)];
- Tank owners are to report fire incidents to the Chief Fire Officer;

- Tank owners are required to notify the Chief Fire Officer upon removal of equipment; and
- Tank owners are required to request approval for the closure in place of a UST.

The Chief Fire Officer is responsible for the maintenance of a Register whereby all registered sites are recorded. This dataset was sourced and analysed as part of this study.

6.3.4 South African National Standards code of practise

In addition to the above legislation, relevant South African National Standards (SANS) apply. SANS documents are 'Codes of Practice' and are generally prepared by expert working groups involved in the respective industries. The codes are not legally binding as standalone documents unless they are specifically referred to in a piece of legislation and / or gazetted. The following SANS codes are applicable to the fuel retailers and own-use industry:

Table 6.1. SANS codes applicable to the fuel industry in South Africa

Code	Description	Application	Nationally or Provincially Legislated
SANS 10089-1:2008 (SABS 089-1)	*The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations*	Storage of > 200m^3	Yes
SANS 10089-3:2010 (SABS 089-3)	*The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations*	Service stations	Yes
SANS 10131:2004	*Above-ground storage tanks for petroleum products*	Storage of < 200m^3 in tanks < 85m^3 capacity	Yes
SANS 1535:2007 (SABS 1535)	*Glass-reinforced polyester-coated steel tanks for the underground storage of hydrocarbons and oxygenated solvents and intended for burial horizontally*	Tank specifications	Yes
SANS 1830:2006 (SABS 1830)	*Flexible piping for underground use at service stations and consumer installations*	Pipework specifications	No
SANS 1668:2007 (SABS 1668)	*Fibre-reinforced plastic (FRP) tanks for buried (underground) storage for petroleum products*	Not used in South Africa	No
SANS 50858-1:2002/EN 858-1:2002 (SABS EN 858-1)	*Separator systems for light liquids (e.g. oil and petrol) Part 1: Principles of product design, performance and testing, marking and quality control*	Applicable to drainage control	No
SANS 50858-2:2003/EN 858-2:2003	*Separator systems for light liquids (e.g. oil and petrol) Part 2: Selection of nominal size, installation, operation and maintenance*	Applicable to drainage control	No

Table 6.1 indicates which standards are legislated either provincially and / or nationally. It is however also possible that some standards are referred to in local government by-laws (not included above). The relevant legislation where the above standards are enforced is summarised in Appendix B.

Preventative measures specified in SANS 10089 Part 3 (2010) are summarised as follows:

1. Glass reinforced polyester corrosion protection on tanks;
2. Corrosion protection on mild steel pipework;
3. Overfill protection device within each tank;
4. Leak detector on submersible pump systems that prevents product dispensing in the event of a line leak;
5. Shear valves can be installed beneath the dispenser pumps, activated in the event of the dispenser being knocked over;
6. Monitoring wells can be installed surrounding the UST and intercept the water table. In the event of a leak, product will enter the monitoring wells;
7. Drainage. Dispensing and filling areas are either not paved, paved with interlocking G blocks or paved with concrete or asphalt. Drainage from these areas should discharge via a gravity separator to sewer (if detergents could occur in the effluent) or to stormwater in the absence of detergents (SANS 10089 Part 3 requirement for diesel dispensing areas at non service station facilities only);
8. Leak proof tank manholes;
9. Leak tests prior to commissioning;
10. Automatic tank gauging (ATG) is a feature of underground tanks that allows for remote tank level gauging (SANS 10089 Part 3 Optional); and
11. In addition to the above, numerous other safety features are prescribed by the various SANS documentation.

6.4 Tank and pipe manufacture in South Africa

Tank manufacturing in South Africa prior to 1991[5] consisted primarily of an unprotected mild steel construction. After 1992, tank manufacturers began producing Glass-fibre Reinforced Polyester (GRP) tanks and it was at this stage that GRP tanks were first utilised by oil companies.

Construction of GRP tanks is now performed according to the above SANS Specification, SANS 1535: 2005. The standard specifies these tanks to be coated with a '*glass-reinforced polyester laminate'*, of minimum thickness 2.5 mm, providing a protective layer between the mild steel and any potentially

[5] In the USA, prior to 1988, all tanks were unprotected mild steel.

corrosive sub-surface soil and groundwater conditions. Of significance however, is the incorporation into this code of item 5.6.10, as follows:

> *'Each tank shall be fitted with a dip stick strike plate. The striker plate shall be fitted diametrically opposite the manhole opening and can consist of the cut out of the manhole. The striker plate shall be welded all the way round. The dimensions of the striker plate shall be as agreed upon.'*

The introduction of the striker plate has significantly reduced the number of tank failures due to puncturing beneath the dip point, as referred to previously. No data are however available to support this.

The introduction of non-ferrous pipework has similarly reduced failure of underground fuel infrastructure. Previously, pipework consisted of mild steel pipework. This material is not always protected with a corrosion wrap. Current installations typically make use of non-ferrous pipework, consisting of either:

- *Type A: Filament wound, glass-fibre-reinforced thermosetting resin; or*
- *Type B:Thermoplastic polymer*

These materials are non-corrosive and normally used in conjunction with secondary containment pipework, whereby, in the event of primary pipework failure, product will discharge into the secondary containment and into either the tank or dispenser manholes.

6.5 Summary of regulatory review

A review of regulations pertaining to control of USTs revealed the following:

- **British**: non-statutory code with few specific protective mechanisms (Groundwater Protection Code - Petrol stations and other fuel dispensing facilities involving underground storage tanks, Department for Environment, Food and Rural Affairs, 2002).
- **Australian**: gazetted regulation with few specific protective mechanisms (Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2008, New South Wales Department of Environment, Climate Change and Water, 2008).
- **Canadian**: Code of Practise that is implemented by listed 'Authorities having jurisdiction' (Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products, Canadian Council of Ministers of the Environment, 2003). Federal entities are not legally required to comply other than parts specified in the Canadian gazetted Official Regulations *(*Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations P.C. 2008-1048, Environment Canada, 2008).
- **American**: Underground fuel installations in the USA are governed by Code 40 CFR Part 280, as well as requirements defined in State specific regulations.

6.6 Key contamination and leak prevention mechanisms

Table 6.2 provides a summary of key contamination and leak prevention measures for both in service and new installations in Canada, the USA and South Africa. Where the measure is specified in regulations, the relevant section is provided.

Table 6.2. Regulatory review of International and South African UST requirements

Key Contamination and Leak Preventative Measures	Canadian (P.C. 2008-1048)		American (Code 40 CFR Part 280)		South African	
	In service	New	In service	New	In service (SABS 089-3:1991 - 1999)	New (SANS 10089-3:2010)
Single walled tanks allowed	Conditional 9.	No 14.1 As per Code's 4.2.4(1) a	Conditional 280.20 (a) (2)		Conditional 4.1.2	Conditional 4.1.2
Single walled pipework allowed	Conditional 10.(2)	No 14.(1)c As per Code's 5.4.1	Conditional 280.20 (b)		Conditional	Conditional 7.
Impermeable tank manholes	Required 14.(1)b	Required 14.1(b)	Required if filler located here 280.20 (c) (i)		Not required 6.2	Required 6.2
Cathodic protection of tanks	Yes, by 2012 (steel tanks)	If required 14.1	If required 280.20 (a) (4) (i)		If required 4.3 (Not in 1991 rev)	If required 4.3
Cathodic protection of steel pipes	Required 10.(2)a	Dual contain-ment pipework required	If required 280.20 (b) (3) (i)		If required 4.3 (Not in 1991 rev)	If required 4.3
Observation wells	Required 9.(1)b	If required 14(1)	If necessary 280.43 (f)		If necessary 5.1.2	Required 5.1.2
Excavation lining	Not required	Yes 14.1 As per Codes 4.3.5	Not required		Optional 5.3.3	Not required
Dual containment pipework	Optional 10.2	Required 14.(1)c As per Code's	Optional		Optional	Optional

Key Contamination and Leak Preventative Measures	Canadian (P.C. 2008-1048)		American (Code 40 CFR Part 280)		South African	
	In service	New	In service	New	In service (SABS 089-3:1991 - 1999)	New (SANS 10089-3:2010)
		5.4.1				
Impermeable filler boxes	Yes 15.(1)	Yes 14.1	Required 280.20 (c) (i)		Required 9.3	Required 6.2 and 8.3
Tank leak detection	Required 16.	Required (14.1)	Required 280.40 – 280.43		Not specified	Conditional Annex B
Submersible pump leak detectors	Required 10.(2)	Options Required 14.(1) As per Code's 6.2.2	Required 280.41 (b) (1) (i)		Required 7.2 and 10.3.1	Required 9.3.1
Line leak detector maintenance	Various options 17.	Various options 14. As per Code's Part 6	Required annually 280.44 (a)		Not specified	Not specified
Pressurised line annual leak test	Conditional 17.1b	Conditional 14. As per Code's Part 6	Conditional 280.41 (b) (1) (ii)		Conditional as per SANS 10089-3:2010 Annex B	Conditional Annex B
Overfill protection	Not specified	Yes 14.1 As per Code's 4.2.4.(1)b	Required for >25 gallons per transfer 280.20 (c) (ii)		Required 7.7.3 and 12.3	Required 11.3
Inventory control	Required 14.1 As per Code's 8.3	Required 14.1 As per Code's 8.3	Required monthly 280.43 (a)		Not specified	Not specified
Pump sumps	Not specified	Required 14.1 As per Code's 4.3.4	Not specified		Not specified	Not specified
Pipework joints in manholes	Not specified	Yes 14.(5)a	Not specified		Not required	Required 7.4.2

Note: N.F.C.C.: National Fire Code of Canada

The following items summarise significant differences between the above countries specifications:

- Single walled tanks for new installations are not permitted according to the Canadian specifications;
- Single walled pipework for new installations are not allowed according to the Canadian specifications;
- The American specification requires annual leak detector maintenance; and
- Inventory control is mandatory according to Canadian and American specifications.

Nadim *et al* (2001) highlights the shortcomings of the USA regulations whereby conditional options allow for the installation of single containment pipework and tanks in certain states, whereas five north-eastern states stipulate all tanks to be dual containment. Similarly, leak detection requirements can result in leaks of up to 6600 L per year not being detected. Nadim *et al* specify various methodologies to reduce failure and improve timeous leak detection.

6.7 Voluntary oil industry specifications

The oil industry has self governing standards whereby company specific specifications and standards are applied both for construction and site management.

For example, Shell Global Solutions currently manage Shell retail sites by means of their Network Environmental Risk Assessment program, or NERA II. The program ranks sites according to various risk assessment criteria. Based on the ranking, sites are managed.

Similarly, Engen Petroleum operate their retail network by means of a Spill Intervention Program (SIP) whereby sites are scored according to a Risk Assessment Programme (RAP). This program allows for sites to be managed according to risk posed by the vulnerability of the groundwater, age of the installation, corrosion potential of the environment, volume throughput of the site etc. Existing sites are scrutinised by means of the Product Inventory Loss Policy (PILP) and interventions are implemented according to certain criteria (Engen, 2009).

Detailed information regarding self governing oil industry specifications are however generally not in the public domain.

CHAPTER 7. STORAGE TANK SYSTEMS AND SOURCES OF LNAPL CONTAMINATION

The numerous mechanisms of failure; the various types of storage equipment and the different rates of failure allow for a complex range of scenarios and resultants risks.

7.1 Reliability

The cornerstone of LNAPL leak prevention is determining quantified reliability of the components of the fuel storage and dispensing system.

Quantitative reliability can be defined as follows (Andrews and Moss, 1993):

> *The probability that an item (component, equipment or system) will operate without failure for a stated period of time under specified conditions.*

Equipment failure is frequently described according to the bath-tub graph, as follows:

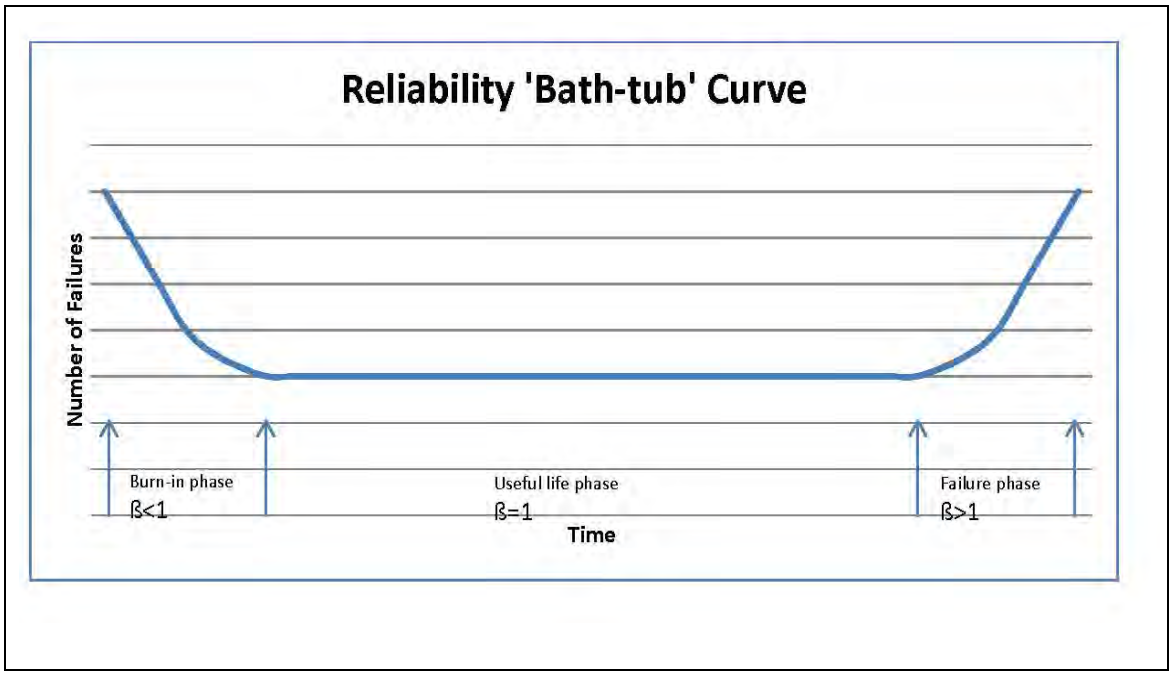

Figure 7.1 Bath-tub curve describing typical mechanical failure characteristics

The bath-tub curve is described by ß, or the shape parameter, where ß<1 describes early life failures (a decreasing failure rate with time), ß>1 wear out failure (a failure rate that increases with time) and ß=1 random failures (a constant failure rate). Failure is also described by renewal theory whereby, in the case of increasing likelihood of failure with time, the unit is described to have positive aging, while the converse is described as negative aging (Cox. 1967).

Reliability of a process, plant, machinery or in the case of LNAPL contamination, fuel storage and dispensing equipment, is of significant importance in terms of preventing system unavailability (denoted by symbol Q); preventing contamination; and maintaining safe standards. Typically, a Reliability Program is implemented from design, through testing, implementation and to operational phases of a plant. It is within this program that consideration for the following factors can be given:

- Implementation of failure tolerant design.
- Implementation of a design allowing for ease of maintenance.
- Consideration for complexity of design.
- Assessment and implementation of various cost considerations.

The greater the attention that is paid to the above Reliability Program, the less the likelihood of failure prior to the anticipated design life, and the lower the risk. Risk is both a function of the consequences of failure, as well as the likelihood of failure occurring. Risk is generally defined in terms of a potential threat to economic, community and occupational factors. With respect to UST systems, risk is also defined according to ecological risk. It should be noted however that eliminating risk completely is not possible, and depending on the scenario, an acceptable risk factor is typically defined.

Risk is typically presented as a probability, with zero representing the inability of an event to occur, and 1 representing the absolute certainty that an event will occur.

Potential risk can also be determined qualitatively by the identification of potential failures and / or out of specification events. A variety of methods are available and include HAZOP studies, rapid ranking, fault trees and failure mode and effect analysis (FMEA).

7.2 Failure

Failure is described by Collins (1993) as follows:

> *'Any change in the size, shape, or material properties of a structure, machine, or machine part that renders it incapable of satisfactorily performing its intended function.'*

Failure may be as a result of the introduction of a single agent, or as a result of the combination of a number of agents acting in synergy. These agents are typically classified into mechanical related or corrosion related. No system or component can be designed to eliminate failure indefinitely, and as such design parameters typically specify minimum life estimates, instead of age of failure estimates, in order to account for economic and safety implications.

7.2.1 Mechanical factors

Mechanical failures primarily occur as a result of impacts, fatigue, elastic deformation, wear, brittle fracture, ductile rupture and fretting.

Conditions that failure occur may vary according to thermal, chemical or nuclear environments, as well as within varying time frames from immediate and explosive, to long term wear related failure.

In order to quantitatively understand failure mechanisms of mechanical components, various parameters need to be determined. The measurement of the relationship between an outcome and a cause can be performed by regression analysis, whereby the relationship between an independent variable is measured against a dependent variable, or explained variable. A causal relationship is assumed, and the relationship can be described as follows:

$Y = \beta_0 + \beta_1 X + e$

Where: X = independent variable (predictors or explanatory variable)

Y = dependent variable (outcome or response variable)

β_0 = regression intercept

β_1 = regression slope

e = error term (the difference between the predicted / modelled Y value and the actual Y value)

Regression analysis assumes a number of key factors, namely that the relationship between X and Y is linear, and that the distribution of Y is normal.

Regression analysis outputs include the 'R' value, or correlation coefficient, which describes the correlation between the predicted and actual values of the dependent variable. The 'R^2' value, or coefficient of determination, is denoted by the value 1 where perfect correlation occurs. Zero does not necessarily imply no correlation, simply no linear correlation. R^2 can be adjusted for the number of independent variables, and is termed the adjusted R^2. Finally, the regression can be described by the standard error of the estimates (Huizingh, 2010).

In order to test the predicted distribution against the observed distribution, a chi-square test is performed.

A logistic regression is however somewhat different and is used to describe scenarios where the mean value of the dependent variable, termed the conditional mean, is greater or equal to zero and less than or equal to 1. Cumulative distributions of the outcome variable are typically S-shaped, and described by the following formula:

$\pi(x) = [e \exp(\beta_0 + \beta_1 X)] / [1 + e \exp(\beta_0 + \beta_1 X)]$

Regression analysis on data is performed and presented in Section 9.3.5.2 and 9.3.5.3 while results of the logistic regression performed on the data is presented in Section 9.3.9.

7.2.2 Corrosion factors

Corrosion may be induced as a result of one of the following mechanisms: pitting, chemical, galvanic, stress, biological, crevice and erosion.

Holt (1997) cites corrosion of USTs to be caused by the following mechanism. Where tank filler points are located in the tank manhole (as opposed to remote fillers), spillage of product can occur here during product off-loading. If the tank has been coated with a protective bituminous lining, the spilt product can attack this lining resulting in the establishment of an electrical cell within the tank, and corrosion as a result of the electrical current between the cathode and sacrificial anode, typically at the base of the tank.

Sub-surface soil conditions also affect the corrosion rate of buried mild steel. The following parameters are considered noteworthy:

i. Moisture Content Paul (2000) indicates that a minimum soil moisture content of 16% is required to sustain corrosion. Fluctuating moisture content, such as that caused by a perched aquifer vulnerable to rainfall and seasonal variation in height, can exacerbate the corrosion potential of a soil by alternating the aerobic and anaerobic nature of the environment.

ii. Chlorides and Sulphates The presence of salts in the sub-surface, particularly chlorides, can contribute significantly to corrosion of mild steel. The higher the salt concentration, the greater the potential for corrosion. High chloride concentrations can be encountered in marine deposited sands in close proximity to coastlines. Paul (2000) suggests a salt concentration of 50 ppm as being characteristic of a *more corrosive* environment.

iii. Sulphate Reducing Bacteria These bacteria respirate anaerobically by means of reducing sulphates to hydrogen sulphide. Hydrogen sulphide is corrosive to exposed and buried steel structures.

iv. Soil Resistivity Soil resistivity is the reciprocal of soil conductivity: the lower the resistivity, the easier current will flow through the soil. Of the measurable soil characteristics, resistivity is generally accepted as the primary indicator of soil corrosivity. A low resistivity is therefore unfavourable for increased soil corrosivity potential. SANS 10199: 2004 indicates the following soil corrosivity potentials:

Table 7.1. Soil resistivity and corresponding corrosivity potential (SANS, 2004)

Soil Resistivity	Soil Corrosivity Potential (Qualitative)
0 – 10	Very severe
10 – 100	Moderate to severe
100 – 1 000	Mild
1 000 -	Probably not corrosive

The introduction of GRP tanks with corrosion protective linings and non-ferrous pipework has reduced the likelihood of corrosion occurring.

7.3 General description and failure mechanisms of UST systems

UST systems consist of the following components (refer to Figures 7.2, 7.3 and 7.4):

1. UST. Up until 1991, all USTs consisted of a single wall steel tank, either with coal tar corrosion protection or not. The introduction of SABS 1535 in 1993 saw the increased use of glass fibre reinforced polyester (GRP[6]) tanks as a corrosion preventative measure. Most tanks installed after 1994 were thus GRP tanks. These tanks consist of an inner steel shell (grade 300WA) and an outer protective reinforced polyester coating with minimum thickness 2.5 mm (SANS, 2005).

2. Pipework. Pipework consists of, either dated mild steel pipework, with a petrolatum gauze wrapping (sometimes absent) and a PVC outer wrap (SANS 1999); or non-ferrous flexible piping constructed of thermoplastic polymers. The non-ferrous pipework sometimes includes secondary containment (also flexible non-ferrous) in the event of primary line failure (SABS, 2001). Secondary containment is primarily used on dispensing lines and not filler or vent lines. SANS 10089 (1999) specifies a minimum burial depth of 300 mm below natural ground level.

3. Fillers are either within the tank manhole or are remote fillers located some distance from the tank.

4. Pumps. Pump configurations are either suction pumps or submersible pumps. Suction pumps are housed within the dispenser, and suck product from the tank. Submersible pumps are located within the tank, with the pump motor housed in the tank manhole. Consequently the dispensing lines are therefore under positive pressure. The two systems offer differing advantages and disadvantages, as follows:

Table 7.2. Advantages and disadvantages of pump system types (Institute of Petroleum, 1999)

Submersible System	Suction System
System more reliable.	System less reliable due to air locks.
One line can be T'ed to service various dispensers thus necessitating less pipework.	One line is required from each dispenser to the respective tank thus necessitating more pipework.
Higher pump rate.	Lower pump rate.
Fewer pumps required.	Pump required in each dispenser.

[6] Nomenclature in the US is different whereby GRP tanks refer to glass reinforced plastic tanks (McConnell, 2007). These tanks are not found in South Africa, and have been exposed to criticism as a result of buckling and / or collapse when being lifted and removed. Steel tank manufacture commenced in the US in 1925, while GRP tank manufacture commenced in 1965. Currently single, double and triple wall tanks are produced in the US.

Submersible System	Suction System
Greater volume loss in the event of line failure.	Lower volume loss in the event of line failure.
Pump failure causes all dispensers serviced to be out of commission.	Pump failure only renders dispenser in question unserviceable.

5. Tank manholes. Dated tank manholes consist of plastered brick construction. Occasionally no tank manholes are present. Tank manholes supplied with GRP tanks generally consist of plastic chambers that are bolted onto the tank.

6. Dispenser sumps. Similarly, dispenser sumps serve as spill collection chambers and are of various construction materials, including plastered brick and fuel resistant plastic. Pump sumps are not always present.

Figures 7.2 and 7.3 illustrate typical UST installations:

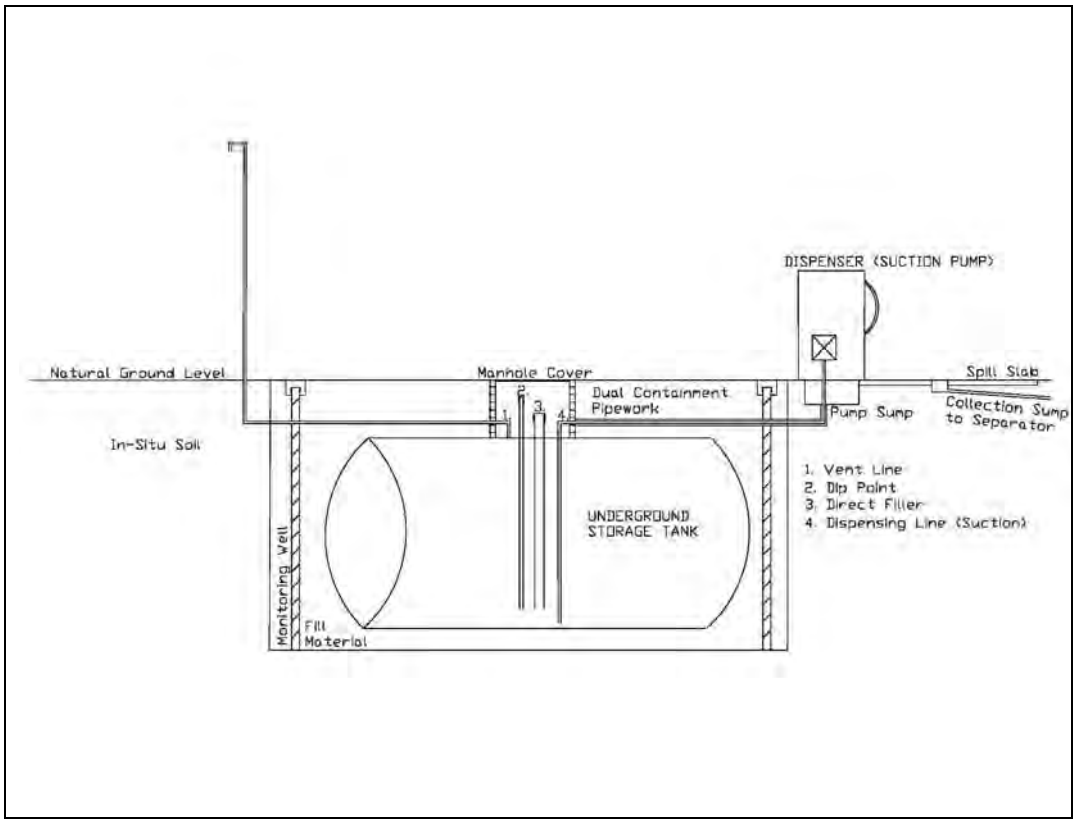

Figure 7.2 Schematic diagram of UST and related infrastructure on a suction system and over-tank filler.

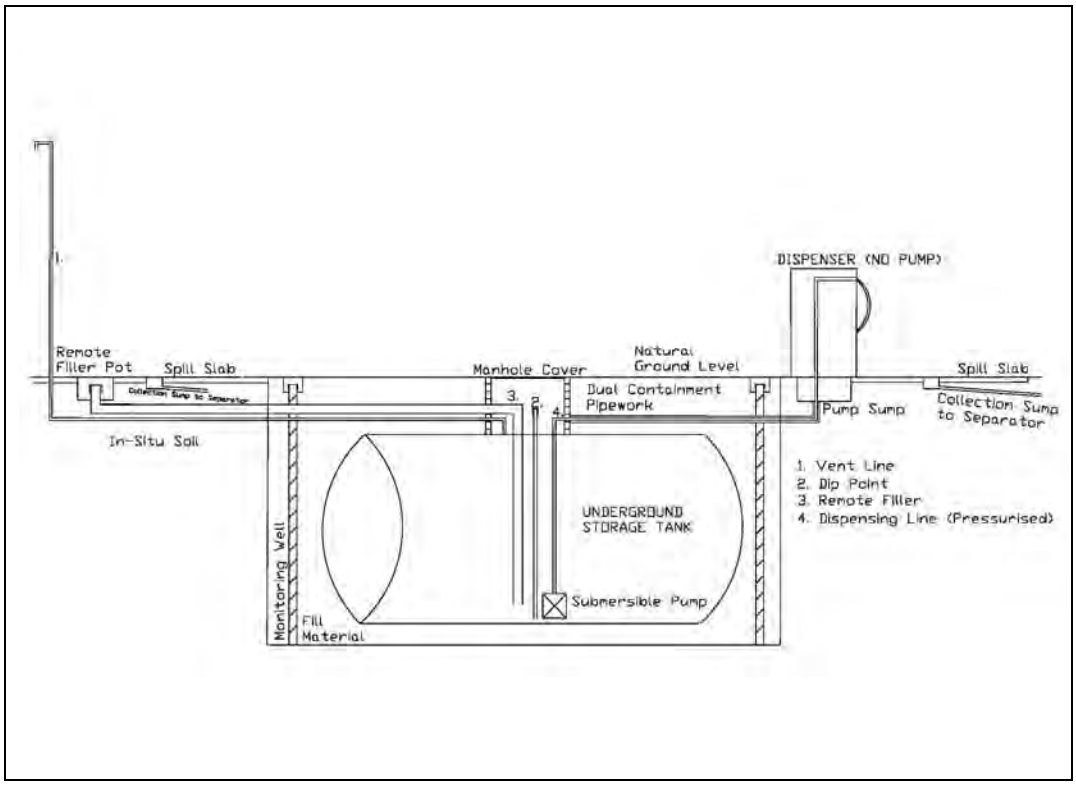

Figure 7.3 Schematic diagram of UST and related infrastructure on a submersible pump system and remote filler.

Failure of the above infrastructure can however occur, thus introducing a contamination source.

A source refers to a contaminant released from its confining medium. The EPA (2004) defines a source as:

> *'a material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure'.*

Product can be lost to ground via one of the following routes:

- Failure of the UST. This can be a result of corrosion; or as a result of metal fatigue and puncturing below the dip point.
- Failure of underground product lines (filler, dispensing and / or vent). Product lines may fail as a result of corrosion, joint failure etc. Pipework buried at insufficient depth can fail due to surface loads transferring stresses to the pipework itself. In cases where leak detectors on submersible pumps are absent or fail, and no secondary containment is in place, product will be pumped to ground.
- Nadim *et al* (2001) indicate that a fluctuating perched water table around a UST can result in buoyancy forces being exerted on the tank and pipework and possible failure as a result. This is of particular significance to the eThekwini region where a perched water table occurs frequently at <5 m below ground level (bgl).

- Tank overfill during product delivery. In such cases product can either be released to *ground* where the delivery is taking place (tank manhole or remote filler point); out the dip point or out of the vent pipe. If discharge occurs to the tank manhole and the manhole is of pervious brick construction, or pipework entry and exit points are not sealed correctly, discharge will occur to ground.

- Product spillage at the dispensing point with insufficient containment.
- Fittings that have become loose or where seals have failed either on the submersible pump or beneath the dispenser pump resulting in soil contamination, particularly in cases where containment sumps are completely absent. In a study by Marcel Maine Associates (2003) for the state of Maine, USA, 51% of dispensers were found to have no containment sumps.
- In cases where product enters dispensing line secondary containment and secondary containment does not terminate in sealed manholes, spreading of contamination across site can occur rapidly.

Contamination may also occur as a result of non-routine or non-failure mechanisms. These include:

- Discharge of the filler hose to impervious tank manholes.
- Contamination at dispensing points not paved with a permeable hard surfacing.
- Spillage during theft.
- Spillage during closure where a product line is severed prior to draining.

7.4 Above-ground storage tanks

Above-ground storage (AST) of LNAPLs can take place in single walled tanks provided that the flash point of the product is greater than 38°C (Section 4.3.2.12, SANS, 2004). Figure 7.4 illustrates a typical AST.

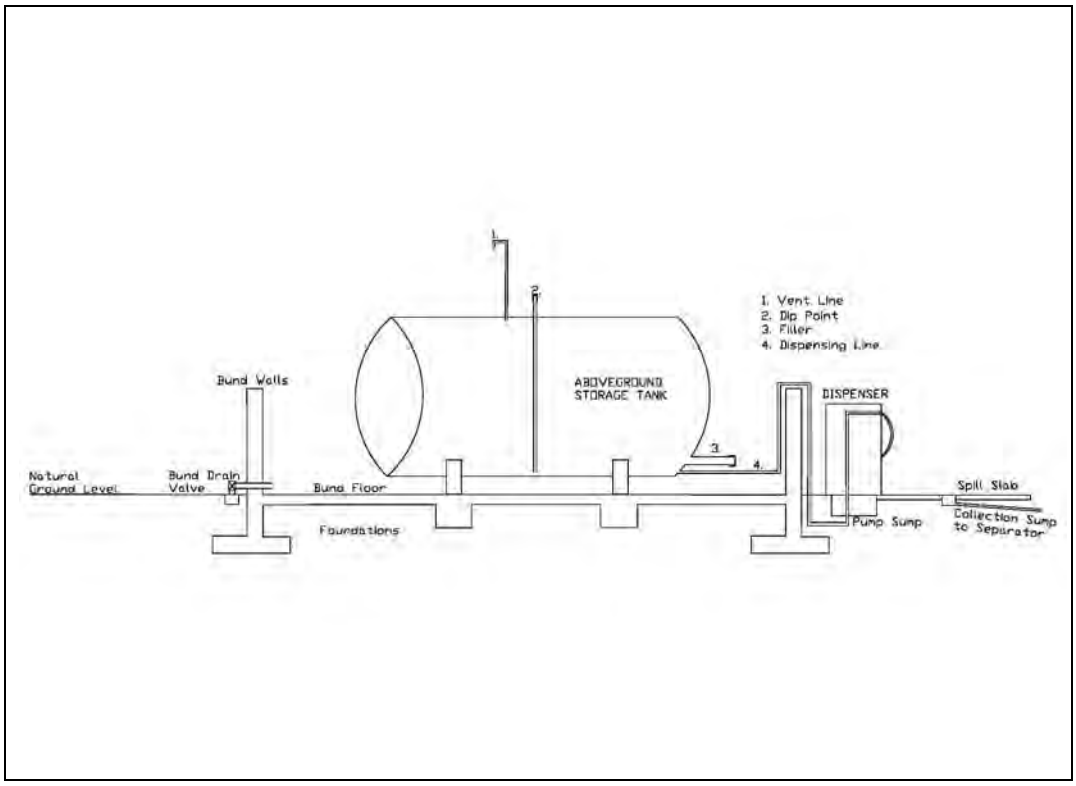

Figure 7.4 Schematic diagram of aboveground storage tank and related infrastructure

Contamination as a result of AST installations is typically associated with one of the following failure mechanisms:

- Bunding absent or permeable;
- Insufficient bund volume and / or unpaved bund floor;
- Spillage within the bund and bund valve left in the open position;
- Dispensing line failure; and
- Spillage at the dispensing point and absence of hard surfacing and / or drainage control.

Note: storage of LNAPLs in self bunded tanks occurs for products with flash points including those less than 38°C. These tanks however will not be addressed within this dissertation considering their occurrence is minuscule.

7.5 Failure literature

Dietz *et al*. (1986) performed research into the integrity of tanks at service stations, commercial sites and farms. The objectives of the study were to determine the following:

- The number of service station's etc housing tanks in the USA;
- The characteristics of the service stations etc;
- The number of tanks;
- The age and type of the tanks; and
- The number of leaking tanks.

The findings of the study reported that approximately 35% of an estimated 796 000 fuel USTs in the USA leaked at that time. This figure was determined by a number of test criteria established during the study and included an assessment of fuel inventory data as well as physical tank tightness testing whereby a sub-sample of 433 tank systems (tank, filler lines, dispensing lines and vent lines) were tested.

The findings indicated that approximately the same number of mild steel tanks and glass fibre reinforced tanks leak.

Similarly the results indicated that the age of the tanks did not have a significant bearing on whether a tank passed or not, with the exception of tanks older than 20 years, where a significant increase in the failure rate was recorded. The mean age of tanks was recorded as 12 years old.

Canter *et al* (as cited in Moschini, 2005) reported in 1988 that approximately 10% of fuel USTs in the USA leak.

Moschini *et al* (2005) performed research into service stations in Brazil and reported that approximately 80% of fuel USTs in Sao Paulo city show evidence of leaking either from the UST or pipework. Reasons for failure include the incorrect method in which the USTs were installed; and the unprotected nature (mild steel) of most of the USTs. Soil type, and in particular acidic soils, was shown to have a correlation to corrosion of USTs; while a perched fluctuating water table was suspected to contribute to varying soil compaction and stresses to underground pipework.

Moschini also cited 20 years as being significant in terms of the feasible life of a UST, prior to failure. This period was reduced to approximately 15 years if the tanks did not have cathodic protection.

Mulroy and Ou (1997) refer to an old tank as being greater than 20 years of age, and make reference to the higher failure rate of these tanks.

The Institute of Petroleum indicate that the leading cause of soil and groundwater contamination at service stations to be line leaks, while the primary cause of underground tank failure is corrosion (Institute of Petroleum, 1999)

7.6 USTs in the United States of America

The USA has a long history of reporting on USTs and associated failures and contamination. Annual reporting performed by the USA EPA Office of Underground Storage Tanks summarise data collected from operators and owners throughout the country. Figure 7.5 and Figure 7.6 provide data for the period 1997 - 2007:

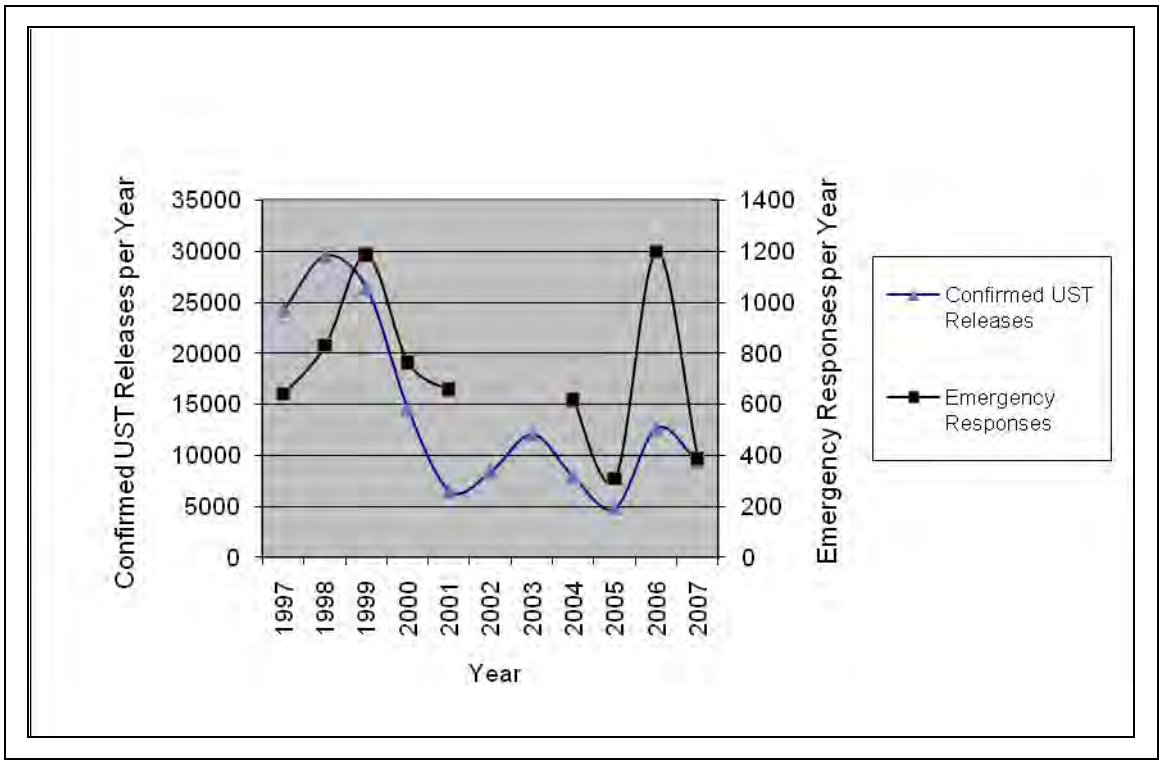

Figure 7.5 **Confirmed UST Releases and Emergency Responses per Year in the USA (United States Environmental Protection Agency, 1997 – 2007)**

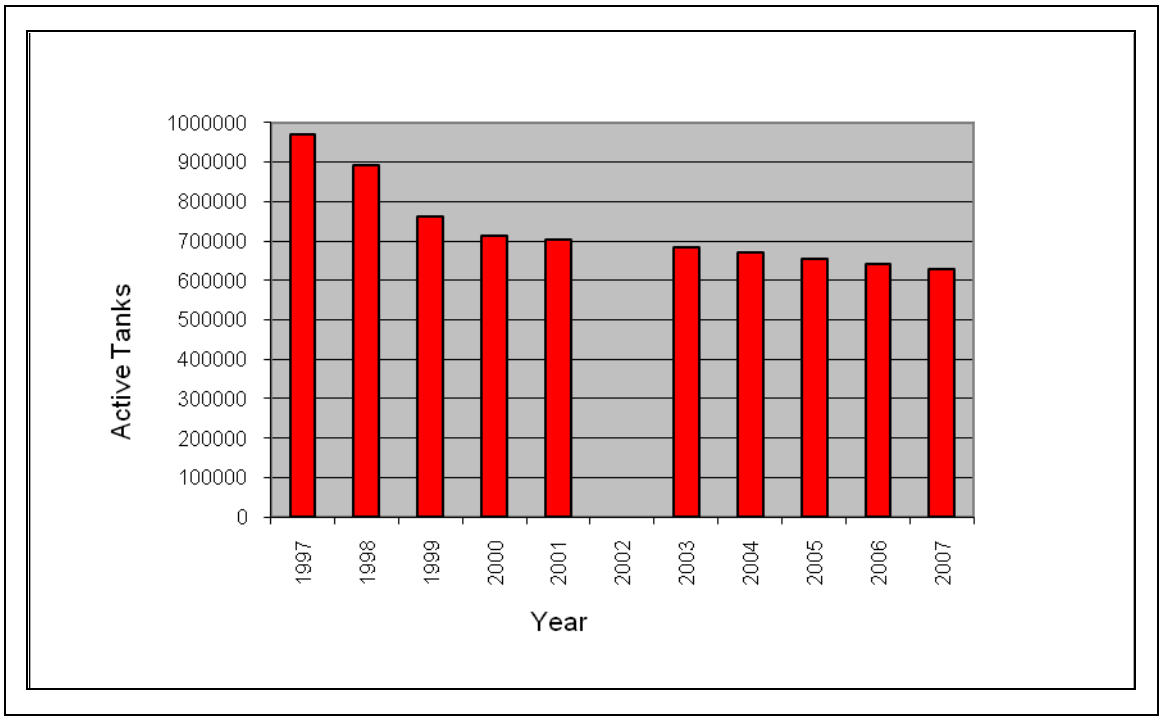

Figure 7.6 **Active USTs per Year in the USA (United States Environmental Protection Agency, 1997 – 2007)**

The terms release and emergency response are defined by the documentation (United States Environmental Protection Agency, 1997 – 2007) as follows:

Release: '*Incidents where the owner / operator has identified a release from a regulated petroleum UST system, reported the release to the state / local or other designated implementing agency, and the state / local implementing agency has verified the release according to state procedures'.*

Emergency Response: '*Sites where the implementing agency takes immediate action to mitigate imminent threats to human health and the environment posed by an UST system release'.*

The above data indicates the number of operational USTs in the USA decreased from 969 652 in 1997 to 629 866 in 2007. The number of releases per year was reported to have similarly decreased from highs of 24 285 and 29 614 in 1997 and 1998 respectively, to 9 399 in 2007. The number of emergency responses however displays a variable trend with maximums for the years 1999 and 2006, with corresponding values of 1 186 and 1 199 emergency responses respectively. The 2007 report indicates significant clean-up response to incidents with 13 862 cleanups being performed during this year. This value is greater than the actual number of releases for the year as a result of the clean-up backlog that exists in this country.

Note should be taken that Cunningham and Saigo (1999) report that the number of USTs in the USA in 1999 to be in excess of 2.5 million. This is significantly different from the above quoted figure and is likely due to the inclusion of abandoned and out of use USTs in the Cunningham and Saigo figure. The same authors indicate that approximately 42 million L of fuel are lost to ground every year as a result of failed UST systems.

A more recent reference indicates that close to 450 000 tanks had leaked in the USA as at March 2005 (USA EPA, undated)

Harris (1989) found that approximately 44% of leaks in the state of Arizona were as a result of product line failures. The causes were mostly related to poor installations and / or leakage at tank or pump fittings. In comparison, only 29% of leaks were attributable to the USTs themselves.

Schwendeman and Wilcox (1987) substantiate this figure, stating that up to 60% of leaks are a result of line failures. Line failures were reported to be caused by:

- Pipework corrosion;
- Joint leakage due to poor installation;
- Insufficient burial of pipes resulting in surface pressures being exerted on pipework;
- Vibrations from the pumping system; or
- Other ground movement.

The Institute of Petroleum (2002) concur, indicating that line leaks are the principle source of contamination at service stations, outnumbering tank failures 10:1. The literature points to corrosion of unprotected mild steel pipework, particularly at screw joint unions where galvanising is compromised, as major causes of failure and contamination.

7.7 South African context

In comparison with the USA, limited literature is available in the public domain with respect to the number of USTs in South Africa, as well as the number of UST systems that have leaked or are leaking. Holt (1997) reports on findings of the South African Oil Industry that 53% of a sample of 206 sites have a UST system leak history. Contamination by LNAPLs could be higher than this figure considering soil contamination occurs at most service stations simply as a result of routine spillage at the dispensing area. A tank specific study performed in 1992 on tanks older than 25 years indicated 9.6% of the sample (979) to have failed. Charman (2003) estimated the number of tanks in South Africa to be 50 000 in 1990.

Holt (1997) further cites the age of USTs that had been taken out of service to range between 8 and 27 years, with the average being 17 years, with the predominant cause of failure being external pitting corrosion.

CHAPTER 8. DATA SOURCE AND CLEANUP

The eThekwini Municipality is an area of approximately 2 300 km^2 and is bounded by the Indian Ocean to the east, Tongaat to the north and Umkomaas in the south. The western extent is Cato Ridge (Jackson, 2003).

To determine the incidence and mechanisms of LNAPL contamination within the eThekwini region, the following sources of information were analysed:

1. Data from the eThekwini Fire and Emergency Services database, Durban;
2. Data from Teleatlas; and
3. Site assessment data from a local consultancy[7].

Figure 8.1 illustrates a Venn Diagram of the above data.

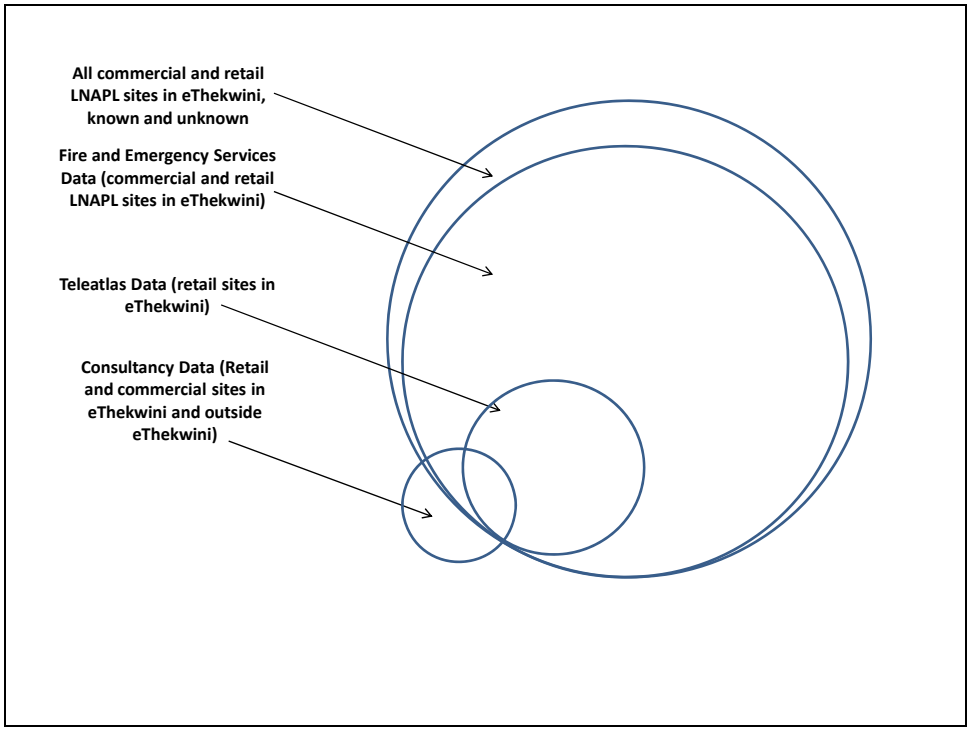

Figure 8.1 Venn diagram illustrating data sources relative to commercial and retail LNAPL storage sites in eThekwini

Figure 8.1 illustrates the following information:

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[7] As specified in the Institute for Groundwater Studies Inception Report (Pretorius, *et al*, 2007)

- The entire population of retail and commercial LNAPL storage sites in eThekwini. The number of sites is likely to have increased substantially considering that the municipal area has increased from 300 km^2 to 2290 km^2 between 1994 and current according to information published on the eThekwini Municipality web page (www.durban.gov.za).
- The population of retail and commercial LNAPL storages sites in eThekwini known to the eThekwini Fire and Emergency Services.
- The Teleatlas data subset of retail LNAPL storage sites in eThekwini.
- The Consultancy data subset of retail and commercial LNAPL storage sites in eThekwini and outside eThekwini.

The following sections provide further details of the above data.

8.1 eThekwini Fire and Emergency Services data

The eThekwini Fire and Emergency Services are responsible for responding to fire related issues; as well as the routine inspection of commercial and industrial properties for compliance with SABS 0400: The Application of the National Building Regulations (SANS, 1990) and the Interim Code Relating to Fire Prevention and Flammable Liquids and Substances (Durban Metropolitan Council, undated). This includes, amongst other duties, the inspection of Certificates of Registration for flammable substances, inspection of the fuel storage facilities and inspection of fire fighting equipment.

Data from the above fieldwork are recorded by Fire Officers on Application Forms for Certificate of Registration and Fire Prevention Worksheets, examples of which are attached as Appendix C and Appendix D respectively.

Data are entered into the database by data clerks. In addition, the database includes any other building structure, including residential properties, that the Fire Department has visited as a result of a fire related matter.

Data was retrieved by a third party from the eThekwini Municipality Fire and Emergency Services database and entered into Microsoft Excel (primary database). The following items summarise the data:

- The primary database contained 65 535 records; and
- Records included all sites from alphabetical letter A to V (site name). Sites with alphabetical letter W to Z were missing.

The following initial fields were of interest, and were extracted from the primary database:

- Name of sites that store Class 1, Class 2 or Class 3 products;
- Site contact person;
- Site address and telephone number;
- Business occupancy classification (class of business);
- Volume of each Class Product stored at each site; and

- Date of plan approval and any other date indicating record entry.

A total of 1567 records were extracted and entered into a final database, however for the purposes of this study,

- 249 additional records were required to be included from the primary database.
- 360 records were removed from the final database.

Table 8.1 presents the criteria for data inclusion in the final database:

Table 8.1. Additional extraction criteria for eThekwini Fire and Emergency Services final database

DATA INCLUDED	COMMENTS
Sites from within eThekwini	The database included sites from outside of the eThekwini region (as per their name) and were thus excluded.
Sites that recorded Class 1, Class 2 or Class 3 product storage.	Class 0 excluded as this is Liquid Petroleum Gas (LPG)
A single entry per site.	Site duplicates with same addresses were excluded.
Sites with volume storage > 2 000 L and < 200 000 L.	This was performed in order to exclude small farm installations and bulk depot storage, including all sites within the Island View Cutler Complex and the Refineries.
Sites known to be service stations by description but with no recorded volume storage. This included sites with the following terms in the name: Service Station Ultra City Filling Station BP Caltex Engen Sasol Shell Total	Excluding oil company offices, gas stores and pipelines

DATA INCLUDED	COMMENTS
Sites known to be service stations by description and with volume storage > 200 000 L.	Some retail sites store > 200 000 L.

Based on the above criteria, a total of 1456 records were extracted and utilised for data analysis.

Table 8.2 presents an example of a data entry in the eThekwini Fire and Emergency Services Database:

Table 8.2. Data entry example for eThekwini Fire and Emergency Services database

Business Or Company Name	Date			Qty Class 1 \ Product	Qty Class 3 \ Product
	First Occupied	Approved	Plans Approved		
ATHLONE SERVICE STATION	not stated	not stated	not stated	NIL 56 000 70 000 L	NIL 14 000

Limitations of the data are as follows:

- The data excludes sites that may store product but the volumes are not recorded;
- The data does not distinguish between underground installations and above-ground installations;
- The data includes sites that are known to have closed;
- Sorting and correction involved necessary interpretation of data entered, including data entered into the wrong field, un-separated product volumes etc

The extracted data are attached as Appendix E: eThekwini Fire and Emergency Services Extracted Data. Appendix F provides a key to the Occupancy Codes (SABS 0400, 1990).

8.2 Teleatlas data

Geographic Information System (GIS) data for the eThekwini Municipality was provided by Teleatlas in the form of a Shape File. Data was retrieved from the Shape File Attribute Table and consisted of the following information:

- Oil company;
- Site name; and
- Site latitude and longitude co-ordinates.

Some sites were only listed as an oil company with no corresponding site name, while others were listed according to oil company and area of location. No records were removed or added.

8.3 Consultancy data

Data from a local engineering and environmental consultancy was retrieved. The consultancy offers services primarily to the oil industry and operates from all major centres within South Africa, serving the Southern Africa region. Assessment reports for service stations and commercial installations were reviewed for the period 1999 to 2009. A total of 229 reports were reviewed for sites from within the eThekwini Municipality and outside the Municipality. The following data fields were extracted:

Table 8.3. Fields extracted from consultancy data

DATA FIELD	DESCRIPTION
Site ID	Unique identification number per site
Durban / not Durban	Site location: either within eThekwini region or outside
Commercial or retail	Classification of facility
Assessment year	Year between 1999 and 2009
Age of installation	The age of the equipment since installation
Submersible or suction	Pump system type
Contamination status of site	Classification of contamination status of the site according to presence and / or occurrence of free phase product and / or soil contamination and / or dissolved phase groundwater contamination and / or contaminated potable water
Product of contamination	Record of the product of contamination in the event of an incident
Volume of product lost	Volume of product lost in litres, if known
Cause of contamination	Classification of the cause of contamination, if contaminated
Reason for assessment	Classification of the reason for assessment
Bias / No Bias	Sites were classified according to whether the assessment was incident related or not. Incident related sites were considered to have introduced a bias into the data, while non-incident related assessments were considered an unbiased population group.
AST or UST	Tank position, either underground, above-ground or semi-buried.
Tank type	Description of the tank type: mild steel (MS), Glass Fibre Reinforced Polyester (GRP) or Double Walled
Line Type	Description of line type (mild steel, non-ferrous single containment or non-ferrous dual containment)
Number of tanks	Number of underground and aboveground horizontal storage tanks

The data, as well as data qualification and notes are attached as Appendix G.

The data was analysed according to the above data fields.

8.4 Regulatory assessment

In addition to the above, local and international regulatory structures were reviewed within the context of the literature and results in order to determine if sufficient legislative mechanisms are in place and whether additional structures are deemed to be required within the South African context. This included:

- The role of municipal governance in areas where preventative measures could be enforced.
- The establishment and maintenance of an effective tank database is discussed in order to manage infrastructure on a local level, and respond to incidents effectively and timeously.
- The potential for the tank data to be extended onto a GIS platform whereby the information can be interfaced spatially.
- The effectiveness of Environmental Impact Assessment regulations is discussed.
- Areas of governance where improvements could be made.

CHAPTER 9. DATA RESULTS AND DISCUSSION

The data from the eThekwini Fire and Emergency Services, Teleatlas and the consultancy data was assessed by means of basic statistical analysis, regression analysis, determination of Chi-Square values and by performing the Hosmer and Lemeshow Goodness-of-Fit test . Chapter 9 provides the results thereof.

9.1 eThekwini Fire and Emergency Services data

According to extraction criteria specified in Table 8.1, 1 456 results were extracted from the eThekwini Fire and Emergency Services primary database which represent commercial and retail LNAPL sites within the eThekwini Municipality in 2010. As sites with descriptions of service stations were included, certain sites extracted did not contain an entry for volume of product(s) stored. The following pie graph illustrates this.

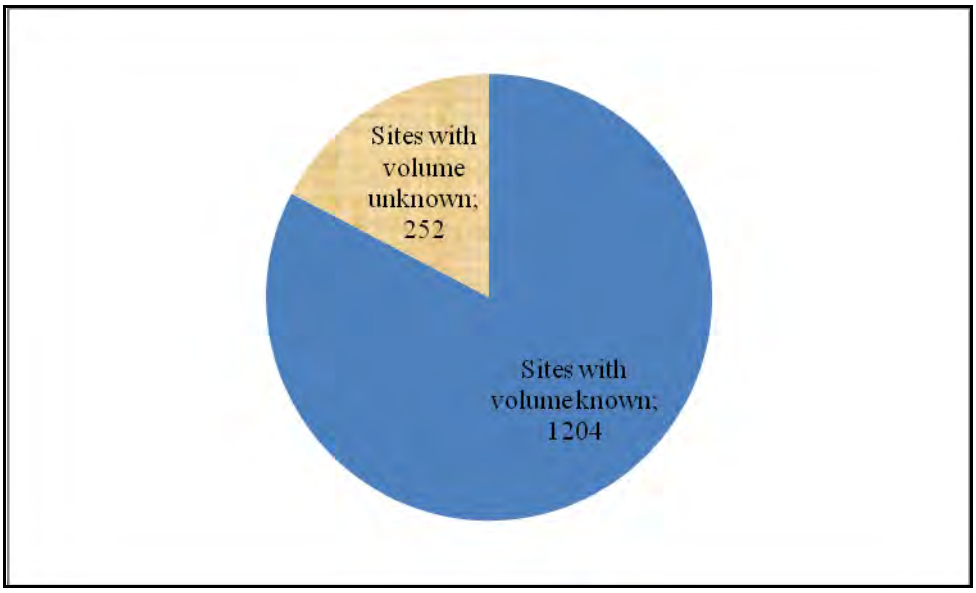

Figure 9.1 **Number of commercial and retail LNAPL sites in eThekwini for sites with capacity >2 000 L and <200 000 L, and including all retail sites including those with storage >200 000 L (eThekwini Fire and Emergency Services data)**

The total volume stored for sites with known volume (1 204 sites) was calculated as 56 410 000 L[8], with a mean volume of 46 853 L per site. The following graph illustrates the total volume stored per class:

[8] 3 significant figures presented.

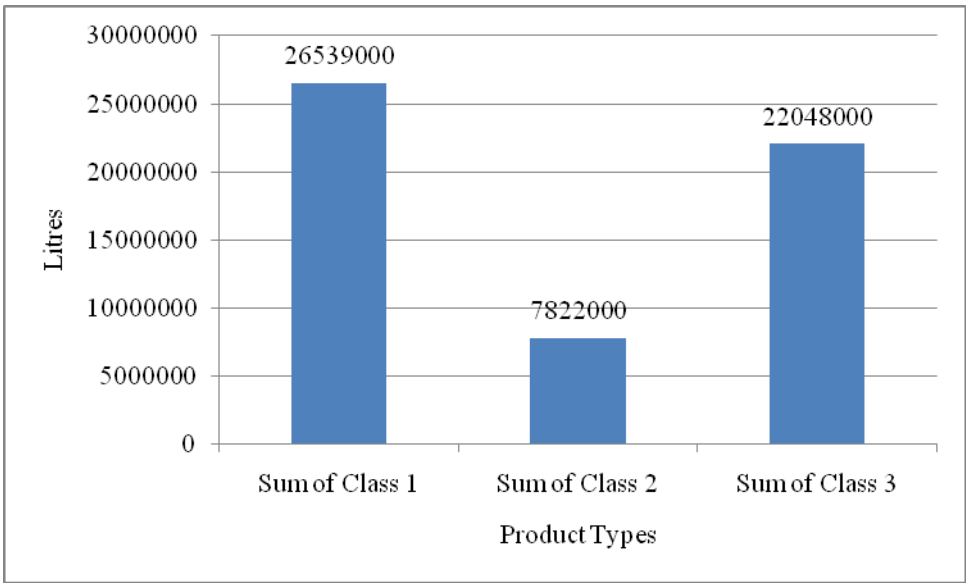

Figure 9.2 **Total commercial and retail LNAPL volume stored (3 significant figures) per Product Class for sites in eThekwini with capacity >2 000 L and <200 000 L, and including all retail sites including those with storage >200 000 L (eThekwini Fire and Emergency data)**

Note that SANS 10089-1:2003 Storage and distribution of petroleum products in above-ground bulk installations indicated Class 2 to have a flash point of >38°C and <60.5°C. Considering that some MSDSs (e.g. the Engen diesel MSDS, Engen Product Safety Advisor, 2006) for diesel indicates a flash point of >55, it is possible that some diesel facilities have been included in Class 2 above.

9.1.1 Age of sites

Age fields extracted included the following:

- Date first occupied;
- Date approved;
- Date plan approved; and
- Certificate of Registration (COR) Date approved.

All of the above fields were found to be relatively incomplete, with the exception of the COR Date Approved field, where, of the 1 456 records retrieved, 1 137 sites had the COR Date Approved recorded. Figure 9.3 illustrates the age distribution of sites in eThekwini according to COR Date Approved:

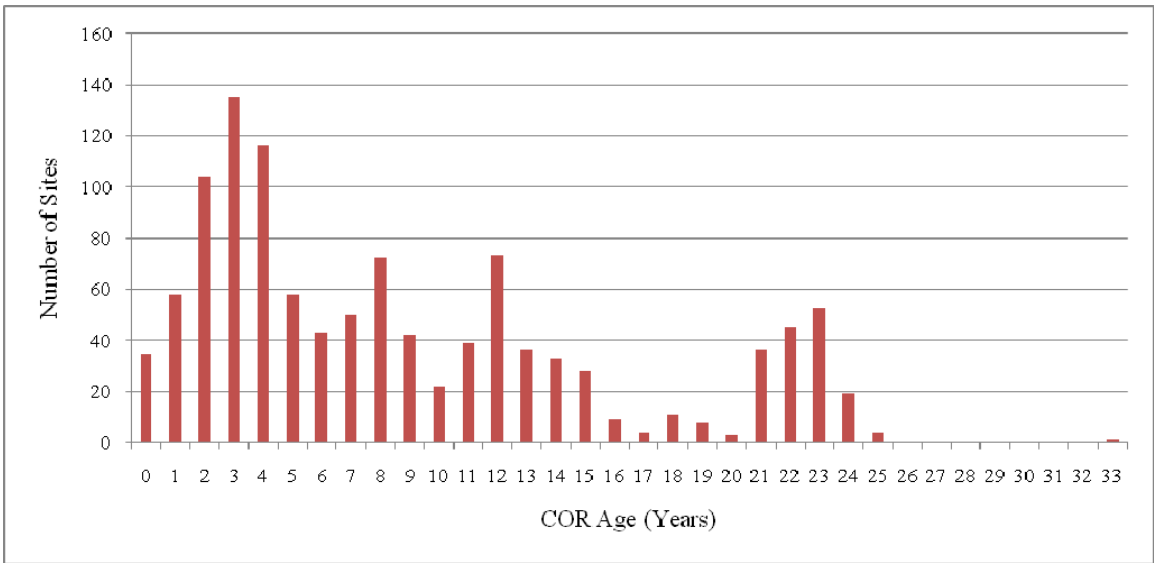

Figure 9.3 **Age distribution of CORs for LNAPL commercial and retail sites in eThekwini (eThekwini Fire and Emergency Service data).**

The COR Age represents the age that the current installation on each site was authorised by the eThekwini Fire and Emergency Service to store a flammable liquid. This certification requires revalidation when a change in capacity occurs or when change in ownership occurs. It therefore does not represent the age of the equipment.

9.2 Teleatlas data

The 2010 Teleatlas data indicated 356 service stations to occur in the eThekwini Municipality. Figure 9.4 illustrates the number of service stations per oil company:

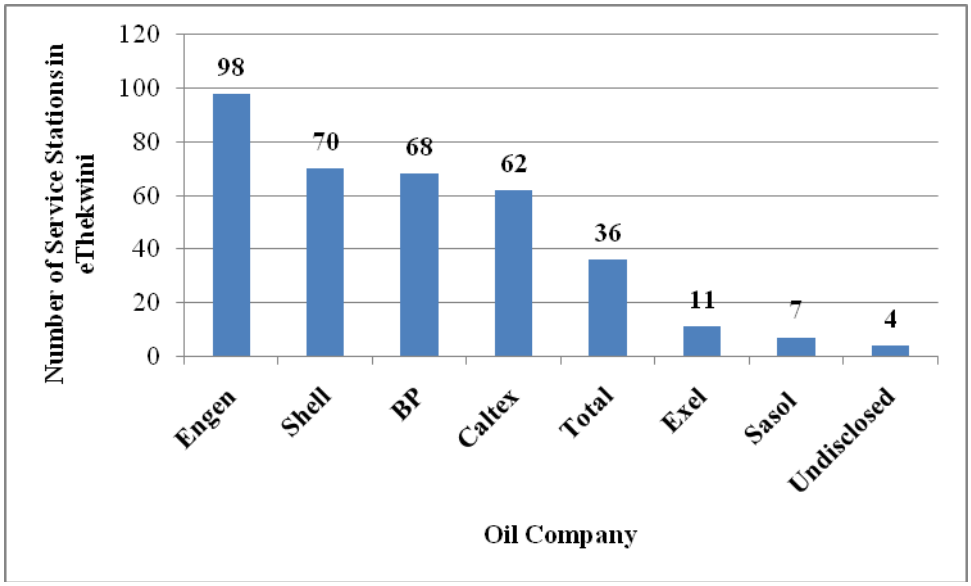

Figure 9.4 **Number of LNAPL retail sites in eThekwini according to oil company (Teleatlas data)**

Figure 9.4 illustrates that the greatest number of sites are operated by Engen Petroleum with 98 service stations, followed closely by Shell, BP and Caltex. Total operates 36 service stations, while Exel and Sasol both operate less than 15 sites in eThekwini.

Considering that the eThekwini Fire and Emergency Service data recorded a total of 1 456 service stations and commercial installations, this equates to a total of 1 100 commercial installations in eThekwini (according to the data category specified).

9.3 Consultancy data

Consultancy assessment reports were reviewed and data extracted and entered into an Excel database.

All contamination incidents involved petrol, diesel or paraffin with the exception of one site involving toluene, one site involving an aliphatic solvent, and one site involving waste oil.

All sites involved underground tank installations, with the exception of 9 sites with above-ground installations and one site with a semi-buried tank.

Sites occurring in the eThekwini Municipality totalled 108, while sites outside of the municipality totalled 121.

9.3.1 Triggers for assessment and the introduction of bias

Sites assessed comprised commercial and retail facilities. The reason for performing the site assessment varied from case to case, such as in response to a failure incident; closure of the site; a product reconciliation discrepancy etc. These reasons for assessments, for the purposes of this study, have been termed *triggers,* and are presented in the following Table 9.1:

Table 9.1. Triggers for site assessments in selected assessment reports

No.	Triggers for Assessment	Description	Incident Related
1.	Closure	Sites that ceased trade, and an assessment was performed following the removal of the equipment, as required by SANS 10089-3:2010, Section 14 Removal of tanks or abandonment of tanks and pipework	Possibly
2.	Ownership transfer	These assessments were performed prior to change of ownership to determine liability for any contamination.	N
3.	Reconciliation	Assessments were performed where product loss was suspected due to product reconciliation discrepancies.	Y
4.	Revamp	Site revamps took place where a site was upgraded. Where tanks were replaced, a contamination assessment was performed.	Possibly
5.	Product surfacing	These assessments were initiated as a result of product daylighting either on or off site.	Possibly
6.	Tank replacement	Tank replacements took place either due to failure or age. Tank replacements required environmental assessment according to SANS 089-3:2010 Section 14.	Possibly
7.	Unrelated excavations	Unrelated excavations refer to excavations either on site or off site where contamination was encountered.	Y
8.	Audit	Site audits were performed for a number of Health, Safety, Environment and Quality (HSEQ) reasons.	Possibly
9.	Unknown /Other	The reason for assessment was not known at the time.	Possibly
10.	Water ingress	Water ingress into an underground tank occurred as a result of failure of fittings in the tank manhole, or other reasons. Investigations were commissioned as water could cause damage to engines.	Possibly
11.	Closure in place	Underground tanks were closed in place if removal was not possible due to *'justified structural or practical reasons'* (Section 16.1, SANS 089-3:1999). In these cases, a contamination assessment was undertaken to support application for authorization by the local authority.	Possibly
12.	Capacity increase	Tanks were replaced in cases where increase in capacity was required and assessment was performed for the same reason provided in Item 6 above.	N
13.	Leak	Assessments were performed where a known tank or line leak had occurred.	Y
14.	Maintenance	During maintenance work performed by Pump and Tank contractors on forecourt infrastructure, contamination was encountered.	Possibly
15.	Overfills	Assessment was performed where a known overfill had occurred, and the product was lost to ground.	Y
16.	Vapour intrusion	Assessment was initiated to determine the cause of hydrocarbon vapour intrusion into on-site or off-site buildings.	Possibly
17.	Contaminated drinking water	In cases where drinking water was suspected of being contaminated with petroleum hydrocarbons, assessment was initiated to determine the cause.	Possibly
18.	Leak detector closed line	Assessment was performed to determine whether contamination had occurred following suspected line failure.	Y

The following graph indicates the number of sites and the respective reasons for assessment:

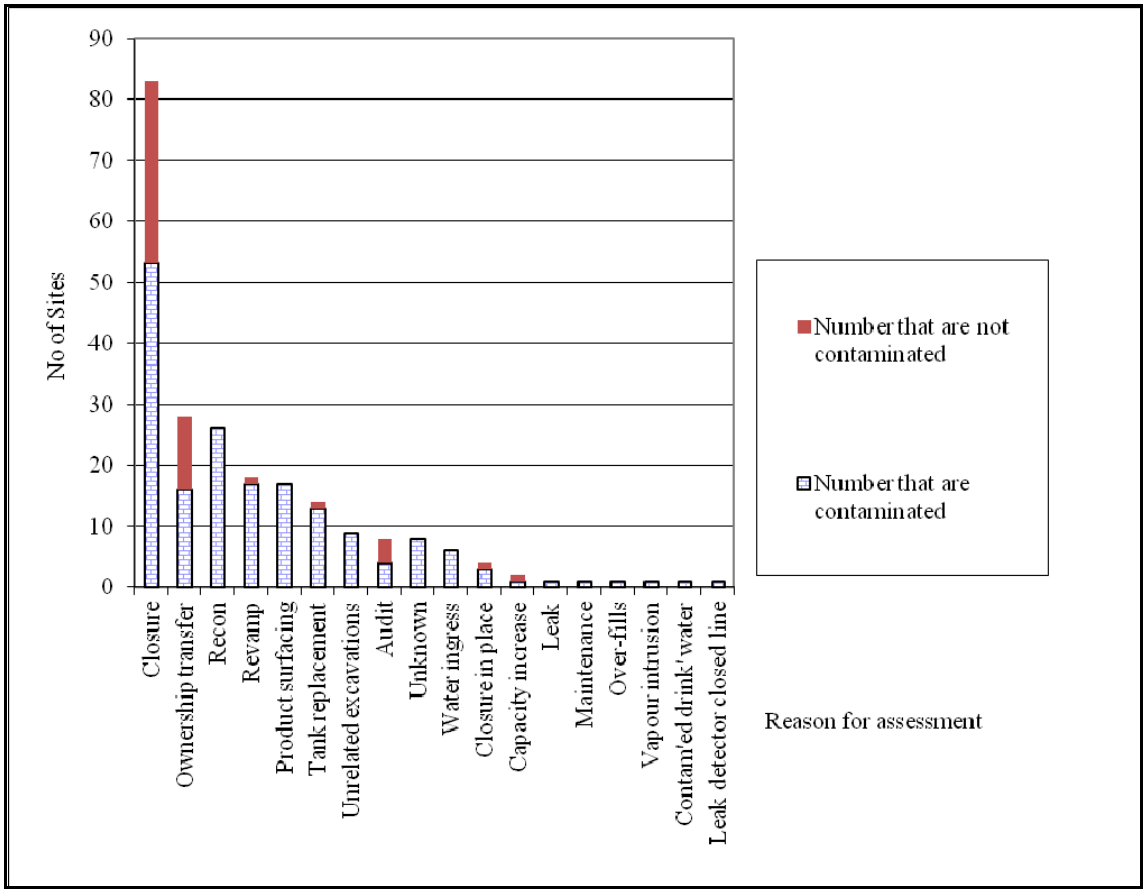

Figure 9.5 **Number of commercial and retail LNAPL sites categorised by trigger for assessment and contamination status (consultancy dataset)**

Considering the data does not represent a random selection of sites, but rather sites that were assessed according to the above triggers, a bias is introduced into the data. Numerous triggers for assessment are directly related to a contamination incident, and as such, the number of sites that are contaminated in the above sub-sample is likely to be greater than the actual population (refer to Column 4 in Table 9.1).

9.3.2 Contamination status

The contamination status of a site may vary from being unimpacted by petroleum hydrocarbons to severe levels of contamination where, for example, significant free phase product occurred on the groundwater table.

The following factors have been utilised to determine the contamination status of the sample sites.

1. Sites assessed by means of a Soil Vapour Survey (SVS) provided an initial indication of the contamination status of the site. The SVS determined the concentration of hydrocarbon vapours in surficial soils by probing at various locations to a maximum depth of 500 mm below ground level and measuring the hydrocarbon concentrations by means of a portable Photo Ionisation

Detector (PID). Sites with concentrations greater than 500 ppm have been considered 'contaminated'.

2. Sites where soil sampling and laboratory analysis had been undertaken were considered 'contaminated' where Gasoline Range Organics (GRO) and / or Diesel Range Organics (DRO) concentrations were greater than 510 mg/kg for industrial sites and 65 mg/kg for residential sites. Similarly, sites assessed by means of groundwater sampling and analysis were considered contaminated where GRO and / or DRO concentrations were in excess of 150 µg/L (for both industrial and residential land use). These figures are based on United States Environmental Protection Agency data (LDEQ RECAP, 2003) and are conservative.

3. In cases where assessment was by means of sampling and analysis of potable water, the site was considered 'contaminated' where a concentration greater than non-detect for petroleum organics was recorded.

4. Sites where free phase product (FPP) was encountered floating on the groundwater table were considered 'contaminated'.

The following chart presents the above categorization:

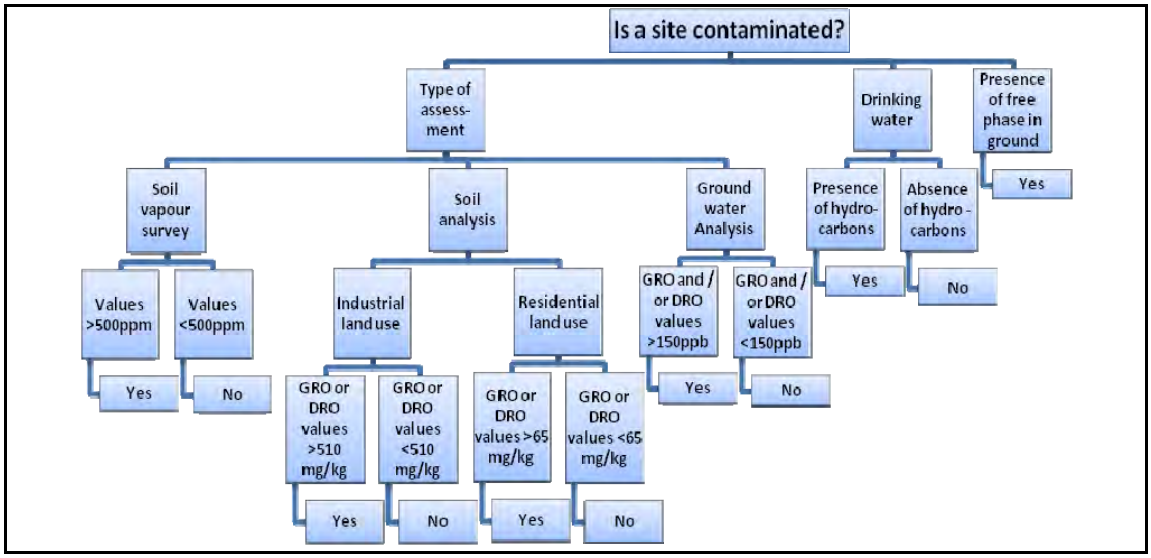

Figure 9.6 Simplistic categorisation / decision tree of site contamination status

Based on the above categorization, the contamination status of sites according to the trigger for assessment is presented in Figure 9.6 above.

Note that the above methodology is a simplification in order that the study sites could be classified into contaminated and not contaminated. Practically, determination of whether a site is contaminated is not only based on the above decision tree. An assessment is typically a complex process and incorporates the following additional considerations:

- The volume of product lost has a bearing on the contamination status of a site.
- The type of assessment and the resources invested in an assessment has a bearing on the assessment outcome.
- Assessments may be performed by means of comparison of results to a plethora of generic guidelines.
- Assessment may also be performed by means of a site specific risk assessment whereby clean-up target values are generated after consideration of site geology, soil permeability, the proximity of nearby receptors, types of pathways and receptors etc.
- Assessment of sites may also be performed by detailed analysis for target compounds, such as the benzene, toluene, ethylbenzene and xylene (BTEX) parameters within the GRO spectrum.
- The degree and extent of contamination is similarly factored into a contamination assessment whereby the degree (concentration) of contamination may be high even though the extent is limited.

The following additional considerations have a bearing on the degree and extent of contamination at a site:

- The migration potential of a product is dictated by numerous factors but primarily the viscosity of the product, with the greater the viscosity, the lower the migration potential.
- Soils with high permeability, such as coarse sands, exacerbate contamination, whereas sites with soils with high clay contents inhibit migration potential and degree of contamination.
- Sites characterised by impermeable bedrock lithology inhibit the degree of contamination while sites with fractured bedrock acting as pathways for migration are found to exacerbate the degree of contamination.
- A shallow groundwater table (<5m bgl) is found to inhibit vertical migration of free phase product and therefore lessens the degree of soil contamination, with the converse being true. This finding is contrary to typical risk determination whereby shallow unconfined aquifers are considered to increase the risk status of a site.
- In cases where free phase contamination of surface water bodies occurs in close proximity to sites, the spread of the contamination is rapid.
- The presence of conduits on contaminated sites has a significant effect on the likelihood of off-site contamination. In cases where product enters conduits such as stormwaters, sewers and / or telephone ducting, migration of product occurs rapidly. Discharge of contaminants from stormwater and sewer reticulation is to rivers and sewer treatment plants respectively. In addition, the presence of hydrocarbons in these confined spaces introduces an explosive atmosphere. Furthermore, entry of hydrocarbon vapours into residential properties via sewer reticulation is found to occur where, for example, the P trap beneath a kitchen sink is absent. The occurrence of these vapours in residential properties is in cases some kilometres from site.

9.3.3 Type of sites assessed

The sample data (Appendix G) included 109 commercial sites and 120 retail sites. Applying the criteria indicated in the decision tree (Figure 9.6), 74% of commercial sites were classified as contaminated, while 87% of retail sites were classified as contaminated.

The above figures indicate the majority of sites assessed to be contaminated. The above contamination status is however not representative of a random selection of sites considering the reasons for assessment introduced a bias, as previously discussed (Section 9.3.1).

9.3.4 Causes of contamination

Causes of contamination are primarily equipment or infrastructure failure; and cases where the cause was unknown. Contamination as a result of operational practises is also cited; or a combination of these. The following graph presents the causes of contamination for the study sites in the consultancy data sample dataset (n=182). The graph includes sites where the cause of contamination is unknown and excludes sites that are not considered contaminated (as per the decision tree model).

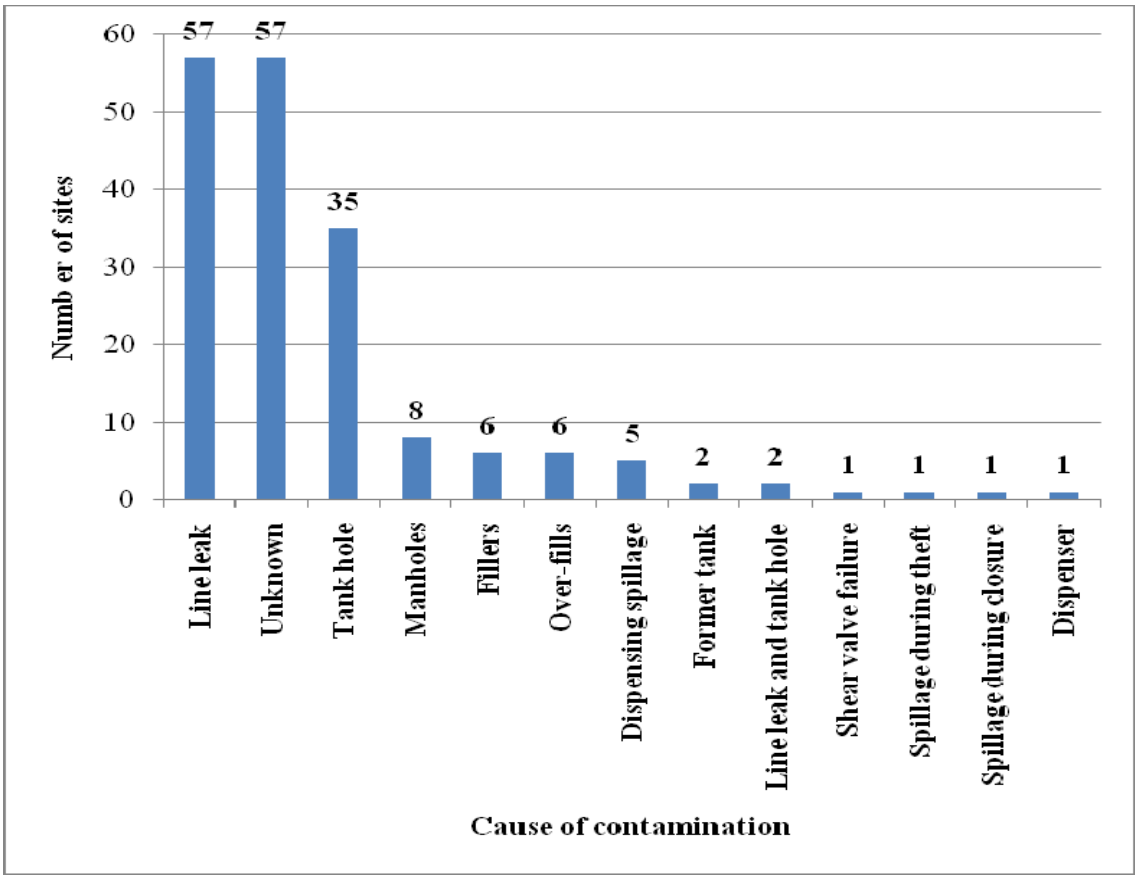

Figure 9.7 Causes of contamination for contaminated LNAPL sites (consultancy data subset)

Figure 9.7 indicates the primary cause of contamination within the sample sites to be line leak (n=57). The mechanism of failure is predominantly corrosion of mild steel pipework and failure of joints on both mild steel pipework and non-ferrous pipework. Failure of compression coupling is noted to occur where

mild steel bolts are used on these brass fittings, particularly if these joints are buried in the subsoil and not installed within junction manholes. Failure of pipework and fittings is also noted to occur where pipework is not buried greater than the prescribed 300 mm below ground level, as per SANS 089-3:2010 (Section 7.4.5). Similarly, where (SANS prescribed) corrosion protection on mild steel is absent, corrosion and failure is likely to be more prevalent (unsubstantiated). Line failure is also noted within tank manholes where unprotected mild steel pipework is subjected to corrosion by water trapped within the manholes. Specifics relating to different line leak failures mechanisms are however not quantified.

Unknown causes of contamination are also recorded as the leading cause of contamination (n=57). Service stations are typically entities that operate for many years and are characterised by changes in equipment, infrastructure, management and ownership. This dynamic nature of the business results in information pertaining to the cause of contamination being lost.

In addition, the following factors contribute to the unknown cause of contamination at retail and commercial facilities:

- The buried nature of fuelling infrastructure renders assigning absolute direct causality difficult.
- The contamination history of sites where management are absent such as closed or sold sites can often not be determined.

Tank holes are the second most common cause of contamination in the study sample (n=35). Mechanisms of failure are both corrosion and the well documented metal fatigue and failure beneath the dip point. (This has subsequently been rectified by the introduction of dip stick striker plates beneath the dip point, as specified by SANS 1535:1999, Section 5.6.10).

In a single case, chaffing of the tank manhole on the tank due to movement resulted in tank failure.

Contamination can result from product being released from the manhole into the sub-surface. Entry of product into manholes is typically as a result of spillage during delivery, where the filler is located within the manhole. In isolated cases where abandoned tanks are used for waste oil, spillage of waste oil had occurred into the manhole. Discharge of contaminants from the manhole is typically as a result of migration through permeable brickwork.

Contamination as a result of fillers (n=6) occurred where either the filler line failed; where containment chambers at the fillers failed or where spillage at the filler points occurred to ground.

Overfill contamination (n=6) occurs on sites where the volume of delivery is greater than the available tank volume. Typically the excess product discharges out of the dip point into the tank manhole. In cases where the dip cap was correctly fitted, discharge to ground occurred via the vent pipe.

Dispensing spillage (n=5) was noted as the cause of contamination where soil and / or groundwater contamination occurs as a result of spillage in front of the dispensing point. Sites where dispensing points are unpaved are particularly vulnerable to this mechanism of contamination, while sites where

interlocking G-block paving is installed at the dispensing point are also vulnerable (impermeable subsurface, such as concrete slab absent).

Former tank contamination is noted where the actual cause of contamination was unknown, however the excavation was found to be contaminated.

Contamination also results from shear valve failure and spillage during theft. Spillage during closure occurs as a result of the pump and tank contractor severing product lines in the open excavation before draining the lines of product.

Dispenser failure and associated contamination is directly related to failure within the dispenser and subsequent product discharge to ground.

A fault tree linking causes of contamination and related severity based on qualitative assessment is attached as Appendix H.

9.3.5 Age of failure

The age of failure for line leaks and tank holes was determined, and the distribution plotted against failures of constant probability. The following section provides further details.

9.3.5.1 Mean age of line and tank failure

Although the number of sites where line leaks and tank holes was recorded as 57 and 35 respectively, the age of failure was not recorded for all these sites. The number of sites where age of failure for line leaks and tank holes was recorded was 40 and 29 respectively. The following graph presents the mean age of failure for line leaks and tank holes.

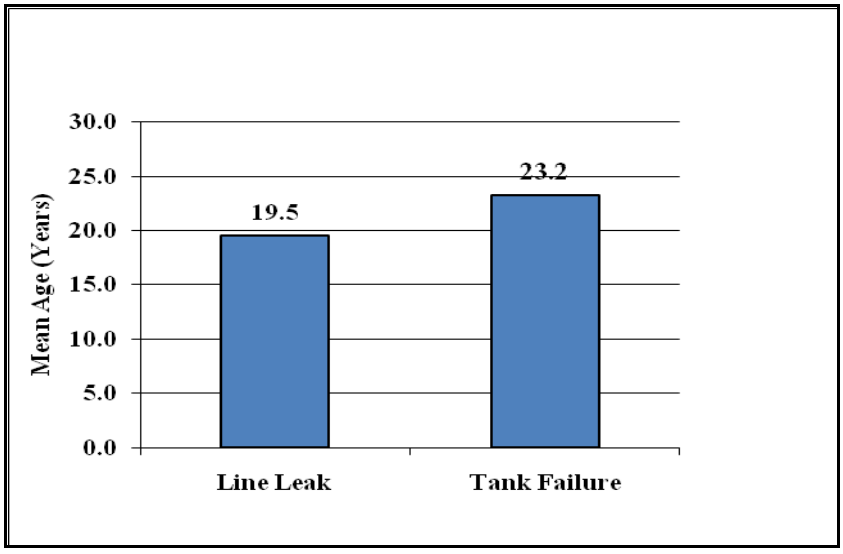

Figure 9.8 Mean age of equipment failure as a result of line leak and tank holes for biased and non-biased sites (consultancy data). Note high standard deviations.

Figure 9.8 illustrates the mean age of line failure to be 19.5 years. All lines were mild steel or unknown, with the exception of two cases, as described below:

> **Case 1**: The failure of a four year old dual containment non ferrous pipe resulted in the loss of 4 000 L petrol to ground. The incident occurred in 2004 and the cause of line failure was unknown.
>
> **Case 2**: The loss to ground of 7 000 L petrol was as a result of a failed single containment non ferrous pipe. The site was serviced by submersible pumps and the loss occurred at a buried fusion weld joint not in a junction manhole.

The standard deviation for line leaks was calculated as 9.0 y with a 95% confidence level of 2.9 y.

The mean age of tank failure for the sample population is 23.2 years with a standard deviation of 11.2 y and a 95% confidence level of 4.3 y.

Of the above tank failures, all were mild steel or unknown construction type, with a single key outlier, as follows:

> **Case 1**: Failure of a GRP tank at age 6 years. The exact cause was unknown.

9.3.5.2 Line failure distribution

Cumulative line failures for non-biased sites (n=15) where the age is known have been plotted in Figure 9.9 against cumulative hypothetical / modelled line failure data with the following assumptions and methodology (for the hypothetical data):

- The probability of failure was constant.
- The population size was calculated based on the total number of sites in the study population that were considered non-biased, where the age was known (n=108).
- The probability of failure (failure rate) was determined by calculating the least sum of squares for the actual and hypothetical data. Using Excel Solver, the probability of failure was calculated as 0.004.

Figure 9.9 presents the results:

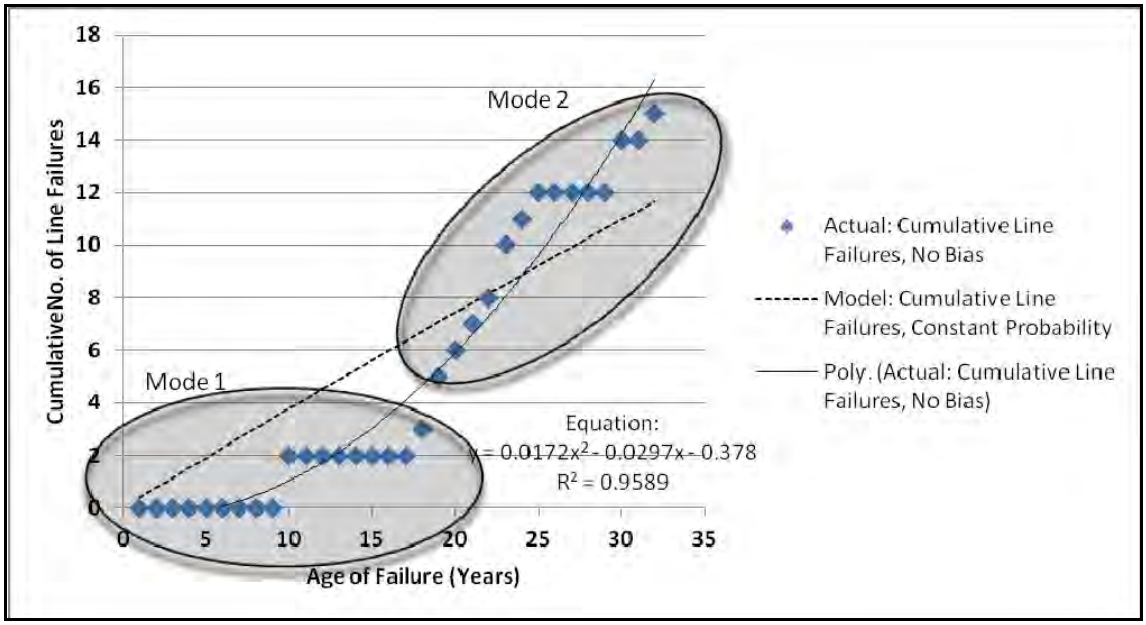

Figure 9.9 **Actual and hypothetical cumulative line failures with age for non-biased sites (consultancy data)**

The above data indicates actual line failures to range between ages of 10 years and 32 years. The best fit regression is described by a polynomial distribution and R^2 value, as follows:

$y = 0.0172x^2 - 0.0297x – 0.378$

$R^2 = 0.9589$

Actual failures are defined by a positive coefficient a (where $f(x)=ax^2+bx+c$) and a concave regression line, while hypothetical line failures with a constant probability have a linear regression line. Results therefore indicate that actual line failures do not occur according to constant probability whereby initial failures are less than the determined constant probability before age 22 years and greater than the determined constant probability after age 22 years.

Line age therefore does influence the likelihood of line failure.

Two likely modes of failure are highlighted, as per the oval shaded areas. Mode 1 indicates few failures before 18 years, while Mode 2 indicates an increasing number of line failures with age. The reason for these two likely modes is unknown. These observations could provide the basis for better modelling.

Distribution of line failures is also presented according to 5 year age categories, as follows:

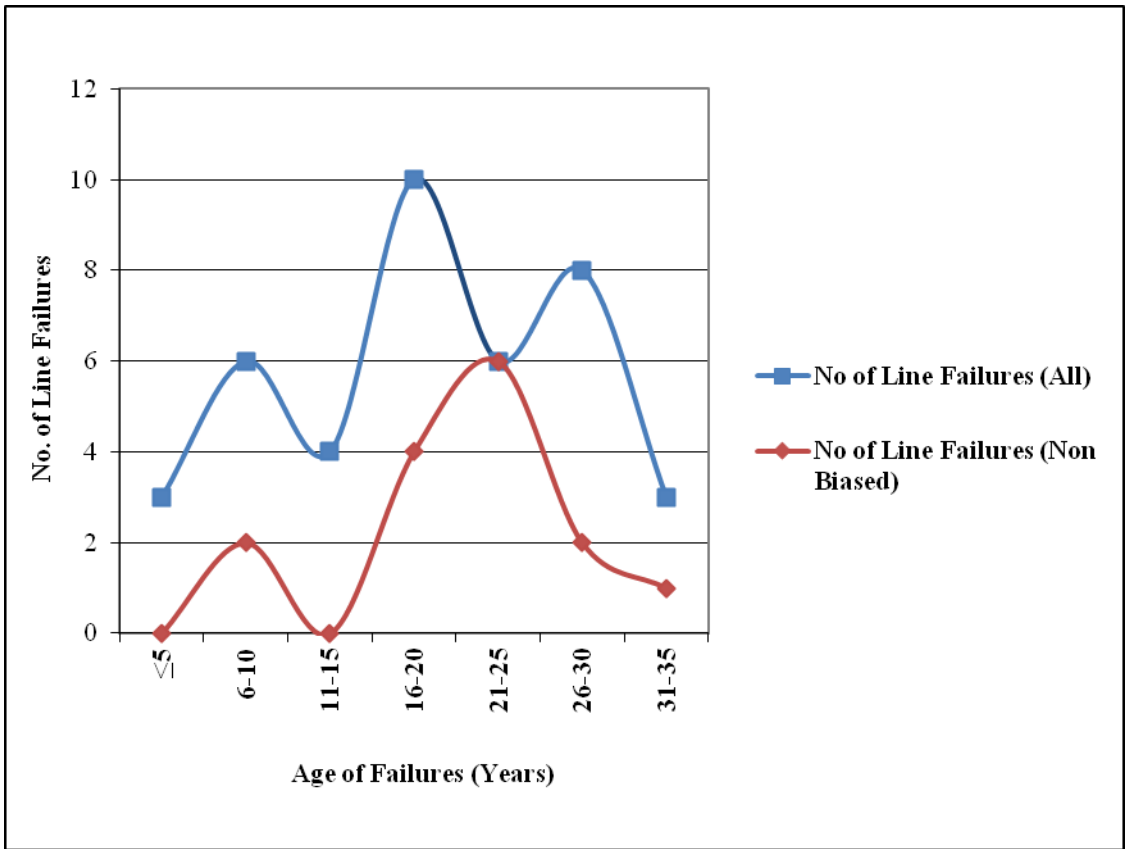

Figure 9.10 **Line failure distribution for all sites (n=40) and non biased sites (n=15) (consultancy data).**

Figure 9.10 illustrates the distribution for both data sets, with maximum number of failures between 16 and 30 years. The inclusion of best fit regressions did not provide any meaningful information.

9.3.5.3 Tank failure distribution

Similarly, actual cumulative tank failures (n=14) have been determined for sites where the age is known and for sites with no bias (Figure 9.11). These data are plotted against hypothetical tank failure data (n=108) where, as per the methodology for line leaks, the rate of constant probability has been calculated as 0.003 (according to least sum of squares for the actual and hypothetical data). Figure 9.11 presents the results:

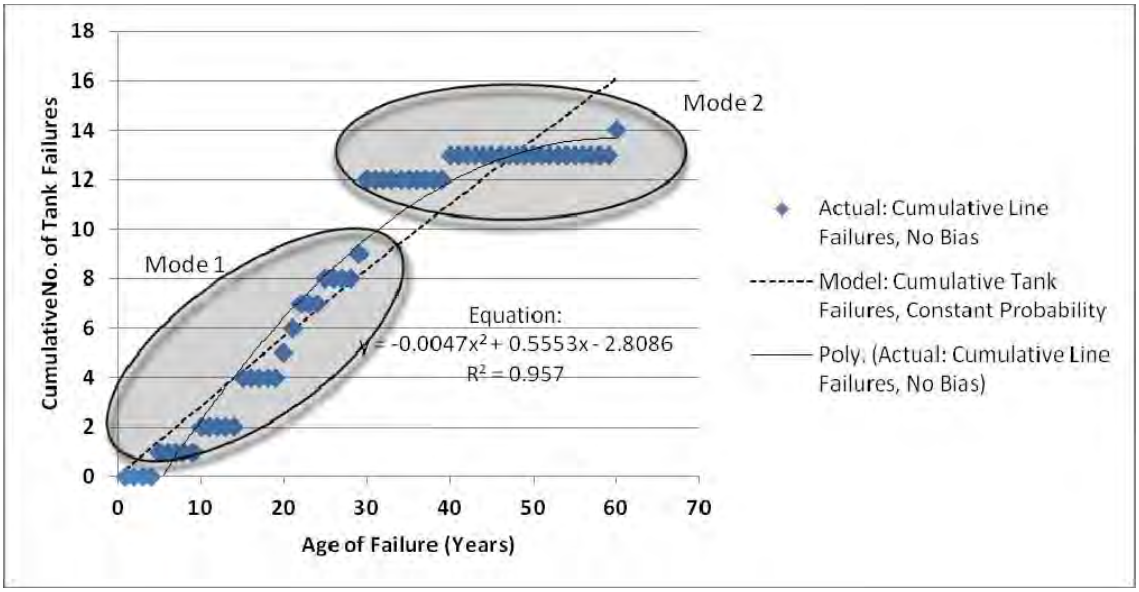

Figure 9.11 Actual and hypothetical cumulative tank failures with age for non-biased sites (consultancy data)

Figure 9.11 indicates that actual tank failures in the sample population occurred between the ages of 5 and 60 years. The best linear regression is polynomial with a negative coefficient a. A relatively good correlation occurs for observed and hypothetical constant probability failures prior to 30 years (Mode 1), however poor correlation thereafter (Mode 2). The actual failure rate is:

- less than failures of constant probability prior to age 21 years,
- greater than failures of constant probability between ages 21 years and 48 years, and
- less than failures of constant probability after age 48 years.

Distribution of tank failures according to 5 year age categories is presented in Figure 9.12.

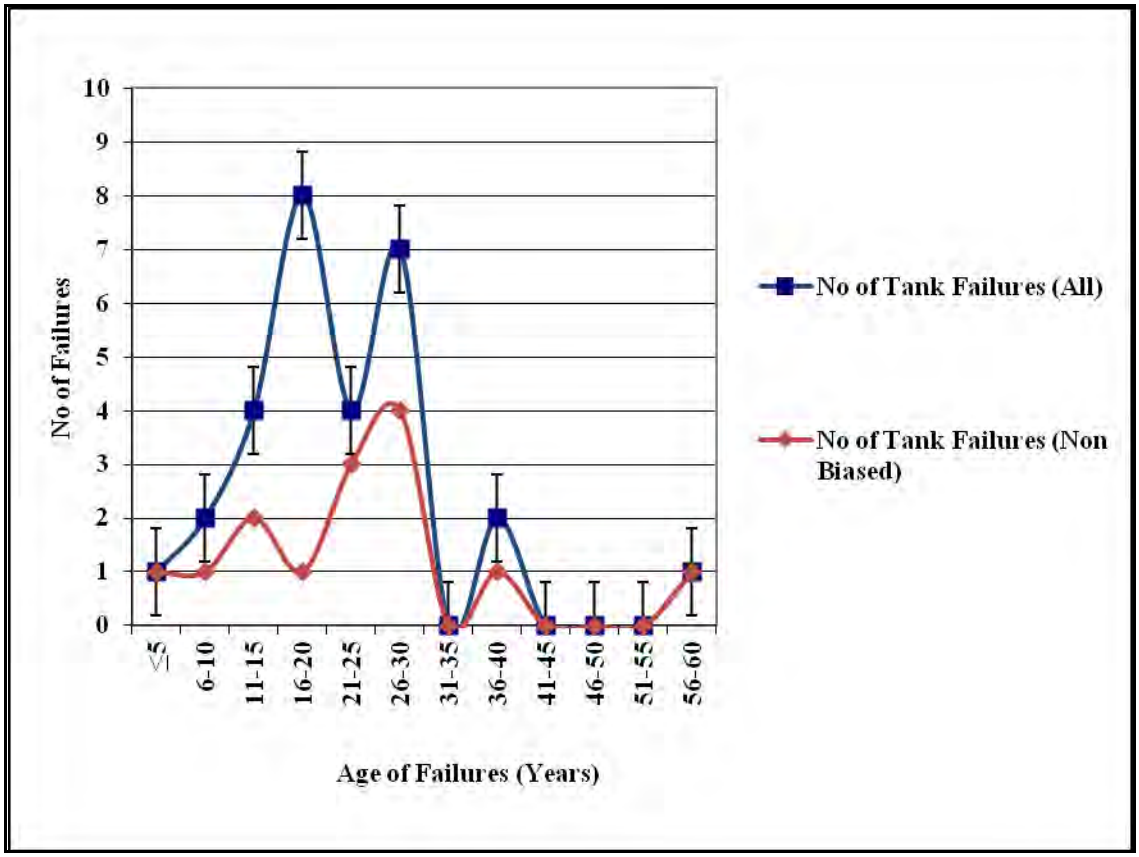

Figure 9.12 Line failure distribution for all sites (n=29) and non biased sites (n=14) (consultancy data)

Figure 9.12 indicates the distribution of tank failures. The inclusion of best fit regressions did not provide any meaningful information.

9.3.6 Pump type

Determination of the volume lost per pump system type was performed where:

- Failure occurred; and
- The age of failure was known; and
- The volume lost was known; and
- The pump system type was known.

Figure 9.13 presents the results.

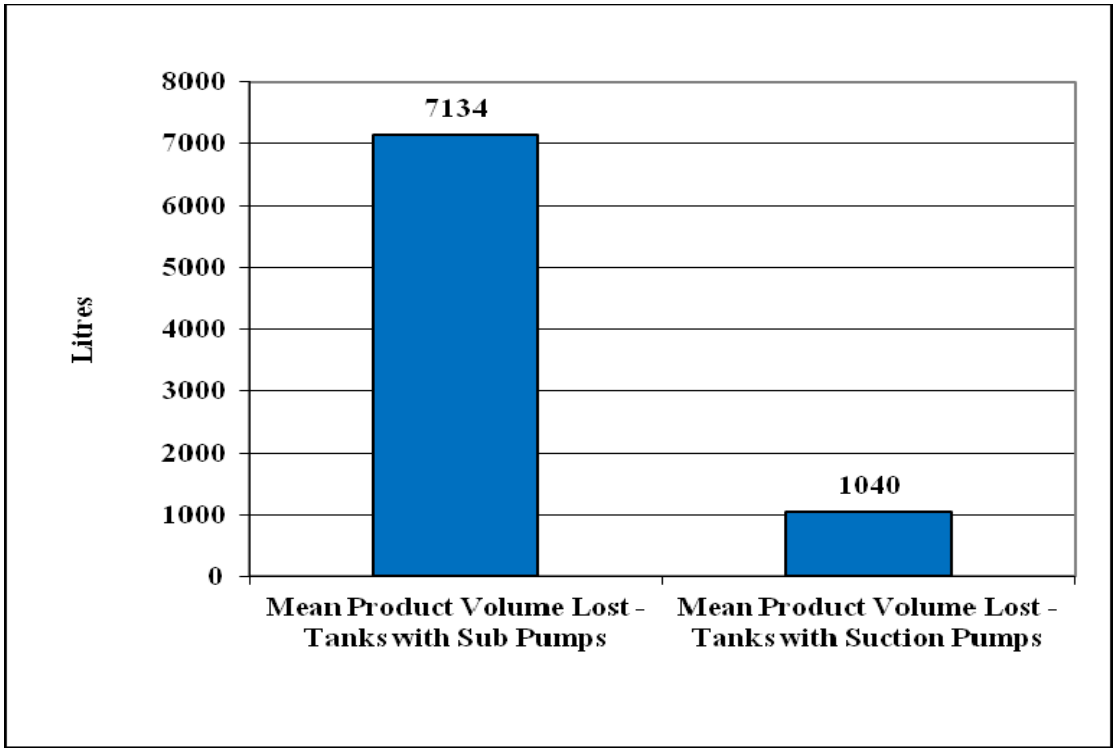

Figure 9.13 **Mean product volume lost for sites categorised according to pump type (consultancy data subset)**

Figure 9.13 indicates a significantly higher mean volume lost for submersible pumps than for suction pumps, with a mean of 7 134 L for submersible systems (n= 20) and 1 040 L for suction systems (n=39).

The above data illustrates that in the event of a failure, the likelihood of significantly greater product loss exists with systems on submersible pumps as opposed to suction pumps.

The above data are corroborated by an examination of the sites with the greatest volume lost, as per Table 9.2:

Table 9.2. **Top ten sites according to highest volume lost where pump type was known (n=10)**

Volume Lost (L)	Cause of Contamination	Pump Type
25 000	Tank failure	Submersible
25 000	Line leak	Submersible
19 000	Line leak	Line pressurised
17 000	Line leak	Submersible
16 000	Line leak	Submersible
15 000	Filler line failure	Suction
14 000	Line leak	Submersible
12 000	Line leak	Submersible
12 000	Line leak	Submersible
9 000	Line leak	Suction

Table 9.2 illustrates that, of the 10 sites with the greatest volume lost (rounded to three significant figures), seven sites were serviced by submersible pumps, two by suction pumps and one where an above-ground line was pressurized.

It should be noted that not all the above incidents were related to the dispensing lines and their associated pump types, as annotated in column 2 (cause of contamination). The time period over which these losses occurred was not recorded.

9.3.7 Volume lost

The mean volume lost per cause was determined for sites (n=75) where volume lost was known (and thus excluding clean sites and sites with cause unknown). Figure 9.14 shows the results of the analysis.

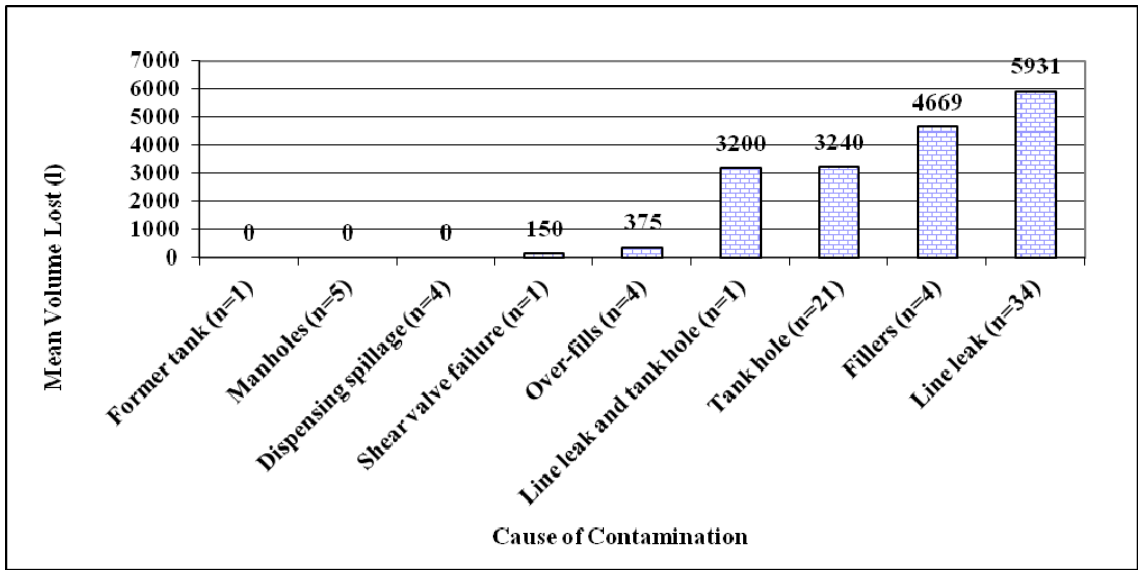

Figure 9.14 Mean volume lost per cause of contamination (where volume lost known, and excluding unknown causes for consultancy data subset)

The greatest mean volume lost per cause is 'Line Leaks', with a value of 5 931 L, followed by 'Fillers' and 'Tank Holes' with values of 4 669 L and 3 240 L respectively.

The sample size for 'Line Leaks and Tank Holes' was n=1 with a corresponding volume loss of 3 200 L.

Mean volumes lost for Overfills and Shear Valve failures were 375 L and 150 L respectively.

The mean volume lost for Dispensing Spillage, Manholes and Former Tank are all recorded as zero. Losses as a result of these causes were therefore not detected.

9.3.8 Relationship between tank age and volume loss

Data were extracted from the database for sites that had had a loss incident and where the volume of product lost and age of the installation were known. The purpose was to determine whether a correlation existed. Figure 9.15 illustrate the data fields.

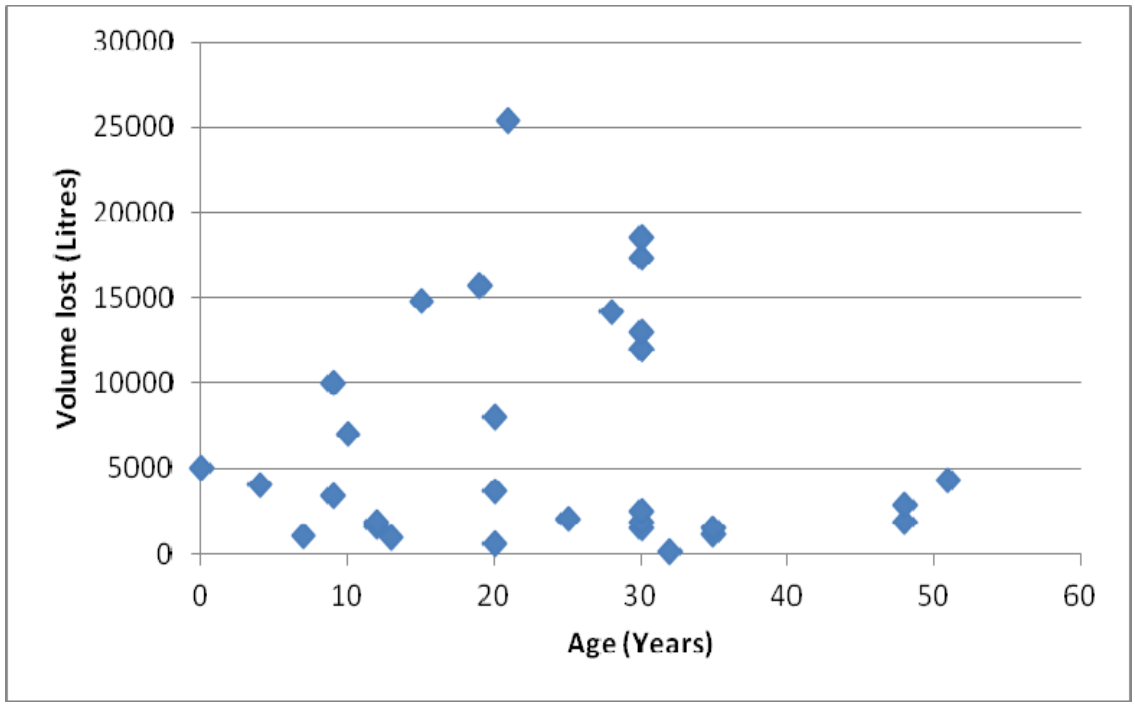

Figure 9.15 Correlation of volume lost with age (consultancy data subset)

Figure 9.15 indicates no correlation between loss volume and age. The deduction is that a large release can occur early in the life of a site, and conversely, because a site is old, it does not imply that a large release is more likely. Furthermore, considering that line leaks are the leading cause of failure, the above data indicate that line failure and the associated volume loss does not discriminate with respect to the age of the pipework. No grouping is observed in the above data.

9.3.9 Modelling of indicator variables

In order to determine whether certain factors increased the likelihood of a site to be contaminated, modelling of indicator variables was performed by means of a logistic regression whereby key parameters were extracted from the database and coded. Table 9.3 summarises the coded variables:

Table 9.3. Variables coded for regression analysis

Variable	Categories	Coding
Site Type	Commercial	0
	Retail	1
Age of Equipment	-	1 - 60

Variable	Categories	Coding
Pump Type	Unknown	0
	Suction	1
	Submersible	2
Position	Above-Ground	0
	Underground	1
Tank Type	Unknown	0
	Mild Steel	1
	GRP or Double Walled[9]	2
Line Type	Unknown	0
	Mild Steel	1
	Non-Ferrous	2
	Non-Ferrous Dual Containment	3
Number of Tanks	-	1 – 10
Contamination Status	Not Contaminated	0
	Contaminated	1

The above coded data are attached as Appendix I.

The logistic regression model was defined as follows:

$$\ln (p/1-p) = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6$$

Where: ρ is the probability of Event E = ρ (contaminated) i.e. probability that a site is contaminated

X_1 = Site Type

X_2 = Position

X_3 = Tank type

X_4 = Pump type

X_5 = Line type

X_6 = Number of tanks

[9] This category consisted of all GRP tanks with the exception of two double walled tanks.

The coded data for all variables was entered into SPSS® Modeller (formerly Statistical Package for the Social Sciences), a statistical software package for data analysis, and the regression performed. Results however indicated high chi-square values, and the model was discarded (four variables >10% chi square). The model (Model 1) was re-run for variables site type, pump type, tank type and position only. The following items summarise the results of the regression analysis (attached as Appendix J):

- A retail site is 2.6 times more likely to be contaminated than a commercial site;
- A site serviced by submersible pumps is 1.8 times more likely to be contaminated than a site serviced by suction pumps;
- A site consisting of mild steel tanks is 2.8 times more likely to be contaminated than a site consisting of GRP tanks; and
- A site consisting of underground tanks is 4.0 times more likely to be contaminated than a site consisting of above-ground tanks.

Table 9.4 presents the respective Chi-Square values for the above variables:

Table 9.4. Model 1 variables and Chi-Square values

Variable	Chi-Square
Site Type	1.2%
Pump Type	44.6%
Tank Type	7.6%
Position	6.0%

Table 9.4 indicates all variables to be significant with Chi-Square values <10%, with the exception of Pump Type where a value of 44.6% was calculated.

The model was tested for 'goodness-of-fit' by means of the Hosmer and Lemeshow Goodness-of-Fit test, where:

H_0 = Hypothesis = Model adequate for data

H_1 = Alternative hypothesis = Model not adequate for data

A ρ value (ChiSq) greater than 0.05 indicates the model to be adequate. In the above model, the ρ value was calculated as 0.7769 thus satisfying the above H_0 hypothesis.

The model (Model 2) was re-run for different parameters, namely Site Type and Age. The data indicate that:

- A retail site is 3.3 times more likely to be contaminated than a commercial site; and
- The likelihood of a site being contaminated increases 4.8% per year.

The associated Chi-Square values are presented in Table 9.5:

Table 9.5. Model 2 variables and Chi-Square values

Variable	Chi-Square
Site Type	0.5%
Age	2.1%

Table 9.5 indicates both Site Type and Age to be significant.

The Hosmer and Lemeshow Goodness-of-Fit Test showed a ρ value of 0.0751, thus indicating the model also to be adequate, but to a lesser degree.

Model 1 and the associated indicator variables was therefore considered the most accurate, and these variables were used to determine the predicted probabilities of contamination. Results indicated the following:

- The site with the lowest predicted probability of contamination (excluding unknown variables) was a commercial, above-ground installation consisting of a mild steel tank and serviced by a suction pump. This predicted probability was calculated as 0.46907 for the sample set; and
- The site with the highest predicted probability of contamination was a retail site consisting of underground tanks of mild steel construction material and serviced by submersible pumps. The predicted probability of this scenario was calculated to be 0.94245 for the sample set.

The above results correlate well with anticipated results considering the following factors:

- Commercial sites are typically serviced with suction pumps, where, in the event that a line failure occurs, entrainment of air into the line occurs (as opposed to a pressurised system serviced by submersible pumps), and the volume of loss is therefore typically smaller.

- Failure of infrastructure above ground is typically more readily noted, preventing further loss, when compared with underground installations.

The detailed results are attached as Appendix J, presenting all combinations of variables and associated probabilities. Note that line type and number of tanks were not used in the models due to the model being fatally flawed by quasi complete-separation, a term used to describe when two variables in a logistic regression are too closely related.

CHAPTER 10. CONCLUSIONS AND RECOMMENDATIONS

Various datasets were sourced for the study. The gaps in the datasets are discussed, as well as findings and recommendations relating to those factors that increase risk of LNAPL contamination.

10.1 eThekwini Fire and Emergency Service database

The eThekwini Fire and Emergency Services database is considered the ideal platform to build the management of LNAPL storage sites in the eThekwini municipality. The following items are however recommended to make the database of more use:

- The user interface should be improved to allow for easier access and retrieval of data.
- The user interface should be changed to allow for data to be viewed and manipulated by fields.
- All duplicates should be removed.
- All sites outside of the municipality should be removed.
- All closed sites be archived in a separate database.
- The Fire Prevention Worksheets should be amended to include data fields for product type (not just product class); age of infrastructure; type of tanks (above-ground or underground, and construction materials) and pipework; and types of pumps servicing the dispensers. Replacement of dated equipment could then be performed in consultation with the oil company concerned, where required.
- Data entries should be quality checked for accuracy and completeness. Automated data validation, such as drop down lists in entry fields, would reduce errors.
- The data should be entered into Geographic Information System (GIS) software as a standalone shape file, and should be accessible to Fire and Emergency Services personnel to assist in emergency response management.

Management would be improved if each LNAPL storage tank (including old tanks) had a unique identification number that was clearly visible throughout the lifetime of the tank, and was recorded in the eThekwini Fire and Emergency Services database. Collaboration between the tank manufacturers would be required.

10.2 Teleatlas GIS database

Currently, the Teleatlas database only records LNAPL service stations and not other commercial and industrial LNAPL storage sites. The Teleatlas database could also be used as a platform for inclusion of these sites.

10.3 Consultancy database

Using consultancy data, various factors were found to give rise to different causes and severity of LNAPL product loss to ground. These factors are presented in the following sections.

10.3.1 Causes of contamination

The following factors were identified as causes of contamination at commercial and retail LNAPL storage sites.

10.3.1.1 Line leaks

The results indicated that, with an increasing age of product lines, particularly mild steel pipework, the likelihood of contamination risk also increased considering a positive coefficient a of the best fit regression line. The mean age of line failure was calculated as 19.5 years and the probability of failure was greater than a modelled constant probability after the age of 22 years.

Single containment pipe replacement, particularly mild steel, should therefore be considered as best practice at a maximum age of 22 years until more comprehensive failure data are available.

10.3.1.2 Unknown Causes of Contamination

The causes of contamination at retail and commercial fuel facilities should be further investigated to determine whether those presented in this dissertation are exhaustive and complete.

10.3.1.3 Tank failures

Although the mean age of tank failure was calculated as 23.2 years, the likelihood of failure was not observed to increase with increasing age, as demonstrated by a negative coefficient a for observed data.

The standard deviation of tank failures was calculated as 11.18, indicating a wide distribution of failure ages.

A higher failure rate was noted for tanks between the ages of 21 and 48 years, when compared with hypothetical constant failure rate data.

Management of tank failures should therefore be performed according to detailed risk assessment consistent with international best practise.

10.3.1.4 Other

Other causes of contamination can be differentiated as follows:

Site Infrastructure. Permeable forecourts, dispensing areas, fill areas and tank manholes were found to increase the likelihood of contamination. Ensuring that these infrastructural elements are impermeable would therefore reduce the likelihood of sub-surface contamination.

Operational Practises. Contamination of the sub-surface was noted to occur as a result of operational practises, such as tank overfilling. Overfill protection devices within the tanks, as well as operator training would serve to reduce the incidents thereof.

Table 10.1 summarises causes of contamination and possible mitigation.

Table 10.1. Methods to reduce contamination risk

Factors Increasing Contamination Risk	Recommendation to Reduce Risk	SANS 10089-3:2010 Requirement (new installations)
Unprotected mild steel pipework.	Replace pipework with non-ferrous.	Yes
Permeable tank manholes.	Seal manholes.	Yes
Tank manholes where dispensing lines were not sealed correctly.	Seal manhole.	Yes
Dispensing pumps where impermeable pump sumps are absent.	Install pump sumps where possible.	No
Remote fillers where spill containment was absent or insufficient.	Refurbish filler area.	Yes
Dispensing areas that were not paved with impermeable hard surfacing, for example g-block paving.	Pave dispensing area with impermeable material where possible.	No
Sites where leak detectors were absent or malfunctioned on submersible pumps.	Ensure leak detectors installed and correctly functioning, where possible.	Yes
	Inspect and check leak detectors on a routine basis, where possible.	No
Sites where tank overfill protection devices were absent or malfunctioned.	Install correctly functioning overfill protectors, where possible.	Yes
Sites where pipework has not been buried to the mandatory 300 mm below ground level.	Re-pipe site in affected area.	Yes
Sites where pipework junctions were not housed within containment chambers.	Install pipework junctions in manholes.	Yes
Sites where tanks are not installed on specified material, as per SANS 089-3: 2010, Section 5.2.	Inspect tank bedding on future installations prior to backfilling to ensure material meets SANS specification.	Yes
Sites where product reconciliation is	Ensure product reconciliation is	No

Factors Increasing Contamination Risk	Recommendation to Reduce Risk	SANS 10089-3:2010 Requirement (new installations)
not performed or is performed poorly.	performed according to established procedure.	

A draft template for Pollution Control Officers has been developed and attached as Appendix K. This template could be used to assist in data collection of infrastructure characteristics; integrity of equipment; occurrence of product on site; and recent incidents.

10.3.2 Severity of an incident

Various factors were found to increase the severity of an incident, as per the following sections.

10.3.2.1 Causes

The severity of an incident was determined by calculating the mean volume lost per cause. Results indicated that the maximum mean was associated with line leaks, followed by filler related incidents and tank holes.

The severity of an incident did not correlate with the age of the infrastructure. Consistent maintenance and management of infrastructure is therefore essential throughout the lifespan of an LNAPL storage facility.

10.3.2.2 Pump type

Pump type was found to significantly influence contamination risk and the severity of an incident. In the event of failure, sites serviced with submersible pumps were found to have a greater mean volume lost compared with sites serviced with suction pumps. The mean volume lost for incident sites serviced with submersible pumps was calculated as 7 134 L while the mean for sites serviced with suction pumps was 1 040 L.

Based on the above findings, it is recommended that sites with submersible pumps are:

- Not serviced with unprotected mild steel single containment pipework, as a minimum; and
- Functionality of leak detectors on the submersible pumps should be checked according to a routine schedule.

10.4 Logistic regression model

The above findings are supported by the results of the logistic regression whereby a relatively higher risk is posed by retail sites serviced by mild steel USTs and submersible pumps, as compared with commercial sites where the installation is generally above-ground and serviced by a suction pump. The

model would suggest that in order to reduce contamination risk, tanks should be placed above-ground where feasible, or serviced by suction pumps, not submersible pumps. This would however be subject to product types, site specifics and requirements of the respective oil companies.

10.5 Municipal governance and regulations

LNAPL storage and distribution should be managed by a newly created department within the eThekwini Municipality. This would require the adoption of the eThekwini Fire and Emergency Services database, or the establishment of a new database. An example questionnaire has been attached as Appendix L that could be used for data capture.

This data could be entered into GIS and used to manage and as well as prevent incidents within the Municipality if used in conjunction with other GIS data such as hydrology, geology, presence of nearby receptors, proximity of conduits for migration etc. Nobre *et al* (2007) demonstrated this in his paper *Groundwater vulnerability and risk mapping using GIS, modelling and a fuzzy logic tool*, as supported by Dixon (2005) in his work *Groundwater vulnerability mapping: a GIS and fuzzy rule based integrated tool*.

Preventative measures are imperative to ensure the protection of groundwater resources. The New Hampshire Department of Environmental Services has demonstrated this by the implemented a number of measures. The Environmental Fact Sheet: *Preventing groundwater contamination at gas stations – what municipalities and water suppliers can do*, includes the following items:

- Siting restrictions whereby new installations are required to be situated beyond a minimum distance from certain receptors, termed setback requirements;
- Spill containment regulating filling areas and dispensing areas;
- Stormwater management where drainage separation is mandatory; and
- Environmental Management Plans where sites are required to submit documentation demonstrating the methodology that will be employed to manage the site.

In addition to the above, the Department recommends the routine inspection and servicing of release prevention and detection systems (New Hampshire Department of Environmental Services, 2007).

The Maine Department of Environmental Protection provide a framework for owners and operators of USTs to submit an '*Annual Inspection Report* and an *Annual Summary Report*' (Maine Department of Environmental Protection. 2007). This system could similarly be implemented in the eThekwini region.

10.6 Loss reporting

The eThekwini Municipality could implement a by-law whereby reconciliation figures for all service stations and commercial installations are required to be submitted to the Municipality on a monthly basis. This could be established for sites handling greater and a specified volume throughput per month. A database could be established whereby losses greater than a threshold are flagged and investigated.

10.7 National governance and regulations

A regulatory framework was proposed by Pretorius and Usher in their unpublished and undated paper where they identify the need for additional guidelines to ensure the protection of groundwater resources; and to further regulate LNAPL storage facilities, including the closure thereof. The authors propose a UST program whereby all tanks are identified and managed, and when incidents occur, these are managed according to risk assessment protocol. It is recommended that this proposal is undertaken by means of a work-shop, and implemented in a phased approach. A literature review and consultation with regulations of other countries would assist in aligning the framework with internationally accepted norms.

The guidelines should be prescribed within a framework of the current and future use of underground storage, as described by Evans *et al* (2009) in his paper investigating use of 'land below ground' in the United Kingdom.

In addition, contaminated sites in South Africa should be documented in a centrally held database that is within the public domain.

The effectiveness of the Environmental Impact Assessment process in preventing soil and groundwater contamination and in addressing soil and groundwater contamination in the event of an incident for new sites should determined by the assessment of these same sites following a set period of time whereby incidents are analysed to determined whether sufficient mitigatory measures were specified in the EIA documentation. In this manner a feedback loop could be introduced into EIA documentation to prevent re-occurrence of similar incident types.

Similarly, the effectiveness of the EIA process required prior to remediation should be determined by the assessment of a number of sample sites. This assessment would incorporate determining whether the EIA process was effective in preventing environmental damage or whether the process facilitated contaminant spreading and migration.

10.8 Probabilistic model and competencies

Due to a lack of suitable data, a probabilistic model could not be constructed. Hall and Strutt (2003) however demonstrate the methodology to develop a model that can be used to predict physical failure of components of a system as a result of processes such as corrosion, wear, fatigue and mechanical overload. The results provide a distribution of time to failure that can then be fitted to a Weibull distribution with parameters to describe failure types characteristic life parameters.

Breton *et al* (2010) demonstrate how the likelihood of pipeline failure can successfully be determined by utilizing a Bayesian probabilistic approach whereby the probability and type (rupture or leakage) of failure is modelled.

It is therefore recommended that a probabilistic model be constructed by one of the above two methodologies in order to determine the likely failure rate of commercial and retail LNAPL

infrastructure, particularly GRP tanks and non-ferrous pipework. It is recommended that this is performed by observation of failures over a set period of time. In this manner, the risk of failure can be determined for a specific site characteristics (age etc) and corrective actions implemented prior to failure occurring. Alternatively, an 'accelerated life test' could be developed whereby failure is observed under conditions likely to increase failure.

The probabilistic model should be based on a non-biased data set from a cross section of oil companies, such as that prepared by the United States Environmental Protection Agency for the State of South Carolina. The study assessed the '*Frequency and extent of dispenser releases at underground storage tank facilities in South Carolina*' (United States Environmental Protection Agency, 2004).

The results of the probabilistic model can be fed back into design of the various components of USTs and dispensing infrastructure in order to allow for more accurate failure prediction.

The dependability of components is also dictated by the competency of the design consultants and the contractors; and the quality of the installation. These three components require competency certification and management to ensure installations are built to minimum requirement specification.

10.9 Non-uniform risk based approach

Metzger (1989) recommends the implementation of a risk based approach for the management of USTs whereby multiple variables are accounted for in determining risk, including and not limited to infrastructure characteristics; the vulnerability of potential receptors; and the nature of the subsurface soils and bedrock. The approach considers the cost of prevention versus the cost of correction and indicates that by risk profiling, non-uniform standards are the most cost effective in preventing LNAPL contamination.

10.10 Investigation of new technologies

Global research into zero discharge of LNAPLs to the environment and limiting contamination impacts is being performed, as demonstrated by Sacile (2006) where a study site in Italy was subjected to remote real-time monitoring, and in the event of an incident, remote remedial works were undertaken.

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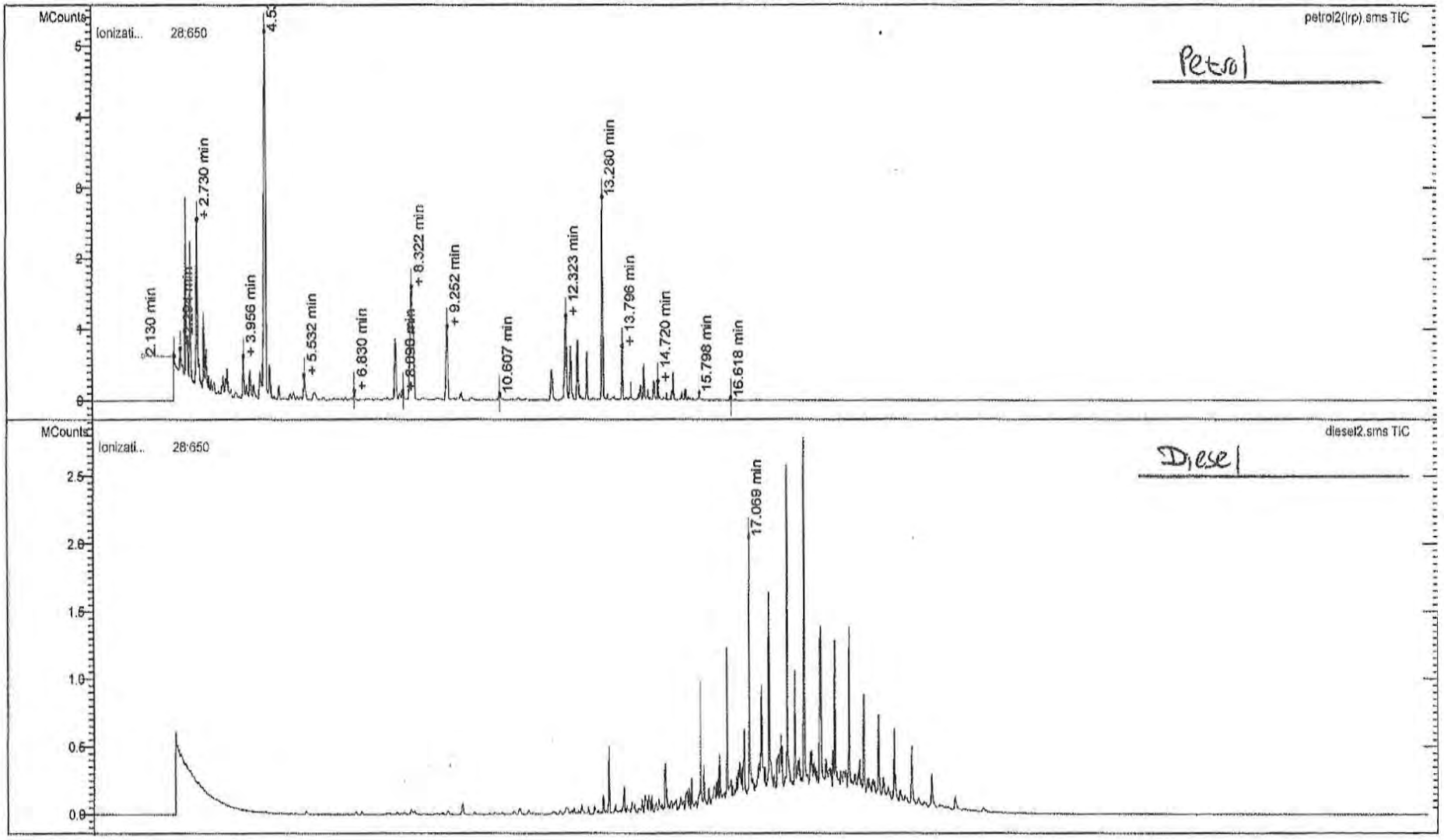
CHAPTER 13. APPENDICES

13.1 APPENDIX A: GAS CHROMATOGRAPH OF PETROL

Chromatogram Plots



13.2 APPENDIX B: LEGISLATED SANS STANDARDS APPLICABLE TO THE FUEL RETAIL INDUSTRY

Act Titles

Total Count: 17

Committee: <All>

Cost Centre:

SANS Number	Year	Ed.	Title	Act Title	Act No/ Year	Regulation	Gov Gazette Date	Gov Gaz No	Notice No	Province
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	WEST COAST DISTRICT MUNICIPALITY: BY-LAW ON FIRE SAFETY	2010-09-01	6777		WCP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	MOSSEL BAY MUNICIPALITY: BY-LAW RELATING TO COMMUNITY FIRE SAFETY	2009-11-20	6678		WCP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	AMATHOLE DISTRICT MUNICIPALITY: FIRE SAFETY BY-LAW	2010-06-09	2378	65	ECP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	MUNICIPALITY OF GREAT KEI: COMMUNITY FIRE SAFETY BY-LAW	2010-06-29	2403	96	ECP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	STANDARD FIRE AND EMERGENCY SERVICES BY-LAW	2010-11-05	101	163	FSP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	UBUNTU MUNICIPALITY: LIQUEFIED PETROLEUM GAS BY-LAW	2010-05-07	1414	47	NCP
SANS 10089-1 (SABS 089-1)	2003	4.01	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LABOUR RELATIONS ACT	66/1995	NATIONAL BARGAINING COUNCIL FOR THE ELECTRICAL INDUSTRY OF SOUTH AFRICA: EXTENSION OF MAIN COLLECTIVE AGREEMENT TO NON-PARTIES	2001-01-26	22010	90	
SANS 10089-1 (SABS 089-1)	2003	4.01	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	OCCUPATIONAL HEALTH AND SAFETY ACT	85/1993	ELECTRICAL INSTALLATION REGULATION	2002-04-15	23323	440	
SANS 10089-1 (SABS 089-1)	2003	4.01	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LABOUR RELATIONS ACT	66/1995	ELECTRICAL INDUSTRY OF SOUTH AFRICA: EXTENSION OF REGION A MAIN ELECTRICAL INDUSTRY OF SOUTH AFRICA: EXTENSION OF REGION A MAIN COLLECTIVE AGREEMENT TO NON-PARTIES COLLECTIVE AGREEMENT TO NON-PARTIES	1999-06-11	20149	717	
SANS 10089-1 (SABS 089-1)	2003	4.01	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	WESTERN CAPE PROVINCIAL DEPARTMENT OF LOCAL GOVERNMENT AND HOUSING		STANDARDS COMMUNITY FIRE SAFETY BY-LAW FOR ADOPTION BY LOCAL MUNICIPALITIES	2006-10-27	6389		WCP
SANS 10089-1 (SABS 089-1)	1983	3.00	The petroleum industry Part 1: The handling, storage and distribution of petroleum products	MACHINERY AND OCCUPATIONAL SAFETY ACT	6/1983	INCORPORATION OF SAFETY STANDARDS	1992-11-06		3062	

Act Titles

Total Count: 17

Committee: <All>

Cost Centre:

SANS Number	Year	Ed.	Title	Act Title	Act No/ Year	Regulation	Gov Gazette Date	Gov Gaz No	Notice No	Province
SANS 10089-1 (SABS 089-1)	2003	4.01	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	DEPARTMENT OF PUBLIC SAFETY OF NORTH WEST PROVICE		FIRE SERVICES, PUBLIC VEHICLES, PARKING GROUNDS, PARKING METERS, DOGS, TRAFFIC AND HAWKERS BY-LAWS	2003-12-05	5957		NWP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	OUDTSHOORN MUNICIPALITY: FIRE SAFETY BY-LAW	2009-06-12	6636		WCP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	CONSTITUTION OF RSA	108/1996	HESSEQUA MUNICIPALITY: FIRE SAFETY BY-LAWS	2010-04-14	6725		WCP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	CONSTITUTION OF RSA	108/1996	UKHAHLAMBA DISTRICT MUNICIPALITY: COMMUNITY FIRE SAFETY BY-LAWS	2009-09-11	2185	115	ECP
SANS 10089-1 (SABS 089-1)	2008	4.03	The petroleum industry Part 1: Storage and distribution of petroleum products in above-ground bulk installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	BERGRIVIER MUNICIPALITY: FIRE SAFETY BY-LAW	2009-11-09	6675		WCP
SANS 10089-1 (SABS 089-1)	1983	3.00	The petroleum industry Part 1: The handling, storage and distribution of petroleum products	MACHINERY AND OCCUPATIONAL SAFETY ACT	6/1983	ELECTRICAL INSTALLATION REGULATION	1992-10-23	14350	2920	

Act Titles

Total Count: 14

Committee: <All>

Cost Centre:

SANS Number	Year	Ed.	Title	Act Title	Act No/ Year	Regulation	Gov Gazette Date	Gov Gaz No	Notice No	Province
SANS 10089-3 (SABS 089-3)	1976	1.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	NATIONAL BUILDING REGUATIONS AND BUILDING STANDARDS ACT	103/1977	REGULATIONS IN TERMS OF SECTION 17(1)	1990-10-12	12780	2378	
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	OCCUPATIONAL HEALTH AND SAFETY ACT	85/1993	ELECTRICAL INSTALLATION REGULATION	2002-04-15	23323	440	
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	AMATHOLE DISTRICT MUNICIPALITY: FIRE SAFETY BY-LAW	2010-06-09	2378	65	ECP
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	MUNICIPALITY OF GREAT KEI: COMMUNITY FIRE SAFETY BY-LAW	2010-06-29	2403	96	ECP
SANS 10089-3 (SABS 089-3)	2010	4.00	The petroleum industry Part 3: The installation, modification, and decommissioning of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	STANDARD FIRE AND EMERGENCY SERVICES BY-LAW	2010-11-05	101	163	FSP
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	DEPARTMENT OF PUBLIC SAFETY OF NORTH WEST PROVICE		FIRE SERVICES, PUBLIC VEHICLES, PARKING GROUNDS, PARKING METERS, DOGS, TRAFFIC AND HAWKERS BY-LAWS	2003-12-05	5957		NWP
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	BERGRIVIER MUNICIPALITY: FIRE SAFETY BY-LAW	2009-11-09	6675		WCP
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	LABOUR RELATIONS ACT	66/1995	ELECTRICAL INDUSTRY OF SOUTH AFRICA: EXTENSION OF REGION A MAIN ELECTRICAL INDUSTRY OF SOUTH AFRICA: EXTENSION OF REGION A MAIN COLLECTIVE AGREEMENT TO NON-PARTIES COLLECTIVE AGREEMENT TO NON-PARTIES	1999-06-11	20149	717	
SANS 10089-3 (SABS 089-3)	1991	2.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework	MACHINERY AND OCCUPATIONAL SAFETY ACT	6/1983	ELECTRICAL INSTALLATION REGULATIONS	1992-10-23		2920	

SANS Number	Year	Ed.	Title	Act Title	Act No/ Year	Regulation	Gov Gazette Date	Gov Gaz No	Notice No	Province
			at service stations and consumer installations							
SANS 10089-3 (SABS 089-3)	1991	2.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	MACHINERY AND OCCUPATIONAL SAFETY ACT	6/1983	INCORPORATION OF SAFETY STANDARDS	1992-11-06		3062	
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	OUDTSHOORN MUNICIPALITY: FIRE SAFETY BY-LAW	2009-06-12	6636		WCP
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	CONSTITUTION OF RSA	108/1996	HESSEQUA MUNICIPALITY: FIRE SAFETY BY-LAWS	2010-04-14	6725		WCP
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	CONSTITUTION OF RSA	108/1996	UKHAHLAMBA DISTRICT MUNICIPALITY: COMMUNITY FIRE SAFETY BY-LAWS	2009-09-11	2185	115	ECP
SANS 10089-3 (SABS 089-3)	1999	3.00	The petroleum industry Part 3: The installation of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations	LABOUR RELATIONS ACT	66/1995	NATIONAL BARGAINING COUNCIL FOR THE ELECTRICAL INDUSTRY OF SOUTH AFRICA: EXTENSION OF MAIN COLLECTIVE AGREEMENT TO NON-PARTIES	2001-01-26	22010	90	

Act Titles

Total Count: 6

Committee: <All>

Cost Centre:

SANS Number	Year	Ed.	Title	Act Title	Act No/ Year	Regulation	Gov Gazette Date	Gov Gaz No	Notice No	Province
SANS 10131	2004	1.00	Above-ground storage tanks for petroleum products	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	AMATHOLE DISTRICT MUNICIPALITY: FIRE SAFETY BY-LAW	2010-06-09	2378	65	ECP
SANS 10131	2004	1.00	Above-ground storage tanks for petroleum products	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	MUNICIPALITY OF GREAT KEI: COMMUNITY FIRE SAFETY BY-LAW	2010-06-29	2403	96	ECP
SANS 10131	2004	1.00	Above-ground storage tanks for petroleum products	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	BERGRIVIER MUNICIPALITY: FIRE SAFETY BY-LAW	2009-11-09	6675		WCP
SANS 10131	2004	1.00	Above-ground storage tanks for petroleum products	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	OUDTSHOORN MUNICIPALITY: FIRE SAFETY BY-LAW	2009-06-12	6636		WCP
SANS 10131	2004	1.00	Above-ground storage tanks for petroleum products	CONSTITUTION OF RSA	108/1996	HESSEQUA MUNICIPALITY: FIRE SAFETY BY-LAWS	2010-04-14	6725		WCP
SANS 10131	2004	1.00	Above-ground storage tanks for petroleum products	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	STANDARD FIRE AND EMERGENCY SERVICES BY-LAW	2010-11-05	101	163	FSP

Act Titles

Total Count: 3

Committee: <All>

Cost Centre:

SANS Number	Year	Ed.	Title	Act Title	Act No/ Year	Regulation	Gov Gazette Date	Gov Gaz No	Notice No	Province
SANS 1535 (SABS 1535)	2007	2.03	Glass-reinforced polyester-coated steel tanks for the underground storage of hydrocarbons and oxygenated solvents and intended for burial horizontally	LOCAL GOVERNMENT: MUNICIPAL SYSTEMS ACT	32/2000	AMATHOLE DISTRICT MUNICIPALITY: FIRE SAFETY BY-LAW	2010-06-09	2378	65	ECP
SANS 1535 (SABS 1535)	2007	2.03	Glass-reinforced polyester-coated steel tanks for the underground storage of hydrocarbons and oxygenated solvents and intended for burial horizontally	CONSTITUTION OF RSA	108/1996	HESSEQUA MUNICIPALITY: FIRE SAFETY BY-LAW	2010-04-14	6725		WCP
SANS 1535 (SABS 1535)	2003	2.01	Glass-reinforced polyester-coated steel tanks for the underground storage of hydrocarbons and oxygenated solvents and intended for burial horizontally	DEPARTMENT OF PUBLIC SAFETY OF NORTH WEST PROVICE		FIRE SERVICES, PUBLIC VEHICLES, PARKING GROUNDS, PARKING METERS, DOGS, TRAFFIC AND HAWKERS BY-LAWS	2003-12-05	5957		NWP

13.3 APPENDIX C: APPLICATION FORM FOR CERTIFICATE OF REGISTRATION (FLAMMABLE LIQUIDS)

0866694707

THIRD SCHEDULE (PREMISES)
ETHEKWINI METROPOLITAN UNICITY MUNICIPALITY
FIRE & EMERGENCY SERVICES

INTERIM CODE RELATING TO FIRE PREVENTION AND FLAMMABLE LIQUIDS AND SUBSTANCES

APPLICATION FOR A CERTIFICATE OF REGISTRATION

(Section 24)

Date : .....

Application for a Certificate of Registration for premises under the Interim code relating to Fire Prevention and Flammable Liquids and Substances. This form must be completed and forwarded to the Chief Fire Officer, Fire Department, accompanied by a plan of the premises in terms of the interim code.

Full name of Applicant, If a Company, the name of Company and its Secretary
(Write in Block Letters)

Name of Applicant .....
Trading as .....
Name of Secretary .....

State the address of the premises to be registered and the name of the owner thereof

Name of Owner .....
Sub-Division ..... Lot .....
Block ..... Street No. .....
Street .....

State class of business .....

Give a full description of existing and proposed buildings .....
.....
.....

How many flammable liquid tanks are there on the premises? .....

How many flammable liquid pumps are there on the premises? .....

State total storage capacity of flammable liquid on the premises (in litres)

Litres .....

State total quantity of each class in litres proposed to be kept on the premises

Class 0 L.P. Gas .....
Class I Flash Point <21°C .....
Class II Flash Point 21°C<55°C .....
Class III Flash Point >55°<100°C .....

Particulars of fixed and portable fire equipment on premises :.....
.....

PARTICULARS OF ACCOUNT

Capacity of Signatory .....Account to be sent to : .....

Address :.....

Contact Person .....Telephone No.....

P O Box : .....Order No.....

Telephone No. .....Cellular Phone .....

Signature of Applicant .....

13.4 APPENDIX D: FIRE PREVENTION WORKSHEET

s12H

EMERGENCY SERVICES SYSTEM

Fire Prevention Worksheet
printed 09 FEB 10 11:58 Item I.D. 13881

Location name :
Complex name :
Address :
Station : C1C
Telephone O/H :

Suburb :
City/town : DURBAN
Section : 05

Contacts O/H :
Telephone A/H : 082 552 9112
Contacts A/H :

Matters :

Type of business : SERVICE STATION\R/P3394P
Occupancy : D2
Occupants :
Floors above ground : 2
Floors below ground : 0
Floor area - sq m. : 541
Method of construction : BRICK UNDER CONCRETE
Plan number : 576/05/07 0764-08-94-2
Fire equipment etc. :

Previous incidents : C09/106853 on 11 AUG 09 at 02:57:26
T09/20291 on 27 JUN 09 at 12:22
T08/28280 on 27 AUG 08 at 19:28

Correspondence received : No documents

C.O.R. Serial Number :
Qty Class 0 Product :
Qty Class 1 Product :
Qty Class 2 Product :
Qty Class 3 product :
Qty Other Flammable :
Special Conditions :
Approved By :
Date Approved :
Account No :

<----- Activity ------>			<----- Follow up ----->
Date	Code	By whom	Comments
27 MAR 01	AD	HARTAR	Contact Collen Hean At 082 6002208 - For Urgent Inspection
03 JUN 97	IR	SOBREC	Inspection By Ravidutt, Order 9901, A12, A13, A19.
24 APR 09	IC	LAVADG	Cor No.3394 Displayed & In Order.
01 MAR 08	IC	LAVADG	Issued Cor 3394p
13 AUG 07	PS	LAVADG	Plan 576/05/07 - Approved
08 AUG 07	AD	MUDRL	Plan 576/05/07 Received
09 JUN 07	PS	LAVADG	Plan 576/05/07 - Approved
05 JUN 07	AD	MUDRL	Plan 576/05/07 Received
03 APR 01	CO	LAVADG	Telcom Mr C Head Advised To Contact Asib For Requirements.
25 NOV 98	AD	TEMP	Capt Anne - Approved
23 NOV 98	IR	LAVARACK	Approved
25 MAR 96	PS	MANILAL	Plan 0764-08-94-2 Referred - Tt34, A9

09 OCT 97	AD	TEMP	Data Cap 08 10 97
08 OCT 97	IR	LAVARACK	Premises Not Approved. C.O.R. To Be Issued

<----- Follow up ----->		
Date	Code	By whom
28 MAR 01	IR	LAVADG
14 JUN 97	OC	SOBREC

<< Fire Prevention Worksheet Continues >>

<< Worksheet for continued >>

Inspection interval : 24 months Last : 24 APR 09 Next : 01 FEB 10

<<< end of print >>>

13.5 APPENDIX E: ETHEKWINI FIRE AND EMERGENCY SERVICES EXTRACTED DATA

Record Number	Business Or Company Name	St No	Street Name	Suburb Or Area	Occupancy (SABS 0400)	Qty Class 1 | Product	Qty Class 2 | Product	Qty Class 3 | Product
58124	09/I12/08/09SPRINGBOK TRUCKING CO.	3	JOYNER ROAD	PROSPECTON	G1D3	10	200	23000
60557	333 LOGISTICS	333	SYDNEY ROAD	CONGELLA	J2B1B2		0	14000
61146	45TH ENGEN	1134	JAN SMUTS HIGHWAY	CENTRAL	B2	92000		23000
61368	530 CLOTHING	530	NORTH COAST ROAD	BRIARDENE	B2	5000	3000	20000
62656	A & T CRANE	14	GRUNTER GULLY			0	0	9000
63134	A B B TURBO CHARGERS	211	SOUTH COAST ROAD	CLAIRWOOD	B3		0	9000
64812	A I PATEL	10	ACORN PATEL	DURBAN	B2		3000	
24	ASSEMBLY LOGISTICS	11	PROSPECTON ROAD	PROSPECTON	D2	23000	23000	46000
32	ASSMANG MANGANESE HOSTEL	39	EDDIE HAGAN DRIVE	CATO RIDGE	D2J2			62000
99	ASTRAFLEX	6	MAHOGANY ROAD	WESTMEAD	J2D2D1D2J1	40000		
162	ATHLONE PARK SERVICE STATION	27	BOOTH ROAD	ATHLONE PARK	B2			
167	ATHLONE SERVICE STATION	80	ATHLONE DIRVE	CENTRAL	B1	126000		14000
197	ATLAS GARAGE AND BREAKDOWN	66	ALICE STREET	DURBAN	B2	72000		9000
228	ATOMIC DEMOLISHERS (PTY) LTD	77	NORTH COAST ROAD	BRIARDENE	F1			4000
315	AUSSIES RADIO TAXIS CC	4000	UMGENI ROAD 350 DURBAN			14000	NIL	NIL
318	AUSSIES TRIANGLE SERVICE STATION	146	FIELD ST			60000	0	4000
330	AUSTERVILLE SERVICE STATION	105	SILVERTREE ROAD	AUSTERVILLE	B2	56000	NIL	NIL
329	AUSTERVILLE SERVICE STATION	180	AUSTERVILLE DRIVE	JACOBS	B2			
488	AUTO STOP SERVICE STATION	284	EDWIN SWALES DRIVE	JACOBS	B2	69000	0	23000
510	AUTOFIX MOTOR GARAGE	786-787	INANDA ROAD			84000	0	14000
640	AVENUE EAST SERVICE STATION	20	THE AVENUE EAST	ISIPINGO	B1	30000	90000	30000
645	AVERY DENNISON	24	WESTMEAD ROAD	PINETOWN	B2J2			2000
661	AVIS		M4	LA MERCY		9000		
665	AVIS RENT A CAR	10	PASCOE ROAD REUNION	REUNION	J4	25000	0	0
672	AVKA PLANT HIRE	40	HUNSLETT ROAD	PHOENIX INDUSTRIA	B3			14000
677	AVOCA CONCRETE	20	TONCORO ROAD	AVOCA	B2			88000
690	AVOCA SERVICE STATION	1427	NORTH COAST ROAD	AVOCA	B2			
712	AVONDALE SERVICE CENTRE	94	CLARENCE ROAD			41000		
805	AZMUTH MOTORS	614 - 618	MOUNTBATTEN DRIVE	RESERVOIR HILLS	B2	69000		14000
910	B K B	100	RICHARD CARTE ROAD	MOBENI	J2			22000
956	B NAGIAH'S SERVICE STATION	14	CHATSWORTH MAIN ROAD - 16	UMHLATUZANA TOWNSHIP		79000	0	9000
965	B P	3	THE TERRACE	WESTVILLE	G1			
966	B P	N2	SOUTH BOUND	REUNION	B2			
967	B P	1	DICKENS ROAD	TWINI	B2			
971	B P BEREA	333	BEREA	BEREA				
972	B P BLUFF CENTRE	100	BLUFF ROAD	BLUFF	B2	92000	0	14000
975	B P CRAZY CAR	944	UMGENI ROAD	CENTRAL	B2			
977	B P DRAKENSBERG	2	COROBRIK ROAD	RIVERHORSE VALLEY	J2			
978	B P DRAKENSBERG	1	DICKENS ROAD	UMBONGITWINI	B2			
980	B P DUBE VILLEAGE	11	IKHATHAZO CLOSE	INANDA	B2	92000		23000
981	B P GARAGE		IRELAND & WICK STREET	VERULAM	B2			
982	B P GARAGE	1319	V SECTION	UMLAZI	B2			
983	B P GARAGE	243	OLD MAIN ROAD	BOTHA'S HILL	B2			
984	B P GARAGE SETTLEMENT		SHALLCROSS ROAD	SHALLCROSS	H3			
985	B P HAMMERSDALE	385	MAIN ROAD	HAMMERDALE	B2	46000	46000	23000
986	B P HILLCREST			HILLCREST	B2			
987	B P MEREWENT SERVICE STATION	3	BOMBAY WALK	WENTWORTH	J2			
988	B P NEW GERMANY	33 - 35	SHEPSTONE ROAD	NEW GERMANY	B1F2B2F2	69000		
989	B P NORTHDENE	670	MAIN ROAD	QUEENSBURGH	B1	92000		23000
991	B P NORTHEND SERVICES	560	NORTH COAST ROAD	BRIADENE	B2	66000	0	23000
992	B P SAM SERVICE STATION	218	MAYIBUYE DRIVE	UMLAZI	B2	69000		23000
993	B P SEAVIEW	531	SARNIA ROAD	CONGELLA	B2			
996	B P SERVICE STATION	2	PROSPECTON ROAD	PROSPECTON	B2	92000		46000
995	B P SERVICE STATION	167	CLARE ROAD	OVERPORT	B2	90000	23000	
997	B P SERVICE STATION	N3	HIGHWAY	CATO RIDGE	J1	70000		70000
998	B P SERVICE STATION	331	BEREA ROAD	BEREA	B2			9000
994	B P SERVICE STATION	172	LEICESTER ROAD	MOBENI	B2			
999	B P SERVICE STATION		M4	UMDLOTI	B2			
1000	B P SERVICE STATION	169	WOOD ROAD	MONTCLAIR	B2			
1003	B P SERVICE STATION	44	ISIAIH NTSHANGASE	CENTRAL	B2			
1004	B P SIBAYA		SIBAYA DRIVE	UMDLOTI	B1			
1005	B P SUNNINGDALE	200	UMHLANGA ROCKS DRIVE	UMHLANGA	B1			
1006	B P UMBILO	566	UMBILO ROAD	UMBILO	B2			
1007	B P VILLAGE MALL	369 - 371	ANDREW ZONDO	AMANZIMTOTI	B1F1G1	56000		14000
1008	B P WEST STREET	208	DR PIXLEY KASEME STREET	CENTRAL	B2	56000		
1009	B P WESTVILLE MOTORS	129	JAN HOFMEYER RD	WESTVILLE	B1F2	92000		
1019	B R S DRUM AFRICA	27	PROSPECTON ROAD	PROSPECTON	D2		87000	2200
1033	B S N MEDICAL	26 - 30	GILLITTS ROAD	PINETOWN	J2D2G1		1020	4500
1066	B.P. SOUTH AFRICA						6500	6500
1198	BADGER MOTORS	126	SHEPSTONE ROAD	NEW GERMANY	B2F2	51000		
1321	BAKERY BALLERS WORLD	47	FLOWER ROAD					2200
1350	BALCO CO (PTY) LTD		STANGER STREET				2500	
1384	BALLENTINE SERVICE STATION		MANGOSUTHO HIGHWAY	UMLAZI	B2	92000	0	23000
1521	BARBERRY CARGO TERMINALS	1	WISELY ROAD	MAYDON WHARF	B2			14000
1647	BARLOWORLD & LOGISTICS	8	TONCORO ROAD	PHOENIX	B2			69000
1650	BARLOWORLD EQUIPMENT	17	IMVUBU PARK PLACE	DURBAN NORTH	B2G1			23000
1740	BASF	369	UMGENI ROAD	DURBAN CENTRAL	J2		2000	
1801	BASSCO PRODUCTS	242	ARCHERY ROAD CLAIRWOOD			0	0	4500
1888	BAY TERRACE CONVENIENCE CENTRE	45	BAY TERRACE	CENTRAL	B2	69000	0	23000
1895	BAYA'S SERVICE STATION	3	THOMAS LANE	ISIPINGO RAIL	B1			
1914	BAYHEAD SERVICE CENTRE	20	BAYHEAD ROAD	BAYHEAD	B1	63000	0	42000
1925	BAYSIDE MOTORS	1	STALWART SIMELANE STREE	DURBAN	B2	69000	69000	18500
1950	BAYVIEW MOTORS	248	PELICAN DRIVE BAYVIEW CH	CHATSWORTH	B2	97000	0	28000
2016	BEACH GARAGE	6	SMITH ST			42000	0	0
2051	BEACHWOOD COUNTRY CLUB	9	BEACHWOOD PLACE	DURBAN NORTH	B2	0	0	2200
2097	BEARES TRANSPORT	164	BEREA ROAD DURBAN			14000	0	14000
2254	BEIER WOOL	3	BALTEX ROAD NO	PROSPECTON	D1	14000	20000	14000

2338	BELLAIR SERVICE STATION	928 - 938	SARNIA ROAD	BELLAIR	B2	42000	0	28000
2614	BEST BREAD BAKERY		STOCKVILLE ROAD	WESTGATE PARK	D2		2000	4000
2810	BIA BAKE TECH	61	MARSEILLES CRESCENT	DURBAN NORTH	B2			2000
2827	BID FREIGHT PORT OPERATIONS	81	METHEVEN ROAD	MAYDON WHARF	J2			7000
2898	BIGFOOT EXPRESS FREIGHT	58	GOODWOOD ROAD					23000
3056	BISSET STREET MOTORS	40	BISSET STREET	UMKOMAAS	B2	46000		
3098	BKB PTY LTD	100 - 101	RICHARD CARTE WAY	MOBENI	B2			28000
3132	BLACKBURN ESTATE		OFF WATERLOO	WATERLOO				9200
3143	BLAIR ATHOLL MOTORS	123	RODGER SISHI	WESTVILLE	B2		92000	23000
3167	BLAZON MOTORS	369	MAHATMA GANDHI ROAD	POINT	B2	50000	42000	23000
3174	BLENDRITE CHEMICALS	140	PAISLEY ROAD	JACOBS	D1	100000	100000	
3173	BLENDRITE CHEMICALS	314	BALFOUR ROAD	JACOBS	D2	0	0	4400
3327	BLUE RIBBON BAKERY	178	LEICESTER ROAD	MOBENI	D3		0	41250
3351	BLUE WATERS HOTEL	175	SNELL PARADE	NORTH BEACH	H1	0	2200	22000
3418	BLUFF SERVICE STATION	1	CHERWELL ROAD	BLUFF	B2	60000	0	23000
3600	BOILER STATION OIL STORE	1	DICKENS ROAD	AMANZIMTOTI	B2		2000	1000
3682	BONAMANZI SERVICE STATION	3	UITSIG ROAD	WINKELSPRUIT	B2			
3764	BOOTH SERVICE STATION		BOOTH ROAD	BELLAIR	B2			
3822	BOSTON LAUNDERERS	240	ABERDARE DRIVE	PHOENIX	B2			23000
3844	BOTHA'S HILL GARAGE	241	OLD MAIN ROAD	HILLCREST	B2	92000	23000	
3894	BOXER CASH & CARRY	17	INWABI ROAD	ISIPINGO	F1		23000	
3903	BOXER SUPERSTORES	101	MEYIWA MAIN ROAD	MPUMALANGA	F1			23000
3901	BOXER SUPERSTORES	22	HILL STREET	PINETOWN	F1		32000	1
3922	BP CHATSWORTH CIRCLE	4	JOYHURST STREET	CHATSWORTH	B2	207000	0	46000
3930	BP KWA MASHU SERVICE STATION	420	MALANDELA ROAD	KWAMASHU	B2	92000		23000
3937	BP RIDGE OASIS	N3	N3 CATO RIDGE	CATO RIDGE	B2	115000		92000
3941	BP SERVICE STATION	232	MOORE ROAD	CONGELLA	B2	84000	0	9000
3939	BP SERVICE STATION	435	MAIN ROAD	QUEENSBURGH	B2			
3940	BP SERVICE STATION	CNR	WICK & IRELAND STREET	VERULAM	B2			
3942	BP SERVICE STATION	11	IKMATMAZO CLOSE	INANDA	B2			
3943	BP SERVICE STATION		MOUNTBATTEN DRIVE					
3944	BP SERVICE STATION		DAHLIA DRIVE					
3945	BP SERVICE STATION	201	TARA ROAD	JACOBS				
3947	BP SERVICE STATION SHOP		PROSPECTON ROAD	PROSPECTON	B1			
3953	BP UMLAZI SERVICE STATION	156		UMLAZI	B2	69000	23000	
3954	BPB CONSTRUCTION	10	DOWNIE CRESCENT	MALVERN	D3	9000		14000
4181	BREWSTERS TRANSPORT LTD	61	HIME ST JACOBS			0	0	8400
4225	BRIARDENE SERVICE STATION	330	NORTH COAST ROAD			40000		9000
4242	BRICKFIELD ROAD GARAGE	413 - 423	BRICKFIELD ROAD	SYDENHAM	B2	56000		14000
4247	BRICKHILL AUTO VALET	124	MAHATMA GANDHI ROAD			10500	0	3500
4248	BRICKHILL MOTORS	124	BRICKHILL ROAD			33000	0	3000
4266	BRIDGE CITY SHOPPING CENTRE	15	STREET 121665GRAVEL ROAD	KWAMASHU	B2			4000
4284	BRIDGEVALE PARK - PARKS DEPARTMEI	12	THE DRIVE	DURBAN NORTH	G1B2	18000	800	18000
4325	BRIGHTON BEACH SERVICE STATION	253	MARINE DRIVE	BLUFF	B2	69000	23000	5000
4354	BRISK ASPHALT SURFACING	30	H QUARRY ROAD	REDCLIFFE	B1	5000	4400	46000
4378	BROAD STREET MOTORS	22	BROAD STREET	CITY	B2	92000		23000
4381	BROAD STREET SERVICE STATION	30	BROAD STREET	DURBAN CENTRAL	B2	100000	25000	0
4456	BROOKDALE SERVICE STATION	1450	NORTHERN DRIVE	PHOENIX	B2	69000		23000
4494	BROWNS HYPERSTORE	2	HUNSLETT ROAD	PHOENIX	F2			25000
4483	BROWN'S SCHOOL	28	MARIANRIDGE DRIVE	MARIANNRIDGE	A3		4500	2200
4550	BSN MEDILAL	30	GILLITS ROAD	PINETOWN	B2	54000		
4555	BTG AGGREGATES		EDDIE HAGAN DRIVE	CATO RIDGE	B2			14000
4575	BUCCO CANOPIES	12-Oct	DEVON ROAD	PINETOWN	D2	620	8000	2550
4604	BUDGET			LA MERCY		9000		
4626	BUDGET RENT A CAR			REUNION	B2		9000	
4648	BUFFELS KLOOF SERVICE STATION	2	REGINA STREET	BELVEDERE	B2			
4654	BUFFELSDALE SERVICE STATION	21	DAHLIA DRIVE	BUFFELSDALE	F2B2			
4692	BUILD IT BOTHA'S HILL	45	OLD MAIN ROAD	BOTHAS HILL	B2	1000		4400
4701	BUILDERS TRADE DEPOT	11	BISHOP ROAD	PINETOWN	B2	200	400	9000
4719	BUILDING PRODUCTS	128	LANDOWN ROAD				4500	
4760	BULWER PARK SERVICE STATION	159	BULWER ROAD	BEREA	B2	92000	0	23000
4881	BUS STOP SUPERMARKET	13	LAURA STREET	TONGAAT	F2		2200	
5028	BUYRITE SUPERMARKET		CALLENDULA AVENUE	CRAIGIEBURN	F1			2200
5143	C H C CHEMICALS	14	THE AVENUE EAST	PROSPECTON	J2	33000	74000	18000
5185	C K T EXPRESS	57 - 63	HUNSLETT ROAD	PHOENIX	B2	0	0	14000
5194	C M C EXPRESS DELIVERIES	2	HAWTHORNE PLACE	WESTMEAD	B2G1			23000
5299	C T P GRAVURE	21	JOYNER ROAD	PROSPECTON	B2	51000		
5318	C VIEW MOTORS	531 - 537	SARNIA ROAD	SEAVIEW	B2	69000	92000	23000
5574	CALTEX	15	THE AVENUE EAST	ISIPINGO	B1			
5575	CALTEX	34	KINGSWAY	WARNER BEACH	B1			
5576	CALTEX	1354	V SECTION	UMLAZI	B2			
5577	CALTEX		OLD MAIN ROAD	GILLITTS	B2			
5578	CALTEX	1180	SOUTH COAST ROAD	MOBENI	J1			
5579	CALTEX	1181	SOUTH COAST ROAD	MOBENI	B2			
5581	CALTEX	251	JACOBS ROAD		D2J2			
5582	CALTEX				B1			
5583	CALTEX		TARA ROAD	BLUFF				
5585	CALTEX CLAIRWOOD MOTORS	644	SOUTH COAST ROAD	CLAIRWOOD	B2	125000		4500
5586	CALTEX CONVENIENCE CENTRE		COWEY ROAD	SPRINGFIELD PARK	G1			
5587	CALTEX CONVENIENCE STORE		O'FLAHERTY ROAD	CLARE ESTATE	F2			
5589	CALTEX GARAGE		STELLA ROAD	HILLARY	B2			
5590	CALTEX GATEWAY	5	CENTENARY BOULEVARD	GATEWAY	F2	96000		23000
5592	CALTEX MOORTON STAR SERVICE STAT	49	MOORCROSS DRIVE	CHATSWORTH	B2	92000		23000
5593	CALTEX MOTORSERV	3	MONTY NAICKER ROAD	CENTRAL	B2			
5595	CALTEX NORTH BEACH	30	PLAYFAIR ROAD	NORTH BEACH	B2		0	9000
5596	CALTEX NU WEST SERVICE STATION	1	LOOPWEST CRESCENT	NEWLANDS	B2	69000		23000
5597	CALTEX OIL	654	SILVERGLEN DRIVE	CHATSWORTH	J1			
5598	CALTEX OIL	55	WILLIAMS ROAD DALBRIDGE					
5605	CALTEX OIL S A	5	O'FLAHERTY ROAD	CLARE HILLS	B2			
5612	CALTEX OIL SA (PTY) LTD	290	SIRDAR ROAD	CLAIRWOOD	B2			
5614	CALTEX S A	87	OLD MAIN ROAD	PINETOWN	B2	70000	18000	18000
5615	CALTEX SERVICE STATION	30 - 32	ALICE STREET	CENTRAL	B2			
5616	CALTEX SERVICE STATION		MAIN ROAD	HAMMARSDALE	B2			
5617	CALTEX SERVICE STATION	CNR	AURORA & CENTENARY ROAD	UMHLANGA	B2			
5618	CALTEX SERVICE STATION		GATEWAY BOULEVARD	UMHLANGA ROCKS	B2			
5619	CALTEX SERVICE STATION		UMHLANGA ROCKS	UMHLANGA	B1			
5620	CALTEX SERVICE STATION	9	CENTENARY ROAD	UMHLANGA	B2			
5621	CALTEX SERVICE STATION			WARNER BEACH	B2			

5622	CALTEX SERVICE STATION		PRINCE ALFRED STREET	CENTRAL	B2			
5623	CALTEX SERVICE STATION		SOUTH COAST ROAD	MOBENI	B2			
5625	CALTEX SITE	74	ARCHARY ROAD	MOBENI	G1J1			
5626	CALTEX STAR COURT	1	HILLHEAD	MT EDGECOMBE	B2			
5627	CALTEX STAR MART	CNR	AURORA & CENTENARY	UMHLANGA	F2			
5628	CALTEX STARMART		AURORA DRIVE	UMHLANGA	A1			
5629	CALTEX STURGEAN MOTORS	810	MAIN ROAD	NORTHDENE				
5630	CALTEX WEST STAR	104	TODD STREET	VERULAM	B2			
5631	CALTEX WESTVILLE	128	JAN HOFMEYER ROAD	WESTVILLE	J2	70000		14000
5664	CAMBRIDGE FOODS	5	HILL STREET	PINETOWN	F1			2000
5667	CAMBRIDGE FOODS BAKERY	150	OLD MAIN ROAD	ISIPINGO	B2F1			2200
5740	CAMSONS SERVICE STATION CC	473	INANDA ROAD	PARLOCK	B2	140000	0	37000
5823	CANERLAND ROOF TILES (PTY) LTD		KWAMASHU ROAD					11000
5903	CAPE LIME	166	ABERDARE DRIVE			0	0	2200
6131	CARGO CARRIERS	201	PO BOX ISANDO JOHANNESBURG			0	35000	35000
6187	CARLTON PAPER	264	ABERDARE DRIVE					9000
6243	CARRIERS TRANSPORT	250	HOUGHTON ROAD			0	0	46000
6344	CASCO TEXTILE MILLS	1	ASHFIELD AVENUE	SPRINGFIELD PARK	B2			4000
6435	CASSIM SUPERMARKET	473	INANDA ROAD	PARLOCK	F2	0	600	9000
6569	CATO RIDGE 1 STOP SERVICE STATION		N3 DURBAN BOUND	CATO RIDGE	F2B2	92000		69000
6582	CATO RIDGE MOTORS		EDDY HAGEN DRIVE	CATO RIDGE	J1F2	90000		30000
6591	CATO RIDGE TRUCK STOP	N3	HIGHWAY	CATO RIDGE	B1	92000		46000
6686	CEDAR FOOD	2	MAHOGANYFIELD WAY			0	0	4500
6814	CELROSE CLOTHING	9	WALTER REID ROAD	MAIDSTONE	B2			10000
6819	CELTIC FREIGHT	28	PALMGATE CRESCENT	UMBOGINTWINI	G1J3			23000
6833	CENTILLION TRADING	170	ABERDARE DRIVE PHOENIX	PHOENIX			0	14000
6844	CENTRAL BOARD & TIMBER	264	INANDA ROAD	SEA COW LAKE	J2		0	2200
6847	CENTRAL CARRIERS	215	DAYAL ROAD	CLAIRWOOD	B3		0	4400
6849	CENTRAL CIVILS & ROADWORKS	2	NIPPER ROAD	NEW GERMANY	D2G1			13500
6856	CENTRAL FIRE STATION	15 - 17	ML SULTAN ROAD	GREYVILLE	B3	14000	0	14000
7007	CHANDLING INTERNATIONAL	410	SYDNEY ROAD	CONGELLA	J2	100000	150000	50000
7008	CHANDLING INTERNATIONAL PTY LTD	19	MACDONALD ROAD CONGELLA DURBAN			50000	150000	50000
7176	CHATSWORTH CENTRE MOTORS	4092	JOYHURST STREET 32 CROFTDENE CHATSWORTH			69000	NIL	NIL
7192	CHATSWORTH FIRE STATION	11	FRAGRANCE STREET	CHATSWORTH	G1			9000
7288	CHECKONE SUPERMARKET	18 - 20	PARAGON PLACE	PHOENIX				38000
7397	CHELTONDALE	137	FLORIDA ROAD MORNINGSIDE			0	2000	0
7406	CHEM WASH	7	SCHENK ROAD	PINETOWN	G1J2D2	3600		1000
7414	CHEMETAL	174	TEAKWOD ROAD JACOBS			100	2800	3000
7426	CHEMICAL INITIATIVES	1	DICKENS ROAD	UMBOGINTWINI	D1	1000	2000	67700
7459	CHEP	01:00 AM	BALTEX ROAD					9000
7462	CHEP SA	135	OLD NORTH COAST ROAD	GLEN ANIL	B2			9000
7496	CHESS SERVICE STATION	87	BELLAIR ROAD	BELLAIR	B2	88000	15000	13000
7514	CHESTER WHOLESALE MEATS	14 - 22	WATFORD ROAD	CONGELLA	B2			23000
7546	CHESTNUT SERVICE STATION	679	CHESTNUT CRESCENT	PINETOWN	B1			
8188	CITY COURIERS	350	UMHLANGANE ROAD	EFFINGHAM	J2G1			30000
8270	CITY METAL PRODUCTS (PTY) LTD	1194	SOUTH COAST ROAD			4000	400	600
8372	CLAREMONT MOTORS	116	FLOWER ROAD	CLAIRWOOD	B3		0	17000
8388	CLARK AND KENT PANEL BEATERS	374	SYDNEY ROAD			9000	0	9000
8396	CLARKE & KENT	360 - 370	SYDNEY ROAD	CONGELLA	B2	5000	2000	9000
8493	CLAYFIELD SERVICE STATION	77 - 79	CLAYFIELD DRIVE	PHOENIX	B2G1	56000	37000	
8520	CLEAR FREIGHT	4	MUNROE PLACE	QUEENSMEAD	B2J2G1		12000	25000
8566	CLERMONT SERVICE STATION	1111	NORTH ROAD	CLERNAVILLE	B2J1			9000
8714	CLOVER S.A	47	OPPENHEIMER STREETOPEN	PINETOWN	D2D2J2			23000
8715	CLOVER SA	100	RICHMOND ROAD	QUEENSBURGH	J2	23000		78000
8788	CMC GRINDROD	6	BLUFF ROAD	BLUFF	J3			23000
8858	COASTAL CENTRE SERVICE STATION	230 - 234	MAIN ROAD	TONGAAT	B2	69000		23000
8863	COASTAL DISTRIBUTORS	18	SASTRI ROAD	CLAIRWOOD	B3			4400
8865	COASTAL DRY CLEANERS	544	SOUTH COAST ROAD	JACOBS	B2	20200		
8898	COASTAL SERVICE STATION	213	DAYAL ROAD CLAIRWOOD	JACOBS	B2			
8934	COATES BROTHERS	2	BALTEX ROAD	PROSPECTON	D1	125000		60000
9021	COIN SECURITY	235	GALE STREET		G1		0	9000
9037	COLD CHAIN	1	DAVEY ROAD	MAYDON WHARF	J3	28000		14000
9234	COMMERCIAL TRUCK	68	CB DOWNES ROAD			16800	16800	16800
9299	COMPASS WASTE SERVICE CC	17	MONTE CARLO ROAD	WESTMEAD	G1D3			23000
9314	COMPETITIVE WHOLESALERS	215	ABERDARE DRIVE	PHOENIX	F2			2200
9439	CONCRETE 2000	20 - 26	PARAGON PLACE	PHOENIX	B2			34000
9470	CONGELLA SERVICE STATION	483	SYDNEY ROAD	CONGELLA	B2	46000	0	9000
9543	CONSOLIDATED ROCK MACHINERY	5 B	MONZA ROAD	WESTMEAD	B2		2800	
9561	CONSTRUCTION PLANT HIRE	80	PREMIER PLACE PHOENIX			0	0	14000
9604	CONTAINERLINK	6	BLUFF JACOBS			0	0	23000
9631	CONTINENTAL PRINTING INKS	5635993	-31			4000	3500	
9697	COO-EE BOTTLING CO NTL [PTY] LTD	261-265	BALFOUR ROAD JACOBS			4500	0	2200
9868	COROBRIK - MOTOR TRANSPORT	8	TONCORO ROAD	AVOCA	D2			50000
9869	COROBRIK AVOCA 1	20	TONCORO ROAD	AVOCA	D3G1D1	0	0	14000
9935	CORROCOAT	42	HARDEN AVENUE - 44 SEAVIEW DURBAN			0	0	2000
10003	COSWORTH CARRIERS	221 - 227	JACOBS ROAD	CLAIRWOOD	B3			14000
10081	COUNTRY HOME	37	ABERDARE DRIVE	PHOENIX	F2	10000	0	0
10105	COURTBRIDGE INVESTMENTS CC	546	RIDGE ROAD - 550 OVERPORT DURBAN			94000	23500	0
10136	COVRIESY S/STATION	179-181	FERNHAM DRIVE			70000		14000
10141	COWEY CENTRE MOTORS	107	COWEY ROAD	BEREA	B2F2	200500	5000	23000
10347	CREIGHTON PRODUCTS	12	CHERRY ROAD	PINETOWN	B2			12000
10369	CREST CHEMICALS	6	STROUDE PLACE	PROSPECTON	G1D1J2	40000	50500	10000
10415	CROC WORLD		OLD SOUTH COAST ROAD	CLANSTHALL	B2			2000
10448	CROMPTON STREET MOTORS	136	CROMPTON STREET	PINETOWN	B2	90000	23000	14000
10482	CROSSMOOR SERVICE STATION	90	BILBERRY AVENUE	CHATSWORTH	B2	69000	0	23000
10485	CROSSMOOR TRANSPORT	3	NEWTON ROAD	PINETOWN	D2			23000
10513	CROWN BOTTLE STORE	640-654	NORTH COAST ROAD			0	0	9000
10519	CROWN CARRIERS	11	SEVENTH AVENUE	ASHLEY	D2			46000
10573	CRYSTAL SERVICE STATION	134	CANEHAVEN DRIVE	PHOENIX	B2	69000	0	23000
10587	CSE EQUIPMENT	14	OTTO VOLEK ROAD	NEW GERMANY	D2D2G1B2			4000
10594	CTC CRANES	40	GRUNTER GULLEY					9000
10733	CUSTOMIZING CENTRE	13	POWER DRIVE	PROSPECTON	B1	4000	800	
10822	CYCLONE WAREHOUSE	40	KARIM LANE	CONGELLA	J2			2200
10879	D & D SERVICE CENTRE		MAIN ROAD	HAMERSDALE	B2	115000		23000
10924	D AND H TANKERS		WILLOW ST STIKLAND CAPE TOWN			0	27500	27500
10926	D B C PLASTICS	11	COROBRIK PLACE	RIVERHORSE VALLEY	G1D2	1500		2000
10996	D H L GLOBAL FORWARDING	35	METHVEN ROAD	MAYDON WHARF	J3			4000
11044	D M L AGENCIES	165	SARNIA ROAD	CONGELLA	J2			4400

11094	D S D EVEREADY	46	RANA ROAD	ISIPINGO RAIL	D3			4000
11128	D T B CARTAGE	34	HUNTER STREET	CENTRAL	J3	9000	9000	9000
11222	DADDYS TRANSPORT	101	DETROIT ST HAVENSIDE			8324	8324	8324
11281	DALBRIDGE DIESEL DEPOT	115	SYDNEY ROAD	CONGELLA	B2			130000
11357	DAN PERKINS TOYOTA	89	WATERKANT ROAD DURBAN NORTH			3500	0	0
11431	DANO TEXTILE INDUSTRIES	1	ANDERSON ROAD	HAMMARSDALE	J2	1000	1000	30000
11541	DAVE MORTON TRANSPORT	213	VOORTREKKER STREET JACOBS			0	0	35000
11570	DAVENPORT SQUARE MOTORS	89	BRAND ROAD	GLENWOOD	B2	69000	6500	23000
11588	DAVID MORTON TRANSPORT	41	DUDLEY STREET			0	0	27000
11632	DAWNS TRUCKING	49	CASSIA ROAD	LOTUSVILLE	B2			9000
11672	DAYANAND MOTORS	45	WOODHURST DRIVE CHATSWORTH			56000	0	28000
11684	DAYTONA MOTORS	2052	OLD SOUTH COAST ROAD	MOBENI	D2	70000	0	14000
11686	DAYTONA SERVICE STATION	2025 OLD	MAIN ROAD	MOBENI				
11710	DCS MAINTAINANCE & SERVICES CC	38	PREMIER PLACE	PHOENIX	J4		14000	0
12061	DENIM TEXTILES	26	ANDERSON ROAD	HAMMARSDALE	D2J2D1			3600
12082	DENNIS MOTORS	4	JASMIN ROAD	MARIANHILL	D1		200	
12084	DENNY MUSHROOM FARM	OFF	SHONGWENI DAM ROAD	SHONGWENI	B2			25000
12089	DENSO CHANCE SA	120	MALACCA ROAD	REDHILL	D2		3200	
12418	DEVONSHIRE GARAGE	11	DEVONSHIRE PLACE				56000	
12431	DEWHAOM CITY SERVICE STATION	2	MARBLE RAY DRIVE			95000	14000	25000
12674	DISA MOTORS	80 - 90	UMBILO ROAD	CONGELLA	B1	69000	0	28000
12737	DISTILL	5	OTTO VOLEK ROAD	NEW GERMANY	J2			2000
12763	DIVE FACTORY THORFAC	174	GALE STREET	CONGELLA	F1	2000	2000	2000
12975	DON RENNIE MOTORS CC	1455	NORTH COAST ROAD	REDHILL	B2	92000		37000
13062	DORMAC	1	BELFAST ROAD	MAYDON WHARF	B2			23500
14006	DUCO SPECIALITY COATING	9	TRANSPORT DRIVE	PROSPECTON	B2J1		20000	58000
14069	DUMARC CC	2	MAHOGANY FIELD WAY	CITY	B2	14000		
14110	DUNLOP TYRES	265	SYDNEY ROAD	CONGELLA	B3D1		2200	44200
14159	DURANT CIVILS	N3	SOUTH BOUND	MARIANHILL				4000
14250	DURBAN BULK SHIPPIING	156	WHARFSIDE ROAD	ISLAND VIEW	J1	0	0	9000
14269	DURBAN CENTREX	300	MONTY NAICKER ROAD	CENTRAL	G1	0	0	20000
14300	DURBAN CITY POLICE CHATSWORTH	8	BHAKTIVEDANTA SWAMI CIRCLE CHATSWORTH			0	14000	0
14304	DURBAN CLOTHING MANUFACTURERS	29	GRIMSBY ROAD	MOBENI	D2	0	0	23000
14326	DURBAN CORPORATION		OLD FORT RD DURBAN			0	6376	6376
14330	DURBAN CORPORATION FIRE DEPT. PHOENIX		ACHILLES PLACE		B2	0	0	4500
14364	DURBAN FIBRES (PTY) LTD	4026	HIME STREET - JACOBS 149				39000	62000
14411	DURBAN INTERNATIONAL AIRPORT	N2	SOUTH BOUND	REUNION	J4		4500	20350
14448	DURBAN METRO ELECTRICITY	1	JELF TAYLOR CRESCENT	CENTRAL	G1			9000
14444	DURBAN METRO ELECTRICITY	11	ELECTRON ROAD	SPRINGFIELD PARK	B3	28000	830	29000
14459	DURBAN METRO WATER SERVICES	17	ELECTRON ROAD SPRINGFIELD			14000	210	53000
14486	DURBAN NORTH FIRE STATION	50	UMHLANGA ROCKS DRIVE	DURBAN NORTH	B2	0	0	4500
14511	DURBAN PANEL BEATERS	499	SYDNEY ROAD	CONGELLA	G1	2000	500	
14552	DURBAN SOLID WASTE	5	KONINGKRAMER ROAD	NEW GERMANY	B2			4000
14550	DURBAN SOLID WASTE	2	GILBERT ROAD	QUEENSBURGH	G1		6270	
14599	DURBAN TRANSPORT		SWINTON & PENDLEBURY ROADS MOBENI					106000
14604	DURBAN TRUCK AND CAR SERVICE STA	575	UMGENI RD			54000	0	4700
14603	DURBAN TRUCK AND CAR SERVICE STA	575	UMGENI ROAD		B1			
14607	DURBAN UNICITY ELECTRICITY NORTHE	133	MALACCA ROAD	REDHILL	G1			9200
14777	E B STEAM MAYDON	73	MAYDON ROAD	MAYDON WHARF	B2			80000
14856	E W C EXPRESS	215	INANDA ROAD	SPRINGFIELD	B2			23000
14855	E W C EXPRESS	13	KLINKER PLACE	BRIARDENE	B2			2000
14859	E W M S	1	MAIN ROAD	HAMMERSDALE	B2			5000
14873	E.P. SMITH	115	SYDNEY RD			0	14000	42000
14898	EAGLE MOTOR SPARES	5	HEADLAND AVENUE	SILVERGLEN	B2	2200	0	0
14987	EASIGAS	1	REFINERY ROAD	JACOBS	J1B1			4400
14993	EAST COAST AIRWAYS		FAIRWAY	DURBAN NORTH	B2	80000	NIL	NIL
15008	EAST COAST CORRUGATED	33	VULCAN PLACE	PHOENIX	J2		4400	
15074	EASTBURY SERVICE STATION	2	EASTBURY DRIVE	PHOENIX	B2			
15307	EDEN SAND SUPPLIERS	635	SUNSET AVENUE	WOODHURST	B2	0	0	23000
15370	EDEVA TRANSPORT	145	ABERDARE DRIVE	PHOENIX	D3		23000	
15466	EDWIN SWALES SERVICE CENTRE	266	EDWIN SWALES DRIVE	JACOBS	B2	92000	0	92000
15641	ELCON CRANKS AND CONSTRUCTION	68	GRUNTER GULLY			0	0	9000
15694	ELECTRICAL WORKSHOPS	1	DICKENS ROAD	UMBOGINTWINI	B3			2000
15778	ELITE CHEMICALS	129	LAKEVIEW DRIVE	CHATSWORTH , SILV	D1		35000	
15987	EMMISION LAB TOYOTA	25 - 27	JOYNER ROAD	PROSPECTON	D1	7270		
16059	ENDURO AUTO	250	UMBILO ROAD CONGELLA DURBAN			27500	0	9000
16074	ENGEN	350 - 360	LILLIAN NGOYI ROAD	MORNINGSIDE	B2			
16075	ENGEN							
16076	ENGEN	202	MAHATMA GANDHI ROAD	CITY	B2			
16080	ENGEN		VILLAGE ROAD	KLOOF	B2			
16081	ENGEN	2	STREET 121585	RIVERHORSE VALLEY	B2			
16082	ENGEN	1	TARA ROAD	MEREWENT	B2			
16083	ENGEN			ROSSBURGH				
16084	ENGEN - MT EDGECOMBE	12	FLANDERS DRIVE	MT EDGECOMBE	B2			
16085	ENGEN @ AUSTERVILLE	178	AUSTERVILLE DRIVE	AUSTERVILLE	B2	72000		14000
16086	ENGEN @ ESSACKS	171	SPARKS ROAD	OVERPORT				
16094	ENGEN ESPLANADE SERVICE STATION	127	MARGARET MNCADI AVENUE	DURBAN CENTRAL	B2F2J4	46500		9000
16095	ENGEN GARAGE	584	JAN SMUTS HIGHWAY	MAYVILLE	B2			
16096	ENGEN GARAGE	5	UNIVERSAL PLACE	CHATSWORTH				
16097	ENGEN GARAGE -MARATHON MOTORS	425	BEREA ROAD	BEREA	B1	69000	0	9000
16098	ENGEN GO GO QUICKSHOP	551	MOUTBATTEN DRIVE	RESERVOIR HILLS	B2			
16100	ENGEN ISLAND CONVENIENCE CENTRE	89	FLANDERS DRIVE	MOUNT EDGECOMBE				
16104	ENGEN MARKETING		TARA RDWENTWORTH				6500	6500
16105	ENGEN ON CHATS	32	JOYHURST STREET	CHATSWORTH	B2	69000	0	14000
16106	ENGEN ON SPARKS	171	SPARKS ROAD	OVERPORT	B2			
16111	ENGEN PETROLEUM	1271	SOUTH COAST ROAD MOBENI			170000	0	9000
16109	ENGEN PETROLEUM		TARA ROAD	WENTWORTH	J1			
16107	ENGEN PETROLEUM	136	VICTORIA EMBANKMENT	CENTRAL	J1			
16108	ENGEN PETROLEUM	314	EDWIN SWALES DRIVE	JACOBS	B2			
16115	ENGEN PETROLEUM	1	CHESTNUT CRESCENT	MARIANNHILL	B2			
16117	ENGEN PETROLEUM	605	SOUTH COAST ROAD	CLAIRWOOD	D2			
16120	ENGEN QUEENSBURGH	171	OLD MAIN ROAD	BOTHAS HILL	B2			
16121	ENGEN QUICK SHOP	66	RUSSELL STREET	CENTRAL	F2			
16132	ENGEN SERVICE STATION	171	MAIN ROAD	QUEENSBURGH	B2			23000
16131	ENGEN SERVICE STATION	48 - 50	MARSHALL DRIVE	MT EDGECOMBE	B2			92000
16125	ENGEN SERVICE STATION	253	MARINE DRIVE	BLUFF	B2			
16126	ENGEN SERVICE STATION	701	EDWIN SWALES DRIVE	JACOBS	B2			
16127	ENGEN SERVICE STATION	17	BARTON PLACE	RESERVOIR HILLS	B2			

16128	ENGEN SERVICE STATION	50	OLD MAIN ROAD	HILLCREST	B2			
16129	ENGEN SERVICE STATION		BAY TERRACE	CITY	B2			
16130	ENGEN SERVICE STATION	176	UNDERWOOD SARINA		D2			
16133	ENGEN SERVICE STATION		HIGGINSON HIGHWAY	MOBENI	D1			
16134	ENGEN SERVICE STATION	851	OLD MAIN ROAD	MARIANHILL				
16140	ENGEN WILLIAMS ROAD DEPOT	79	WILLIAMS ROAD	DURBAN CENTRAL	J1			
16147	ENGINE PLANT 1	15	PROSPECTON ROAD	PROSPECTON	D3	10260		
16149	ENGINE SERVICE STATION		MOUNTBATTON DRIVE	RESERVOIR HILLS	B1			
16155	ENGINEERING CENTRE	15-Nov	PROSPECTON ROAD	PROSPECTON	G1B2	138000		61890
16203	ENSIMBINI TERMINALS	187	MAYDON ROAD					4400
16202	ENSIMBINI TERMINALS	4	PARKER ROAD	MAYDON WHARF	J2	9000	0	37000
16205	ENTABENI HOSPITAL	148	SOUTH RIDGE ROAD	GLENWOOD	E2			4400
16207	ENTEBBE INVESTMENTS	21	CORONATION ROAD	TONGAAT	B2	37000		9000
16232	ENVIRO SOLVENT RECLAMATION CC	4	HAWTHORN ROAD	PINETOWN	B2	10000	40000	10000
16239	ENVIROSERV LANDFILL DIVISION	1	SHONGWENI ROAD	SHONGWENI	J1			14000
16240	ENVIROSERVE	10	KYALAMI ROAD	WESTMEAD	D2			14000
16355	ESCOMBE SERVICE STATION	439	MAIN ROAD	ESCOMBE	B2			
16394	ESOR	130	ABERDARE DRIVE	PHOENIX	D2	0	0	2270
16395	ESOR GROUND ENGINEERING	63	ABERDARE DRIVE			0	0	9000
16460	ESSENWOOD SERVICE STATION	4001	ST THOMAS ROD 223 DURBAN			40000	NIL	NIL
16459	ESSENWOOD SERVICE STATION	223	ST THOMAS ROAD	MUSGRAVE	B2			
16524	ETHEKWINI ELECTRICITY	70	ASTRAL DRIVE	CHATSWORTH	B2	4500	0	9500
16526	ETHEKWINI ELECTRICITY DEPARTMENT	50	GILLITTS ROAD	PINETOWN	D2	900	9000	
16536	ETHEKWINI HOSPITAL	11	RIVERHORSE ROAD	RIVERHORSE VALLEY	E2J4E2			9000
16553	ETHEKWINI MUNICIPALITY	44	ISIAH NTSHANGASE	CENTRAL	B2			14000
16549	ETHEKWINI MUNICIPALITY	14	KNELSBY AVENUE	HILLCREST	D2			4500
16561	ETHEKWINI PETROLEUM	182	WICK STREET	VERULAM	B2		9000	42000
16608	EURO BLITZ	314	SOUTH COAST ROAD	ROSSBURGH	J2			102000
16651	EUROPCAR		M4	LA MERCY	B2	55000		23000
16812	EXCEL	2	INTERSITE AVE	DURBAN NORTH				
16814	EXCEL AUTO CENTRE	86	ANTON LEMBEDE STREET	CENTRAL	B2	0	41500	0
16816	EXCEL CONVENTION CENTRE	2	MARBLERAY DRIVE	NEWLANDS	A1			
16817	EXCEL ILLOVO & WAVECREST AUTO		ELIZABETH AVENUE	ILLOVO	B2			
16818	EXCEL MT EDGECOMBE	34	SIPHOSETHU ROAD	MT EDCECOMBE	B2	69000	63000	23000
16820	EXCEL SERVICE STATION		PHOENIX HIGHWAY	MT EDGECOMBE	B2			
16826	EXCELL	5	CORDOVA CLOSE	DURBAN NORTH	B3			
16832	EXCELL SERVICE STATION	97	GOODWOOD ROAD	WESTMEAD				
16910	EXEL AT AIRPORT		AIRPORT ROAD	REUNION	B2	59000		23000
16912	EXEL SERVICE STATION	151	DURBAN AIRPORT ROAD		J1G1			
16914	EXEL SERVICE STATION	1	ELIZABETH AVENUE	10	D2			
17014	EXPRESS SERVICE STATION	37	ORDNANCE ROAD	CENTRAL	B3			
17036	EXQUISITE TRADING	204	SYDNEY ROAD	CONGELLA	J3	0	0	14000
17061	EXTRUDED COPPER	439	SYDNEY ROAD			0	0	14000
17080	EYETHU CONVENIENCE CENTRE	1606	SOUTH COAST ROAD	MOBENI	F2	46000	0	31000
17117	EZRAY CONVENIENCE CENTRE	584	TARA ROAD	BLUFF	B1	56000	0	14000
17140	F B N TRANSPORT	463	SYDNEY ROAD	CONGELLA	J2G1			28000
17149	F F S REFINERS	104	UMHLATUZANA ROAD	SEA VIEW	D2B2	0	0	42000
17155	F G H CHEMICALS	166	BLUFF ROAD	JACOBS	B2		2200	
17381	FAIRWAY CONVENIENCE CENTRE	84	OLD MILL WAY	DURBAN NORTH	B2		0	14000
17403	FAIRYVILLE CONVENIENCE STORE	2	MT MORIAH DRIVE	PHOENIX	B2	69000	0	23000
17524	FANTON (PTY) LTD	201	ABERDARE DRIVE PHOENIX INDUSTRIAL PARK			0	0	14000
17551	FARM FAIR	11	LEICESTER ROAD			0	0	9000
17626	FASHION FINISHERS	03:00 AM	EATON ROAD	CONGELLA	B2	0	4506	0
17746	FAVOURS CASH & CARRY	7	PARAGON PLACE	PHOENIX	F3		60000	2200
17788	FEDERAL MOGUL	15	ALEXANDER ROAD	WESTMEAD	D2	7.5	25	2120
17799	FEDERATED TIMBERS PTY LTD	10	QUALITY STREET MOBENI			14000	14000	14000
17840	FELTEX LIMITED	291	PAISLEY ROAD	JACOBS	D2		1200	1200
17925	FFS REFINERS	130 - 132	TEAKWOOD ROAD	JACOBS	D1	420	23000	
17964	FIELD STREET SERVICE STATION	146	FIELD STREET	CENTRAL	B2	92000	112000	23000
17965	FIELD'S HILL GARAGE	12	OLD MAIN ROAD	KLOOF	B2	93000		14000
18009	FIMAX FOODS	167 - 185	VOORTREKKER STREET JAC	JACOBS	F2			2200
18063	FINE SCRAP [PTY] LTD	14-33	INDUSTRIP ST JACOBS			0	0	9000
18075	FINLAM TEXTILES	19 - 23	MANCHESTER ROAD	NEW GERMANY	D2J2D2D2J1J2	1500	9000	
18154	FIRST CARGO	7	EYRIE PLACE	NEW GERMANY	J2B2			14000
18343	FIVE STAR SERVICE STATION	90	FRAGRANCE STREET	CHATSWORTH	B2	22680		23000
18394	FLAMITE		OLD MAIN ROAD	CATO RIDGE	J2			14000
18455	FLEETRENT	449	SYDNEY ROAD			0	0	14000
18478	FLEXOTHENE PLASTICS	44 - 46	ABERDARE DRIVE	PHOENIX IND PARK	J1D1D2	29500	1000	
18544	FLORIDA ROAD MOTORS	180	FLORIDA ROAD	MORNINGSIDE			23000	13500
18629	FLOWCRETE PROPERTIES	17	MARTIN DRIVE	QUEENSBURGH	D3G1			4400
18716	FOKUS BANDE INDUSTRIES	4060	LEICESTER ROAD 216 MOBENI			0	0	3200
18827	FOREST DRIVE MOTORS	40	FOREST DRIVE	UMHLANGA	B2		92000	
18850	FOREST PRODUCT TERMINAL	34	CRABTREE ROAD	MAYDON WHARF	J2			28000
18884	FORM SCAFF	149	SHEPSTONE ROAD	NEW GERMANYPINE	B2G1D3J3	210	2500	9000
18885	FORM SCAFF	70	GILLITTS ROAD	WESTMEAD	B2			2200
18927	FORUMLA ONE TRUCKING	12	TEAKWOOD ROAD	JACOBS	J2			9000
18930	FOSA	60	FOSA ROAD NEWLANDS			0	0	4500
19010	FOUNTAIN CIVILS & ENGINEERING	64	TORVALE CRESCENT	PHOENIOX				14000
19029	FOUR SEASONS HOTEL	81 - 83	GILLESPIE STREET	POINT	H3	0	0	4500
19042	FOURTY FIFTH SERVICE STATION	928 - 930	JAN SMUTHS HIGHWAY	OVERPORT	B2	120000		60000
19067	FRAME TEXTILE CORPORATION	9	WARRINGTON ROAD	MOBENI	D1D1G1	2285	12680	68520
19108	FRANKE KITCHEN SYSTEMS	1194	SOUTH COAST ROAD	MOBENI	B2		10000	
19109	FRANKE MANUFACTURING	1194	SOUTH COAST ROAD	MOBENI	D3	4000	400	600
19155	FRED LANG SERVICE STATION	17A	NORTHWAY DURBAN NORTH			58500	0	0
19189	FREE START METALS (PTY) LTD	8	VAN DER BIJL ROAD	NEW GERMANY	D2			60000
19231	FREIGHT MAX	1	BELFAST ROAD	CONGELLA	J1		49442	11827
19234	FREIGHT PAK	12-Oct	MAHOGANY ROAD	WESTMEAD	J1G1			23000
19242	FREIGHTLINER TRANSPORT	154	DAYAL ROAD	CLAIRWOOD	B3			28000
19248	FREIGHTMAX TRANSPORT	11	MILNER STREET DURBAN			0	0	69000
19259	FREIGHTPAK PTY LTD	116	TEAKWOOD RD JACOBS			0	8000	8000
19260	FREIGHTPAK PTY LTD	116	TEAKWOOD ROAD					23000
19311	FRESH START BAKERY	40	PIET RETIEF ROAD	QUEENSBURGH	B2		2200	2200
19365	FRIENDLY SERVICE STATION	03-Jan	DELHOO LANE	ISIPINGO	J3	115000		14000
19429	FRY FOODS GROUPS	36	WESTMEAD ROAD	PINETOWN	D1		2000	
19438	FTR HANDLING [PTY] LTD	294	CHAMBERLAIN ROAD			0	0	2200
19442	FUEL & ALL SERVICE STATION		CRAIGEBURN DRIVE	CRAIGEBURN DRIVE	B2			
19454	FUELNET AUTO	299	EDWIN SWALES DRIVE ROSSBURGH			92000	0	23000
19524	FUNEKA SUPERETTE		B1401[2] UMLAZI			2700	2700	2700

19771	G MOTORS	20	CASPIAN STREET	WESTCLIFF	B2	140000	0	9000
19773	G N C DEMOLITION	190	TEAKWOOD ROAD	JACOBS	B3D2		0	2200
19960	GALE MOTORS	186	GALE STREET	UMBILO	B2	125400	0	37000
19961	GALE SERVICE CENTRE PTY	186	GALE ST			56000	0	9500
20071	GAN TRANS	21	INDUSTRIAL STREET	JACOBS	B3			23000
20075	GANDHI SERVICE STATION		MAIN ROAD	TONGAAT	B2			
20076	GANDHI'S SERVICE STATION	455	MAIN ROAD	GANDHI'S HILL	B2	24000		12000
20098	GAP CHEMICALS	10-Aug	KRUGER PLACE	PHOENIX	B1			14400
20208	GARTH FLEUR		OLD MILL SITE	CANELANDS				14000
20241	GAS N GO (PTY) LTD	1455	NORTH COAST ROAD			115000		16000
20300	GATEWAY SERVICE STATION	605	SOUTH COAST ROAD	CLAIRWOOD	B2		0	0
20409	GEDORE TOOLS	103	SHEPSTONE ROAD	NEW GERMANY	D2G1	200	500	5000
20561	GEOCHEM	135	SHEPSTONE ROAD	NEW GERMANY	B2	3630	28800	46225
20760	GILLITTS SERVICE STATON	15	OLD MAIN ROAD	GILLITTS	B2J1	92000		14000
20791	GINO'S CORNER		RICHFOND CIRCLE	UMHLANGA	B2			11000
20826	GL SPECIALISED	8	HAWTHORN PLACE	WESTMEAD	D1	5000	25000	25000
20877	GLAZER MOTORS	220	SOUTH COAST ROAD	ROSSBURGH	B2	70000	0	41000
20891	GLEBE TAXI SERVICE CENTRE	197	OLD MAIN ROAD	UMLAZI	B2	69000		14000
20962	GLENASHLEY SERVICE STATION	36	NEWPORT AVENUE	GLENASHLEY	B2	69000	0	23000
21027	GLENVIEW SERVICE STATION	43	ASHLEY AVENUE	GLENASHLEY	B2	153000	83000	40000
21038	GLENWOOD FORD	360	GALE ST			54800	0	9000
21142	GLV FREIGHT SERVICES	21 - 23	DUDLEY STREET	JACOBS	B3		0	9000
21164	GO GO'S SERVICE STATION	551	MOUNT BATTON DRIVE	RESERVOIR HILLS	B1			
21169	GO WELL SERVICE STATION	27	STANLEY COPLEY DRIVE ASH	ERVILLE		69000	0	26000
21291	GOLDEN GATEWAY SCHOOL	893	BELLAIR ROAD	CATO MANOR				2000
21339	GOLDEN RIBBON		HAZELMERE ROAD	CANELANDS	B2			8000
21356	GOLDFIELD LOGISTICS	15	KONINGKRAMER ROAD	NEW GERMANY	B2			28000
21438	GOODWOOD PITSTOP CC	95	GOODWOOD ROAD	WESTMEAD	B2B1F2D3B2B	150000	25000	50000
21458	GOOLAMS SERVICE STATION	10	PARTHENON STREET	PHOENIX	B2	50000	0	0
21476	GORA'S SERVICE STATION	179	FERNHAM DRIVE	REDFERN	B2	68880	0	22960
21546	GOSS & BALF	1	DICKENS ROAD	UMBOGINTWINI	B2			4400
21729	GRAFTON EVEREST	2	NYALA ROAD	CANELANDS	D2	3000	3805	1510
21773	GRAND MOTOR SERVICE STATION	19	OLD MAIN ROAD	ISIPINGO	B2			
21825	GRANT SECURITY & HONEY COMBS	76	REFINERY ROAD	PROSPECTON	B3			2200
21837	GRANTS MOTORS	3	OPPENHEIMER ROAD	UMBOGINTWINI	B2	65000		23000
21907	GREENBURY FILLING STATION		GREENBURY DRIVE	PHOENIX				
21917	GREENBURY SERVICE STATION	175 - 177	REDBERRY ROAD	PHOENIX	B2	98000	0	28000
21927	GREENFERN SERVICE STATION	469	MAIN ROAD	GANDHI'S HILL	B2			
21946	GREENGEL	37	CIRCUIT ROAD	PINETOWN	B2	16000	10000	2000
21949	GREENHEAT SA	7	FLAMBOYANT CLOSE	UMHLANGA ROCKS	B2	50000	50000	
22026	GREYSTONE CARGO SYSTEM	32	WATFORD ROAD	UMBILO	J3			4400
22065	GRINAKER	4	LINCOLW TERRACE	WESTVILLE	B2			4400
22068	GRINAKER CONSTRUCTION	59	HENWOOD ROAD	NEW GERMANY	D3G1			6600
22071	GRINAKER LTA EARTHWORKS (SA)	1	BELL STREET	POINT	B2			23000
22072	GRINAKER PRECAST	787	EFFINGHAM ROAD			0	0	16000
22083	GRINDROD INTERMODAL	201	EDWIN SWALES	CONGELLA	B2		14400	
22097	GRINROD INTERMODEL	201	EDWIN SWALES DRIVE	JACOBS	B2			23000
22099	GRINROD J & J LOGISTICS	10	BREMEN ROAD	CONGELLA	J2			2200
22138	GROUP 5		OLD MAIN ROAD	KWAMAKHUTHA	B2			8800
22136	GROUP 5	20	DICKENS ROAD	TOTI	G1			23000
22142	GROUP 5 PLANT & EQUIPMENT	50	LARK ROAD	AVOCA	B2			23000
22149	GROUP FIVE	60	WILLS STREET	WARWICK TRIANGLE	B2		80	4000
22152	GROUP FIVE KZN	1	JACK MARTENS DRIVE	PAVILLION	B2			23000
22191	GT FAST FOODS		OPPENHEIMER & ARBOUR	ARBOUR CROSSING	F2			9000
22202	GUD FILTERS	1	PROSPECTON ROAD	PROSPECTON	D3		2200	
22314	H & M ROLLERS	15 - 19	VALLEY VIEW ROAD	PINETOWN	D1G1			2000
22597	HALFWAY MALANDA TOYOTA	1	ROZEL ROAD	WIDENHAM	B2	56000		18000
22689	HAMMERTONE FUELS	102	MARSEILLES CRESCENT	BRIADENE	B1	1000	1000	52000
22726	HANNAFORD SERVICE STATION	3	HANNAFORD DRIVE	SUNFORD	B1			
22747	HANSCO MOTORS	29	IRELAND STREET	VERULAM	B2	125000		37000
22792	HARBOUR LIGHT	107	CHELMSFORD ROAD			0	0	2200
22801	HARBOUR VIEW SERVICE STATION	47	VICTORIA EMBANKMENT	DURBAN CENTRAL	B2	42000	0	9000
22912	HARRISON FOOD & HARDWARE	130	OLD MAIN ROAD	CATO RIDGE	F3	0	2100	0
22996	HASSIM SERVICE STATION	171	SPARKS ROAD	OVERPORT	B1			
23048	HAVEN PROPERTY TRUST	126-332	CHAMBERLAIN ROAD JACOBS				6000	
23060	HAVENSIDE SERVICE STATION	10	KINGSBURY WALK	HAVENSIDECHATSW(	B2	69000	0	23000
23088	HAY HOE SERVICE STATION & MOTORS	6	UNDERWOOD ROAD	PINETOWN	B1			
23110	HAZELMARE W T N							4000
23114	HAZELMERE GARAGE		NDWEDWE ROAD	COTTONLANDS	B2	14000	2000	40000
23210	HEARTLAND LEASING	1	DICKENS ROAD	UMBONGITWINI	B2			11000
23214	HEARTLANDS FOODS	31	HUNSLETT ROAD	PHOENIX	D1F2		11500	11500
23346	HENDOCK	190 - 200	ABERDARE DRIVE	PHOENIX	D2			14000
23414	HERITAGE MOTORS	5	OLD MAIN ROAD	HILLCREST	B2	69000		23000
23460	HERTLBERGER FARM	39	ST HELIER ROAD	GILLITTS	B2			2200
23478	HEYDEN SERVICE STATION	3	THOMAS LANE	ISIPINGO RAIL	B1	92000		14000
23493	HI KALCHEM	30 - 32	PREMIER PLACE	PHOENIX	B1	80000	42000	0
23529	HI TECH INKS	18	MANCHESTER STREET	JACOBS	D1	0	4200	0
23531	HI TECH PIPING	8	SAGE ROAD	WENTWORTH	D2			9000
23571	HIGGINSON CONVENIENCE CENTRE	20	HIGGINSON HIGHWAY	MOBENI	B2		69000	23000
23705	HIGHWAY SERVICE STATION	25	OLD MAIN ROAD	PINETOWN	B2			28000
23706	HIGHWAY SERVICE STATION	5	WATSON HIGHWAY	TONGAAT	B2			
23721	HIKEM	55	RECREATION ROAD ROSSBURGH			10000	10000	0
23737	HILL SERVICE STATION	102 - 106	HILL STREET	OVERPORT	B2	37000	NIL	NIL
23826	HILLCREST SERVICE STATION	9	OLD MAIN ROAD	HILLCREST	B1	93000		14000
23842	HILLCREST VILLAGE MOTORS	65	OLD MAIN ROAD	HILLCREST	B2	120000		14000
23859	HILLHEAD ESTATE		OFF SIBAYA DRIVE	UMDLOTI	D3			9000
24078	HOLCIM	1	MAHATMA GANDHI ROAD	CENTRAL	B2			4400
24077	HOLCIM	15	JEFFELS ROAD	JEACA	B2			23000
24081	HOLCIM S A	2	MAHATMA GANDHI ROAD	OTTAWA	D3			4400
24096	HOLIDAY SERVICE STATION	53	SMITH ST			22500	0	4500
24151	HOME ARMATURE	79	WOODFORD GROVE	STAMFORD HILL	B1		2000	
24213	HOMECARE HARDWARE CC		INANDA ROAD - WATERFALL SHOPPING CENTRE			0	2200	0
24245	HONDA MARINE	34	UNDERWOOD ROAD	PINETOWN	B2	42000		10000
24324	HOPEWELL FOOTWEAR	68	PAISLEY ROAD	JACOBS	G1D2D2	0	2000	0
24351	HOSAF FIBRES	149	HIME STREET	JACOBS	D1		70000	4000
24505	HOUSE OF PAINT	139	OLD MAIN ROAD	PINETOWN	B2	4200	2000	1000
24509	HOUSE OF PAINTS	870 - 880	UMGENI ROAD	CENTRAL	B2	4200	2000	1000
24548	HOUSING PROJECTS	17	DOVESIDE PLACE	PHOENIX	J2	28000	0	28000

24608	HULETTS REFINERIES	444	SOUTH COAST ROAD	ROSSBURGH	D2	0	9000	0
24619	HULTRANS [PTY] LTD	28	JACO PLACE			9000	0	23000
24689	HUNTSMAN TIOXIDE S A		LOWDSTAR AVENUE	UMBOGINTWINI	D2D1	525	2200	6600
24763	HYPACK	320	SOUTH COAST ROAD	ROSSBURGH	D2D1	3200	100	
24816	I & J FROZEN FOODS	1150	NORTH COAST ROAD REDHILL	DURBAN		0	0	21000
24838	I C C	45	BRAM FISHER ROAD	CENTRAL	G1			4000
24842	I C M		SOUTH COAST ROAD	MOBENI	B2			4000
24956	IAFARGE RIDGEVIEW QUARRY	N/N	RIDGEVIEW ROAD	PINETOWN				37000
24964	IAN FULLER AGENCIES	10	NOTTINGHAM PLACE	MOBENI	D2			23000
25087	IDWALA SALES	3	ELMFIELD PLACE	SPRINGFIELD	D3		4000	
25138	IKHWEZI SERVICE STATION	1A 34	KWADEBEKA ROAD	CLERNAVILLE	B1J1	69000		14000
25210	ILLOVO SUGAR		LOWER ILLOVO	ILLOVO	D2J3			14000
25240	IMAGE CONSOLIDATED FREIGHT	38	SUCROSE CRESCENT	MT EDGECOMBE	B2			23000
25293	IMPALA SERVICE STATION	21 - 23	IRELAND STREET	VERULAM	B2	80000		14000
25304	IMPERIAL CAR RENTAL	19	PASCOE ROAD	PROSPECTON	G1	23000		46000
25305	IMPERIAL CARGO	11	MILNER STREET	JACOBS	B3			70000
25315	IMPERIAL FURNITURE	257	BALFOUR ROAD	JACOBS	D2			8000
25329	IMPERIAL SUPPORT SERVICES.	48	GOODWOOD ROAD	WESTMEAD	B2			23000
25338	IMPERIAL TRUCK SYSTEMS	67	BARRIER LANE	MOBENI	B2			15000
25341	IMPERIAL WAREHOUSING LOGISTICS	67	BARRIER LANE	MOBENI	J2			25000
25455	INANDA QUARRY		INANDA ROAD	INANDA	B3	0	0	9000
25460	INANDA ROAD SERVICE STATION	2	DOYERS ROAD	WATERFALL	B2	37000		
25463	INANDA SERVICE STATION		OPPOSITE INANDA SAPS	INANDA	B1	51000	23000	14000
25524	INDEPENDENT FARMING	24	CARLISLE ST DURBAN			16000	16000	16000
25528	INDEPENDENT FARMING SERVICES	213	DAYAL ROAD CLAIRWOOD				4500	4500
25631	INDUSTRIAL OLEOCHEMICAL PRODUCTS	323	CHAMBERLAIN ROAD	JACOBS	D1		113500	8000
25638	INDUSTRIAL SCRAP METALS	04-Feb	SWANFIELD ROAD	WESTMEAD	D2			4000
25656	INEOS SILICAS	188	LANSDOWNE ROAD	JACOBS	D2	400	400	15800
25684	INFRA PROJECTS CC		SOUTHAMPTON STREET	POINT	B2			2200
25693	INFRASET	747	EFFINGHAM ROAD	RIVERHORSE VALLEY	B3	0	2200	8800
25764	INKOSI PLASTICS	12	THORN ROAD	JACOBS	D2		0	9000
25773	INKWAZI STEVEDORING	4	PARKER ROAD MAYDON WHARF	DURBAN		9000	0	9000
25787	INNES JUNCTION	116	INNES ROAD	MORNINGSIDE	B2	5600	0	4500
25849	INSULATION CONTRACTORS	1	WILLIAMS RD			0	0	9000
25881	INTER TEK TESTING SERVICES	311	EDWIN SWALES	CONGELLA	B2G1			2500
25892	INTERCHANGE 117 UMKOMAAS / 124 ULTRA CITY		N2	UMKOMAAS	B3			
25893	INTERCHANGE 124 ULTRA CITY / 128 UMGABABA		N2	AMANZIMTOTI	B3			
25999	INTERNATIONAL SLAB SALES	133	ROCHDALE RAOD	SEACOW LAKE				14000
26029	INTERSHIPPING OPERATIONS [PTY] LTD	13-Jul	JOHNSTONE ROAD MAYDON	WHARF		0	0	9000
26040	INTERSTATE TRUCKERS	30	ABERDARE DRIVE	PHOENIX	B2			23000
26094	INYANINGA ESTATE		OLD MAIN ROAD	TONGAAT				9000
26226	ISIPINGO BEACH SERVICE STATION	23	THE AVENUE EAST		B2		60000	32000
26259	ISIPINGO GENERAL DEALER	154	OLD MAIN ROAD	ISIPINGO BEACH	F2			22000
26322	ISITHEBE TRANSPORT	95	JAN SMUTS HIGHWAY			0	0	9000
26365	ISLAND PARK SERVICE STATION	89	FLANDER'S DRIVE	MOUNT EDGECOMBE	B2			
26378	ISLAND VIEW SERVICE STATION	7	ISLAND VIEW ROAD	BLUFF	B2	46000	0	0
26417	ISOLITE	75	TEAKWOOD ROAD	JACOBS	B2		14000	3000
26419	ISOLITE POLYSTYRENE MFG	1	MITRE ROAD	PINETOWN	D1		4500	22000
26514	IVORY INDUSTRIALS (PTY) LTD	54	SAGE ROAD JACOBS	JACOBS	B2D1		10500	2800
26562	J & L SERVICE STATION	318	TARA ROAD	BLUFF	B2	70000	0	90000
26565	J & R SERVICE STATION	318	TARA ROAD	BLUFF	B2			
26642	J H STANDER & SONS	68	BEACHGATE CRESCENT	SOUTHGATE	B2			23000
26777	J T ROSS PROPERTIES	25 - 27	JACO PLACE	JACOBS	D1	88000	65000	27500
26801	J.C. CALITZ FUEL DISTRIBUTORS	3	SIXTH STREET EMPANGENI			0	8600	8600
26836	JABU & QUEEN SERVICE STATION	892	F	NTUZUMA	B2			
26859	JABULA SUPERMARKET	2	CARLOW ROAD	CATO MANOR	F2		2300	
26967	JACOBS FILLING STATION	1230	CHAMBERLAIN ROAD	JACOBS	B2			
26971	JACOBS GARAGE	230	CHAMBERLAIN ROAD	JACOBS	B2	46000	0	27000
27111	JAMADARS SERVICE STATION	72	OLD MAIN ROAD	ISIPINGO RAIL	B2	41000	0	14000
27108	JAMADAR'S WHOLESALE	17	OLD MAIN ROAD	ISIPINGO	F2		37000	9000
27123	JAMAICA SERVICE STATION	300	KLAARWATER ROAD	KLAARWATER	B1	92000	23000	23000
27239	JAVELIN TRUCKING	12	HIME LANE			0	0	32500
27243	JAVSEAL	43	ALLY RROAD	ISIPINGO				100000
27297	JAYSONS MOTORS	230	TEAKWOOD ROAD JACOBS			56000	0	32500
27370	JEENAS WHOLESALE CASH AND CARRY	239	SIRDAR ROAD	CLAIRWOOD	F1	0	0	14000
27786	JOHN BULL MOTORS	1400	SARNIA ROAD			51000	0	4500
27894	JOHNSON CRANE HIRE	14	GRUNTER GULLY	BAYHEAD	B2			9000
27978	JOOSABE WHOLESALERS	90	BILBERRY AVE	CROSSMOORCHATSW	B2			
28018	JOTUN PAINTS	41	LIVINGSTONE ROAD	PINETOWN	D1J1B2	6000	130000	4000
28314	JUST REFREGERATION	22	TRAFFORD ROAD	WESTMEAD	D1			23000
28345	JVR SERVICES	197	MAIN ROAD	UMZINTO	B1		13500	14000
28387	K & N FREIGHTLINERS	8	CORDOVA CLOSE	BRIADENE	J2			23000
28574	K S N LOGISTICS	40	TRURO ROAD	CONGELLA	J2			23000
28619	K.C. MOTORS	240	ROLAND CHAPMAN DRIVE			25000	0	10000
28765	KAMPARA SERVICE STATION	5	O'FLAHERTY ROAD	CLARE ESTATE	B3			
28831	KARGO NATIONAL	19	SUZUKA ROAD	PINETOWN	B2			46000
28885	KARTALA TRADING	264	INANDA ROAD	SPRINGFIELD PARK	B2		5000	
28925	KATHRADAS SERVICE STATION	2A	IRELAND STREET	VERULAM	B2			
28998	KAYS BREAKDOWN SERVICE	71	ABERDARE DRIVE			0	0	9000
29030	KDM SERVICE STATION		UN NAMED ROAD	SHALLCROSS	B1			
29122	KEMPSTER AUTO	284	EDWIN SWALES V.C. DRIVE	ROSSBURGH		74500	0	14000
29129	KEMPSTON HIRE	1	MILNER STREET	DURBAN	B3		0	9000
29128	KEMPSTON HIRE	31	MELBOURNE RD			0	0	2000
29131	KEMPSTON TRUCK HIRE	26	RICHMOND ROAD	PINETOWN	B3			14000
29132	KEMSTON TRUCK HIRE	9	KONIGKRAMER ROAD	NEW GERMANY		6000		9000
29152	KENFIELD MOTORS & TYRE	236 - 240	BRICKFIELD ROAD	OVERPORT	D2	60000		28000
29188	KENPRING	70	SAGE ROAD			0	0	23000
29209	KENSTEL AUTO SERVICES	187 - 193	ALPINE ROAD	SPRINGFIELD	B2	70000	14000	
29210	KENSTEL SERVICE STATION	187	ALPINE ROAD	OVERPORT	B2			
29349	KESTIGO	88	ABERDARE DRIVE	PHOENIX	B2			23000
29393	KEY TRUCK & CAR	101	OLD MAIN ROAD	PINETOWN	B2	9000		4500
29394	KEY TRUCK & HIRE	28	ALEXANDER ROAD	PINETOWN	B2		200	4500
29488	KHANGELA BREWERIES	21	GLASTONBURY ROAD	CONGELLA	B3			20000
29527	KHATANI INDUSTRIES	57	NORTH COAST RD			0	0	14000
29549	KHAZIMULA SERVICE STATION	129	INANDA	INANDA - NEWTOWN	B2	69000		14000
29770	KING SHAKA AIRPORT		M4	LA MERCY	D4		100000	25200
29775	KING ZWELITHINI STADIUM	371	MANGOSUTHU HIGHWAY	UMLAZI	A5A1			9000
29871	KINGS REST CONTAINER PARK	201	BREEDE ROAD	BAYHEAD	B3			4000

29986	KINGSWAY SERVICE STATION	404	KINGSWAY	AMANZIMTOTI	B2	92000		23000
30051	KIRAN SALES	225	CHAMBERLAIN ROAD	JACOBS	B2		9000	
30077	KIT KAT	404	ACORN ROAD	MARIANNHILL	F1		14000	
30145	KLEENTEX	117	MALACCA ROAD	REDHILL	B2	0	4500	0
30162	KLOOF CONVENIENCE CENTRE	21	VILLAGE ROAD	KLOOF	B2B1F2B2		88000	14000
30214	KNIGHTS CARTAGE	42	FLOWER ROAD	CLAIRWOOD	B2			6000
30242	KOCHS CUT & SUPPLY	22	KYALAMI ROAD	WESTMEAD	D3			9000
30351	KRANTZ MOTORS	330	NORTH COAST RD			46000	0	4500
28614	K'S SERVICE STATION	115 - 117	LONGCROFT DRIVE	PHOENIX	B2	56000		
30425	KSM MILLING CO	50	LEUCHARS RD MAYDON WHARF			4500	0	18000
30535	KWA MASHU SERVICE STATION	950	MALANDELA ROAD			74000	32000	14000
30661	KWAMASHU WATER & WASTE		STONEBRIDGE ROAD	PHOENIX	B2	200	100	2400
30824	KYNOCHEM FEEDS (PTY) LTD		IPITHI ROAD			210		3455
30844	KZN COMPOSITES	59	ACUTT AVENUE	DURBAN NORTH	J2			60000
30896	KZN RESINS	295	BALFOUR ROAD	BLUFF	B2D2	30000	45000	0
30970	L G GREEN	6	HENDERSON ROAD	NEW GERMANY	D3			9000
31021	L V Y FILLING STATION		UMZINTO MAIN ROAD	CRAIGIEBURN	B1			
31083	LA FARGE ROOFING	58	LARK ROAD	AVOCA	B2G1		0	6000
31105	LA LUCIA SERVICE STATION	47	ARMSTRONG AVENUE	UMHLANGA	B2			
31258	LAFARGE		LANGERBERG ROAD	JACOBS	B2			14000
31254	LAFARGE		WALTER GILBERT ROAD	CENTRAL	B2			9000
31261	LAFARGE INDUSTRY	1500	RIDGEVIEW ROAD	CATO MANOR	B2G1			23000
31262	LAFARGE READYMIX	13	JEFFELS ROAD	PROSPECTON	B2			9000
31265	LAFARGE READYMIX	8	ROADHOUSE CRESCENT	BRIARDENE	B3	0	0	19000
31267	LAFARGE SOUTH AFRICA	19	DEVON ROAD	PINETOWN	B2			14500
31436	LANDWIDE LONGHAULS	8	NEWTON ROAD	MARIANN IND.PARK	B2			23000
31437	LANDWIDE LONGHAULS CC	80	DAYAL ROAD	CLAIRWOOD	B2			6600
31444	LANGEBERG FOODS	279	INANDA ROAD	SEA COW LAKE	J3		0	18000
31464	LANXESS	54	TOMANGO ROAD	MEREBANK	D2B2	2500	0	2500
31591	LAWSONS FILLING STATION	116	SARNIA ROAD	SEAVIEW	B2		0	37000
31643	LE MANS SERVICE STATION	74	KENYON HOWDEN ROAD	MONTCLAIR	B2	72500	0	14000
31729	LEE METALS C C	22	HUNSLETT ROAD PHOENIX			0	0	4500
31736	LEE SCRAP METALS	7	VULCAN PLACE	PHOENIX	D2			15000
31771	LEFTY'S IZWELISHA	20	MANGOSUTHU HIGHWAY	UMLAZI	B2	132000	0	23700
31987	LEVER PONDS	73	MAYDON ROAD	MAYDON WHARF	D2		0	4400
31982	LEVER POND'S	22	WATFORD ROAD			0	0	2000
32139	LIGHTHOUSE SERVICE STATION	2	LIGHTHOUSE ROAD	UMHLANGA	B2			
32297	LINKHILLS SERVICE STATION	4	LINK ROAD	WATERFALL	B2			
32653	LOMBARDS TRANSPORT [NTL] [PTY] LTD	41	DUDLEY ST			0	0	37000
32707	LONGCROFT MOTORS	430	LONGBURY DRIVE	PHOENIX	F2B2	56000	0	14000
32715	LONGDISTANCE NATAL [PTY] LTD	49	TEAKWOOD ROAD JACOBS			0	0	46000
32717	LONGFELLAS SERVICE STATION	115	LONGCROFT DRIVE - 117 PHOENIX			56000	0	14000
32849	LOTUS BUILDERS SUPPLIES	601	UMBUMBULU ROAD	ISIPINGO	F2			8400
32883	LOTUS SERVICE STATION	14	CHATSWORTH MAIN ROAD	CHATSWORTH	B2	158000	0	9000
33083	LUMINE LIGHTING	316	GALE STREET	CONGELLA	B2		2200	
33260	M & J SERVICE STATION	4052	DAYAL ROAD 213 CLAIRWOOD			0	18000	47000
33304	M A RAWAT & SONS	14	POSSELT ROAD	NEW GERMANY	F1		9000	
33397	M GOVENDER'S CARTAGE	100	ALPHA ROAD	SILVERGLEN				23000
33471	M NAIDOO	92	SOUTH HAUL CARRIERS ABERDARE DRIVE PHOENIX					14000
33663	MACDONALD STEEL	403	CHAMBERLAIN ROAD	JACOBS	J3			4500
33664	MACDONALD TRANSPORT	100	ALPHA CRESCENT	CONGELLA	B2			126000
33673	MACHINE MOVING & ENGINEERING	20	CLUBHOUSE PLACE	WESTMEAD	D2			15000
33693	MACKS AUTO SERVICES	798	SEA COW LAKE RD			0	0	46000
33701	MACLO MOTORS CC	663	JAN SMUTS HIGHWAY	MAYVILLE	B2	69000	0	23000
33725	MACSTEEL	46	JEFFELS ROAD	PROSPECTION	D2	9.4		37000
33726	MACSTEEL (PTY) LTD	230	ABERDARE DRIVE	PHOENIX	D3			9000
33866	MAGIK SERVICE STATION	169	NORTH COAST ROAD	BRIARDENE	B1	46000	0	69000
33978	MAHATMA GANDHI MEMORIAL HOSPITAL	100	PHOENIX HIGHWAY	PHOENIX	E2	500		32000
34042	MAIDSTONE SERVICE STATION	780	MAIN ROAD	MAIDSTONE	B2	69000	10000	23000
34092	MAISAI HAKE HOUSE SERVICES	199	SOUTH COAST ROAD	ROSSBURGH	J2		2200	2200
34105	MAITERS SERVICE STATION	104	WICK STREET	VERULAM CBD	B2	50000		9000
34186	MAKSONS WHOLESALERS	322	SEA COW LAKE ROAD	SEA COW LAKE	F2		2200	0
34277	MALVERN GARAGE	384	STELLA ROAD	MALVERN	B2F2	60000		9000
34332	MAMBA'S SUPERMARKET	130	WESTHAM DRIVE	WESTHAM	F2			22000
34354	MAN TRUCK & BUS	21	TRAFFORD ROAD	PINETOWN	D2	2000	12800	41000
34464	MANJOE SERVICE STATION	A1012	MSHADO ROAD	INANDA	B2	69000	9000	15000
34465	MANJOE SERVICE STATION	P 17	MALANDELA ROAD	KWA MASHU	B2	92000	22000	23000
34533	MANPATH SINGH	560	NORTH COAST ROAD			60000		4500
34694	MARIANHILL CASH & CARRY	841	OLD RICHMOND ROAD	MARIANHILL	F1	40	41000	
34701	MARIANHILL SERVICE STATION	932	CHESNUT CRESCENT	MARIANNHILL	B2			
34707	MARIANN SERVICE STATION	932	CHESTNUT CRESCENT	MARIANHILL	B2	69000	14000	23000
34712	MARIANNHILL SHELL SERVICE STATION	10	CHESTNUT CRESCENT	PINEVIEW	F2	37000		9000
34722	MARIANNSTAR SERVICE STATION	851	OLD RICHMOND ROAD	MARIANHILL	B2	92000		23000
34736	MARINA SERVICE STATION	56	VICTORIA EMBANKMENT	DURBAN CENTRAL	B2			
34755	MARINE GROUPAGE WAREHOUSE	4026	CHAMBERLAIN ROAD 256 JACOBS			0	0	2200
34834	MARK NORRIS LANDSCAPE	11	LECKHAMPTON	CAMPERDOWN	B2			2000
34906	MARLEY ROOF TILES	35 - 37	EDMUND MOOREWOOD ROAD	TRUROLANDS	D3		14000	13800
35011	MARX SERVICE STATION	07-May	INANDA ROAD	HILLCREST	G1B2			
35088	MASTER BAKERS	173	ABERDARE DRIVE PHOENIX			0	0	9000
35131	MASTERBAKE	354	ABERDARE DRIVE PHOENIX				14000	14000
35137	MASTERTRANS	14	PASCOE ROAD			0	0	23000
35139	MAT CHEM	30	MONTE CARLO ROAD	WESTMEAD	D2J2		4000	
35156	MATERIALS MANAGEMENT	767	MALANDELA ROAD	CENTRAL	B3		0	8000
35158	MATERIALS MANAGEMENT BRANCH		UMLAZI (NPA) DEPOT			18500	0	22500
35161	MATERIALS MANAGEMENT DEPARTMEN	166	OLD FORT ROAD	CITY	J2	500		4000
35162	MATERIALS MANAGEMENT DIVISION	2	COLLINGWOOD ROAD JACOBS			9200	0	9200
35164	MATERIALS MANAGEMENT NORTH/SOUTH COUNC	SECTION A INANDA NEWTOWN NPA DEPOT				0	0	14000
35165	MATERIALS MANAGEMENT NORTH/SOUTH COUNC	UMHLATUZANA ROAD CLAIRWOOD				0	0	14000
35163	MATERIALS MANAGEMENT NORTH/SOUT	614G	DALMENU ROAD KWA MASHU			14000	0	28000
35222	MATTRESS KING	49	FLOWER ROAD	CLAIRWOOD	B3		0	9000
35231	MATURAS SERVICE STATION	82	LOT EMONA	EMONA	B2			
35331	MAXIMS CC FOODS	14	ABERDARE DRIVE	PHOENIX	D2	0	48000	45000
35428	MAYVILLE MOTORS	663	JAN SMUTS HIGHWAY MAYVILLE			42000	0	14000
35589	MCINTOSH MOTORS	52	CIRCUIT ROAD	WESTMEAD				9000
35605	MD MULTYLAYERS	2	JOYNER ROAD	PROSPECTON	B3	9000		9000
35645	MEAT	200	QUALITY STREET	JACOBS	D3		4500	
35686	MED SHIPPING	2	LANGEBERG ROAD	CLAIRWOOD	B2			23000
35810	MEDITERRANEAN SHIPPING COMPANY	1	LANGERBERG ROAD	BAYHEAD	J3			23000

35826	MEDWOOD MOTORS	537	UMBILO ROAD	UMBILO	B2	120000	0	69000
35844	MEGA CITY SERVICE STATION	50	MANGOSUTHU HIGHWAY	UMLAZI	B2			
35881	MEGAPAK	10-Aug	NICHOLSON ROAD	PINETOWN	D2		23000	
35972	MEMBREY TRANSPORT	17	JOYNER ROAD	PROSPECTON	B3			23000
35973	MEMBREY TRANSPORT	4	POWER DRIVE	PROSPECTON	B3			51000
36073	MEREWENT SERVICE STATION	3	BOMBAY WALK	MEREBANK	B2			
36074	MEREWENT SERVICE STATION	3	RAJ MAHAL ROAD MEREBANK			74000		9000
36099	MERLOG FOODS	47	OPPENHEIMER STREET	PINETOWN	J2			14000
36129	MESH GEAR	88	BLUFF ROAD	JACOBS	D3	840	0	13500
36140	METAL BOX FLEXIBLE PACKAGING	1290	SOUTH COAST ROAD			59000	20000	0
36194	METIER CONCRETE MIX	39	VULCAN PLACE	PHOENIX	F1			14000
36214	METRO BUS SERVICES	76	HUNSLETT ROAD	PHOENIX	B2	0	0	84000
36222	METRO ELECTRICITY DEPOT	2	GREENBURY DRIVE	PHOENIX	B2G1D4	4000	0	14000
36299	METSO MD ENGINEERING	60	CARRICK ROAD	QUEENSBURGH	D2	100	100	4400
36450	MID-ILLOVO GARAGE AND SERVICE STATION		MAIN ST	MID ILLOVO	B2			
36497	MIDWAY SERVICE STATION	530	BRICKFIELD ROAD	OVERPORT	B2			4000
36537	MIKES SERVICE STATION	56	VICTORIA STREETVICTORIA EMBANKMENT			51000	0	4500
36678	MILLING TECHNICS	11	7TH AVENUE	PINETOWN	D2			20000
36775	MINI MOVES	5	WALTER PLACE MAYVILLE			0	0	9000
36844	MISRA MOTORS	17	STANMORE DRIVE PHOENIX			56000	0	14000
36884	MISTER MOVER CC	10	CAVERSHAM ROAD	PINETOWN	J2			4500
36901	MISTRY`S PINE FURNITURE	14	VULCAN PLACE	PHOENIX	B2		2000	17000
36920	MITCHELL PARK SERVICE STATION	109	NORTH RIDGE ROAD	MORNINGSIDE	B2	92000	0	14000
37064	MOBENI SERVICE STATION	1427	SOUTH COAST ROAD	MOBENI	B1	172000	85000	80000
37073	MOBIL OIL	136	P.O. BOX DURBAN			0	17640	0
37071	MOBIL OIL		MARITIME HOUSE SALMON GROVE			0	18000	0
37072	MOBIL OIL		MARITIME HOUSE SALMON GROVE			0	18000	0
37081	MOBIL OIL S.A.		TARRA RD			0	33000	33000
37083	MOBIL OIL S.A. [PTY] LTD	136	PO BOX DURBAN			0	35000	35000
37082	MOBIL OIL S.A. PTY LTD	136	PO BOX DURBAN			0	35000	35000
37085	MOBIL OIL SA [PTY]		MARITIME HSE SALMON GROVE DURBAN			0	32500	0
37084	MOBIL OIL SA PTY		MARITIME HSE SALMON GROVE DURBAN			0	32500	0
37100	MOBILE TELEPHONE NETWORKS (PTY) L	3	VALLEY VIEW ROAD	NEW GERMANY	B2			9000
37139	MODEL GARAGE	163	JAN SMUTS HIGHWAY	MAYVILLE	B1	58000	0	9000
37174	MODERN SERVICE STATION	180	CROFTDENE DRIVE	CROFTDENE	B2	65000	0	14000
37175	MODERN TOWER GARAGE	19-Jul	BRIGHTON ROAD	JACOBS	B2	90000	0	13500
37311	MONDI BOARD MILLS	43	SEA COW LAKE RD			10820	0	4319
37313	MONDI CARTON BOARD	43	SEA COW LAKE ROAD	PARLOCK	B3		4000	8000
37314	MONDI CARTONBOARD - UMGENI	43	SEA COW LAKE ROAD			5000	18800	5000
37322	MONDI RECYCLING	231	MAYDON ROAD	MAYDON WHARF	B2			14000
37326	MONDI WASTE PAPER	8	MOSS ROAD	WESTMEAD	J2			9000
37328	MONDIPAK	17	OPPENHEIMER STREET	PINETOWN	D2	140	200	99000
37356	MONIER ROOFING	19	BOUGANVILLA ROAD	QUEENSMEAD	D2			19000
37464	MONTFORD SERVICE STATION	160	ROAD 701	MONTFORDCHATSW(	B2	98000	14000	63000
37495	MONTWOOD MOTORS	123	MONTCLAIR ROAD	MONTCLAIR	B2	126000	0	14000
37566	MOONDROPS	45	BRUNNING PLACE	JACOBS	B2			14000
37671	MORGADO PLANT HIRE	161	OLD NORTH COAST ROAD	GLEN ANIL	B2			23000
37708	MORNINGSIDE CONVENIENCE CENTRE	350	WINDERMERE ROAD	MORNINGSIDE	B2	70500	0	23500
37766	MOTECH SERVICE STATION	477	MAIN ROAD	GANDI'S HILL	B2			
37789	MOTO VATION MOTORS	17	GLENUGIE ROAD	PINETOWN	B2	70000		13000
37830	MOTORSERV	11	BRICKHILL RD			96000	0	14000
37837	MOTORVIA		EDDIE HAGAN DRIVE	CATO RIDGE	J2			4400
37904	MOURBON TRADING CC	101	ACUTTS DRIVE	HILLCREST	B2			2000
38060	MR CARRIERS	21	TRENT ROAD	CLAIRWOOD	B3			9000
38108	MR FUELS	127	ABERDARE DRIVE	PHOENIX	B2		23000	23000
38107	MR FUELS	625	SUNSET AVENUE	CHATSWORTH			9000	42000
38406	MRS BOWLES	8	MACK ROAD	PROSPECTON		2000	9000	33100
38537	MT EDGECOMBE SERVICE STATION	48 - 50	MARSHALL DRIVE	PHOENIX	B2			
38588	MTN SWITCH CENTRE	162	BEREA ROAD	BEREA	B2			9000
38598	MUCHENI PLANT CC	494	LINK HILLS		B2			4000
38659	MULTI LAYER TRADING	2	JOYNER ROAD	PROSPECTON	D1			2200
38740	MUNICH MOTORS	877	NORTH COAST ROAD			36000	0	9000
38752	MUNICIPAL MNGT SERVICES	44	ISAIAH NTSHANGASE ROAD	CENTRAL				11500
38773	MUNSAMY GOUNDEN	2	REGINA STREET, BELVEDERE	TONGAAT		69000		23000
38785	MURRAY & DADDYS SERVICE STATION	4182	MAIN ROAD	UMZINTO NORTH	F2			
38802	MURRY & DADDY SERVICE STATION	301	MAIN ROAD	UMZINTO	B2			
38835	MUSGRAVE MOTORS	108	ESSENWOOD ROAD	MUSGRAVE	B2	70000	0	14000
38969	MYCROCHEM	6	SHEPSTONE ROAD	NEW GERMANY	J1	149000	15000	100
38973	MYHILL PHOENIX SERVICE STATION CC	17 - 21	INDUSTRIAL PARK RD			70000	0	14000
39149	N M R LOGISTICS	9	CORRELGATE COVE	SOUTHGATE	B2			30000
39261	NADASENS TRANSPORT	1	TOMANGO ROAD	MOBENI	B3J3	9000	0	41500
39295	NAGINA SERVICE STATION	2	SONI WAY	MARIANHILL	B2	74000		14000
39410	NAMANDLA ROAD & CIVILS		UPPINGHAM GROVE	PHOENIX	B2			6600
39413	NAMANDLA ROADS		1H560	WELBEDUCT EAST	B2			9000
39416	NAMANDLA ROADS & CIVILS	15	MORELAND DRIVE	UMKOMAAS	D4			9000
39418	NAMANDLA ROADS AND CIVILS		INKHANYEZI TOWNSHIP	SHALLCROSS	B2			4400
39429	NAMPAK	5	CREWE ROAD	MOBENI			54000	
39432	NAMPAK CARTON & LABEL	32	CIRCUIT ROAD	PINETOWN	J2			9000
39433	NAMPAK CARTON & LABELS	23	HAGART ROAD	PINETOWN	D2J2	1500	4500	5500
39435	NAMPAK CARTON AND PRINT	30	PAISLEY ROAD JACOBS			0	0	3100
39437	NAMPAK CORRUGATED CONTAINERS	17	WILTSHIRE ROAD	MARIAN INDUSTRIAL	D2	100	600	87000
39443	NAMPAK RECYCLING	7	HAGART ROAD	PINETOWN	D2			2000
39447	NAMPAK SACKS	71	LEICESTER ROAD	MOBENI	B2	3300		2000
39605	NATAL ART CRAFT INDUSTRIES	156	GALE STREET	CONGELLA	B2		0	9000
39652	NATAL COMPONENTS	60	MILNER STREET	JACOBS	D2			25000
39727	NATAL PORTLAND CEMENT	199	CODEMORE ROAD	BELLAR	J3			16200
39766	NATAL SOLVENT RECOVERY	10	CLUB HOUSE PLACE	WESTMEAD	D1	10000	40000	
39785	NATAL UNITED TRANSPORT	91	ARCHARY ROAD CLAIRWOOD			0	35000	35000
39869	NATIONAL ASPHALT	LOT AE 66	CLIFFDALE ROAD	CLIFFDALE	D3			36000
39882	NATIONAL BRANDS	1	MALCOM ROAD	WESTMEAD	D2		22500	59000
39896	NATIONAL CO-OPERATIVE DAIRIES	499	SYDNEY ROAD			13000	0	14500
39897	NATIONAL CO-OPERATIVE DAIRIES	465	SYDNEY ROAD			13500	0	23000
39918	NATIONAL FOODS	11	LEICESTER ROAD			0	0	9000
39961	NATIONAL SERVICE STATION	14	HUNSLETT ROAD	PHOENIX	B2	102000		28000
39963	NATIONAL SHIP CHANDLERS	438	SYDNEY ROAD	CONGELLA	D3G1J2B2		35000	7000
39966	NATIONAL STARCH & CHEMICAL COMPA	188	LANSDOWNE ROAD JACOBS			400	400	13600
39974	NATIONAL TWO GARAGE	560	NORTH COAST RD			46000	0	14000
39987	NATIONWIDE FUEL DISTRIBUTORS	175	WILLIAMS RD DURBAN			18000	18000	18000

39988	NATIONWIDE FUEL DISTRIBUTORSW	175	WILLIAMS ROAD DURBAN			28000	28000	28000
39990	NATIONWIDE PETROLEUM	175	WILLIAMS ROAD			69000	0	115000
39992	NATIONWIDE PETROLEUM DISTRIBUTOR	175	WILLIAMS RD			0	0	92000
39993	NATIONWIDE PETROLEUM DISTRIBUTOR	175	WILLIAMS RD			0	0	184000
39991	NATIONWIDE PETROLEUM DISTRIBUTOR	175	WILLIAMS RD DURBAN			16000	16000	16000
39999	NATLITE	200	ABERDARE DRIVE PHOENIX			0	0	2200
40015	NATRO FREIGHT	6	KOBE ROAD	BAYHEAD	B2	0	0	27000
40066	NAVY SERVICE STATION	19	PUNJAB CIRCLE	MEREBANK	B2	26000	0	13000
40069	NAYIONAL SERVICE STATION	14	HUNSLETT ROAD					
40121	NCP YEAST	200	STANGER STREET	DURBAN CENTRAL	D3			40000
40324	NELSON MOTORS	211	BEREA ROAD	BEREA	B1	92000	0	14000
40369	NESTLE	31	LANNER ROAD	NEW GERMANY	J2J4G1	30	60050	46000
40380	NETCARE PHARMACY	319	UMHLANGA ROCKS DRIVE	UMHLANGA	B2			9000
40407	NEVADA SERVICE STATION		BLUFF ROAD	FYNNLANDS	B2			
40428	NEW AGE BEVERAGES	17	PREMIER PLACE	PHOENIX	D2	1100	8290	87704
40476	NEW ENERGY SERVICE STATION	138 - 140	ABERDARE DRIVE	PHOENIX	B2	46000		23000
40613	NEW SERVICE STATION		MAYIBUYE DRIVE		B2			
40651	NEW WAY CARTAGE	8	GOODWOOD ROAD	WESTMEAD	D2			5000
40694	NEWHEART SERVICE STATION	7	ST GEORGES ST			18000	0	0
40707	NEWLANDS CITY SERVICE STATION	2	MARBLERAY DRIVE	NEWLANDS EAST	B2	92000		37000
40748	NEWPARK CONVENIENCE CENTRE	827	INANDA ROAD	NEWLANDS WEST	B2			
40916	NINIAN & LESTER	33	RICHMOND ROAD	WESTMEAD	B2D2J2G1D2			60000
40972	NISSAN WEST SERVICE STATION	1134	JAN SMUTS HIGHWAY	MAYVILLE	B2			
41013	NKANYISO GENERAL DEALER	6	KAULA ROAD	LAMONTVILLE	F1	0	0	4500
41033	NKOZI CO-OP	6	SWANFIELD ROAD	WESTMEAD	B2			23000
41054	NMT ELECTRODES	28	HILLCLIMB ROAD	WESTMEAD	D2		4600	
41077	NOBBY'S CONSTRUCTION	2	SPRING PLACE	RIVERVIEW	G1			2200
41128	NON FERROUS METAL WORKS	288	BALFOUR ROAD	JACOBS	D3		9000	9000
41131	NON FERROUS METALS	1	THE AVENUE EAST	PROSPECTON	D2		3200	2200
41195	NORMAN'S TRANSPORT	126	HUNSLETT ROAD	PHOENIX	G1			23000
41253	NORTH COAST SERVICE STATION	1195	NORTH COAST ROAD	RED HILL	B2	163200	37000	130000
41276	NORTH RING MOTORS	1469	NORTH COAST ROAD	AVOCA	B2	115000		23000
41292	NORTHERN DRIVE SERVICE STATION	3000	NORTHERN DRIVE	PHOENIX	B2	69000		23000
41302	NORTHERN WASTE WATER TREATMENT WORKS		JOHANNA ROAD	SEA COW LAKE	B3	4200	2200	
41315	NORTHLAND SERVICE STATION	4	MACKEURTAN AVENUE	DURBAN NORTH	B2	92000	0	14000
41392	NOVELL PLANT	3	BASSA CRESCENT	QUEENSMEAD	B2			14000
41410	NPC DURBAN	199	COEMORE ROAD	BELLAIR				4400
41411	NPN AUTO CENTRE	14-Dec	ST JOHNS AVENUE	PINETOWN	B2	295000		139000
41426	NTI SERVICE STATION	10	MAYDON ROAD	CONGELLA	B2			
41439	NTOKOZWENI SERVICE STATION	871	F SECTION	UMLAZI	B1	70000	14000	
41441	NTOKOZWENI STATION		SPINAL ROAD F871			70000	14000	
41456	NTUZUMA BUS DEPOT	129	MBODWE ROAD	NTUZUMA	B2			68200
41464	NTUZUMA FILLING STATION	499	DALMENY MAIN ROAD	NTUZUMA	B1			
41466	NTUZUMA FIRE STATION	1331	MAGEBA ROAD	SECTION C	B2			4500
41476	NTUZUMA SERVICE STATION	892	DALMENY ROAD	NTUZUMA	B2	64000		23000
41550	NU PARK WELDING SUPPLIERS	188	HUNSLETT ROAD	PHOENIX	B1		0	14000
41578	NU WEST SERVICE STATION	7	LOOPWEST CRESCENT	NEWLANDS WEST	B1F2	69000		23000
41600	NULAID REARING UNIT A		NOORDSBERG ROAD	UPPER TONGAAT	B2			2200
41602	NULAID REARING UNIT B		NOODSBERG ROAD	TONGAAT	B2			2200
41603	NULAID REARING UNIT C		NOODSBERG ROAD	TONGAAT	D3			2200
41615	NUNDLALL`S TRANSPORT	19	STANHOPE PLACE	BRIARDENE	B3		0	14000
41662	NWN AUTOMOTIVE PRECISION ENGINEE	12	SUZUKA ROAD	WESTMEAD	D1			4500
41682	NYATHI TEXTILES	51120183	OLD KWA-MASHU HIGHWAY	PHOENIX	B2B3			23000
41751	O.T.K OPERATING COMPANY	5	PREMIER PLACE PHOENIX					9000
41759	OAK SERVICE STATION	12	OAK AVENUE	CHATSWORTH	B2	42000	0	24000
41913	OCEAN SPARES	LOT 82	EMONA	EMONA	D3			14000
41935	OCEAN VIEW SERVICE STATION		SPATHDIA DRIVE	ISIPINGO	B2			
41949	OCEANCO	10	ROTTERDAM ROAD BAYHEAD			0	0	2200
41984	ODEON SERVICE STATION	63 - 65	NEWMARKET STREET	CHATSWORTH	B2	46000	0	23000
42033	OHLANGA CASH & CARRY	76 - 86	HUNSLET ROAD	PHOENIX	F3		46000	1400
42119	OLD DUTCH GARAGE AND SERVICE STA	239	GALE STREET			36000	0	9000
42140	OLD MILL SERVICE STATION	48 - 50	MARSHALL DRIVE	PHOENIX	B2			
42306	OMAR'S SERVICE STATION	240	RANDLES ROAD	SYDENHAM	B2	42000	0	14000
42891	OVERPORT MOTORS	16	SOUTH ROAD	OVERPORT	B2	69000	21000	46000
42892	OVERPORT SERVICE STATION		SOUTH ROAD	OVERPORT	B3			
43197	PACKAGING CONSULTANTS	1	IMVUBUPARK CLOSE	RIVERHORSE VALLEY	J2D2	25000		4200
43201	PACKAGING CONVERTERS	143	OLD MAIN ROAD	PINETOWN		9000	8000	
43233	PADDY'S SERVICE STATION		MAIN ROAD	TONGAAT				
43288	PAINTEC	24	ALEXANDER ROAD	WESTMEAD	B1	7000	1500	
43318	PAKCO	1	PAKCO STREET	VERULAM	B2			4500
43339	PALACE'S FRESH PRODUCE	290	SIDAR ROAD	CLAIRWOOD	B2			46000
43388	PALM SERVICE STATION	170	RINALDO ROAD	DURBAN NORTH	B2	106000	0	19000
43440	PALMVIEW SERVICE STATION	388	PALMVIEW DRIVE	PALMVIEW	B2	92000	0	23000
43550	PANDA MOTORS	30	ROLAND CHAPMAN DRIVE			42000	0	14000
43585	PANJIVANS CASH & CARRY	10	MAHES ROAD	ISIPINGO	F1	4000	20000	
43638	PAPER FACTORY	234	TRAVENCORE DRIVE	MEREBANK	D1J1		4200	36000
43641	PAPER MOULDED PRODUCTS	33	VULCIAN PLACE PHOENIX					2200
43653	PAPERKEM	15	VALLEY VIEW ROAD	NEW GERMANY	G1	2000	5000	1000
43833	PARKIN TRANSPORT SERVICES	74	HIME LANE JACOBS			22600	22600	22600
43868	PARKS DEPARTMENT	19	SYDENHAM ROAD	CENTRAL	B2	13000		10000
43875	PARKS DEPT	129	CALSHOT CRESCENT PHOENIX			10000		9000
43905	PARMALAT	9	IMVUBUPARK PLACE	RIVERHORSE VALLEY	J2			23000
43917	PART PLANT	15	PROSPECTON ROAD	PROSPECTON	B2	90	18000	2200
43997	PATERS SERVICE STATION	41	ARCHARY ROAD	CLAIRWOOD	B1			
44080	PAVILLION HOTEL	15	OLD FORT ROAD	MARINE PARADE	H1	0	0	4000
44103	PB SERVICE STATION		DAHLIA DRIVE	BUFFELSDALE				
44215	PEKAY CHEMICALS	9	SWANFIELD ROAD	PINETOWN	D1J1	28600	1000	2000
44221	PELICAN MIS SYSTEMS	793	NORTH COAST ROAD	BRIARDENE	B2	0	0	4500
44226	PELICAN SERVICE STATION	14	PELICAN PLACE	YELLOWWOOD PARK	B1	65000	14000	0
44516	PERMOSEAL	12	HILLCLIMB ROAD	PINETOWN	D2J1D1D1B2G	300	9525	
44638	PETRO WEST INVEST - SHELL SHOP	275	ABERDARE DRIVE	PHOENIX	F2	70000		9000
44640	PETROCHEM	6	SPRITE PLACE	PINETOWN	D2J1		50000	50000
44645	PETROL FILLING STATION.	670	MAIN ROAD	QUEENSBURGH	B1			
44648	PETROLEUM DISTRIBUTORS	34	CLARE RD SYDENHAM			0	16000	0
44649	PETROLEUM FINE PRODUCTS	4	SILICON ROAD	MARIAN IND PARK	D2			18000
44656	PETROPORT N2 NORTH	5001	NATIONAL ROUTE N2	RIVERHORSE VALLEY	B1	225000		90000
44658	PETROPORT N2 SOUTH	5020	NATIONAL ROUTE N2	RIVERHORSE VALLEY	B1F2B2		200000	90000
44736	PHEZULU GAME ESTATE	25	MOUNTAIN RIDGE ROAD	BOTHAS HILL	B2			2000

44823	PHOENIX COMMUNITY HEALTH CENTRE	32	BROOKSTONE PLACE	PHOENIX	E2G1		0	10000
44841	PHOENIX GALVANIZING	274	ABERDARE DRIVE	PHOENIX	D2			14000
44865	PHOENIX PARK SERVICE STATION	2	SULZER PLACE	PHOENIX	B2	46946	0	46946
44866	PHOENIX PARKS DEPARTMENT	129	CALSHOT CRESCENT	CLAYFIELD	G1			9000
44889	PHOENIX SERVICE STATION	21	INDUSTRIAL PARK ROAD	PHOENIX	B2		14000	14000
44903	PHOENIX WASTE WATER	79	NEW MAIN ROAD	OTTAWA	B2	60	210	5500
44909	PHOLA SERVICE STATION	1679	U UMLAZI	UMLAZI	B2	60000	14000	14000
45096	PICK 'N PAY GARAGES	19	WATERKANT ROAD	DURBAN NORTH	B2	106000		37000
45406	PINETOWN ENGINEERING FOUNDRY	6	FOUNDARY LANE	NEW GERMANY		10200	1600	33000
45409	PINETOWN EXEL GARAGE	92	OLD MAIN ROAD	PINETOWN	B2	52000		9000
45469	PINETOWN SERVICE STATION	52	OLD MAIN ROAD	PINETOWN	B1F2	60000		30000
45531	PINNACLE MOTORS	473	INANDA ROAD NEWLANDS DURBAN			42000	0	14000
45533	PINNOY'S MULTI SERVICE	3	WEBB ROAD	WINKLESPRUIT	B1	69000		14000
45536	PINNOY'S SERVICE STATION							
45587	PIRATE PLANT HIRE	6	SUGARBUSH ROAD	WESTMEAD	G1		4000	4400
45756	PLASCON INKS AND PACKAGING COATIN	255	LANDSDOWNE RD			0	50000	147000
45873	PLAZA SERVICE STATION	259	NORTH COAST ROAD	BRIARDENE	B2			
46004	POLANDS SERVICE STATION	107	GALE STREET	UMBILO	B3			
46019	POLO PONY SERVICE STATION	7	KASSIER ROAD	ASSAGAY	B1	115000	23000	
46158	PORT SERVICING STEVEDORING	35	GRUNTERS GULLY	CONGELLA	D2			4400
46184	PORTNET MARINE SERVICES		SMALL CRAFT BASIN		B2			13500
46205	POST AND TELECOMMUNICATIONS	90	HUNSLETT ROAD POST OFFICE ENGINEERS YARD PHOENIX			28000	0	14000
46313	POWAFIX	1474	SOUTH COAST ROAD	MOBENI	B2	26000	35000	
46359	POWER MOTION	111	BLUFF ROAD			2000	8000	0
46414	PQ SILICAS SA	188	LANDSDOWNE ROAD	JACOBS	B2			2200
46453	PRECAST CEMENT PRODUCTS	55	STAPLETON ROAD	PINETOWN	D3			4500
46514	PREMIER BB BAKERY	341	SYDNEY ROAD	UMBILO	B2	30000	30000	18000
46528	PREMIER FOODS	8	WAREING ROAD	PINETOWN	D2		14500	23000
46547	PREMIER SPRING INDUSTRIES	116	LEICESTER ROAD	MOBENI	D2	0	0	14000
46631	PRESTIGE SERVICE STATION	172	LEICESTER ROAD	MOBENI	B2	56000		28000
46711	PRIME DIME PTY LTD	31	MELBOURNE ROAD	CONGELLA	B2			18000
46881	PRO AFRICA TRUCKING	21	SUPPLY ROAD	SPRINGFIELD	B2			56000
46984	PROCUREMENT DEPARTMENT	2	WICK STREET	VERULAM	B2			13500
46983	PROCUREMENT DEPARTMENT		BHOOLA ROAD	TRUROLANDS	B2	9000	13500	
47082	PROMINENT PAINTS	2	KUBU AVENUE	RIVERHORSE VALLEY	J2F2	2000	2400	
47098	PRONTO SERVICEPRONTO SERVICES	12	MANCHESTER ROAD	PINETOWN	J1B2J2B2G1D2			60000
47200	PROTEA INDUSTRIAL CHEMICALS	150 - 187	QUALITY STREET	JACOBS	J1	126000	50000	
47227	PROTEKON	221	LANGEBERG ROAD	CONGELLA	J1G1D3		2500	
47231	PROTOCOL SERVICE STATION	174	WINGATE ROAD	MONTCLAIR	J1F2	15000		5000
47272	PUBLIC COMPANY	11	LEICESTER ROAD MOBENI			0	0	18000
47392	Q-RENTALS	65	NORTH COAST ROAD		G1		0	2200
47447	QUALICHEM	12	SWANFIELD ROAD	PINETOWN	J1D2J2	45700		11500
47471	QUALITY PICK & PAY	14 - 16	OLD MAIN ROAD	PINETOWN	B2		14000	23000
47478	QUALITY PRODUCTS	174	CHAMBERLAIN ROAD	JACOBS	D2	14000	4400	5200
47482	QUALITY STREET MOTORS	210	QUALITY STREET	JACOBS	B2	70000		23000
47600	QUEENSBURGH PLANT SALES	13-Jan	BOUGANVILLEA ROAD	PINETOWN	D2	50		14000
47603	QUEENSBURGH SERVICE CENTRE	60	MAIN ROAD	QUEENSBURGH	B1	60000		18000
47621	QUEENSMEAD SERVICE STATION CENTR	22	PIET RETIEF ROAD	QUEENSBURGH	B1			
47639	QUENTINS SERVICE CENTRE	570	UMBILO ROAD	CONGELLA	B1	70000	0	9000
47730	R & C TRANSPORT	230	LEICESTER ROAD MOBENI			0	0	46000
47766	R A KADER CC	9	WALTER PLACE	MAYVILLE	B2	0	0	4500
47816	R F B TRANSPORT	36	HARDEN AVENUE SEA VIEW			0	0	23000
47882	R K KHAN HOSPITAL	101	CHATSWORTH CIRCLE	CHATSWORTH	E2		23000	5920
48117	RAFLATAC	11	MALONE ROAD	WESTMEAD	D1	1600	23000	
48173	RAINBOW CHAIR	170	ROCHDALE ROAD	SEA COW LAKE	B2		0	9000
48287	RALLY MOTORS	172	LEICESTER ROAD	MOBENI	B2		0	28000
48317	RAMBULIP SERVICE CENTRE	09-May	SAVANNAH DRIVE	PINETOWN	B2	45000		5000
48320	RAMDAW'S TRANSPORT	120	ROCHDALE ROAD	SEA COW LAKE	B2	0	0	18000
48400	RANDEREE SERVICE STATION CC	163-165	ALBERT STREET DURBAN		J1	92000		23000
48413	RANDLES ROAD SERVICE STATION	240	RANDLES ROAD	OVERPORT	B2	65000		14000
48529	RATNER AND COLLETT [PTY] LTD	230	LEICESTER ROAD MOBENI		B2		0	46000
48536	RATTANS LIQUOR WHOLESALERS	123	ABERDARE DRIVE	PHOENIX	B3			13500
48608	RAYS MOTORS	909	UMGENI RD			43000	0	9500
48581	RAY'S REMOVALS	188	ARCHARY ROAD	CLAIRWOOD	J2	0	0	23000
48635	RAZAS SERVICE STATION	759	NORTH COAST ROAD	GREENWOOD PARK	B2	0	33000	3000
48749	RECLAMATION GROUP	212	SYDNEY ROAD	CONGELLA	B2J3			14000
48754	RECMIX	2	EDDIE HAGAN DRIVE	CATO RIDGE	D2		20000	
48784	RED FAB ENGINEERING	755	SUNSET AVENUE	WOODHURST	B3		0	2200
48837	REDCLIFFE HAULIERS	18	PRIMROSE DRIVE VERULM			0	35000	0
48838	REDCLIFFE HAULIERS	196	PO BOX VERULAM			16000	16000	16000
48852	REDDY'S CORNER HOUSE	226	SILVERGLEN DRIVE	CHATSWORTH	F2	0	2500	14000
48887	REDFIN TRANSPORT	1201	SOUTH COAST ROAD			0	0	23000
48949	REEF UNITED TRANSPORT	91	ARCHARY RD DURBAN			0	35000	35000
48985	REGAL SERVICE STATION	26	MIDDLE CRESCENT	RESERVOIR HILLS		42000		14000
48986	REGAL SERVICE STATION	1208	QUARRY ROAD	SPRINGFIELD	B2		0	0
49102	REMANT ALTON	102	ALICE STREET	CENTRAL	J4	17150	4500	157000
49130	RENAISSANCE	92	JOHNSTONE ROAD	CONGELLA	J3			2200
49165	RENFREIGHT	6	BONNINGTON PLACE	JACOBS		14400	14400	14400
49186	RENNIES	237	SOUTH COAST ROAD	ROSSBURGH	B2	13500	0	13500
49192	RENNIES CARGO TERMINALS	128	LANDSDOWNE ROAD	JACOBS	J2			23000
49193	RENNIES CARGO TERMINALS		CRABTREE ROAD MAYDON WHARF DURBAN			4500	0	4500
49199	RENNIES DISTRIBUTION SERVICES		JOHNSON ROAD	MAYDON WHARF	B2			2200
49198	RENNIES DISTRIBUTION SERVICES	5	MITRE ROAD	PINETOWN	J2			23000
49350	RESERVOIR HILLS SERVICE STATION	292	MOUNTBATTEN DRIVE	RESERVOIR HILLS	B2	138000	0	18500
49403	REST ASSURED	16	BOUGANVILLA ROAD	QUEENSBURGH	J2			2000
49502	RHEEM	12	THE AVENUE EAST	PROSPECTON	B2		40000	
49571	RICHMOND ROAD SERVICE STATION	12-Aug	RICHMOND ROAD	PINETOWNWESTMEN	B1F2G1B2F2	74000		300000
49633	RIDGEWAY MOTORS	29	SPARKS ROAD			60500	0	9000
49711	RISEGATE SERVICE STATION	1	STONEBRIDGE DRIVE	PHOENIX	B2		6900	23000
49810	RIVERSIDE MOTORS	590	RIVERSIDE ROAD	DURBAN NORTH	B2	139000	0	37000
49826	RIVERVIEW HARDWARE	9	INANDA ROAD	HILLCREST	D2J1	0	2200	2200
49863	RMC MOTORS	99	UMBILO RD			51000	0	9000
49898	ROAD TECH	73	VINTNER PLACE			25000	25000	25000
49935	ROADWAY LIQUORS		EMONA ROAD	EMONA	B2		4400	
49936	ROADWAY LOGISTICS	28	LAKEVIEW PLACE	RIVERVIEW	G1			23000
49938	ROADWAY SERVICE STATION		EMONA	TONGAAT	B2			
50019	ROBS FUEL STATION	360	GALE STREET DURBAN			37000	0	28000
49958	ROB'S SERVICE STATION	21	STOKES ROAD	HILLARY	H4			

50072	ROCKVIEW SERVICE STATION	36	ROCKVIEW ROAD	AMANZIMTOTI	B2		30000	7000
50083	ROCLA	10	OTTO VOLEK ROAD	NEW GERMANY	B2	40	14000	9000
50084	ROCLA TRADING	11	OTTO VOLEK ROAD	NEW GERMANY	D3			14000
50100	RODRIGUES MOTOR CENTRE	99	UMBILO RD			51000	0	14000
50119	ROHLIG GRINROD AIRFREIGHT			AIRPORT	B2	14000	0	69000
50134	ROLLER COASTER SERVICE STATION	1400	SARNIA ROAD	SARNIA	B1	70000	0	4000
50152	ROMALALLS CARTAGE	40	HUNSLETT ROAD	PHOENIX	J2		0	28000
50177	ROMATEX EXTRUDED FABRICS	199	QUALITY STREET JACOBS			0	0	9000
50214	RONNIES SERVICE STATION	11	MARKHOUSE PLACE					
50376	ROSSBURGH AUTO SERVICE	116	SARNIA ROAD	ROSSBURGH	B2		0	9400
50387	ROSSBURGH SERVICE STATION	27	TITREN ROAD	SEA VIEW	B2	54000	0	9000
50484	ROY CLOSE MOTORS	563	BEREA RD			80000	0	14000
50549	ROYAL HOTEL	269	ANTON LEMBEDE STREET	CENTRAL	H1	0	0	20600
50558	ROYAL MOTOR GARAGE	660	SUNSET AVENUE	CHATSWORTH	B2	0	0	52000
50572	ROYAL SERVICE STATION		INANDA ROAD	VERULAM	B2			
50594	ROYAL VULCANISING STATION	1159	UMGENI ROAD	GREYVILLE	B2		4000	
50636	RUBBERTEK	6	RICHMOND ROAD	NEW GERMANY	B2D2G1D2			30000
50709	RUSSELL STREET MOTORS	66	RUSSELL STREET	CENTRAL	B2	70000	0	14000
50807	S & G PRINT & CARTON	1169	SOUTH COAST ROAD	MOBENI	D1	9000	9000	9000
50819	S & M SINGH SERVICE STATION	1	CRAIGIEBURN	CRAIGIEBURN	B2	46000	46000	
50839	S A B C	100	OLD FORT ROAD	CENTRAL	G1		0	13500
50842	S A BREWERIES	221	INANDA ROAD	SEA COW LAKE	J2	0	0	46000
50852	S A COATERS	38 - 40	GILLITS ROAD	PINETOWN	D2	23000	9000	
50918	S A PAPER MILLS	159	BLUFF ROAD	JACOBS	D2		0	40000
50939	S A POST OFFICE	67	N M R AVENUE	N M R	G1B2	14000	2000	14000
50943	S A RESERVE BANK	8	COMMERCIAL ROAD	CITY	G1			6000
50953	S A SUGAR TERMINAL	25	LEUCHARS ROAD	MAYDON WHARF	J3	400		13500
51196	S. WAINSTEIN AND CO [PTY] LTD	75	LEICESTER RD MOBENI			0	0	9000
51204	S.A. POLICE	2	ESCOMBE TERRACE			26000	0	26000
51207	S.A. STEVEDORES		NEW PIER BAYHEAD			0	0	14000
51209	S.A. STEVEDORES LTD	21	SOUTHAMPTON STREET			0	0	4500
51252	SA BOTSWANA HAULERS	29	KOBE ROAD			0	0	23000
51254	SA BREWERIES	9	JEFFELS ROAD	PROSPECTON	J2		28000	
51265	SA CROSS BORDER	14	PASCOE ROAD	MEREBANK	B2			46000
51392	SAFAL STEEL		OLD MAIN ROAD	CATO RIDGE	D3J1	4400		14000
51398	SAFARI SERVICE STATION	75	ST JOHNS AVENUE	PINETOWN	B2	107000	13000	14000
51433	SAFINTRA	48	PROSPECTON ROAD	PROSPECTON	D3			14000
51456	SAGEX NATAL	107	ESCOM ROAD	NEW GERMANY	D2		200	14000
51494	SAIBS SERVICE STATION	108	WOODVIEW DRIVE	PHOENIX	B2	69000	0	9000
51770	SAMCO SERVICE STATION	21	CORONATION ROAD	TONGAAT	B2	37000		9000
51771	SAMDAKAHLE SERVICE STATION	797	Q SECTION	UMLAZI	B2		4500	12000
51804	SAMSON'S TRANSPORT	123	PALM ROAD CHATSWORTH				1000	1000
51868	SANBONANI FUELS CC	47	VICTORIA EMBANKMENT	CITY	B2	42000		14000
51869	SANBONANI FUELS WYEBANK	84	CIRCLE DRIVE	WYEBANK	B2	56000		14000
51881	SANCRYL CHEMICALS	5	JOYNER ROAD	PROSPECTON	D2		60000	25000
51937	SANDOP MINING	10	OLD MAIN ROAD	HARRISON FLATS	D3			20000
52104	SANYATI ROADS	112	OLD MIAN ROAD	BOTHAS HILL	B2	16000		2000
52130	SAPPI SAICOR		UNMKOMAAS DRIFT ROAD	UMKOMAAS	D2J3	54000	81000	
52131	SAPPI WASTE PAPER (PTY) LTD	45	RICHARD CARTE ROAD MOBENI					9000
52152	SAPS - SAFETY & SECURITY	1297	SPINAL ROAD			14000	0	4400
52173	SARA LEE D E	15	TROTTER ROAD	PINETOWN	D2J1G1	75000	9000	
52207	SARNIA SERVICE STATION	176	UNDERWOOD ROAD	PINETOWN	B2	60000		12000
52237	SASOL	1169	UMGENI ROAD	CENTRAL	B2D1	69000		46000
52234	SASOL	39	ARCHARY ROAD	CLAIRWOOD	B2			
52236	SASOL	145	OLD MAIN ROAD	PINETOWN	G1			
52238	SASOL	153	SHEPSTONE ROAD	NEW GERMANY				
52239	SASOL AVOCA	1501	KWA MASHU HIGHWAY	AVOCA	B2	92000	46000	23000
52240	SASOL BOOTH ROAD EAST	121	BOOTH ROAD	CATO MANOR	B2	138000		46000
52241	SASOL COWIES HILL	860	OLD MAIN ROAD	PINETOWN	B1	130000	70000	23000
52242	SASOL DELIGHTS	27 - 29	OLD MAIN ROAD	ISIPINGO RAIL	B2	69000		23000
52244	SASOL FIBRES	N/N	FIBRES ROAD	ISIPINGO	D3		0	60000
52245	SASOL FILLING STATION	58	WINDER STREET	POINT	B2			
52252	SASOL GAS STATION	25	JOYNER ROAD	PROSPECTON	B2			
52256	SASOL SERVICE STATION	2	BOOTH ROAD	CATO MANOR	B2	92000		23000
52283	SATI CONTAINER DEPOT	6	BEECHGATE CRESCENT	UMBOGINTWINI	G1J2J4			45000
52345	SAVANNAH SERVICE STATION	10	SHEPSTONE ROAD	NEW GERMANY	B2	56000		28000
52380	SAVEMOR EARTHMOVING	24 - 26	GILLITTS ROAD	PINETOWN	D2			9000
52580	SCORPIO TRANSPORT	1266	NORTH COAST ROAD	RED HILL	J2			37300
52615	SCOTTY'S PLANT HIRE	11	7TH AVENUE	ASHLEY	B2			4200
52665	SEA COW LAKE SERVICE STATION	22 - 26	JOYCE ROAD	SEA COW LAKE	B2	115000	0	49000
52695	SEA SHELL GARAGE	30	HARVEY STREET	UMKOMAAS	B2	32000		9000
52752	SEADOONE SERVICE STATION	30	SEADOONE ROAD	DOONSIDE	B2			
52753	SEADOONE SERVICE STATION	26	SEADOONE ROAD	TOTI	B2			
52798	SEALAND ENGINEERING CC	21	GRUNTER GULLY	BAYHEAD	D2	0	0	6000
53102	SEEBRAN MOTORS	30	MERANTI STREET	MOBENI HEIGHTS	B2	97000	0	55000
53216	SENSATION SERVICE STATION	115-117	LONGCROFT DRIVE PHOENIX			56000	0	14000
53235	SENTINEL LOGISTICS	90	BARRIER ROAD	CLAIRWOOD	B2		23000	
53236	SENTINEL TRANSPORT	1271	SOUTH COAST ROAD	MOBENI	B2	0	0	46000
53249	SENZANGAKHO TRADING	8	GRIMSBY ROAD	MOBENI	B2			4000
53260	SEPTIC TANK SERVICES		OFF FISHER ROAD	WATERFALL	B2			6000
53304	SERVICE STATION	928	JAN SMUTS HIGHWAY	BONELLA	B1			
53305	SERVICE STATION	115	MUSGRAVE ROAD	MUSGRAVE	B2			
53306	SERVICE STATION	2	STREET 121005	CATO MANOR	B1			
53307	SERVICE STATION	150	SIBUSISO MDAKANE DRIVE	UMLAZI	B2			
53308	SERVICE STATION		MKHIWANE STREET	UMLAZI	B2			
53309	SERVICE STATION	15	PALMGATE CRESCENT	AMANZIMTOTI	B1			
53310	SERVICE STATION	1317	SARNIA ROAD	BELLAIR	B2			
53312	SERVICE STATION		SPATHODIA ROAD	ISIPINGO HILLS	B1			
53313	SERVICE STATION	101	INDUSTRIAL PARK ROAD	PHOENIX	B1			
53328	SERVOCHEM NATAL	18	NORTHGATE PLACE				8000	500
53330	SERVOCHEM NATAL PTY LTD	8	RUSTIC CLOSE	BRIARDENE	J1	20000	40000	40000
53391	SEWS PLANT HIRE	1	SULZER PLACE	PHOENIX	B3			23000
53486	SHAHS SERVICE STATION	17	DUDLEY GROVE NEWLANDS	NEWLANDS		69000		
53538	SHALLCROSS SERVICE STATION	19	EVEREST ROAD	SHALLCROSS	B2		60000	10000
53720	SHAVE & GIBSON	1290	SOUTH COAST ROAD	MOBENI	B2D2B2	48000	0	2200
53802	SHELL	09-Jul	LINK ROAD	WATERFALL	B2			
53804	SHELL	186	MGWAZA MAPHALALA STREE	BEREA	B2			
53808	SHELL AUTO	213	STAMFORD HILL	CENTRAL	G1			

53811	SHELL AUTO SERV	152	OLD MAIN ROAD	PINETOWN	B2			
53813	SHELL BUS DEPOT		ETNA LANE			0	0	70000
53815	SHELL CHEMICALS		REUNION ROCKS ROAD	RE UNION	B2	2000	6500	6500
53816	SHELL GARAGE	275	ABERDARE DRIVE	PHOENIX	B2			
53817	SHELL GARAGE			KLOOF	B2			
53818	SHELL GARAGE	156	ISIPINGO					
53819	SHELL GARAGE	156	OLD MAIN ROAD					
53820	SHELL GARAGE	15	ALICE STREET	DURBAN CENTRAL	B2			
53821	SHELL GREENBURY SELECT	175	REDBERRY ROAD	PHOENIX	F2			
53825	SHELL KWA MASHU		MALANDELA ROAD	KWA MASHU	B2			
53826	SHELL KWAMASHU	1135	MALANDELA ROAD	KWA MASHU	B2J1	92000	23000	46000
53832	SHELL S A	20	HERMAN DRIVE	CHATSWORTH	B2	92000		23000
53831	SHELL S A	17 - 19	WATERKANT ROAD	DURBAN NORTH	G1			
53833	SHELL S A	90	UMBILO ROAD	UMBILO	B2			
53835	SHELL S A		N-N LANGEBERG ROAD	BAYHEAD	J1			
53839	SHELL S.A	3046311	31			0	0	9000
53840	SHELL S.A (PTY) LTD	221	ANTON LEMBEDE STREET	CENTRAL	G1			
53841	SHELL S.A.	3561	P.O. BOX DURBAN			35000	35000	35000
53842	SHELL S.A. [PTY] LTD	2095	P.O. BOX DURBAN			0	18000	0
53846	SHELL SELECT ISIPINGO	156	OLD MAIN ROAD	ISIPINGO	B1	69000		23000
53847	SHELL SELECT SHOP	146	FIELD STREET	CENTRAL	F2			
53853	SHELL SERVICE STATION	155	MAYDON ROAD	MAYDON WHARF	B2	46000		69000
53848	SHELL SERVICE STATION	86	ANTON LEMBEDE STREET	DURBAN CENTRAL	B2			
53849	SHELL SERVICE STATION	88	MOSS STREET	VERULAM	B2			
53850	SHELL SERVICE STATION	6	MOUNTBUTTON DRIVE	RESERVOIR HILLS	F2			
53851	SHELL SERVICE STATION	89	DAVENPORT ROAD	GLENWOOD	B1			
53852	SHELL SERVICE STATION		OVERPORT DRIVE	OVERPORT	B2			
53854	SHELL SERVICE STATION	325	UMHLANGA ROCKS DRIVE	UMHLANGA	B2			
53855	SHELL SERVICE STATION	467	MAIN ROAD	MAIDSTONE	B2			
53858	SHELL ULTRA CITY		N2 NORTH/SOUTH BOUND	UMGABABA	F2			
53859	SHELL ULTRA CITY	N2	SOUTH BOUND	UMKOMAAS	B2			
53869	SHELTAM GRINDROD	180 - 200	FAIRWAY	VIRGINIA	B2	17000	46000	0
53908	SHEPSTONE ROAD MOTORS	109	SHEPSTONE ROAD	NEW GERMANY	B2	70000		9000
54120	SHONGWENI SUGAR ESTATE		KASSIER ROAD EXTENSION	SHONGWENI	B2	4000		9000
54350	SHV POWDERS AFRICA	40	OLD MAIN ROAD	CATO RIDGE				2000
54478	SIKA	9	HOCKING PLACE	WESTMEAD	J1J2D2	2300	4560	2318
54506	SILIC LOGISTICS	40 - 44	WISELY ROAD	MAYDON WHARF	B2			69000
54564	SILVER SERVICE STATION	27	STANLEY COPELY DRIVE	OVERPORT	B2	70500	14000	14000
54565	SILVER SERVICE STATION	230	TEAKWOOD ROAD	CLAIRWOOD	B2	40000		10000
54597	SILVERAY STATIONERY	70	RICHARD CARTE ROAD JACOBS			9000	0	9000
54599	SILVERCROSS TRANSPORT	213	DAYAL ROAD	CLAIRWOOD	B3	0	0	2200
54598	SILVERCROSS TRANSPORT	41	DUDLEY STREET	JACOBS	B3	0	0	13800
54600	SILVERCROSS TRANSPORT CC			JACOBS				28000
54691	SIMJEE'S CONVENIENCE CENTRE	17	BARTON PLACE	CLARE ESTATE	B2	69000		46000
54692	SIMMS BP	6	POWER DRIVE	PROSPECTON	D1G1B2		24000	183000
54755	SIMS B P SERVICE STATION	39	ARCHARY ROAD	JACOBS	B1	0	14000	46000
54796	SIMUNYE SUPERMARKET	1	HARVEY ROAD	PINETOWN	F1		23000	
54798	SIMUNYE WAREHOUSING	84A	DUDLEY STREET JACOBS			0	0	2200
54811	SINCLAIR'S SERVICE STATION	1	KALANDEN ROAD	OVERPORT		40000	0	11000
54977	SIVA'S FUEL	28	BARTON PLACE CLARE ESTATE			0	0	5880
55005	SIYABONGA SUPERMARKET	1171	HLABANGE K ROAD	UMLAZI	F1	0	9000	0
55037	SIYANDA PETROLEUM	213	DAYAL ROAD	CLAIRWOOD	B2		0	37000
55336	SMIRC TRADING (MOTORSERV)	4001	MONTY NAICKER ROAD			97000	0	14000
55351	SMITH MANUFACTURING SA	2	PROGRESS ROAD	NEW GERMANY	D2	2500	500	5000
55578	SOLID WASTE SOUTHERN REGION	2	COLLINGWOOD ROAD	JACOBS	G1		0	9000
55825	SOUTH AFRICAN BULK TERMINALS	101	MAYDON ROAD	MAYDON WHARF	J2B2	45000		23000
55849	SOUTH AFRICAN SUGAR ASSOCIATION	170	FLANDERS ROAD	UMHLANGA	B2	100		3500
55872	SOUTH COAST AUTO	34	KINGSWAY	WARNER BEACH	B2		14000	28000
55875	SOUTH COAST BUS SERVICES	18	OLD MAIN ROAD	ISIPINGO RAIL	B2			37000
55984	SOUTHERN SUN ELANGENI	63 - 69	SNELL PARADE	CENTRAL	H1	0	0	2500
56047	SOUTHWAY CONVENIENCE CENTRE	701	EDWIN SWALES DRIVE	JACOBS	B1	92000		23000
56049	SOUTHWAY FREIGHT	28	JEFFELS ROAD	ISIPINGO	J2			4400
56092	SPACE CITY SERVICE STATION	250	MAIN INANDA ROAD	VERULAM	B2	69000	23000	23000
56093	SPACE FILLING STATION			TONGAAT	B2			
56098	SPACE SERVICE STATION		ROSEMARY DRIVE	BRINGHAVEN	B2			
56144	SPAR DISTRIBUTION WAREHOUSE	304	ABERDARE DRIVE	PHOENIX	J2	14000	0	69000
56219	SPCA DURBAN & COAST		DUNBAR ROAD	CATO MANOR	B3	9000	4000	0
56299	SPECTRA SPRAY	31	PIET RETIEF ROAD	QUEENSBURGH	D1	14000	8000	
56315	SPECTRUM TEXTILES	85	BLAKE ROAD	CONGELLA	D2	0	0	23000
56610	SPRINGBOK FOODS	120	UMHLATUZANA ROAD	SEAVIEW	J3	0	0	9000
56638	SPRINGFIELD SERVICE STATION	26	PALMFIELD ROAD	SPRINGFIELD PARK	B2	37000	0	9000
56637	SPRINGFIELD SERVICE STATION	6	ROYAL PALM AVENUE	SPRINGFIELD PARK	B1B2	92000	0	23000
56644	SPRINGLAKE SERVICE STATION	186	INANDA ROAD	SEA COW LAKE	B2	69000	0	84500
56653	SPRINGMASTER	9	MARSHALL DRIVE	MOUNT EDGECOMBE	D3	0	9000	0
56654	SPRINGPARK CONVENIENT SHOP	26	PALMFIELD ROAD	SPRINGFIELD PARK	F2	60000		69000
56658	SPRINGRITE	2	KONINGKRAMER STREET	NEW GERMANY				4500
56670	SPRINPARK BUS LINES	27	SULZER PLACE	PHOENIX	B2			23000
56747	SS ROSSHEENS TRANSPORT	6	ERNEST CLOEKIE ROAD	PROSPECTON	B3			37000
56759	ST AIDANS HOSPITAL	33	CENTENARY ROAD	GREYVILLE	E2		4500	
56774	ST AUGUSTINES HOSPITAL	107	CHELMSFORD ROAD	BEREA	E2G1E2	0	0	9000
56840	ST JAMES HOTEL	444	MAHATMA GANDHI ROAD	POINT	H1	0	0	3000
56874	ST MARY'S HOSPITAL	1	ABBOT FRANCIS ROAD	MARIANNHILL	E2			18000
56938	STADIUM SERVICE STATION	363	MAIN ROAD	CENTRAL	B2	24000	9000	13000
56937	STADIUM SERVICE STATION			TONGAAT	B2			
56948	STAG SERVICE STATION	516 - 524	ANTON LEMBEDE STREET	CENTRAL	B2	254000	0	13600
56966	STALLION TRANSPORT	290	BAMBANANI STREET	CATO MANOR	B2			37000
56992	STAND & DELIVER	4	WESTMEAD ROAD	WESTMEAD	D2			9000
57050	STANDARD BANK	cnr	KINGSMEAD WAY	CENTRAL	B2			18000
57173	STAR LOVAT SERVICE STATION		HILLHEAD DRIVE	MT EDGECOMBE	B2			
57215	STARCOUNT SERVICE STATION	1	HILLHEAD ROAD	MT EDGECOMBE	A1F2			
57308	STEDON CIVILS	90	ESCOM ROAD	NEW GERMANY	B2			11000
57313	STEDONE CIVILS		CHRISTIAN BERG KROUS ROA	CLERMONT				14000
57315	STEDONE CIVILS		LANGEBERG ROAD	BAYHEAD			14000	
57311	STEDONE CIVILS		CHAMBERLAIN ROAD	TWINI VILLAGE	B2			14000
57317	STEDONE EMERGING CIVILS	54	INANDA ROAD	HILLCREST	B2			4000
57347	STEELBANK MERCHANTS	19 - 21	TROTTER ROAD	PINETOWN	D3			5000
57462	STEFANUTTI STOCKS		MOSSKOLNICK ROAD	TOTI	B2			14000
57461	STEFANUTTI STOCKS		NEW KSIA ACCESS ROAD					6600

57460	STEFANUTTI STOCKS	14-Dec	EDISON ROAD	PINETOWN	D2			9000
57463	STEFANUTTI STOCKS CIVILS KZN	14-Dec	CIRCUIT ROAD	WESTMEAD	B2			9000
57487	STELLA PARK SERVICE STATION	40	SARNIA ROAD	UMBILO	B2		4.5	14000
57577	STERKSPRUIT AGGREGATES	9	CLIFFDALE ROAD	ASSAGAY	D3J1	4500		37000
57648	STOBEL	30	GOODWOOD ROAD	PIENTOWN	J1J2	14000	15000	15000
57653	STOCKS BUILDING	190	ABERDARE DRIVE	PHOENIX	B2	0	0	14000
57674	STONEAGE CONCRETE INDUSTRIES	126	CROMPTON STREET	PINETOWN	D2	210	400	4500
57725	STORE 9 LOGISTICS	15	PROSPECTON ROAD	PROSPECTON	B2		3200	
57761	STORM & CO	46	RICHARD CARTE RDMOBENI				6500	6500
57765	STORM & CO.	46	RICHARD CARTE ROAD MOBENI			14000	0	83000
57763	STORM & CO.	46	RICHARD CARTE ROAD MOBENI				6500	6500
57764	STORM & CO.	24	RICHARD CARTE ROAD MOBENI				22000	22000
57768	STORM AND CO.	49	FENNISCOWLES RD			0	35000	35000
57766	STORM AND CO.	49	FENNISCOWLES RD UMBILO			35000	35000	35000
57789	STRADCO [PTY] LTD	18	CASSIAFIELD GROVE SPRINGFIELD PARK			65000	14000	4500
57909	STUARTS TRANSPORT	3	WESTGATE PLACE	WESTMEAD	J2			13800
57942	STURGEON MOTORS	810	MAIN ROAD	QUEENSBURGH	B2	65000	200	4500
58007	SUBURBAN SERVICE STATION	34	KALANDEN ROAD	CATO MANOR	B2	54000	0	9000
58012	SUBWAY MOTORS	13	BRICKFIELD ROAD	OVERPORT	B2	70000	6000	9000
58033	SUDS INDUSTRIAL LAUNDRIES	38	STANHOPE PLACE			0	0	37500
58049	SUGAR CITY DISTRIBUTORS	14	KING GEORGE RD STANGER			20000	20000	20000
58185	SUMMERFIELDS SERVICE STATION	62	ROLAND CHAPMAN DRIVE	MONTCLAIR	B2	64000		14000
58218	SUN CARRIERS	48	KARIM LANE	SEAVIEW	B1			23000
58343	SUNLAND FOODS	1169	SOUTH COAST ROAD		B2	4500	0	4500
58375	SUNPARK SERVICE STATION	90	SHALLCROSS ROAD	SHALLCROSS	B2F2	115000		23000
58388	SUNRISE EXPRESS	10	MONTE CARLO ROAD	PINETOWN	B2			4400
58389	SUNRISE EXPRESS CC	22 - 24	GILLITTS ROAD	PINETOWN	B2		120	4000
58522	SUNSET MOTORS AND TYRES	670	SUNSET AVENUE CHATSWORTH			0	0	9400
58607	SUPER AUTO PAINTS	247 - 249	ABERDARE DRIVE	PHOENIX	F1		0	27000
58615	SUPER CASH & CARRY	60 - 66	WICK STREET	VERULAM	B2			2200
58643	SUPER MININGS & CIVILS	12	KRUGER PLACE	PHOENIX	B2			14000
58657	SUPER RENT	47	OPPENHEIMER STREET	PINETOWN	B2			28000
58655	SUPER RENT	217	LECEISTER ROAD			0	0	28000
58664	SUPER SERVICE STATION	95	BRICKHILL ROAD	CENTRALDURBAN	B2	51000		14000
58665	SUPER SERVICE STATION	88 - 90	MOSS STREET	VERULAM	B2	9000	41500	14000
58771	SUPPLY CHAIN	10	COLUMBINE PLACE AVOCA	AVOCA	J2			23000
58857	SURFSIDE MOTORS	1	SOUTH BEACH ROAD	TONGAAT	B2			23500
58992	SWEET FROM HEAVEN	115	MUSGRAVE ROAD	MUSGRAVE	F2B3			
59154	SYDNEY ROAD TRUCK STOP	115	SYDNEY ROAD	CONGELLA	B2F2	0	0	102000
59163	SYLKO	08-Jun	PROSPECTON ROAD	PROSPECTON	J2	16000		16000
59273	T F M C	296	MONTY NAICKER ROAD	CENTRAL	B2			10000
59511	TAKE 'N PAY SERVICE STATION	27	BUSINESS SQUARE	WESTCLIFF	B2	69000		23000
59621	TANKER SERVICES	46	RICHARD CARTE ROAD	MOBENI	B3J3B2J2			40000
59631	TANKER SERVICES	5	LIECESTER ROAD	MOBENI	B1	0		84000
59624	TANKER SERVICES	1401	BARLOW ST GERMISTON 250			0	6500	6500
59625	TANKER SERVICES	250	DENIS HURLEY STREET			68000	94000	94000
59633	TANKER SERVICES PTY LTD	4060	LEICESTER ROAD 5 MOBENI DURBAN			0	0	69000
59711	TASHIKK LAUNDRY	29	CATO SQUARE	CENTRAL	B2		9000	
59752	TASTIC RICE	75	LEICESTER ROAD	MOBENI	J2	0	0	29000
59786	TATE & LYLE MOLASSES		AVENUE EAST	PROSPECTON	B2			23000
59902	TECHNI PANEL BEATERS&SPRAY PAINTE	31	OPPENHEIMER STREET	PINETOWN	D2	40	20040	400
59909	TECHNICAL PORT OPERATIONS	CNR	SHADWELL & JENKYN	MAYDON WHARF	B2			23000
60127	TELKOM S A	3	REGAL CRESCENT	NEW GERMANY	G1J2			8500
60129	TELKOM S A		CROMPTON STREET	PINETOWN	B2			4000
60171	TEMPEST CAR SERVICES	54	WINDER ST			42000	0	4500
60221	TENSIDE CHEMICALS	166	BLUFF ROAD	JACOBS	D1		2200	
60294	TEXAS TRUCKING	130	BOOTH					23000
60393	THAVLYN SERVICE STATION	14	SYRINGA AVENUE	BEREA	B1B2			
60441	THE AVENUE EAST SERVICE STATION	23 - 25	THE AVENUE EAST	PROSPECTON	B2	90000		30000
60907	THE FILLING STATION	251	UMGENI ROAD	UMGENI	B2			
61206	THE LION BUSINESS PARK	892	UMGENI ROAD	UMGENI	D2		0	4500
61286	THE METAL PRESS CO PTY LTD	206	LEICESTER ROAD	MOBENI	D3		3200	800
61336	THE NEW RECLAMATION GROUP	38	JEFFELS ROAD	PROSPECTON	B2			23000
61480	THE RECLAMATION GROUP	148	ABERDARE DRIVE	PHOENIX	B2			4400
61482	THE RECLAMATION GROUP	38	JEFFLES ROAD	PROSPECTON	B2			23000
61622	THE STAMFORD	269	STAMFORD HILL ROAD	STAMFORD HILL	B2	65000		13000
61640	THE STUMP TERMINATOR	819 6	BLESSING MSENGA ROAD	HILLCREST				2000
61876	THEKWINI MARINE SERVICES	14	KOBE ROAD	BAYHEAD	D2			12000
61883	THEKWINI TOYOTA	58	MOORE RD	DURBAN CENTRAL	B2		0	13500
61887	THEKWINI TRUCKING	213	DAYAL ROAD	CLAIRWOOD	B2			
62058	THORNTONS UNITED TRANSPORT	91	ARCHARY RD CLAIRWOOD			0	16500	16500
62054	THORNTONS UNITED TRANSPORT	91	ARCHAR RD			0	17500	17500
62057	THORNTONS UNITED TRANSPORT	91	ARCHARY RD			0	17500	17500
62048	THORNTONS UNITED TRANSPORT	91	ARCHARY RD CLAIRWOOD			0	20000	20000
62051	THORNTONS UNITED TRANSPORT	91	ARCHARY RD CLAIRWOOD			0	22000	22000
62055	THORNTONS UNITED TRANSPORT	91	ARCHARY RD CLAIRWOOD			0	22000	22000
62052	THORNTONS UNITED TRANSPORT	91	ARCHARY RD CLAIRWOOD			0	27500	27500
62059	THORNTONS UNITED TRANSPORT PTY L	91	ARCHARY ROAD CLAIRWOOD			0	20000	20000
62063	THORNWOOD SUPPLY STORE	304	THORNWOOD ROAD	MARIANHILL	F2			9000
62066	THORPROP PROSPCTON	14	OUTER CIRCUIT ROAD	PROSPECTON	B2			69000
62088	THRUTAINERS CONTAINER DEPOT	248	LEICESTER ROAD	MOBENI	G1J3J2	50000	0	14000
62094	THULANI SERVICE STATION		MR 566	XIMBA	B2			
62181	TIGER BRANDS SNACKS & TREATS	36	PHILLIP FRAME STREET	JACOBS	D3B2	9000	0	4500
62256	TIMBER LOAD			BALLITO	B2		23000	
62258	TIMBER LOGISTICS		ROAD MR 197	UMKOMAAS	B2			46000
62442	TOLLGATE MOTORS	563	BEREA ROAD	DURBAN CENTRAL	B2	74000		14000
62516	TONGAAT ESTATE		OFF WATSON HIGHWAY	TONGAAT	B2			9000
62526	TONGAAT FUEL	1	OLD MILL ROAD	AMANZIMUYAMA	F2	27000		18000
62546	TONGAAT HULETTS SUGAR		MAIDSTONE MILL	MAIDSTONE	J2			23000
62629	TONY WATSON SERVICE CENTRE	38 - 52	FLANDERS DRIVE	UMHLANGA	B2		92000	
62657	TONYS SUPERMARKET	3135	PO BOX 5 NQUTU			7280	7280	7280
62662	TOOL & DIE	26	PROSPECTON ROAD	PROSPECTON	J1	3240		2200
62814	TORINO MOTORS	10	STAMFORD HILL ROAD	GREYVILLE	B2	70000	0	10000
62825	TOTAL	1	SOUTH BEREA	UMDLOTI	B2			
62826	TOTAL		NATIONAL 5020	SEA COW LAKE	B1			
62838	TOTAL GARAGE	1	CORONATION ROAD	MITHANAGER	B2			
62839	TOTAL GARAGE		OLD MAIN ROAD	KWAMAKHUTA	B2			
62841	TOTAL GATEWAY	03-Jan	JUBILLE GROVE	UMHLANGA	B2	35000		10000

62850	TOTAL ON BROADWAY	13	BROADWAY	DURBAN NORTH	B1	69000		13000
62851	TOTAL ON RIDGE	546 - 550	RIDGE ROAD	OVERPORT	B2			
62852	TOTAL PINETOWN	55	ESCOM ROAD	NEW GERMANY	B1	52000		35000
62857	TOTAL RISEGATE	1	RISEGATE DRIVE	PHOENIX		69000		23000
62860	TOTAL S A		EFFINGHAM ROAD	EFFENGHAM	B2			
62861	TOTAL S A	48	ALEXANDER ROAD	PINETOWN	B2			
62864	TOTAL SA	320	DENIS HURLEY STREET	CENTRAL	G1			
62865	TOTAL SA			UMKOMAAS	J2			
62866	TOTAL SA	30	DR YUSUF DADOO STREET	CENRAL	B2			
62868	TOTAL SA	7	THE BOULEVARD	WESTVILLE	G1			
62870	TOTAL SERVICE STATION	53	OLD MAIN ROAD	BOTHAS HILL	B2			
62871	TOTAL SERVICE STATION		UMHLANGA ROCKS CENTRE	UMHLANGA	B2			
62872	TOTAL SERVICE STATION		INANDA ROAD	MOUNTVIEW	B1			
62873	TOTAL SERVICE STATION	18	BROAD STREET	CENTRAL	B2			
62874	TOTAL SERVICE STATION		LINK ROAD	UMHLABUYALINGA	J1F2			
62875	TOTAL SERVICE STATION	82	CORONATION STREET		B2			
62876	TOTAL SERVICE STATION	86	PLATT ROAD	ISIPINGO HILLS	B2			
62877	TOTAL SERVICE STATION		SOUTH BEACH ROAD	UMDLOTI	J2			
62896	TOTAL UMBILO	250	UMBILO ROAD	UMBILO	B2			
62897	TOTAL WESTVILLE	35	WESTVILLE ROAD	WESTVILLE	B2J2F2		69000	14000
62932	TOTI FORD & MAZDA	36	ROCKVIEW ROAD	AMANZIMTOTI	D2	67500		9000
63047	TOWNSEND MOTORS	53	SMITH ST			21000	0	5000
63080	TOYOTA SA MOTORS	15-Nov	PROSPECTION ROAD	PROSPECTION	B2		3240	
63097	TRACE CONTRACTORS	1	THE AVENUE EAST	PROSPECTON	G1			2200
63136	TRADE PORT	80	HUNSLETT ROAD	PHOENIX	F1		46000	14000
63147	TRADE UP FRONT	78	LEICESTER ROAD	MOBENI	D1	0	9000	9000
63160	TRADE ZONE CASH & CARRY	16C	CIRCUIT ROAD	WESTMEAD	F1		23000	
63235	TRANS NATAL CARRIERS	798	SEA COW LAKE RD			21000	21000	21000
63259	TRANSITION TRANSPORT	46	HARDEN AVE SEAVIEW			4500	0	13500
63330	TRANSNET RAIL ENGINEERING	401	EDWIN SWALES DRIVE				6500	6500
63337	TRANSPEC NATAL CC	1	ALEXANDER ROAD	WESTMEAD	J2	42000	1000	23000
63359	TRANSWERK	311	EDWIN SWALES DRIVE	CLAIRWOOD	D3	4000	10150	9000
63413	TREASURY DEPARTMENT	21 - 23	ALEXANDER ROAD	WESTMEAD	G1			4500
63429	TREK SERVICE STATION		BEREA ROAD	BEREA	B1			
63474	TRENSTAR	303 - 305	CHAMBERLAIN ROAD	JACOBS	B2		0	46000
63628	TRITON EXPRESS	12	FICUS PLACE	WESTMEAD	J2			23000
63637	TRIVETTES ELECTRICAL SERVICES	2	BALFAST ROAD BAYHEAD			0	0	9000
63653	TROPIC PLASTIC & PACKAGING INDUSTR	320 - 340	CHAMBERLAIN ROAD	JACOBS	D2	14000	8500	19000
63706	TRUCK CENTRE NATAL	49	FENNIS CLOSE	UMBILO	B2			37000
63744	TRULITE CANDLES	57	NORTH COAST ROAD	BRIARDENE	B2	0	0	10000
63848	TSA STAMPING DIVISION	185179 - 1	LEICESTER ROAD	MOBENI	B2J4	0	28000	28000
63950	TURNERS FLEET MAINTENANCE	45	HALIFAX ROAD	PINETOWN	D2D1J2			23000
63954	TURNERS TRANSPORT	17	BLAIR ROAD	NEW GERMANY	B2			65000
64006	TW BECKETT AND CO.	22	MAHATMA GANDHI ROAD			13500	0	4500
64150	U D S MOTORS	48 - 50	ALEXANDER ROAD	WESTMEAD	J1B2	92000		115000
64155	U E C TECHNOLOGIES	1	MOUTGOMERY DRIVE	MT EDGECOMBE	B2			4000
64157	U E C TECHNOLOGY	30	MARSHALL DRIVE	MT EDGECOMBE	B2			18000
64162	U K Z N	276	KING GEORGE V AVENUE	CONGELLA	A3			14000
64287	ULTRA CITY			UMGABABA	B2			
64386	UMDLOTI SERVICE STATION		SOUTH BEACH ROAD	UMDLOTI	B2			
64432	UMGENI ROAD SERVICE STATION	300	CLAIR ROAD	UMGENI	B2			
64440	UMGENI WATER			INANDA	D3			2000
64439	UMGENI WATER	13	PINESIDE ROAD	NEW GERMANY	D2J2G1	5000	1000	9000
64514	UMHLOTI ESTATE		OFF MT MORELAND ROAD	VERULAM	B2			9000
64586	UMLAZI BUS DEPOT		MANGOSUTHU HIGHWAY	UMLAZI	B1			69000
64598	UMLAZI FIRE STATION	W 414	MANGOSUTHU HIGHWAY	UMLAZI	B3	0	0	9000
64619	UMLAZI MEGACITY SERVICE STATION	50	MANGOSUTHU HIGHWAY	UMLAZI	B2	120000		30000
64775	UNILEVER ADVANCE CLEANERS	63	COLUMBINE PLACE	DURBAN NORTH	B2		2200	
64777	UNILEVER CANTEEN	73	MAYDON ROAD	MAYDON WHARF	D2	400	800	40104
64780	UNILEVER ENGINEERING STORES	73	MAYDON ROAD	MAYDON WHARF	D2J1J2	2800	2800	26104
64782	UNILEVER H P C	166	HUNSLETT ROAD	PHOENIX	B2D1	109000	15000	22900
64785	UNILEVER PERSONAL CARE	67	MAYDON ROAD	MAYDON WHARF	D2	2300	2000	20000
64933	UNITAINER	34	SHADWELL RD	MAYDON WHARF	J3		0	32000
64964	UNITED CONTAINER DEPOT	4	ROTTERDAM ROAD	BAYHEAD	J3			2200
65032	UNITRANS	20	IMVUBU PARK CLOSE	RIVERHORSE VALLEY	J2			23000
65031	UNITRANS	45	HARDEN AVENUE	SEAVIEW	J2			56000
65025	UNITRANS	91	ARCHARY ROAD CLAIRWOOD	DURBAN			6500	6500
65018	UNITRANS	18	BERLIYIUM RD			17500	17500	17500
65039	UNITRANS FREIGHT	91	ARCHARY ROAD	CLAIRWOOD	B2			92000
65042	UNITRANS FREIGHT FUEL & CHEM DIV	91	ARCHARY ROAD	JACOBS	B2		4500	92000
65043	UNITRANS FUEL & CHEMICAL	1	DICKENS ROAD	UMBOGINTWINI	G1	300	200	47400
65131	UNITRANS TANKERS	454	CHAMBERLAIN RDJACOBS				6500	6500
65153	UNITY TANKERS	990	QUARRY RD SPRINGFIELD	DURBAN		0	17500	17500
65160	UNIVERSAL CARGO	61	ALPHA CRESCENT	CONGELLA	B2	61500	0	14000
65221	UNTRANS SUGAR	267	STATION ROAD	TONGAAT	B2			93000
65324	USHAKA SERVICE STATION	202	MAHATMA GANDHI ROAD	POINT	B2			
65330	USHUKELA TERMINALS	25	LEUCHARS ROAD					4400
65350	UTILITIES WORKSHOP	1	DICKENS ROAD	TOTI	B2	1000	2000	1000
65391	V E C TECHNOLOGIES	15-Sep	BURNSIDE DRIVE	MT EDGECOMBE	B2			10800
21190		61	NMR AVENUE	UMGENI	B2	69000		23000
31623		2	PROSPECTON ROAD	PROSPECTON	J2			5000
29224		1	DICKENS ROAD	UMBOGINTWINI	D2			2200
21257		230	TEAKWOOD ROAD	JACOBS		45000		20000
21890		106	BLUFF ROAD	JACOBS	B2		25000	34000
21590			STONEBRIDGE MOTORS	STONEBRIDGE PHOENIX		56000		9000
21601		602	GREENBURY SERVICE STATION	REDBERRY ROAD PHOENIX		98000		28000
21723		35	ZEESHAN FUELS	ABERDARE DRIVE PHOENIX				42000
21623		798	VIRANNA'S EXP CO	SEA COW LAKE ROAD				43000
21579		73	VINTNER PLACE	PROSPECTON			9000	46000
21668		6	FOG DISTRIBUTORS	ASHFIELD AVE SPR - PRK			23000	69000
21501		380	EDWIN SWALES DRIVE			0	0	9000
21446		369	MAHATMA GANDHI ROAD			50000	0	4000
21812		250	DENIS HURLEY STREET			33000	33000	33000
21045						226	45000	
21568		16	BURNHAM DRIVE	LA LUCIA			60000	

13.6 APPENDIX F: OCCUPANCY CODES

Class of Occupancy or Building	Occupancy
A1	Entertainment and public assembly
A2	Theatrical and indoor sport
A3	Places of instruction
A4	Worship
A5	Outdoor sport
B1	High risk commercial service
B2	Moderate risk commercial service
B3	Low risk commercial service
C1	Exhibition hall
C2	Museum
D1	High risk industrial
D2	Moderate risk industrial
D3	Low risk industrial
D4	Plant room
E1	Place of detention
E2	Hospital
E3	Other institutional
F1	Large shop
F2	Small shop
F3	Wholesalers store
G1	Office
H1	Hotel
H2	Dormitory
H3	Domestic residence
H4	Dwelling house
J1	High risk storage
J2	Moderate risk storage
J3	Low risk storage
J4	Parking garage

Notes: above information copied verbatim (SANS 0400, 1990).

13.7 APPENDIX G: CONSULTANCY DATA, DATA QUALIFICATION AND NOTES

Site ID No.	Durban / Not Durban	Comm / Ret	Age of Equipment	Sub / Suct	Site Contaminated	Volume Lost	Cause of contamination	Reason for assessment	Bias / No Bias	AST or UST	Tank type	Line type	Number of Tanks
1	D	Retail	60	Unknown	yes	Unknown	Tank hole	Closure	NB	UST	MS	Unknown	6
2	D	Retail	Unknown	Unknown	yes	Unknown	Unknown	Closure	NB	UST	Unknown	Unknown	4
3	D	Commercial	20	Unknown	No	0	Clean site	Closure	NB	UST	MS	Unknown	1
4	ND	Commercial	Unknown	Unknown	Yes	Unknown	Unknown	Ownership transfer	NB	UST	Unknown	Unknown	3
5	D	Retail	Unknown	Unknown	Yes	Unknown	Tank hole	Unknown	B	UST	Unknown	Unknown	4
6	D	Retail	20	Unknown	Yes	3700	Tank hole	Recon	B	UST	MS	unknown	Unknown
7	ND	Retail	23	Submersible	Yes	Unknown	Line leak	Ownership transfer	NB	UST	MS	Unknown	3
8	D	Commercial	15	Unknown	Yes	0	Unknown	Closure	NB	UST	MS	Unknown	1
9	D	Commercial	20	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown	1
10	ND	Retail	Unknown	Unknown	Yes	15000	Line leak	Leak	B	UST	Unknown	Unknown	8
11	ND	Retail	Unknown	Unknown	Yes	Unknown	Line leak	Closure	NB	UST	Unknown	MS	2
12	ND	Commercial	50	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown	1
13	ND	Retail	49	Unknown	Yes	0	Unknown	Revamp	NB	UST	MS	Unknown	5
14	ND	Retail	7	Unknown	yes	0	Unknown	Revamp	NB	UST	GRP	Unknown	5
15	ND	Retail	Unknown	Unknown	yes	0	Unknown	Revamp	NB	UST	GRP	Unknown	5
16	ND	Retail	49	Unknown	yes	0	Unknown	Revamp	NB	UST	MS	Unknown	5
17	ND	Retail	49	Unknown	yes	0	Unknown	Revamp	NB	UST	MS	Unknown	5
18	D	Retail	12	Unknown	Yes	0	Manholes	Closure	NB	UST	MS	Unknown	4
19	D	Retail	Unknown	Unknown	Yes	3000	Line leak	Recon	B	UST	Unknown	Unknown	unknown
20	ND	Retail	30	Unknown	Yes	0	Unknown	Revamp	NB	UST	MS	MS	3
21	D	Retail	Unknown	Unknown	Yes	3200	Line leak and tank hole	Recon	B	UST	MS	MS	5
22	ND	Commercial	20	Unknown	Yes	8000	Tank hole	Recon	B	UST	MS	MS	1
23	D	Commercial	20	Unknown	Yes	0	Unknown	Closure	NB	UST	MS	Unknown	2
24	ND	Retail	Unknown	Unknown	Yes	10000	Tank hole	Recon	B	UST	MS	Unknown	unknown
25	ND	Commercial	Unknown	Suction	Yes	0	Over-fills	Product surfacing	B	UST	Unknown	MS	2
26	ND	Retail	Unknown	Unknown	Yes	Unknown	Line leak	Product surfacing	B	UST	Unknown	Unknown	unknown
27	ND	Retail	30	Unknown	Yes	2500	Tank hole	Ownership transfer	NB	UST	MS	MS	6
28	ND	Retail	Unknown	Unknown	No	0	Clean site	Closure	NB	UST	Unknown	Unknown	10
29	ND	Retail	4	Unknown	Yes	4000	Line leak	Recon	B	UST	Unknown	Dual containment non-ferrous	1
30	D	Retail	Unknown	Unknown	Yes	8500	Unknown	Recon	B	UST	Unknown	MS	5
31	D	Retail	Unknown	Unknown	No	0	Clean site	Closure	NB	UST	MS	MS	4
32	D	Retail	43	Unknown	No	0	Clean site	Revamp	NB	UST	MS	MS	7
33	D	Retail	Unknown	Unknown	Yes	800	Line leak	Recon	B	UST	Unknown	Unknown	unknown
34	D	Commercial	Unknown	Unknown	Yes	360	Line leak	Recon	B	UST	Unknown	Unknown	1
35	D	Retail	35	Unknown	Yes	0	Line leak	Maintenance	B	UST	MS	MS	Unknown
36	ND	Retail	Unknown	Submersible	Yes	5000	Line leak	Product surfacing	B	UST	MS	MS	4
37	ND	Retail	28	Submersible	Yes	14200	Line leak	Product surfacing	B	UST	MS	MS	unknown
38	D	Retail	Unknown	Submersible	Yes	150	Shear valve failure	Product surfacing	B	UST	Unknown	MS	5
39	ND	Commercial	Unknown	Unknown	Yes	0	Line leak	Capacity increase	NB	UST	GRP	MS	2
40	ND	Commercial	unknown	unknown	Yes	0	Fillers	Unknown	B	UST	MS	Unknown	2
41	D	Commercial	10	Suction	No	0	Clean site	Closure	NB	UST	GRP	Unknown	1
42	D	Commercial	Unknown	unknown	Yes	Unknown	Unknown	Closure in place	B	UST	Unknown	Unknown	1
43	D	Retail	Unknown	Submersible	Yes	25000	Line leak	Recon	B	UST	MS	Unknown	6
44	D	Commercial	20	Unknown	Yes	0	Tank hole	Closure in place	B	UST	MS	Unknown	4
45	ND	Commercial	30	Unknown	No	0	Clean site	Closure	NB	UST	MS	Unknown	4
46	D	Retail	30	Unknown	Yes	1818	Tank hole	Water ingress	B	UST	MS	Unknown	2
47	ND	Commercial	20	Suction	Yes	0	Dispensing spillage	Ownership transfer	NB	UST	MS	Unknown	2
48	ND	Commercial	20	Suction	Yes	0	Dispensing spillage	Ownership transfer	NB	UST	MS	Unknown	2
49	ND	Commercial	24	Suction	No	0	Clean site	Ownership transfer	NB	UST	MS	Unknown	2
50	ND	Commercial	30	Unknown	No	0	Clean site	Ownership transfer	NB	UST	MS	Unknown	3
51	ND	Commercial	4	Unknown	No	0	Clean site	Ownership transfer	NB	UST	GRP	Unknown	1
52	ND	Commercial	30	Unknown	Yes	0	Unknown	Ownership transfer	NB	UST	MS	Unknown	2
53	ND	Commercial	30	Unknown	Yes	0	Unknown	Ownership transfer	NB	UST	MS	Unknown	2
54	ND	Commercial	2	Unknown	Yes	0	Former tank	Ownership transfer	NB	UST	GRP	Unknown	1
55	ND	Commercial	24	Unknown	No	0	Clean site	Ownership transfer	NB	UST	MS	Unknown	2
56	D	Retail	Unknown	Unknown	No	Unknown	Clean site	Closure in place	B	UST	Unknown	MS	5
57	ND	Commercial	Unknown	Suction	Yes	Unknown	Line leak	Recon	B	AST	MS	MS	1
58	D	Retail	Unknown	Unknown	Yes	3850	Fillers	Revamp	NB	UST	MS	Unknown	10
59	D	Retail	Unknown	Unknown	Yes	12500	Line leak	Revamp	NB	UST	MS	Unknown	10
60	ND	Retail	Unknown	Unknown	Yes	Unknown	Line leak	Revamp	NB	UST	MS	MS	5
61	ND	Retail	Unknown	Unknown	Yes	Unknown	Dispensing spillage	Revamp	NB	UST	MS	MS	5
62	D	Commercial	unknown	Suction	Yes	0	Line leak	Closure in place	B	UST	Unknown	Unknown	1
63	D	Retail	Unknown	Unknown	Yes	9031	Line leak	Unrelated excavations	B	UST	MS	Unknown	7
64	D	Retail	Unknown	Unknown	Yes	1705	Tank hole	Product surfacing	B	UST	MS	Unknown	7
65	D	Retail	Unknown	Unknown	Yes	Unknown	Unknown	Tank replacement	B	UST	MS	Unknown	7
66	D	Commercial	9	Suction	Yes	0	Unknown	Tank replacement	B	UST	GRP	MS	1
67	D	Commercial	Unknown	Unknown	No	0	Clean site	Ownership transfer	NB	UST	MS	MS	1
68	D	Commercial	26	Unknown	Yes	Unknown	Over-fills	Unknown	B	UST	MS	MS	4
69	D	Commercial	35	Suction	Yes	1100	Line leak	Recon	B	UST	MS	MS	4
70	D	Retail	48	Suction	Yes	2871	Unknown	Unrelated excavations	B	UST	MS	MS	8
71	D	Retail	48	Suction	Yes	1831	Unknown	Unrelated excavations	B	UST	MS	MS	6
72	D	Retail	51	Suction	Yes	4332	Unknown	Unrelated excavations	B	UST	MS	MS	5
73	D	Commercial	26	Unknown	Yes	0	Unknown	Closure	NB	UST	MS	MS	3
74	D	Commercial	30	Unknown	Yes	13000	Tank hole	Tank replacement	B	UST	MS	MS	4
75	ND	Commercial	15	Unknown	No	0	Clean site	Closure	NB	UST	MS	Unknown	1
76	ND	Retail	4	Submersible	Yes	0	Over-fills	Unrelated excavations	B	UST	Unknown	Unknown	5
77	ND	Retail	22	Unknown	Yes	0	Tank hole	Closure	NB	UST	MS	Unknown	5
78	ND	Retail	22	Unknown	Yes	Unknown	Spillage during theft	Closure	NB	UST	MS	Unknown	5
79	ND	Commercial	20	Suction	Yes	607	Line leak	Product surfacing	B	Partially bu	MS	MS	1
80	ND	Retail	unknown	Unknown	Yes	Unknown	Unknown	Ownership transfer	NB	UST	Unknown	Unknown	unknown
81	D	Retail	28	Unknown	Yes	0	Line leak	Water ingress	B	UST	MS	MS	5
82	ND	Commercial	Unknown	Unknown	Yes	Unknown	Manholes	Closure	NB	UST	MS	Unknown	2
83	ND	Retail	Unknown	Suction	Yes	unknown	Line leak and tank hole	Tank replacement	B	UST	MS	Unknown	2
84	D	Retail	15	Submersible	Yes	0	Unknown	Tank replacement	B	UST	MS	Unknown	5
85	D	Retail	15	Submersible	Yes	0	Tank hole	Tank replacement	B	UST	MS	Unknown	5
86	ND	Retail	17	Suction	Yes	Unknown	Tank hole	Unrelated excavations	B	UST	MS	Unknown	3
87	D	Retail	Unknown	Unknown	Yes	0	Unknown	Closure	NB	UST	MS	MS	5
88	D	Commercial	20	Unknown	Yes	Unknown	Line leak	Tank replacement	B	UST	MS	MS	2
89	ND	Retail	Unknown	Unknown	Yes	Unknown	Former tank	Audit	NB	UST	Unknown	Unknown	3
90	D	Retail	Unknown	Suction	Yes	1000	Tank hole	Recon	B	UST	MS	Unknown	6
91	D	Retail	35	Submersible	Yes	1500	Over-fills	Over-fills	B	UST	MS	Unknown	5
92	ND	Commercial	10	Unknown	Yes	Unknown	Line leak	Closure	NB	UST	MS	MS	5
93	ND	Commercial	10	Unknown	Yes	Unknown	Tank hole	Closure	NB	UST	MS	MS	5

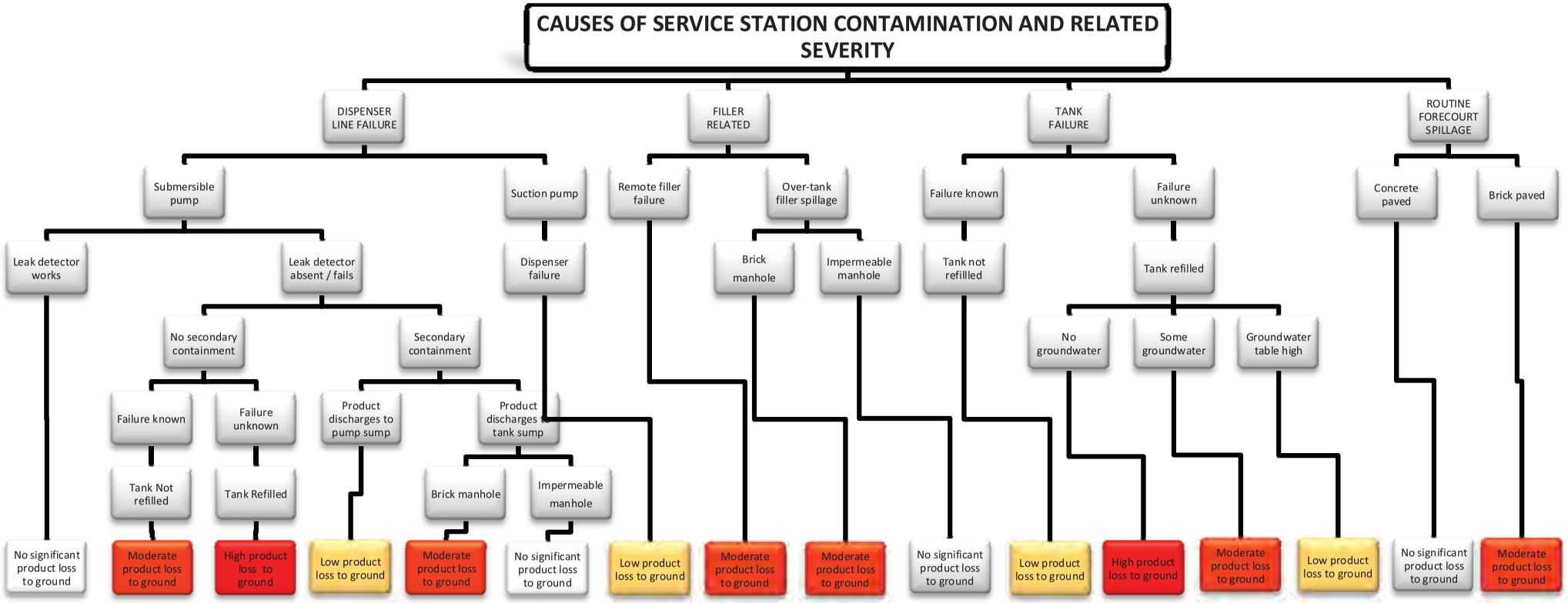
94	D	Commercial	Unknown	Suction	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown		1
95	D	Commercial	26	Unknown	Yes	0	Unknown	Closure	NB	UST	MS	MS		1
96	ND	Commercial	30	Line pressurisec	Yes	18500	Line leak	Closure	NB	UST	MS	MS		2
97	D	Commercial	15	Unknown	Yes	Unknown	Tank hole	Closure	NB	UST	MS	MS		2
98	ND	Commercial	15	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	MS		2
99	ND	Commercial	10	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	GRP	MS		2
100	D	Commercial	27	Suction	Yes	0	Line leak	Unknown	B	UST	MS	MS	unknown	
101	D	Retail	29	Unknown	Yes	0	Tank hole	Closure	NB	UST	MS	MS		6
102	ND	Commercial	Unknown	Suction	No	0	Clean site	Closure	NB	AST	MS	MS		5
103	ND	Retail	16	Suction	Yes	0	Tank hole	Unrelated excavations	B	UST	Unknown	Unknown		5
104	ND	Retail	25	Unknown	Yes	2000	Unknown	Tank replacement	B	UST	MS	Unknown		6
105	D	Retail	15	Suction	Yes	14825	Fillers	Product surfacing	B	UST	Unknown	Unknown		6
106	D	Retail	Unknown	Suction	Yes	0	Fillers	Vapour intrusion	B	UST	Unknown	MS		4
107	ND	Retail	25	Unknown	Yes	0	Line leak	Revamp	NB	UST	MS	MS		8
108	ND	Retail	20	Unknown	Yes	0	Unknown	Revamp	NB	UST	MS	Unknown		8
109	ND	Retail	40	Unknown	Yes	Unknown	Tank hole	Revamp	NB	UST	MS	Unknown		8
110	ND	Commercial	12.5	Unknown	Yes	Unknown	Line leak	Product surfacing	B	UST	MS	MS		2
111	ND	Commercial	30	Unknown	Yes	0	Line leak	Closure	NB	UST	MS	MS		2
112	ND	Commercial	10	Suction	No	0	Clean site	Closure	NB	UST	GRP	Unknown		3
113	D	Retail	Unknown	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown		4
114	ND	Commercial	25	Suction	Yes	0	Tank hole	Water ingress	B	UST	MS	Unknown		1
115	ND	Retail	40	Unknown	Yes	0	Tank hole	Tank replacement	B	UST	Unknown	MS		5
116	ND	Commercial	1	Suction	No	0	Clean site	Audit	NB	AST	MS	MS		3
117	ND	Retail	9	Submersible	Yes	3348	Unknown	Unrelated excavations	B	UST	GRP	MS and non ferrous		5
118	D	Retail	19	Submersible	Yes	15708	Line leak	Closure	NB	UST	MS	MS		4
119	D	Retail	21	Submersible	Yes	25413	Tank hole	Closure	NB	UST	MS	MS		4
120	D	Commercial	1	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	GRP	Unknown		2
121	D	Retail	30	Submersible	Yes	17307	Line leak	Recon	B	UST	MS	MS		5
122	D	Retail	30	Submersible	Yes	1459	Unknown	Recon	B	UST	MS	MS		5
123	D	Commercial	37	Suction	Yes	Unknown	Over-fills	Unrelated excavations	B	UST	MS	MS		3
124	D	Commercial	20	Suction	Yes	0	Line leak	Product surfacing	B	UST	MS	Unknown		4
125	D	Retail	18	Submersible	Yes	Unknown	Line leak	Contaminated drinking water	B	UST	MS	Unknown		4
126	ND	Retail	10	Submersible	Yes	7000	Line leak	Recon	B	UST	Unknown	Single containment non-ferrous		5
127	ND	Retail	5	Unknown	No	0	Clean site	Closure	NB	UST	GRP	Single containment non-ferrous		3
128	D	Commercial	25	Suction	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown		3
129	ND	Commercial	Unknown	Suction	Yes	9000	Line leak	Recon	B	AST	MS	Unknown		2
130	ND	Retail	40	Suction	Yes	Unknown	Fillers	Unknown	B	UST	MS	Unknown		3
131	ND	Retail	10	Unknown	Yes	Unknown	Line leak	Unknown	B	UST	Unknown	Unknown		5
132	ND	Commercial	32	Unknown	No	100	Line leak	Ownership transfer	NB	UST	MS	Unknown		4
133	ND	Commercial	unknown	Suction	No	Unknown	Clean site	Closure	NB	UST	MS	Unknown		1
134	ND	Commercial	5	Suction	No	0	Tank hole	Closure	NB	UST	MS	Unknown		3
135	ND	Retail	20	Suction	Yes	Unknown	Line leak	Revamp	NB	UST	MS	MS		4
136	ND	Retail	20	Suction	Yes	0	Tank hole	Revamp	NB	UST	MS	MS		4
137	ND	Retail	21	Suction	Yes	Unknown	Line leak	Closure	NB	UST	MS	MS		6
138	ND	Retail	21	Suction	Yes	Unknown	Fillers	Closure	NB	UST	MS	MS		6
139	ND	Retail	19	Suction	Yes	Unknown	Line leak	Closure	NB	UST	MS	MS		6
140	D	Retail	22	Suction	Yes	Unknown	Line leak	Closure	NB	UST	MS	MS		4
141	ND	Commercial	3	Submersible	No	0	Clean site	Ownership transfer	NB	UST	Double walled	Unknown		1
142	ND	Retail	Unknown	Suction	Yes	Unknown	Tank hole	Recon	B	UST	MS	MS		4
143	D	Commercial	Unknown	unknown	Yes	Unknown	Unknown	Tank replacement	B	UST	Unknown	Dual containment non-ferrous		2
144	D	Commercial	Unknown	Unknown	Yes	0	Unknown	Closure	NB	UST	MS	Unknown		2
145	D	Commercial	8	Suction	No	0	Clean site	Ownership transfer	NB	UST	GRP	MS		1
146	D	Commercial	7	Suction	Yes	0	Dispensing spillage	Ownership transfer	NB	UST	GRP	MS		1
147	ND	Commercial	25	unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown		3
148	D	Commercial	3	Suction	No	0	Clean site	Audit	NB	AST	MS	Unknown		1
149	D	Commercial	23	Suction	Yes	0	Line leak	Closure	NB	UST	MS	MS		2
150	D	Commercial	7	Suction	No	0	Clean site	Closure	NB	UST	GRP	Unknown		1
151	D	Commercial	8	Suction	Yes	0	Manholes	Ownership transfer	NB	UST	Unknown	Single containment non-ferrous		1
152	D	Commercial	20	Suction	Yes	Unknown	Unknown	Ownership transfer	NB	UST	MS	Unknown		2
153	ND	Commercial	20	Unknown	Yes	0	Tank hole	Water ingress	B	UST	MS	Unknown		1
154	ND	Retail	38	Suction	Yes	0	Unknown	Tank replacement	B	UST	MS	Unknown		7
155	ND	Retail	17	Suction	Yes	0	Unknown	Tank replacement	B	UST	GRP	Unknown		7
156	ND	Retail	Unknown	Unknown	Yes	0	Manholes	Tank replacement	B	UST	GRP	Unknown		5
157	ND	Retail	12	Submersible	Yes	1600	Line leak	Recon	B	UST	GRP	MS		4
158	ND	Retail	30	Submersible	Yes	12000	Line leak	Recon	B	UST	MS	Unknown		3
159	ND	Retail	30	Submersible	Yes	12000	Line leak	Recon	B	UST	MS	Unknown		3
160	ND	Commercial	28	Suction	Yes	0	Over-fills	Ownership transfer	NB	UST	MS	Unknown		2
161	ND	Commercial	Unknown	Suction	No	0	Clean site	Closure	NB	UST	MS	Unknown		4
162	ND	Commercial	11	Unknown	Yes	0	Dispensing spillage	Ownership transfer	NB	UST	GRP	Unknown		7
163	ND	Commercial	10	Suction	No	0	Clean site	Ownership transfer	NB	UST	GRP	MS		1
164	ND	Commercial	10	Suction	No	0	Clean site	Ownership transfer	NB	UST	GRP	MS		1
165	D	Retail	60	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown		3
166	D	Retail	15	Unknown	No	Unknown	Clean site	Closure	NB	UST	MS	Unknown		3
167	ND	Retail	24	Unknown	No	Unknown	Clean site	Closure	NB	UST	MS	Unknown	unknown	
168	ND	Retail	18	unknown	Yes	Unknown	Spillage during closure	Closure	NB	UST	MS	Unknown		5
169	ND	Retail	18	unknown	Yes	unknown	Unknown	Product surfacing	B	UST	MS	Unknown	unknown	
170	ND	Retail	25	Suction	Yes	Unknown	Unknown	Product surfacing	B	UST	MS	Unknown		5
171	ND	Retail	25	Unknown	No	unknown	Clean site	Closure	NB	UST	MS	Unknown		3
172	ND	Retail	Unknown	Unknown	Yes	Unknown	Line leak	Product surfacing	B	UST	Unknown	Unknown	unknown	
173	D	Retail	6	Unknown	No	Unknown	Clean site	Closure	NB	UST	MS	Unknown		3
174	D	Commercial	30	unknown	Yes	unknown	Tank hole	Closure	NB	UST	MS	Unknown		6
175	ND	Retail	24	Unknown	Yes	Unknown	Line leak	Closure	NB	UST	MS	Unknown		6
176	ND	Retail	30	Unknown	No	Unknown	Clean site	Closure	NB	UST	MS	unknown		3
177	D	Retail	25	Unknown	No	Unknown	Clean site	Closure	NB	UST	MS	Unknown		4
178	D	Retail	unknown	Unknown	Yes	Unknown	Tank hole	Product surfacing	B	UST	MS	Unknown		5
179	D	Commercial	13	Unknown	No	Unknown	Clean site	Closure	NB	UST	MS	Unknown		3
180	D	Commercial	15	unknown	Yes	Unknown	Manholes	Closure	NB	UST	MS	Unknown		1
181	D	Commercial	20	unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown		1
182	D	Commercial	30	Unknown	Yes	Unknown	Tank hole	Closure	NB	UST	MS	Unknown		1
183	ND	Retail	30	Unknown	Yes	0	Tank hole	Unknown	B	UST	MS	Unknown		3
184	D	Retail	30	unknown	yes	unknown	manholes	closure	NB	UST	MS	Unknown		3
185	D	Commercial	30	Unknown	No	0	Clean site	Closure	NB	UST	MS	MS		3
186	ND	Commercial	20	Unknown	Yes	Unknown	Line leak	Product surfacing	B	UST	MS	MS		3
187	ND	Commercial	13	Unknown	Yes	900	Tank hole	Recon	B	UST	MS	Unknown		1
188	D	Commercial	30	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown		3
189	ND	Retail	6	Unknown	Yes	Unknown	Tank hole	Water ingress	B	UST	GRP	Unknown		6
190	ND	Retail	5	Unknown	Yes	Unknown	Line leak	Unknown	B	UST	GRP	MS		6
191	D	Commercial	20	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	MS		5
192	ND	Commercial	15	Unknown	Yes	Unknown	Tank hole	Closure	NB	UST	MS	MS		2
193	D	Retail	20	Unknown	Yes	unknown	Tank hole	Water ingress	B	UST	MS	MS		3
194	D	Retail	20	Unknown	Yes	Unknown	Line leak	Recon	B	UST	MS	MS		6

195	ND	Commercial	20	unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	unknown	1
196	D	Retail	20	Unknown	Yes	Unknown	Unknown	Closure	NB	UST	MS	Unknown	8
197	D	Commercial	3	unknown	No	Unknown	Clean site	Closure	NB	UST	GRP	Dual containment non-ferrous	2
198	ND	Commercial	20	Unknown	Yes	Unknown	unknown	Closure	NB	UST	MS	Unknown	1
199	ND	Retail	Unknown	Unknown	No	Unknown	Clean site	Audit	NB	UST	Unknown	Unknown	3
200	ND	Retail	Unknown	Unknown	No	Unknown	clean site	Closure	NB	UST	Unknown	Unknown	4
201	ND	Retail	Unknown	Unknown	No	0	Clean site	Closure	NB	UST	Unknown	unknown	4
202	D	Commercial	25	Unknown	No	unknown	Clean site	Tank replacement	B	UST	MS	Unknown	2
203	D	Commercial	Unknown	Unknown	No	0	Clean site	Capacity increase	NB	AST	MS	Unknown	1
204	D	Commercial	17.5	Unknown	Yes	0	unknown	Audit	NB	UST	Unknown	Unknown	7
205	ND	Commercial	3	Unknown	No	0	Clean site	Audit	NB	AST	MS	Unknown	9
206	D	Commercial	10	unknown	Yes	unknown	Line leak	Audit	NB	AST	MS	Unknown	2
207	ND	Commercial	5	Unknown	Yes	0	Manholes	Audit	NB	UST	Unknown	Unknown	1
208	D	Retail	12	unknown	Yes	1837	Line leak	Recon	B	UST	Unknown	Unknown	4
209	D	Commercial	Unknown	Unknown	No	unknown	Clean site	Closure	NB	UST	Unknown	Unknown	1
210	D	Retail	9	Unknown	Yes	10000	Line leak	Recon	B	UST	Unknown	Unknown	6
211	ND	Commercial	25	Unknown	No	0	Tank hole	closure	NB	UST	unknown	Unknown	1
212	D	Retail	Unknown	Unknown	Yes	unknown	Unknown	revamp	NB	UST	Unknown	Unknown	3
213	ND	Commercial	0	Suction	Yes	5000	Line leak	Product surfacing	B	AST	MS	MS	4
214	D	Commercial	22	unknown	Yes	0	Manholes	Closure	NB	UST	MS	MS	2
215	D	retail	20	Unknown	Yes	0	unknown	Revamp	NB	UST	MS	unknown	6
216	D	Retail	20	unknown	Yes	unknown	unknown	Closure	NB	UST	MS	Unknown	5
217	ND	Commercial	Unknown	Suction	Yes	Unknown	Dispenser	Product surfacing	B	UST	MS	MS	2
218	ND	Retail	18	unknown	Yes	Unknown	Line leak	Ownership transfer	NB	UST	MS	Unknown	4
219	ND	Retail	11	Submersible	Yes	Unknown	Line leak	Leak detector closed line	B	UST	Unknown	Unknown	8
220	D	Retail	7	Submersible	Yes	1000	Line leak	Recon	B	UST	GRP	Unknown	4
221	D	Commercial	20	Unknown	No	0	Clean site	Closure	NB	UST	MS	MS	2
222	D	Commercial	30	Unknown	No	0	Clean site	Closure	NB	UST	MS	MS	2
223	ND	Commercial	Unknown	Unknown	Yes	Unknown	Line leak	Closure	NB	UST	Unknown	Unknown	2
224	D	Retail	13	Submersible	No	0	Clean site	Closure	NB	UST	MS	MS	5
225	ND	Commercial	Unknown	Unknown	Yes	Unknown	Unknown	Ownership transfer	NB	UST	GRP	MS	1
226	ND	Commercial	Unknown	Suction	No	Unknown	Clean site	closure	NB	UST	MS	MS	2
227	ND	Commercial	16	Suction	Yes	0	Unknown	Closure	NB	UST	MS and GRP	Unknown	2
228	D	Commercial	2	Unknown	No	0	Clean site	Ownership transfer	NB	UST	Permatank	Dual containment non-ferrous	1
229	D	Commercial	17	Unknown	No	0	clean site	Ownership transfer	NB	UST	MS	Unknown	1

CONSULTANCY DATA QUALIFICATIONS AND NOTES

1. A line leak always refers to a dispensing line leak not a filler line leak.
2. In some isolated cases the age of equipment failure may be exaggerated when the age of actual failure is unknown. The age may therefore represent the age of equipment as at removal and not failure. Where age of actual failure is known however, it has been recorded as this.
3. Where age was known to be greater than a particular figure, the minimum age has been used for statistical purposes.
4. Certain sites have volume lost recorded as zero, and yet the site is contaminated. This discrepancy can be as a result of a number of factors, including losses that occurred prior to the occupancy by the current dealer.
5. Numerous sites have a combination of tank and line types. Where a failure occurred, the tank or line type that failed has been recorded.
6. Line leaks beneath the dispenser have been classified as line leaks.
7. Age of equipment refers to age of installation and not age of equipment. In isolated cases, used ASTs were known to have been used.
8. Unknown volume lost may be a result of numerous factors, not presented here.
9. Data discrepancies may have occurred as a result of different analytical techniques, such as the dated TPH IR Method 418.1 compared with the current EPA Method 8015.
10. The tank hole description includes holes caused by tank chaffing on the tank manhole.
11. In cases where more than one tank failed on the same site but at different dates, this has been recorded more than once. Similarly, sites with tanks of known age differences have been recorded more than once.
12. Tank failure does not necessarily imply contamination to have occurred. In cases where underlying clay material occurs, this material can prevent the discharge of product from the tank.
13. Line failure does not necessarily imply contamination, particularly in cases where the line failure is affiliated with a suction pump. This failure results in the ingress of air into the line and dispensing of product does not occur.

13.8 APPENDIX H: FAULT TREE OF CAUSES OF CONTAMINATION AND RELATED SEVERITY


CAUSES OF SERVICE STATION CONTAMINATION AND RELATED SEVERITY
DISPENSER LINE FAILURE
FILLER RELATED
TANK FAILURE
ROUTINE FORECOURT SPILLAGE
Submersible pump
Suction pump
Remote filler failure
Over-tank filler spillage
Failure known
Failure unknown
Concrete paved
Brick paved
Leak detector works
Leak detector absent / fails
Dispenser failure
Brick manhole
Impermeable manhole
Tank not refillled
Tank refilled
No secondary containment
Secondary containment
No groundwater
Some groundwater
Groundwater table high
Failure known
Failure unknown
Product discharges to pump sump
Product discharges to tank sump
Tank Not refilled
Tank Refilled
Brick manhole
Impermeable manhole
No significant product loss to ground
Moderate product loss to ground
High product loss to ground
Low product loss to ground
Moderate product loss to ground
No significant product loss to ground
Low product loss to ground
Moderate product loss to ground
Moderate product loss to ground
No significant product loss to ground
Low product loss to ground
High product loss to ground
Moderate product loss to ground
Low product loss to ground
No significant product loss to ground
Moderate product loss to ground

13.9 APPENDIX I: CODED DATA VARIABLES

Site ID No.	SITE TYPE Commercial (0) Ret (1)	AGE OF EQUIPMENT Unknown (0) Known (1-60)	PUMP TYPE Unknown (0) Suction (1) Submersible (2)	CONTAMINATION STATUS Not Contaminated (0) Contaminated (1)	POSITION Aboveground (0) Underground (1)	TANK TYPE Unknown (0) Mild Steel (1) GRP (2)	LINE TYPE Unknown (0) Mild Steel (1) Single Containment Non Ferrous (2) Dual Containment Non Ferrous (3)	NUMBER OF TANKS Unknown (0) Known (1-10)
1	1	60	0	1	1	1	0	6
2	1	0	0	1	1	0	0	4
3	0	20	0	0	1	1	0	1
4	0	0	0	1	1	0	0	3
5	1	0	0	1	1	0	0	4
6	1	20	0	1	1	1	0	0
7	1	23	2	1	1	1	0	3
8	0	15	0	1	1	1	0	1
9	0	20	0	1	1	1	0	1
10	1	0	0	1	1	0	0	8
11	1	0	0	1	1	0	1	2
12	0	50	0	1	1	1	0	1
13	1	49	0	1	1	1	0	5
14	1	7	0	1	1	2	0	5
15	1	0	0	1	1	2	0	5
16	1	49	0	1	1	1	0	5
17	1	49	0	1	1	1	0	5
18	1	12	0	1	1	1	0	4
19	1	0	0	1	1	0	0	0
20	1	30	0	1	1	1	1	3
21	1	0	0	1	1	1	1	5
22	0	20	0	1	1	1	1	1
23	0	20	0	1	1	1	0	2
24	1	0	0	1	1	1	0	0
25	0	0	1	1	1	0	1	2
26	1	0	0	1	1	0	0	0
27	1	30	0	1	1	1	1	6
28	1	0	0	0	1	0	0	10
29	1	4	0	1	1	0	3	1
30	1	0	0	1	1	0	1	5
31	1	0	0	0	1	1	1	4
32	1	43	0	0	1	1	1	7
33	1	0	0	1	1	0	0	0
34	0	0	0	1	1	0	0	1
35	1	35	0	1	1	1	1	0
36	1	0	2	1	1	1	1	4
37	1	28	2	1	1	1	1	0
38	1	0	2	1	1	0	1	5
39	0	0	0	1	1	2	1	2
40	0	0	0	1	1	1	0	2
41	0	10	1	0	1	2	0	1
42	0	0	0	1	1	0	0	1
43	1	0	2	1	1	1	0	6
44	0	20	0	1	1	1	0	4
45	0	30	0	0	1	1	0	4
46	1	30	0	1	1	1	0	2
47	0	20	1	1	1	1	0	2
48	0	20	1	1	1	1	0	2
49	0	24	1	0	1	1	0	2
50	0	30	0	0	1	1	0	3
51	0	4	0	0	1	2	0	1
52	0	30	0	1	1	1	0	2
53	0	30	0	1	1	1	0	2
54	0	2	0	1	1	2	0	1
55	0	24	0	0	1	1	0	2
56	1	0	0	0	1	0	1	5
57	0	0	1	1	0	1	1	1
58	1	0	0	1	1	1	0	10
59	1	0	0	1	1	1	0	10
60	1	0	0	1	1	1	1	5
61	1	0	0	1	1	1	1	5
62	0	0	1	1	1	0	0	1
63	1	0	0	1	1	1	0	7
64	1	0	0	1	1	1	0	7
65	1	0	0	1	1	1	0	7
66	0	9	1	1	1	2	1	1
67	0	0	0	0	1	1	1	1
68	0	26	0	1	1	1	1	4
69	0	35	1	1	1	1	1	4
70	1	48	1	1	1	1	1	8
71	1	48	1	1	1	1	1	6
72	1	51	1	1	1	1	1	5
73	0	26	0	1	1	1	1	3
74	0	30	0	1	1	1	1	4
75	0	15	0	0	1	1	0	1
76	1	4	2	1	1	0	0	5
77	1	22	0	1	1	1	0	5
78	1	22	0	1	1	1	0	5
79	0	20	1	1	1	1	1	1
80	1	0	0	1	1	0	0	0
81	1	28	0	1	1	1	1	5
82	0	0	0	1	1	1	0	2
83	1	0	1	1	1	1	0	2
84	1	15	2	1	1	1	0	5
85	1	15	2	1	1	1	0	5
86	1	17	1	1	1	1	0	3
87	1	0	0	1	1	1	1	5
88	0	20	0	1	1	1	1	2
89	1	0	0	1	1	0	0	3
90	1	0	1	1	1	1	0	6
91	1	35	2	1	1	1	0	5

92	0	10	0	1	1	1	1	5
93	0	10	0	1	1	1	1	5
94	0	0	1	1	1	1	0	1
95	0	26	0	1	1	1	1	1
96	0	30	2	1	1	1	1	2
97	0	15	0	1	1	1	1	2
98	0	15	0	1	1	1	1	2
99	0	10	0	1	1	2	1	2
100	0	27	1	1	1	1	1	0
101	1	29	0	1	1	1	1	6
102	0	0	1	0	0	1	1	5
103	1	16	1	1	1	0	0	5
104	1	25	0	1	1	1	0	6
105	1	15	1	1	1	0	0	6
106	1	0	1	1	1	0	1	4
107	1	25	0	1	1	1	1	8
108	1	20	0	1	1	1	0	8
109	1	40	0	1	1	1	0	8
110	0	12.5	0	1	1	1	1	2
111	0	30	0	1	1	1	1	2
112	0	10	1	0	1	2	0	3
113	1	0	0	1	1	1	0	4
114	0	25	1	1	1	1	0	1
115	1	40	0	1	1	0	1	5
116	0	1	1	0	0	1	1	3
117	1	9	2	1	1	2	1	5
118	1	19	2	1	1	1	1	4
119	1	21	2	1	1	1	1	4
120	0	1	0	1	1	2	0	2
121	1	30	2	1	1	1	1	5
122	1	30	2	1	1	1	1	5
123	0	37	1	1	1	1	1	3
124	0	20	1	1	1	1	0	4
125	1	18	2	1	1	1	0	4
126	1	10	2	1	1	0	2	5
127	1	5	0	0	1	2	2	3
128	0	25	1	1	1	1	0	3
129	0	0	1	1	0	1	0	2
130	1	40	1	1	1	1	0	3
131	1	10	0	1	1	0	0	5
132	0	32	0	0	1	1	0	4
133	0	0	1	0	1	1	0	1
134	0	5	1	0	1	1	0	3
135	1	20	1	1	1	1	1	4
136	1	20	1	1	1	1	1	4
137	1	21	1	1	1	1	1	6
138	1	21	1	1	1	1	1	6
139	1	19	1	1	1	1	1	6
140	1	22	1	1	1	1	1	4
141	0	3	2	0	1	2	0	1
142	1	0	1	1	1	1	1	4
143	0	0	0	1	1	0	3	2
144	0	0	0	1	1	1	0	2
145	0	8	1	0	1	2	1	1
146	0	7	1	1	1	2	1	1
147	0	25	0	1	1	1	0	3
148	0	3	1	0	0	1	0	1
149	0	23	1	1	1	1	1	2
150	0	7	1	0	1	2	0	1
151	0	8	1	1	1	0	2	1
152	0	20	1	1	1	1	0	2
153	0	20	0	1	1	1	0	1
154	1	38	1	1	1	1	0	7
155	1	17	1	1	1	2	0	7
156	1	0	0	1	1	2	0	5
157	1	12	2	1	1	2	1	4
158	1	30	2	1	1	1	0	3
159	1	30	2	1	1	1	0	3
160	0	28	1	1	1	1	0	2
161	0	0	1	0	1	1	0	4
162	0	11	0	1	1	2	0	7
163	0	10	1	0	1	2	1	1
164	0	10	1	0	1	2	1	1
165	1	60	0	1	1	1	0	3
166	1	15	0	0	1	1	0	3
167	1	24	0	0	1	1	0	0
168	1	18	0	1	1	1	0	5
169	1	18	0	1	1	1	0	0
170	1	25	1	1	1	1	0	5
171	1	25	0	0	1	1	0	3
172	1	0	0	1	1	0	0	0
173	1	6	0	0	1	1	0	3
174	0	30	0	1	1	1	0	6
175	1	24	0	1	1	1	0	6
176	1	30	0	0	1	1	0	3
177	1	25	0	0	1	1	0	4
178	1	0	0	1	1	1	0	5
179	0	13	0	0	1	1	0	3
180	0	15	0	1	1	1	0	1
181	0	20	0	1	1	1	0	1
182	0	30	0	1	1	1	0	1
183	1	30	0	1	1	1	0	3
184	1	30	0	1	1	1	0	3
185	0	30	0	0	1	1	1	3
186	0	20	0	1	1	1	1	3
187	0	13	0	1	1	1	0	1
188	0	30	0	1	1	1	0	3
189	1	6	0	1	1	2	0	6

190	1	5	0	1	1	2	1	6
191	0	20	0	1	1	1	1	5
192	0	15	0	1	1	1	1	2
193	1	20	0	1	1	1	1	3
194	1	20	0	1	1	1	1	6
195	0	20	0	1	1	1	0	1
196	1	20	0	1	1	1	0	8
197	0	3	0	0	1	2	3	2
198	0	20	0	1	1	1	0	1
199	1	0	0	0	1	0	0	3
200	1	0	0	0	1	0	0	4
201	1	0	0	0	1	0	0	4
202	0	25	0	0	1	1	0	2
203	0	0	0	0	0	1	0	1
204	0	17.5	0	1	1	0	0	7
205	0	3	0	0	0	1	0	9
206	0	10	0	1	0	1	0	2
207	0	5	0	1	1	0	0	1
208	1	12	0	1	1	0	0	4
209	0	0	0	0	1	0	0	1
210	1	9	0	1	1	0	0	6
211	0	25	0	0	1	0	0	1
212	1	0	0	1	1	0	0	3
213	0	0	1	1	0	1	1	4
214	0	22	0	1	1	1	1	2
215	1	20	0	1	1	1	0	6
216	1	20	0	1	1	1	0	5
217	0	0	1	1	1	1	1	2
218	1	18	0	1	1	1	0	4
219	1	11	2	1	1	0	0	8
220	1	7	2	1	1	2	0	4
221	0	20	0	0	1	1	1	2
222	0	30	0	0	1	1	1	2
223	0	0	0	1	1	0	0	2
224	1	13	2	0	1	1	1	5
225	0	0	0	1	1	2	1	1
226	0	0	1	0	1	1	1	2
227	0	16	1	1	1	1	0	2
228	0	2	0	0	1	2	3	1
229	0	17	0	0	1	1	0	1

13.10 APPENDIX J: LOGISTIC REGRESSION MODEL RESULTS

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (ALL VARIABLES)

The LOGISTIC Procedure

Model Information

Data Set	WORK.CONTAM
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	229
Number of Observations Used	229

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	179
2	0	50

Probability modeled is contaminated=1.

Class Level Information

Class	Value	Design Variables		
tanktype	0	1	0	
	1	0	0	
	2	0	1	
linetype	0	1	0	0
	1	0	0	0
	2	0	1	0
	3	0	0	1
pumptype	0	1	0	
	1	0	0	
	2	0	1	

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

The LOGISTIC Procedure

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	242.358	237.708
SC	245.792	275.479
-2 Log L	240.358	215.708

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (ALL VARIABLES)

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	24.6503	10	0.0060
Score	24.9872	10	0.0054
Wald	21.2285	10	0.0196

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
sitetype	1	3.1618	0.0754
position	1	3.8277	0.0504
tanktype	2	4.6048	0.1000
pumptype	2	1.2071	0.5469
linetype	3	2.2827	0.5159
notanks	1	0.6278	0.4282

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.1176	0.7817	0.0226	0.8805
sitetype		1	0.7780	0.4376	3.1618	0.0754
position		1	1.4745	0.7536	3.8277	0.0504
tanktype	0	1	0.1396	0.5092	0.0752	0.7840
tanktype	2	1	-0.9608	0.4780	4.0404	0.0444
pumptype	0	1	-0.2226	0.4155	0.2870	0.5922
pumptype	2	1	0.6046	0.8647	0.4889	0.4844
linetype	0	1	-0.4978	0.3869	1.6550	0.1983
linetype	2	1	-1.1562	1.3799	0.7021	0.4021
linetype	3	1	-1.0219	1.1723	0.7598	0.3834
notanks		1	0.0763	0.0962	0.6278	0.4282

The LOGISTIC Procedure

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
sitetype	2.177	0.924	5.133
position	4.369	0.997	19.136
tanktype 0 vs 1	1.150	0.424	3.119
tanktype 2 vs 1	0.383	0.150	0.976
pumptype 0 vs 1	0.800	0.355	1.807
pumptype 2 vs 1	1.831	0.336	9.968

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (ALL VARIABLES)

linetype 0 vs 1	0.608	0.285	1.298
linetype 2 vs 1	0.315	0.021	4.704
linetype 3 vs 1	0.360	0.036	3.582
notanks	1.079	0.894	1.303

Association of Predicted Probabilities and Observed Responses

Percent Concordant	70.7	Somers' D	0.430
Percent Discordant	27.7	Gamma	0.437
Percent Tied	1.7	Tau-a	0.147
Pairs	8950	c	0.715

Partition for the Hosmer and Lemeshow Test

		contaminated = 1		contaminated = 0	
Group	Total	Observed	Expected	Observed	Expected
1	23	11	10.88	12	12.12
2	20	13	13.05	7	6.95
3	25	18	17.50	7	7.50
4	21	15	15.64	6	5.36
5	25	20	19.93	5	5.07
6	24	19	20.01	5	3.99
7	23	20	19.81	3	3.19
8	23	23	20.42	0	2.58
9	23	19	21.05	4	1.95
10	22	21	20.71	1	1.29

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
5.7997	8	0.6697

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1 Supplementary Information)

The LOGISTIC Procedure

Model Information

Data Set	WORK.CONTAM
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	229
Number of Observations Used	229

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	179
2	0	50

Probability modeled is contaminated=1.

Class Level Information

Class	Value	Design Variables	
tanktype	0	1	0
	1	0	0
	2	0	1
pumptype	0	1	0
	1	0	0
	2	0	1

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

The LOGISTIC Procedure

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	242.358	232.880
SC	245.792	256.916
-2 Log L	240.358	218.880

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1 Supplementary Information)

Likelihood Ratio	21.4787	6	0.0015
Score	22.0278	6	0.0012
Wald	19.2187	6	0.0038

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
sitetype	1	6.3937	0.0115
position	1	3.5435	0.0598
tanktype	2	5.1648	0.0756
pumptype	2	1.6158	0.4458

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.1239	0.6851	0.0327	0.8565
sitetype		1	0.9465	0.3743	6.3937	0.0115
position		1	1.3872	0.7369	3.5435	0.0598
tanktype	0	1	-0.0886	0.4822	0.0338	0.8542
tanktype	2	1	-1.0412	0.4612	5.0981	0.0240
pumptype	0	1	-0.3016	0.4036	0.5585	0.4548
pumptype	2	1	0.5861	0.8575	0.4672	0.4943

The LOGISTIC Procedure

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
sitetype	2.577	1.237	5.366
position	4.003	0.944	16.970
tanktype 0 vs 1	0.915	0.356	2.355
tanktype 2 vs 1	0.353	0.143	0.872
pumptype 0 vs 1	0.740	0.335	1.631
pumptype 2 vs 1	1.797	0.335	9.648

Association of Predicted Probabilities and Observed Responses

Percent Concordant	64.4	Somers' D	0.406
Percent Discordant	23.8	Gamma	0.460
Percent Tied	11.8	Tau-a	0.139
Pairs	8950	c	0.703

Partition for the Hosmer and Lemeshow Test

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1 Supplementary Information)

Group	Total	contaminated = 1 Observed	Expected	contaminated = 0 Observed	Expected
1	26	12	12.76	14	13.24
2	16	12	11.26	4	4.74
3	49	36	35.45	13	13.55
4	24	19	18.65	5	5.35
5	25	20	21.49	5	3.51
6	1	1	0.86	0	0.14
7	50	42	43.54	8	6.46
8	23	23	20.85	0	2.15
9	15	14	14.14	1	0.86

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
4.0252	7	0.7769

The LOGISTIC Procedure

Model Information

Data Set	WORK.CONTAM
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	229
Number of Observations Used	229

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	179
2	0	50

Probability modeled is contaminated=1.

Class Level Information

Class	Value	Design Variables	
tanktype	0	1	0
	1	0	0
	2	0	1

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1 Supplementary Information)

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	242.358	230.685
SC	245.792	247.854
-2 Log L	240.358	220.685

The LOGISTIC Procedure

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	19.6732	4	0.0006
Score	20.7317	4	0.0004
Wald	18.3801	4	0.0010

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
sitetype	1	8.1067	0.0044
position	1	3.1849	0.0743
tanktype	2	4.4950	0.1057

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.2231	0.6708	0.1106	0.7395
sitetype		1	1.0275	0.3609	8.1067	0.0044
position		1	1.2806	0.7176	3.1849	0.0743
tanktype	0	1	-0.1305	0.4801	0.0739	0.7858
tanktype	2	1	-0.9581	0.4533	4.4671	0.0346

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
sitetype	2.794	1.377	5.668
position	3.599	0.882	14.688
tanktype 0 vs 1	0.878	0.343	2.249
tanktype 2 vs 1	0.384	0.158	0.933

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1 Supplementary Information)

Association of Predicted Probabilities and Observed Responses

Percent Concordant	58.2	Somers' D	0.368
Percent Discordant	21.4	Gamma	0.463
Percent Tied	20.5	Tau-a	0.126
Pairs	8950	c	0.684

The LOGISTIC Procedure

Partition for the Hosmer and Lemeshow Test

		contaminated = 1		contaminated = 0	
Group	Total	Observed	Expected	Observed	Expected
1	27	12	13.45	15	13.55
2	12	10	8.60	2	3.40
3	70	52	51.96	18	18.04
4	10	9	7.55	1	2.45
5	29	24	25.40	5	3.60
6	81	72	72.04	9	8.96

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
2.8746	4	0.5790

The LOGISTIC Procedure

Model Information

Data Set	WORK.DROPAGE
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	166
Number of Observations Used	166

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	129
2	0	37

Probability modeled is contaminated=1.

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1 Supplementary Information)

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	178.140	164.349
SC	181.252	173.685
-2 Log L	176.140	158.349

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	17.7915	2	0.0001
Score	15.9940	2	0.0003
Wald	14.4012	2	0.0007

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-0.1215	0.4185	0.0842	0.7716
age	1	0.0471	0.0204	5.3368	0.0209
sitetype	1	1.2026	0.4306	7.7979	0.0052

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
age	1.048	1.007	1.091
sitetype	3.329	1.431	7.742

Association of Predicted Probabilities and Observed Responses

Percent Concordant	70.1	Somers' D	0.427
Percent Discordant	27.4	Gamma	0.438
Percent Tied	2.5	Tau-a	0.149
Pairs	4773	c	0.714

Partition for the Hosmer and Lemeshow Test

Group	Total	contaminated = 1 Observed	Expected	contaminated = 0 Observed	Expected

1	16	6	8.35	10	7.65
2	18	12	11.00	6	7.00
3	21	18	14.48	3	6.52
4	16	12	11.96	4	4.04
5	17	10	13.38	7	3.62
6	17	15	14.17	2	2.83
7	18	18	15.80	0	2.20
8	17	14	15.31	3	1.69
9	17	16	15.83	1	1.17
10	9	8	8.72	1	0.28

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
14.2663	8	0.0751

Obs	position	sitetype	pumptype	tanktype	pred
1	0	0	0	1	0.39520
2	0	0	0	1	0.39520
3	0	0	0	1	0.39520
4	0	0	1	1	0.46907
5	0	0	1	1	0.46907
6	0	0	1	1	0.46907
7	0	0	1	1	0.46907
8	0	0	1	1	0.46907
9	0	0	1	1	0.46907
10	1	0	0	0	0.70537
11	1	0	0	0	0.70537
12	1	0	0	0	0.70537
13	1	0	0	0	0.70537
14	1	0	0	0	0.70537
15	1	0	0	0	0.70537
16	1	0	0	0	0.70537
17	1	0	0	0	0.70537
18	1	0	0	0	0.70537
19	1	0	0	1	0.72345
20	1	0	0	1	0.72345
21	1	0	0	1	0.72345
22	1	0	0	1	0.72345
23	1	0	0	1	0.72345
24	1	0	0	1	0.72345
25	1	0	0	1	0.72345
26	1	0	0	1	0.72345
27	1	0	0	1	0.72345
28	1	0	0	1	0.72345
29	1	0	0	1	0.72345
30	1	0	0	1	0.72345
31	1	0	0	1	0.72345
32	1	0	0	1	0.72345
33	1	0	0	1	0.72345
34	1	0	0	1	0.72345

Obs	position	sitetype	pumptype	tanktype	pred
35	1	0	0	1	0.72345
36	1	0	0	1	0.72345
37	1	0	0	1	0.72345
38	1	0	0	1	0.72345
39	1	0	0	1	0.72345
40	1	0	0	1	0.72345
41	1	0	0	1	0.72345
42	1	0	0	1	0.72345
43	1	0	0	1	0.72345
44	1	0	0	1	0.72345
45	1	0	0	1	0.72345
46	1	0	0	1	0.72345
47	1	0	0	1	0.72345
48	1	0	0	1	0.72345
49	1	0	0	1	0.72345
50	1	0	0	1	0.72345
51	1	0	0	1	0.72345

Obs	position	sitetype	pumptype	tanktype	pred
52	1	0	0	1	0.72345
53	1	0	0	1	0.72345
54	1	0	0	1	0.72345
55	1	0	0	1	0.72345
56	1	0	0	1	0.72345
57	1	0	0	1	0.72345
58	1	0	0	1	0.72345
59	1	0	0	1	0.72345
60	1	0	0	1	0.72345
61	1	0	0	1	0.72345
62	1	0	0	1	0.72345
63	1	0	0	1	0.72345
64	1	0	0	1	0.72345
65	1	0	0	1	0.72345
66	1	0	0	1	0.72345
67	1	0	0	1	0.72345
68	1	0	0	2	0.48011
69	1	0	0	2	0.48011
70	1	0	0	2	0.48011
71	1	0	0	2	0.48011
72	1	0	0	2	0.48011
73	1	0	0	2	0.48011
74	1	0	0	2	0.48011
75	1	0	0	2	0.48011
76	1	0	0	2	0.48011
77	1	0	1	0	0.76398
78	1	0	1	0	0.76398
79	1	0	1	0	0.76398
80	1	0	1	1	0.77959
81	1	0	1	1	0.77959
82	1	0	1	1	0.77959
83	1	0	1	1	0.77959
84	1	0	1	1	0.77959
85	1	0	1	1	0.77959
86	1	0	1	1	0.77959
87	1	0	1	1	0.77959
88	1	0	1	1	0.77959
89	1	0	1	1	0.77959
90	1	0	1	1	0.77959
91	1	0	1	1	0.77959
92	1	0	1	1	0.77959
93	1	0	1	1	0.77959
94	1	0	1	1	0.77959
95	1	0	1	1	0.77959
96	1	0	1	1	0.77959

97	1	0	1	1	0.77959
98	1	0	1	1	0.77959
99	1	0	1	1	0.77959
100	1	0	1	2	0.55528
101	1	0	1	2	0.55528
102	1	0	1	2	0.55528

Obs	position	sitetype	pumptype	tanktype	pred
103	1	0	1	2	0.55528
104	1	0	1	2	0.55528
105	1	0	1	2	0.55528
106	1	0	1	2	0.55528
107	1	0	1	2	0.55528
108	1	0	2	1	0.86406
109	1	0	2	2	0.69172
110	1	1	0	0	0.86050
111	1	1	0	0	0.86050
112	1	1	0	0	0.86050
113	1	1	0	0	0.86050
114	1	1	0	0	0.86050
115	1	1	0	0	0.86050
116	1	1	0	0	0.86050
117	1	1	0	0	0.86050
118	1	1	0	0	0.86050
119	1	1	0	0	0.86050
120	1	1	0	0	0.86050
121	1	1	0	0	0.86050
122	1	1	0	0	0.86050
123	1	1	0	0	0.86050
124	1	1	0	0	0.86050
125	1	1	0	0	0.86050
126	1	1	0	0	0.86050
127	1	1	0	0	0.86050
128	1	1	0	0	0.86050
129	1	1	0	0	0.86050
130	1	1	0	0	0.86050
131	1	1	0	0	0.86050
132	1	1	0	1	0.87081
133	1	1	0	1	0.87081
134	1	1	0	1	0.87081
135	1	1	0	1	0.87081
136	1	1	0	1	0.87081
137	1	1	0	1	0.87081
138	1	1	0	1	0.87081
139	1	1	0	1	0.87081
140	1	1	0	1	0.87081
141	1	1	0	1	0.87081
142	1	1	0	1	0.87081
143	1	1	0	1	0.87081
144	1	1	0	1	0.87081
145	1	1	0	1	0.87081
146	1	1	0	1	0.87081
147	1	1	0	1	0.87081
148	1	1	0	1	0.87081
149	1	1	0	1	0.87081
150	1	1	0	1	0.87081
151	1	1	0	1	0.87081
152	1	1	0	1	0.87081
153	1	1	0	1	0.87081

Obs	position	sitetype	pumptype	tanktype	pred

154	1	1	0	1	0.87081
155	1	1	0	1	0.87081
156	1	1	0	1	0.87081
157	1	1	0	1	0.87081
158	1	1	0	1	0.87081
159	1	1	0	1	0.87081
160	1	1	0	1	0.87081
161	1	1	0	1	0.87081
162	1	1	0	1	0.87081
163	1	1	0	1	0.87081
164	1	1	0	1	0.87081
165	1	1	0	1	0.87081
166	1	1	0	1	0.87081
167	1	1	0	1	0.87081
168	1	1	0	1	0.87081
169	1	1	0	1	0.87081
170	1	1	0	1	0.87081
171	1	1	0	1	0.87081
172	1	1	0	1	0.87081
173	1	1	0	1	0.87081
174	1	1	0	1	0.87081
175	1	1	0	1	0.87081
176	1	1	0	1	0.87081
177	1	1	0	1	0.87081
178	1	1	0	1	0.87081
179	1	1	0	1	0.87081
180	1	1	0	1	0.87081
181	1	1	0	1	0.87081
182	1	1	0	2	0.70410
183	1	1	0	2	0.70410
184	1	1	0	2	0.70410
185	1	1	0	2	0.70410
186	1	1	0	2	0.70410
187	1	1	0	2	0.70410
188	1	1	1	0	0.89294
189	1	1	1	0	0.89294
190	1	1	1	0	0.89294
191	1	1	1	1	0.90112
192	1	1	1	1	0.90112
193	1	1	1	1	0.90112
194	1	1	1	1	0.90112
195	1	1	1	1	0.90112
196	1	1	1	1	0.90112
197	1	1	1	1	0.90112
198	1	1	1	1	0.90112
199	1	1	1	1	0.90112
200	1	1	1	1	0.90112
201	1	1	1	1	0.90112
202	1	1	1	1	0.90112
203	1	1	1	1	0.90112
204	1	1	1	1	0.90112

Obs	position	sitetype	pumptype	tanktype	pred
205	1	1	1	1	0.90112
206	1	1	1	1	0.90112
207	1	1	1	2	0.76288
208	1	1	2	0	0.93745
209	1	1	2	0	0.93745
210	1	1	2	0	0.93745
211	1	1	2	0	0.93745
212	1	1	2	1	0.94245
213	1	1	2	1	0.94245
214	1	1	2	1	0.94245

215	1	1	2	1	0.94245
216	1	1	2	1	0.94245
217	1	1	2	1	0.94245
218	1	1	2	1	0.94245
219	1	1	2	1	0.94245
220	1	1	2	1	0.94245
221	1	1	2	1	0.94245
222	1	1	2	1	0.94245
223	1	1	2	1	0.94245
224	1	1	2	1	0.94245
225	1	1	2	1	0.94245
226	1	1	2	1	0.94245
227	1	1	2	2	0.85254
228	1	1	2	2	0.85254
229	1	1	2	2	0.85254

Obs	position	sitetype	tanktype	pred
1	0	0	1	0.44446
2	0	0	1	0.44446
3	0	0	1	0.44446
4	0	0	1	0.44446
5	0	0	1	0.44446
6	0	0	1	0.44446
7	0	0	1	0.44446
8	0	0	1	0.44446
9	0	0	1	0.44446
10	1	0	0	0.71647
11	1	0	0	0.71647
12	1	0	0	0.71647
13	1	0	0	0.71647
14	1	0	0	0.71647
15	1	0	0	0.71647
16	1	0	0	0.71647
17	1	0	0	0.71647
18	1	0	0	0.71647
19	1	0	0	0.71647
20	1	0	0	0.71647
21	1	0	0	0.71647
22	1	0	1	0.74222
23	1	0	1	0.74222
24	1	0	1	0.74222
25	1	0	1	0.74222
26	1	0	1	0.74222
27	1	0	1	0.74222
28	1	0	1	0.74222
29	1	0	1	0.74222
30	1	0	1	0.74222
31	1	0	1	0.74222
32	1	0	1	0.74222
33	1	0	1	0.74222
34	1	0	1	0.74222
35	1	0	1	0.74222
36	1	0	1	0.74222
37	1	0	1	0.74222
38	1	0	1	0.74222
39	1	0	1	0.74222
40	1	0	1	0.74222
41	1	0	1	0.74222
42	1	0	1	0.74222
43	1	0	1	0.74222
44	1	0	1	0.74222
45	1	0	1	0.74222
46	1	0	1	0.74222
47	1	0	1	0.74222

48	1	0	1	0.74222
49	1	0	1	0.74222
50	1	0	1	0.74222
51	1	0	1	0.74222

Obs	position	sitetype	tanktype	pred
52	1	0	1	0.74222
53	1	0	1	0.74222
54	1	0	1	0.74222
55	1	0	1	0.74222
56	1	0	1	0.74222
57	1	0	1	0.74222
58	1	0	1	0.74222
59	1	0	1	0.74222
60	1	0	1	0.74222
61	1	0	1	0.74222
62	1	0	1	0.74222
63	1	0	1	0.74222
64	1	0	1	0.74222
65	1	0	1	0.74222
66	1	0	1	0.74222
67	1	0	1	0.74222
68	1	0	1	0.74222
69	1	0	1	0.74222
70	1	0	1	0.74222
71	1	0	1	0.74222
72	1	0	1	0.74222
73	1	0	1	0.74222
74	1	0	1	0.74222
75	1	0	1	0.74222
76	1	0	1	0.74222
77	1	0	1	0.74222
78	1	0	1	0.74222
79	1	0	1	0.74222
80	1	0	1	0.74222
81	1	0	1	0.74222
82	1	0	1	0.74222
83	1	0	1	0.74222
84	1	0	1	0.74222
85	1	0	1	0.74222
86	1	0	1	0.74222
87	1	0	1	0.74222
88	1	0	1	0.74222
89	1	0	1	0.74222
90	1	0	1	0.74222
91	1	0	1	0.74222
92	1	0	2	0.52484
93	1	0	2	0.52484
94	1	0	2	0.52484
95	1	0	2	0.52484
96	1	0	2	0.52484
97	1	0	2	0.52484
98	1	0	2	0.52484
99	1	0	2	0.52484
100	1	0	2	0.52484
101	1	0	2	0.52484
102	1	0	2	0.52484

Obs	position	sitetype	tanktype	pred
103	1	0	2	0.52484

104	1	0	2	0.52484
105	1	0	2	0.52484
106	1	0	2	0.52484
107	1	0	2	0.52484
108	1	0	2	0.52484
109	1	0	2	0.52484
110	1	1	0	0.87594
111	1	1	0	0.87594
112	1	1	0	0.87594
113	1	1	0	0.87594
114	1	1	0	0.87594
115	1	1	0	0.87594
116	1	1	0	0.87594
117	1	1	0	0.87594
118	1	1	0	0.87594
119	1	1	0	0.87594
120	1	1	0	0.87594
121	1	1	0	0.87594
122	1	1	0	0.87594
123	1	1	0	0.87594
124	1	1	0	0.87594
125	1	1	0	0.87594
126	1	1	0	0.87594
127	1	1	0	0.87594
128	1	1	0	0.87594
129	1	1	0	0.87594
130	1	1	0	0.87594
131	1	1	0	0.87594
132	1	1	0	0.87594
133	1	1	0	0.87594
134	1	1	0	0.87594
135	1	1	0	0.87594
136	1	1	0	0.87594
137	1	1	0	0.87594
138	1	1	0	0.87594
139	1	1	1	0.88944
140	1	1	1	0.88944
141	1	1	1	0.88944
142	1	1	1	0.88944
143	1	1	1	0.88944
144	1	1	1	0.88944
145	1	1	1	0.88944
146	1	1	1	0.88944
147	1	1	1	0.88944
148	1	1	1	0.88944
149	1	1	1	0.88944
150	1	1	1	0.88944
151	1	1	1	0.88944
152	1	1	1	0.88944
153	1	1	1	0.88944

Obs	position	sitetype	tanktype	pred
154	1	1	1	0.88944
155	1	1	1	0.88944
156	1	1	1	0.88944
157	1	1	1	0.88944
158	1	1	1	0.88944
159	1	1	1	0.88944
160	1	1	1	0.88944
161	1	1	1	0.88944
162	1	1	1	0.88944
163	1	1	1	0.88944
164	1	1	1	0.88944
165	1	1	1	0.88944

Obs	position	sitetype	tanktype	pred
166	1	1	1	0.88944
167	1	1	1	0.88944
168	1	1	1	0.88944
169	1	1	1	0.88944
170	1	1	1	0.88944
171	1	1	1	0.88944
172	1	1	1	0.88944
173	1	1	1	0.88944
174	1	1	1	0.88944
175	1	1	1	0.88944
176	1	1	1	0.88944
177	1	1	1	0.88944
178	1	1	1	0.88944
179	1	1	1	0.88944
180	1	1	1	0.88944
181	1	1	1	0.88944
182	1	1	1	0.88944
183	1	1	1	0.88944
184	1	1	1	0.88944
185	1	1	1	0.88944
186	1	1	1	0.88944
187	1	1	1	0.88944
188	1	1	1	0.88944
189	1	1	1	0.88944
190	1	1	1	0.88944
191	1	1	1	0.88944
192	1	1	1	0.88944
193	1	1	1	0.88944
194	1	1	1	0.88944
195	1	1	1	0.88944
196	1	1	1	0.88944
197	1	1	1	0.88944
198	1	1	1	0.88944
199	1	1	1	0.88944
200	1	1	1	0.88944
201	1	1	1	0.88944
202	1	1	1	0.88944
203	1	1	1	0.88944
204	1	1	1	0.88944

Obs	position	sitetype	tanktype	pred
205	1	1	1	0.88944
206	1	1	1	0.88944
207	1	1	1	0.88944
208	1	1	1	0.88944
209	1	1	1	0.88944
210	1	1	1	0.88944
211	1	1	1	0.88944
212	1	1	1	0.88944
213	1	1	1	0.88944
214	1	1	1	0.88944
215	1	1	1	0.88944
216	1	1	1	0.88944
217	1	1	1	0.88944
218	1	1	1	0.88944
219	1	1	1	0.88944
220	1	1	2	0.75528
221	1	1	2	0.75528
222	1	1	2	0.75528
223	1	1	2	0.75528
224	1	1	2	0.75528
225	1	1	2	0.75528
226	1	1	2	0.75528
227	1	1	2	0.75528

228	1	1	2	0.75528
229	1	1	2	0.75528

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1)

The LOGISTIC Procedure

Model Information

Data Set	WORK.CONTAM
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	229
Number of Observations Used	229

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	179
2	0	50

Probability modeled is contaminated=1.

Class Level Information

Class	Value	Design Variables	
tanktype	0	1	0
	1	0	0
	2	0	1
pumptype	0	1	0
	1	0	0
	2	0	1

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

The LOGISTIC Procedure

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	242.358	232.880
SC	245.792	256.916
-2 Log L	240.358	218.880

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1)

Likelihood Ratio	21.4787	6	0.0015
Score	22.0278	6	0.0012
Wald	19.2187	6	0.0038

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
sitetype	1	6.3937	0.0115
position	1	3.5435	0.0598
tanktype	2	5.1648	0.0756
pumptype	2	1.6158	0.4458

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.1239	0.6851	0.0327	0.8565
sitetype		1	0.9465	0.3743	6.3937	0.0115
position		1	1.3872	0.7369	3.5435	0.0598
tanktype	0	1	-0.0886	0.4822	0.0338	0.8542
tanktype	2	1	-1.0412	0.4612	5.0981	0.0240
pumptype	0	1	-0.3016	0.4036	0.5585	0.4548
pumptype	2	1	0.5861	0.8575	0.4672	0.4943

The LOGISTIC Procedure

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
sitetype	2.577	1.237	5.366
position	4.003	0.944	16.970
tanktype 0 vs 1	0.915	0.356	2.355
tanktype 2 vs 1	0.353	0.143	0.872
pumptype 0 vs 1	0.740	0.335	1.631
pumptype 2 vs 1	1.797	0.335	9.648

Association of Predicted Probabilities and Observed Responses

Percent Concordant	64.4	Somers' D	0.406
Percent Discordant	23.8	Gamma	0.460
Percent Tied	11.8	Tau-a	0.139
Pairs	8950	c	0.703

Partition for the Hosmer and Lemeshow Test

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1)

Group	Total	contaminated = 1 Observed	Expected	contaminated = 0 Observed	Expected
1	26	12	12.76	14	13.24
2	16	12	11.26	4	4.74
3	49	36	35.45	13	13.55
4	24	19	18.65	5	5.35
5	25	20	21.49	5	3.51
6	1	1	0.86	0	0.14
7	50	42	43.54	8	6.46
8	23	23	20.85	0	2.15
9	15	14	14.14	1	0.86

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
4.0252	7	0.7769

The LOGISTIC Procedure

Model Information

Data Set	WORK.CONTAM
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	229
Number of Observations Used	229

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	179
2	0	50

Probability modeled is contaminated=1.

Class Level Information

Class	Value	Design Variables	
tanktype	0	1	0
	1	0	0
	2	0	1

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1)

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	242.358	230.685
SC	245.792	247.854
-2 Log L	240.358	220.685

The LOGISTIC Procedure

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	19.6732	4	0.0006
Score	20.7317	4	0.0004
Wald	18.3801	4	0.0010

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
sitetype	1	8.1067	0.0044
position	1	3.1849	0.0743
tanktype	2	4.4950	0.1057

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-0.2231	0.6708	0.1106	0.7395
sitetype		1	1.0275	0.3609	8.1067	0.0044
position		1	1.2806	0.7176	3.1849	0.0743
tanktype	0	1	-0.1305	0.4801	0.0739	0.7858
tanktype	2	1	-0.9581	0.4533	4.4671	0.0346

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
sitetype	2.794	1.377	5.668
position	3.599	0.882	14.688
tanktype 0 vs 1	0.878	0.343	2.249
tanktype 2 vs 1	0.384	0.158	0.933

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1)

Association of Predicted Probabilities and Observed Responses

Percent Concordant	58.2	Somers' D	0.368
Percent Discordant	21.4	Gamma	0.463
Percent Tied	20.5	Tau-a	0.126
Pairs	8950	c	0.684

The LOGISTIC Procedure

Partition for the Hosmer and Lemeshow Test

		contaminated = 1		contaminated = 0	
Group	Total	Observed	Expected	Observed	Expected
1	27	12	13.45	15	13.55
2	12	10	8.60	2	3.40
3	70	52	51.96	18	18.04
4	10	9	7.55	1	2.45
5	29	24	25.40	5	3.60
6	81	72	72.04	9	8.96

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
2.8746	4	0.5790

The LOGISTIC Procedure

Model Information

Data Set	WORK.DROPAGE
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	166
Number of Observations Used	166

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	129
2	0	37

Probability modeled is contaminated=1.

APPENDIX J - LOGISTIC REGRESSION MODEL RESULTS FINAL (MODEL 1)

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	178.140	164.349
SC	181.252	173.685
-2 Log L	176.140	158.349

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	17.7915	2	0.0001
Score	15.9940	2	0.0003
Wald	14.4012	2	0.0007

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-0.1215	0.4185	0.0842	0.7716
age	1	0.0471	0.0204	5.3368	0.0209
sitetype	1	1.2026	0.4306	7.7979	0.0052

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
age	1.048	1.007	1.091
sitetype	3.329	1.431	7.742

Association of Predicted Probabilities and Observed Responses

Percent Concordant	70.1	Somers' D	0.427
Percent Discordant	27.4	Gamma	0.438
Percent Tied	2.5	Tau-a	0.149
Pairs	4773	c	0.714

Partition for the Hosmer and Lemeshow Test

		contaminated = 1		contaminated = 0	
Group	Total	Observed	Expected	Observed	Expected

1	16	6	8.35	10	7.65
2	18	12	11.00	6	7.00
3	21	18	14.48	3	6.52
4	16	12	11.96	4	4.04
5	17	10	13.38	7	3.62
6	17	15	14.17	2	2.83
7	18	18	15.80	0	2.20
8	17	14	15.31	3	1.69
9	17	16	15.83	1	1.17
10	9	8	8.72	1	0.28

Hosmer and Lemeshow Goodness-of-Fit Test

Chi-Square	DF	Pr > ChiSq
14.2663	8	0.0751

Obs	position	sitetype	pumptype	tanktype	pred
1	0	0	0	1	0.39520
2	0	0	0	1	0.39520
3	0	0	0	1	0.39520
4	0	0	1	1	0.46907
5	0	0	1	1	0.46907
6	0	0	1	1	0.46907
7	0	0	1	1	0.46907
8	0	0	1	1	0.46907
9	0	0	1	1	0.46907
10	1	0	0	0	0.70537
11	1	0	0	0	0.70537
12	1	0	0	0	0.70537
13	1	0	0	0	0.70537
14	1	0	0	0	0.70537
15	1	0	0	0	0.70537
16	1	0	0	0	0.70537
17	1	0	0	0	0.70537
18	1	0	0	0	0.70537
19	1	0	0	1	0.72345
20	1	0	0	1	0.72345
21	1	0	0	1	0.72345
22	1	0	0	1	0.72345
23	1	0	0	1	0.72345
24	1	0	0	1	0.72345
25	1	0	0	1	0.72345
26	1	0	0	1	0.72345
27	1	0	0	1	0.72345
28	1	0	0	1	0.72345
29	1	0	0	1	0.72345
30	1	0	0	1	0.72345
31	1	0	0	1	0.72345
32	1	0	0	1	0.72345
33	1	0	0	1	0.72345
34	1	0	0	1	0.72345

35	1	0	0	1	0.72345
36	1	0	0	1	0.72345
37	1	0	0	1	0.72345
38	1	0	0	1	0.72345
39	1	0	0	1	0.72345
40	1	0	0	1	0.72345
41	1	0	0	1	0.72345
42	1	0	0	1	0.72345
43	1	0	0	1	0.72345
44	1	0	0	1	0.72345
45	1	0	0	1	0.72345
46	1	0	0	1	0.72345
47	1	0	0	1	0.72345
48	1	0	0	1	0.72345
49	1	0	0	1	0.72345
50	1	0	0	1	0.72345
51	1	0	0	1	0.72345

Obs	position	sitetype	pumptype	tanktype	pred
52	1	0	0	1	0.72345
53	1	0	0	1	0.72345
54	1	0	0	1	0.72345
55	1	0	0	1	0.72345
56	1	0	0	1	0.72345
57	1	0	0	1	0.72345
58	1	0	0	1	0.72345
59	1	0	0	1	0.72345
60	1	0	0	1	0.72345
61	1	0	0	1	0.72345
62	1	0	0	1	0.72345
63	1	0	0	1	0.72345
64	1	0	0	1	0.72345
65	1	0	0	1	0.72345
66	1	0	0	1	0.72345
67	1	0	0	1	0.72345
68	1	0	0	2	0.48011
69	1	0	0	2	0.48011
70	1	0	0	2	0.48011
71	1	0	0	2	0.48011
72	1	0	0	2	0.48011
73	1	0	0	2	0.48011
74	1	0	0	2	0.48011
75	1	0	0	2	0.48011
76	1	0	0	2	0.48011
77	1	0	1	0	0.76398
78	1	0	1	0	0.76398
79	1	0	1	0	0.76398
80	1	0	1	1	0.77959
81	1	0	1	1	0.77959
82	1	0	1	1	0.77959
83	1	0	1	1	0.77959
84	1	0	1	1	0.77959
85	1	0	1	1	0.77959
86	1	0	1	1	0.77959
87	1	0	1	1	0.77959
88	1	0	1	1	0.77959
89	1	0	1	1	0.77959
90	1	0	1	1	0.77959
91	1	0	1	1	0.77959
92	1	0	1	1	0.77959
93	1	0	1	1	0.77959
94	1	0	1	1	0.77959
95	1	0	1	1	0.77959
96	1	0	1	1	0.77959

97	1	0	1	1	0.77959
98	1	0	1	1	0.77959
99	1	0	1	1	0.77959
100	1	0	1	2	0.55528
101	1	0	1	2	0.55528
102	1	0	1	2	0.55528

Obs	position	sitetype	pumptype	tanktype	pred
103	1	0	1	2	0.55528
104	1	0	1	2	0.55528
105	1	0	1	2	0.55528
106	1	0	1	2	0.55528
107	1	0	1	2	0.55528
108	1	0	2	1	0.86406
109	1	0	2	2	0.69172
110	1	1	0	0	0.86050
111	1	1	0	0	0.86050
112	1	1	0	0	0.86050
113	1	1	0	0	0.86050
114	1	1	0	0	0.86050
115	1	1	0	0	0.86050
116	1	1	0	0	0.86050
117	1	1	0	0	0.86050
118	1	1	0	0	0.86050
119	1	1	0	0	0.86050
120	1	1	0	0	0.86050
121	1	1	0	0	0.86050
122	1	1	0	0	0.86050
123	1	1	0	0	0.86050
124	1	1	0	0	0.86050
125	1	1	0	0	0.86050
126	1	1	0	0	0.86050
127	1	1	0	0	0.86050
128	1	1	0	0	0.86050
129	1	1	0	0	0.86050
130	1	1	0	0	0.86050
131	1	1	0	0	0.86050
132	1	1	0	1	0.87081
133	1	1	0	1	0.87081
134	1	1	0	1	0.87081
135	1	1	0	1	0.87081
136	1	1	0	1	0.87081
137	1	1	0	1	0.87081
138	1	1	0	1	0.87081
139	1	1	0	1	0.87081
140	1	1	0	1	0.87081
141	1	1	0	1	0.87081
142	1	1	0	1	0.87081
143	1	1	0	1	0.87081
144	1	1	0	1	0.87081
145	1	1	0	1	0.87081
146	1	1	0	1	0.87081
147	1	1	0	1	0.87081
148	1	1	0	1	0.87081
149	1	1	0	1	0.87081
150	1	1	0	1	0.87081
151	1	1	0	1	0.87081
152	1	1	0	1	0.87081
153	1	1	0	1	0.87081

Obs	position	sitetype	pumptype	tanktype	pred

Obs	position	sitetype	pumptype	tanktype	pred
154	1	1	0	1	0.87081
155	1	1	0	1	0.87081
156	1	1	0	1	0.87081
157	1	1	0	1	0.87081
158	1	1	0	1	0.87081
159	1	1	0	1	0.87081
160	1	1	0	1	0.87081
161	1	1	0	1	0.87081
162	1	1	0	1	0.87081
163	1	1	0	1	0.87081
164	1	1	0	1	0.87081
165	1	1	0	1	0.87081
166	1	1	0	1	0.87081
167	1	1	0	1	0.87081
168	1	1	0	1	0.87081
169	1	1	0	1	0.87081
170	1	1	0	1	0.87081
171	1	1	0	1	0.87081
172	1	1	0	1	0.87081
173	1	1	0	1	0.87081
174	1	1	0	1	0.87081
175	1	1	0	1	0.87081
176	1	1	0	1	0.87081
177	1	1	0	1	0.87081
178	1	1	0	1	0.87081
179	1	1	0	1	0.87081
180	1	1	0	1	0.87081
181	1	1	0	1	0.87081
182	1	1	0	2	0.70410
183	1	1	0	2	0.70410
184	1	1	0	2	0.70410
185	1	1	0	2	0.70410
186	1	1	0	2	0.70410
187	1	1	0	2	0.70410
188	1	1	1	0	0.89294
189	1	1	1	0	0.89294
190	1	1	1	0	0.89294
191	1	1	1	1	0.90112
192	1	1	1	1	0.90112
193	1	1	1	1	0.90112
194	1	1	1	1	0.90112
195	1	1	1	1	0.90112
196	1	1	1	1	0.90112
197	1	1	1	1	0.90112
198	1	1	1	1	0.90112
199	1	1	1	1	0.90112
200	1	1	1	1	0.90112
201	1	1	1	1	0.90112
202	1	1	1	1	0.90112
203	1	1	1	1	0.90112
204	1	1	1	1	0.90112

Obs	position	sitetype	pumptype	tanktype	pred
205	1	1	1	1	0.90112
206	1	1	1	1	0.90112
207	1	1	1	2	0.76288
208	1	1	2	0	0.93745
209	1	1	2	0	0.93745
210	1	1	2	0	0.93745
211	1	1	2	0	0.93745
212	1	1	2	1	0.94245
213	1	1	2	1	0.94245
214	1	1	2	1	0.94245

215	1	1	2	1	0.94245
216	1	1	2	1	0.94245
217	1	1	2	1	0.94245
218	1	1	2	1	0.94245
219	1	1	2	1	0.94245
220	1	1	2	1	0.94245
221	1	1	2	1	0.94245
222	1	1	2	1	0.94245
223	1	1	2	1	0.94245
224	1	1	2	1	0.94245
225	1	1	2	1	0.94245
226	1	1	2	1	0.94245
227	1	1	2	2	0.85254
228	1	1	2	2	0.85254
229	1	1	2	2	0.85254

Obs	position	sitetype	tanktype	pred
1	0	0	1	0.44446
2	0	0	1	0.44446
3	0	0	1	0.44446
4	0	0	1	0.44446
5	0	0	1	0.44446
6	0	0	1	0.44446
7	0	0	1	0.44446
8	0	0	1	0.44446
9	0	0	1	0.44446
10	1	0	0	0.71647
11	1	0	0	0.71647
12	1	0	0	0.71647
13	1	0	0	0.71647
14	1	0	0	0.71647
15	1	0	0	0.71647
16	1	0	0	0.71647
17	1	0	0	0.71647
18	1	0	0	0.71647
19	1	0	0	0.71647
20	1	0	0	0.71647
21	1	0	0	0.71647
22	1	0	1	0.74222
23	1	0	1	0.74222
24	1	0	1	0.74222
25	1	0	1	0.74222
26	1	0	1	0.74222
27	1	0	1	0.74222
28	1	0	1	0.74222
29	1	0	1	0.74222
30	1	0	1	0.74222
31	1	0	1	0.74222
32	1	0	1	0.74222
33	1	0	1	0.74222
34	1	0	1	0.74222
35	1	0	1	0.74222
36	1	0	1	0.74222
37	1	0	1	0.74222
38	1	0	1	0.74222
39	1	0	1	0.74222
40	1	0	1	0.74222
41	1	0	1	0.74222
42	1	0	1	0.74222
43	1	0	1	0.74222
44	1	0	1	0.74222
45	1	0	1	0.74222
46	1	0	1	0.74222
47	1	0	1	0.74222

48	1	0	1	0.74222
49	1	0	1	0.74222
50	1	0	1	0.74222
51	1	0	1	0.74222

Obs	position	sitetype	tanktype	pred
52	1	0	1	0.74222
53	1	0	1	0.74222
54	1	0	1	0.74222
55	1	0	1	0.74222
56	1	0	1	0.74222
57	1	0	1	0.74222
58	1	0	1	0.74222
59	1	0	1	0.74222
60	1	0	1	0.74222
61	1	0	1	0.74222
62	1	0	1	0.74222
63	1	0	1	0.74222
64	1	0	1	0.74222
65	1	0	1	0.74222
66	1	0	1	0.74222
67	1	0	1	0.74222
68	1	0	1	0.74222
69	1	0	1	0.74222
70	1	0	1	0.74222
71	1	0	1	0.74222
72	1	0	1	0.74222
73	1	0	1	0.74222
74	1	0	1	0.74222
75	1	0	1	0.74222
76	1	0	1	0.74222
77	1	0	1	0.74222
78	1	0	1	0.74222
79	1	0	1	0.74222
80	1	0	1	0.74222
81	1	0	1	0.74222
82	1	0	1	0.74222
83	1	0	1	0.74222
84	1	0	1	0.74222
85	1	0	1	0.74222
86	1	0	1	0.74222
87	1	0	1	0.74222
88	1	0	1	0.74222
89	1	0	1	0.74222
90	1	0	1	0.74222
91	1	0	1	0.74222
92	1	0	2	0.52484
93	1	0	2	0.52484
94	1	0	2	0.52484
95	1	0	2	0.52484
96	1	0	2	0.52484
97	1	0	2	0.52484
98	1	0	2	0.52484
99	1	0	2	0.52484
100	1	0	2	0.52484
101	1	0	2	0.52484
102	1	0	2	0.52484

Obs	position	sitetype	tanktype	pred
103	1	0	2	0.52484

Obs	position	sitetype	tanktype	pred
104	1	0	2	0.52484
105	1	0	2	0.52484
106	1	0	2	0.52484
107	1	0	2	0.52484
108	1	0	2	0.52484
109	1	0	2	0.52484
110	1	1	0	0.87594
111	1	1	0	0.87594
112	1	1	0	0.87594
113	1	1	0	0.87594
114	1	1	0	0.87594
115	1	1	0	0.87594
116	1	1	0	0.87594
117	1	1	0	0.87594
118	1	1	0	0.87594
119	1	1	0	0.87594
120	1	1	0	0.87594
121	1	1	0	0.87594
122	1	1	0	0.87594
123	1	1	0	0.87594
124	1	1	0	0.87594
125	1	1	0	0.87594
126	1	1	0	0.87594
127	1	1	0	0.87594
128	1	1	0	0.87594
129	1	1	0	0.87594
130	1	1	0	0.87594
131	1	1	0	0.87594
132	1	1	0	0.87594
133	1	1	0	0.87594
134	1	1	0	0.87594
135	1	1	0	0.87594
136	1	1	0	0.87594
137	1	1	0	0.87594
138	1	1	0	0.87594
139	1	1	1	0.88944
140	1	1	1	0.88944
141	1	1	1	0.88944
142	1	1	1	0.88944
143	1	1	1	0.88944
144	1	1	1	0.88944
145	1	1	1	0.88944
146	1	1	1	0.88944
147	1	1	1	0.88944
148	1	1	1	0.88944
149	1	1	1	0.88944
150	1	1	1	0.88944
151	1	1	1	0.88944
152	1	1	1	0.88944
153	1	1	1	0.88944

Obs	position	sitetype	tanktype	pred
154	1	1	1	0.88944
155	1	1	1	0.88944
156	1	1	1	0.88944
157	1	1	1	0.88944
158	1	1	1	0.88944
159	1	1	1	0.88944
160	1	1	1	0.88944
161	1	1	1	0.88944
162	1	1	1	0.88944
163	1	1	1	0.88944
164	1	1	1	0.88944
165	1	1	1	0.88944

Obs	position	sitetype	tanktype	pred
166	1	1	1	0.88944
167	1	1	1	0.88944
168	1	1	1	0.88944
169	1	1	1	0.88944
170	1	1	1	0.88944
171	1	1	1	0.88944
172	1	1	1	0.88944
173	1	1	1	0.88944
174	1	1	1	0.88944
175	1	1	1	0.88944
176	1	1	1	0.88944
177	1	1	1	0.88944
178	1	1	1	0.88944
179	1	1	1	0.88944
180	1	1	1	0.88944
181	1	1	1	0.88944
182	1	1	1	0.88944
183	1	1	1	0.88944
184	1	1	1	0.88944
185	1	1	1	0.88944
186	1	1	1	0.88944
187	1	1	1	0.88944
188	1	1	1	0.88944
189	1	1	1	0.88944
190	1	1	1	0.88944
191	1	1	1	0.88944
192	1	1	1	0.88944
193	1	1	1	0.88944
194	1	1	1	0.88944
195	1	1	1	0.88944
196	1	1	1	0.88944
197	1	1	1	0.88944
198	1	1	1	0.88944
199	1	1	1	0.88944
200	1	1	1	0.88944
201	1	1	1	0.88944
202	1	1	1	0.88944
203	1	1	1	0.88944
204	1	1	1	0.88944

Obs	position	sitetype	tanktype	pred
205	1	1	1	0.88944
206	1	1	1	0.88944
207	1	1	1	0.88944
208	1	1	1	0.88944
209	1	1	1	0.88944
210	1	1	1	0.88944
211	1	1	1	0.88944
212	1	1	1	0.88944
213	1	1	1	0.88944
214	1	1	1	0.88944
215	1	1	1	0.88944
216	1	1	1	0.88944
217	1	1	1	0.88944
218	1	1	1	0.88944
219	1	1	1	0.88944
220	1	1	2	0.75528
221	1	1	2	0.75528
222	1	1	2	0.75528
223	1	1	2	0.75528
224	1	1	2	0.75528
225	1	1	2	0.75528
226	1	1	2	0.75528
227	1	1	2	0.75528

228	1	1	2	0.75528
229	1	1	2	0.75528

The LOGISTIC Procedure

Model Information

Data Set	WORK.DROPAGE
Response Variable	contaminated
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	166
Number of Observations Used	166

Response Profile

Ordered Value	contaminated	Total Frequency
1	1	129
2	0	37

Probability modeled is contaminated=1.

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	178.140	164.349
SC	181.252	173.685
-2 Log L	176.140	158.349

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	17.7915	2	0.0001
Score	15.9940	2	0.0003
Wald	14.4012	2	0.0007

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-0.1215	0.4185	0.0842	0.7716
age	1	0.0471	0.0204	5.3368	0.0209

sitetype	1	1.2026	0.4306	7.7979

0.0052

Odds Ratio Estimates

Effect	Point Estimate	95% Wald Confidence Limits	
age	1.048	1.007	1.091
sitetype	3.329	1.431	7.742

Association of Predicted Probabilities and Observed Responses

Percent Concordant	70.1	Somers' D	0.427
Percent Discordant	27.4	Gamma	0.438
Percent Tied	2.5	Tau-a	0.149
Pairs	4773	c	0.714

13.11 APPENDIX K: POLLUTION CONTROL OFFICER WORKSHEET

POLLUTION CONTROL OFFICER WORKSHEET AND CHECKLIST

ITEMS	SANS REFERENCE
Check monitoring wells	5.1.2
Tank manholes impermeable	6.2
Line integrity test*	7.3.1 and 7.4.7
Presence of shear valves	7.3.6
Corrosion protection (wrapping) on mild steel pipework	7.5
Leak detectors on submersible pumps	9.3.1
Tank integrity test*	12
Emergency stop button	13.6

Other:
Inspect separator
Inspect manholes for product
Inspect reconciliation records

Notes
*Required:
After installation
After repair, maintenance or upgrade
After change in ownership
After indication of a leak
Every 2 years if continuous leak detection monitoring or Stock Inventory Reconciliation is not performed.

13.12 APPENDIX L: FUEL FACILITY QUESTIONNAIRE

SERVICE STATION QUESTIONNAIRE

General *Instructions:* *Please complete all shaded grey blocks, or tick your selected response. Any additional comments, clarifications or explanations may be written in the space provided at the end of the survey form (Section F).*

A. General Details

1.	Dealer / Manager Name	
2.	Name of Service Station	
3.	Physical Address	
4.	Postal Address	
5.	Phone Number	
6.	Phone Number in Case of Emergency	
7.	Fax Number	
8.	Email Address	
9.	Oil Company	
10.	Should you wish to get the results of this survey, please indicate the postal address to which they should be sent.	
	☐ Yes: Please send me the results of this survey to the above postal address	☐ No: Do not send me any further correspondence on this survey.

B. Tank Details

1.	What is the total number of tanks at this service station?	
2.	Provide the specification of each tank at this service station.	

Tank No.	Size (m^3)	Product	Year of installation, or age of tank	Type (Mild steel or dual containment)
1				
2				
3				
4				
5				
6				
7				
8				
Abandoned tanks:				

C. Pump and Pipework Details

Provide the specification of the pumps and pipework at this service station.

1.	Pump Type	Suction (pump in bowser)	Submersible (pump in tank manhole)
		☐Yes	☐Yes

2.	Pipework Type	Mild Steel	Non Ferrous (Plastic)	Dual Containment Non Ferrous
		☐Yes	☐Yes	☐Yes

D. Contamination History

1.	**What is the total number of years you have been at this service station?**	

2.	**Please provide details of any product leaks, losses, spillage or other contamination incidents that have occurred during your occupancy at site. Please provide dates, description / cause of incident and volume of product lost:**

E. Descriptive Information

1.	**Are there monitoring wells around the tanks?**		
	☐Yes: There are monitoring wells around the tanks.	☐ No: There are no monitoring wells at this service station.	☐ Unknown

2.	**Are the monitoring wells inspected routinely?**		
	☐Yes: The monitoring wells are inspected routinely.	☐ No: The monitoring wells are not inspected routinely.	☐ Unknown

3.	**Do the submersible pumps have leak detectors?**		
	☐Yes: There are leak detectors on the submersible pumps.	☐ No: There are no leak detectors at this service station.	☐ Unknown

4.	**Are the leak detectors in good working order?**		
	☐ Yes	☐ No	☐ Unknown

5.	**Do the tanks have overfill protection?**		
	☐Yes: There is overfill protection on the tanks.	☐ No: There is no overfill protection on the tanks.	☐ Unknown

6.	**What is the construction type of the tank manholes?**		
	☐ Brick	☐ Plastic Chamber	☐ Unknown
7.	**Is forecourt drainage directed to an on site separator?**		
	☐ Yes	☐ No	☐ Unknown
8.	**Is the separator inspected and maintained?**		
	☐ Yes	☐ No	☐ Unknown
9.	**What does the forecourt paving consist of?**		
	☐ Brick	☐ Asphalt	☐ Concrete	☐ Unpaved
10.	**Is there an Environmental Management Plan implemented on site?**		
	☐ Yes	☐ No	☐ Unknown
	Details:		
9.	**What is the method of product reconciliation used at the site?**		
10.	**What total average volume do you pump per month?**		
11.	**When was the site built?**		
12.	**Have any tanks been replaced on site?**		
	☐ No	☐ Yes, if yes specify the details in the space provide.	
13.	**Has any pipework been replaced on site?**		
	☐ No	☐ Yes, if yes specify the details in the space provide.	

F. Other Information

1.	**The following space is provided should you wish to provide additional information. You might want to state some related issues which require further investigation relating to the contamination risk posed by your service station.**
2.	**Does your service station require any infrastructure upgrade that would reduce risk of contamination?**
3.	**If there was a contamination incident on your site, who would be affected?**