Western Cape Government
Environmental Affairs & Development Planning

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Status Quo of Waste Management in the Consumer Formulated Chemical Sector of the Western Cape

DEPARTMENT OF ENVIROMENTAL AFFAIRS AND DEVELOPMENT PLANNING

STATUS QUO OF WASTE MANAGEMENT IN THE CONSUMER–FORMULATED CHEMICAL SECTOR OF THE WESTERN CAPE.

OCTOBER 2007

DANIDA

Developed with the support of the
DANISH URBAN ENVIROMENTAL MANAGEMENT PROGRAMME

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ACKNOWLEDGEMENTS

The Project Team of Process Optimisation and Resource Management (PORM) hereby wish to express our sincere gratitude to the Department of Environmental Affairs and Development Planning for affording us this opportunity to research and develop the content of this report.

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The project by its very nature required input and co-operation from various individuals and companies without whose contributions this report would not have been possible. A special note of thanks is extended to all those companies and their staff that kindly set aside valuable time, under often pressing conditions, to accommodate us and furnish the crucial information needed. We would also like to thank everyone for what we have learnt from the vast experience of these persons who unselfishly educated us on the intricacies of their industry. Once more these contributions which are too extensive to allow individual mention are gratefully acknowledged.

A very special note of gratitude and appreciation is extended to the Danish International Donor Agency (DANIDA) through the Urban Environmental Management Programme (UEMP) for the generous funding and support in initiating and realizing this project.

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EXECUTIVE SUMMARY

INTRODUCTION

The South African Government's National Waste Management Strategy strongly promotes the philosophy of Integrated Waste Management Planning. In support of this approach, the Department of Environmental Affairs and Development Planning (D:EA&DP) has undertaken several projects including:

- The facilitation of Integrated Waste Management Planning at municipal level, and
- The development of the Western Cape Provincial Hazardous Waste Management Plan (HWMP)

In support of its obligations with regards to the implementation of the HWMP, the D:EA&DP has initiated this project which focuses on waste management planning at a facility level and which in particular, aims to reduce the effects of bad hazardous waste management on the rural and urban poor.

To accomplish this task, Professional Services were requested to conduct a Status Quo of Waste Management in the Consumer-Formulated Chemical Sector (CFCS) and to draft a generic Intergrated Waste Management Planning Guideline to promote Intergrated Waste Management within the Consumer-Formulated Chemical Sector. In the initial discussion with D:EA&DP, it was agreed that the definition of Consumer-Formulated Chemical Sector would be restricted to industries which are closest to the final consumer in terms of the value chain. In this way, large chemical companies were excluded from the sample population.

This report presents a description of the status quo with respect to waste chemical handling transportation and waste disposal in the Consumer-Formulated Chemical Sector. This is followed by a description and evaluation of the Best Practical Environmental Options (BPEOs) for managing the common chemical wastes.

The possible effects of inappropriate hazardous waste management on the rural and urban poor are then discussed and thereafter conclusions and recommendations are made.

REVIEW OF THE STATUS QUO

As part of the study, a total of 21 companies in the consumer-formulated sector were approached to participate in a survey of which 19 responded. Companies from the following specialised areas or sub-sectors within the Consumer Formulated Chemical Sector were surveyed:

- Automotive
- Cleaning Industry
- Construction and Engineering
- Pharmaceutical, Medical and Personal Health
- Personal Care/Hygiene
- Printing
- Surface Coatings
- Surface Joining

The main aim of the survey was to gather information about various aspects of chemical handling and hazardous waste disposal. The major components of the survey questionnaire were as follows:

- Chemicals usage and production
- Hazardous waste stream handling
- Chemical inventory records
- Personnel competence and training
- Waste minimisation
- House-keeping and quality control
- Risk profiling of facility
- Emergency planning and safety
- Barriers to implementation of the Western Cape Hazardous Waste Management Plan

RESULTS FROM THE SURVEY OF COMPANIES WITHIN THE CONSUMER-FORMULATED CHEMICAL SECTOR

A summary of the results obtained from the survey is presented in **Table A**.

TABLE A: SUMMARY OF SURVEY RESULTS

KEY INDICATORS	SUB-SECTORS							
	Automotive	Cleaning	Construction & Engineering	Medical	Personal Care	Printing	Surface Coatings	Surface Joining
Uses chemical inventory	3/3	3/3	1/1	2/2	2/2	3/3	3/3	1/1
Separates hazardous from non-hazardous waste	1/3	0/3	1/1	2/2	1/2	2/3	2/3	1
Settles particulates from liquid effluent	2/3	1/3	1/1	1/2	1/2	N/A	3/3	0/1
At least ISO 9000 accredited	3/3	3/3	1/1	1/2	2/2	2/3	2/3	0/1
Continuous refresher training courses for site staff	2/3	3/3	1/1	2/2	2/2	3/3	3/3	1/1
Reconditioning of failed batches to reduce waste	1/3	1/3	1/1	N/A	2/2	0/3	2/3	N/A
Recycling of packaging material	2/3	1/2	1/1	2/2	2/2	1/3	2/3	1/1
On-site monitoring of raw material quality	3/3	2/3	1/1	1/2	2/2	3/3	2/3	1/1
On-site monitoring of product	3/3	2/3	1/1	2/2	2/2	2/3	2/3	1/1
Monitoring of effluent quality	2/3	3/3	1/1	1/2	2/2	1/2	1/3	1/1
Has documented emergency plans	2/3	3/3	0/1	2/2	2/2	3/3	3/3	1

**Numbers represent number of companies meeting survey criteria vs. total number of companies surveyed.*

TECHNOLOGIES AVAILABLE FOR WASTE MINIMISATION

A first order analysis of several upstream and end-of-pipe technologies was also undertaken. The applicability of the upstream techniques is presented in **Appendix D**. End-of-pipe treatment options were found to be specific to the type of hazardous waste produced and would therefore require more detailed analysis of the effluent streams before implementation.

CONCLUSIONS

Based on the information obtained from the survey and the preceding discussion, the following conclusions can be drawn:

- A non-uniformed approach in responsible chemical management and disposal exists across all sectors of the Consumer-Formulated Chemical Industry which leads to a wide variety of approaches with differing efficiencies being applied.
- Training of staff is implemented but does not receive the level of importance that it deserves. This is particularly true for issues related to hazardous waste management and occupational health and safety.
- Electronic chemical inventory records appear to be used throughout all the sectors. This is, however, to be expected as the loss of raw materials relates directly to the loss of profits.
- Generally, housekeeping is of a poor standard throughout most of the sectors and needs urgent attention. These changes could potentially result in high rates of return on investment because of the minimal capital input required.
- Quality control is of a high standard when performed on products produced. The monitoring of effluent water quality or of hazardous waste streams is seldom instituted considering that this information would be required when deciding on the treatment regime necessary for stabilisation of these streams, prior to disposal.
- Emergency planning and safety does not receive the attention that it deserves, mainly due to the lack of manpower and finances. This could, however, be very costly in the long run if a disaster should occur. All facilities should be able to provide an up-to-date floor plan to the local municipalities so that this may be used as a mechanism for monitoring compliance for the storage component.
- In most cases, only first order waste minimisation is undertaken due to a lack of technical expertise and financial constraints.
- The effect of hazardous waste stream handling on the rural and urban poor areas should receive high priority in the development of companies Integrated Waste Management Plan. This is particularly necessary when the disposal of hazardous waste or the reconditioning of containers in which hazardous waste was stored is out-sourced to external contractors.

RECOMMENDATIONS

Based on the discussion and conclusions, the following recommendations can be made:

- A uniformed approach based on prescribed guidelines for the handling, storage and transportation of chemicals as well as hazardous waste should be implemented by all Consumer-Formulated Chemical Industries. This will require closer interaction between the D:EA&DP, local municipalities and the private sector especially in terms of providing support to smaller companies which do not have the manpower, technical expertise or finances to design a programme for effectively dealing with chemicals and hazardous waste streams.
- Training of staff at the various companies should be monitored by the D:EA&DP as an indication of the level of compliance to identify facilities which may require support with regards to this issue. Monitoring of a proposed training programme for the staff at various companies can be used as an additional measure of compliance for the training component.
- A list of good housekeeping techniques specific to a sector should be circulated to all companies and an assessment should be undertaken to establish the needs in terms of manpower, technical expertise and financial investment required. This information would provide the basis for the level of intervention required to assist these facilities.
- The quality of all effluent and hazardous waste streams should be monitored to determine the treatment regime required for stabilisation before disposal at a hazardous landfill facility. This, however, will require in-depth analysis of the exact composition of hazardous waste streams to ensure that the correct treatment regime is applied. The exact nature of this treatment regime will be company and waste stream specific.
- All companies should aim to have a documented emergency plan. This could be based on generic components of emergency plans that have successfully been implemented at other companies, which can then be made available to companies in need of assistance.
- Implementation of higher order waste minimisation techniques should be implemented to minimise waste generation. Implementation of these initiatives may require specialist input and the D:EA&DP should facilitate this process for those facilities, which require this intervention.
- Companies generating hazardous and non-hazardous waste must ensure that such waste is disposed of in an appropriate manner that does pose a threat to human health and the enviroment, especially the urban and rural poor. All external contractors used by companies must be registered with the D:EA&DP.

GLOSSARY/ABBREVIATIONS

%	Percentage
BAC	Benzalkonium Chloride Solution
BAT	Best Available Technique
BPEOs	Best Practice Environmental Options
$CaCO_3$	Calcium Carbonate
COD	Chemical Oxygen Demand
CSIR	Centre for Industrial and Scientific Research
D:EA&DP	Department of Environmental Affairs and Development Planning
DETOX	Catalysed Chemical Oxidation
EC	Electrical Conductivity
EDTA	Ethylenediaminetetraacetic Acid
ELI	Eco Logic International Inc
ERP	Enterprise Resource Planning
EU	European Union
H:H	High Hazardous
H_2S	Hydrogen Sulphide
H_2SO_4	Suphuric Acid
HACCP	Hazard Analysis and Critical Control Point
HCl	Hydrochloric acid
HIV	Human Immune Deficiency Virus
HF	Hydrofluoric Acid
HWMP	Hazardous Waste Management Plan
ISO	International Standards Organisation
ISO 9000	ISO for Quality
ISO 14000	ISO for Environmental Standards
ISO 18000	ISO for Occupational Safety and Health
kg	Kilogram
kl /month	Kilolitres per Month
k/Pa	Kilo Pascals
l/month	Litres per Month
LANL	Los Alamos National Laboratory
LSO	Low Sulphur Oil
m^3	Cubic Metres
MAG*SEP	Magnetic Separation
MEK	Methyl Ethyl Ketone
mg/l	Milligrams per Litre
MHI	Major Hazardous Installations
MP9's	Concentrated Multi Surface Cleaner
Mpcol	Solvent
MSDS's	Material Safety Datasheets
NaOCl	Sodium Hypochlorite
NGO	Non-Governmental Organisation
NH_3	Ammonia
OHSA	Occupational Health and Safety Act
OHSO	Occupational Health and Safety Officer
PCB's	Polychlorinated Biphenyls
pH	Measure of the Concentration of Hydrogen Ions in Solution
PNNL	Pacific Northwest National Laboratory
PPC	Personal Protective Clothing
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PVA	Polyvinyl Acrylics
PVC	Poly Vinyl Chloride

Q-CEP	Quantum-Catalytic Extraction Process
R	Rands
SA	South Africa
SABS(SANS)	South African Bureau of Standards(South African National Standards)
SAP	South African Police
SEG	Scientific Ecology Group
SHEQ	Safety, Health, Environment and Quality
STPP	Sodium Tripolyphosphate
UK	United Kingdom
USA	United States of America
VOC	Volatile Organic Carbons

1. INTRODUCTION

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2. SURVEY METHODOLOGY

During the course of the project several companies in the consumer-formulated sector were visited to establish the current practices in terms of chemical handling, processing, storage, transportation, waste treatment and disposal with particular attention being afforded to hazardous chemicals. Companies from the following specialised areas within the consumer-formulated chemical sector were surveyed:

- Automotive
- Cleaning Industry
- Construction and Engineering
- Pharmaceutical/Medical And Personal Health
- Personal Care/Hygiene
- Printing
- Surface Coatings
- Surface Joining

The information presented in the ensuing sections was assimilated by conducting interviews with appropriate staff members (e.g. Technical or SHEQ managers) at the various chemical companies and recording the information on a questionnaire (See **Appendix A**). A total of 19 companies were interviewed in the City of Cape Town and two in the outlying areas, specifically George and Wellington. The information from these companies had not been received and is not included in this report. Where information was withheld due to it being regarded as sensitive, it has been indicated as "**could not be established**".

The list of companies is tabulated according to their sector in **TABLE 1**. Several companies produce products which serve more than one sector, these have been named Multiple Companies.

TABLE 1: LIST OF COMPANIES INTERVIEWED IN THE CONSUMER-FORMULATED CHEMICAL SECTOR

COMPANIES	SECTORS							
	Automotive	Cleaning	Construction & Engineering	Medical	Personal Care	Printing	Surface Coatings	Surface Joining
Coating Company A							✓	
Cleaning Company A		✓						
Multiple Company A	✓	✓						
Printing Company A						✓		
Multiple Company B	✓	✓						
Pharmaceutical Company A				✓				
Pharmaceutical Company B				✓				
Hygiene Company A					✓			
Cleaning Company B		✓						
Multiple Company C	✓	✓						
Coating Company B							✓	
Coating Company C							✓	
Multiple Company D	✓	✓						
Printing Company B						✓	✓	
Surface Joining Company A								✓
Automotive Company E	✓	✓				✓		
Printing Company C						✓		
Construction Company A			✓					
Hygiene Company B					✓			

3. RESULTS OF THE SURVEY (AUTOMOTIVE SECTOR)

3.1.1 CHEMICAL USAGE AND PRODUCTION

MULTIPLE COMPANY A

It was evident from a site visit to the factory that the manufacturing process consisted of mixing raw materials on a batch basis. The quantities of raw material that are used in bulk or those considered hazardous are listed in **TABLE 2.**

TABLE 2: MAJOR RAW MATERIALS USED AT MULTIPLE COMPANY A

RAW MATERIAL	QUANTITIES *(kilolitres per month)*
Alcohol ethoxylate	Could not be established
Ammonia	0.25
Hydrochloric acid	0.2
Sulphuric acid	0.2
White spirits	0.5
Xylene	1.5

The products and quantities are depicted in **TABLE 3.**

TABLE 3: QUANTITIES OF PRODUCTS PRODUCED AT MULTIPLE COMPANY A

PRODUCTS	QUANTITIES *(tons per month)*
Air fresheners (orange oil)	Approximately 5.5
Auto valet range (car shampoo ~ 4%)	
Degreasers (water based – cement and mag-wheel cleaners)	
Deodorants	
Detergents (water based)	
Disinfectants	
Floor polishers	
Graffiti removal products	
Hand-cleaners (multi-purpose soap ~33% exported)	
Sealers (Nanoseal R800 per litre)	

Service chemicals are manufactured on-site as needed and the quantity is unknown.

No waste or by-products are produced.

MULTIPLE COMPANY B

This facility uses a broad range of raw materials which are depicted in **TABLE 4.**

TABLE 4: MAJOR RAW MATERIALS USED AT MULTIPLE COMPANY B

RAW MATERIALS	QUANTITY
Sulphonic Acid	9.0 (tons per month)
Sodium carbonate	4.2 (tons per month)
EDTA	Could not be established
Sodium Laurel-Ether-Sulphate	Could not be established
MP9's	Could not be established
White Spirits	Could not be established
Kerosene	Could not be established

The broad product range of Multiple Company B is shown in **TABLE 5**.

TABLE 5 : QUANTITIES OF PRODUCTS PRODUCED AT MULTIPLE COMPANY B

PRODUCTS	QUANTITIES
Detergent (marine, household)	Could not be established
Disinfectants	Could not be established
Degreasers	Could not be established
Chemicals for construction industry	Could not be established

The chemicals that Multiple Company B uses for cleaning are taken from the raw materials stock. Specifically, a mixture of sulphonic acid and MP9's are used for cleaning purposes. A water-based degreasing chemical product, "Prosolve", is also purchased as a cleaning agent.

Multiple Company B produces minimal amounts of waste products which consist mainly of fluid used in the cleaning of the mixing tanks. This fluid contains the cleaning agents that are used as well as a small quantity of white spirits which is discharged to the municipal sewer system. No by-products are produced in the process.

AUTOMOTIVE COMPANY E

This facility uses a broad range of raw materials and produces a broad range of products. The quantity of each chemical is represented by its maximum storage that it has on the facility.

Products consist of the raw materials that are either diluted or concentrated. These chemicals are also used for cleaning purposes. The major raw materials used as well as the maximum inventory are shown in **TABLE 6**.

TABLE 6: MAJOR RAW MATERIALS USED AT AUTOMOTIVE COMPANY E

RAW MATERIAL	MAXIMUM QUANTITIES IN STORAGE *(tons)*
Liquefied Gases	136
Sodium Hyperchlorite Solution	80
Bulk Acids	448
Bulk Alkalis	2013
Bulk Solvents	818
Peroxides	80

The company blends raw materials into a wide range of products. These products are produced periodically and in small quantities. The only chemical process is the creation of the sodium hyperchlorite solution.

Automotive Company E produces the waste streams indicated in **TABLE 7** but did not wish to provide information on the quantities of waste and products produced.

TABLE 7: WASTE STREAM PRODUCED AT AUTOMOTIVE COMPANY E

WASTE	QUANTITY
Containers	Could not be established
Metal drums	Could not be established
Deposits on containers	Could not be established
Plastics	Could not be established
Scrap metals	Could not be established
Pallets	Could not be established
Tank wash-off	Could not be established
Tank residues	Could not be established

Automotive company E produces no by-products because all processes have 100% product yield of the raw material.

MULTIPLE COMPANY C

Multiple Company C manufacture industrial cleaning products. They also produce kitchen and cloakroom products, spot removers, garment cleaning fluids, floor-care products, laundry products, hand-care products, transport and shipping products, industrial cleaning solvents and degreasers.

The major raw materials used at the facility as well as the quantity are as listed in **TABLE 8**.

TABLE 8: MAJOR RAW MATERIALS USED AT MULTIPLE COMPANY C

RAW MATERIAL	QUANTITY
Soda ash	4.0 – 5.0 (tons per month)
STPP	2.0 (tons per month)
Sodium meta-silicate	2.0 (tons per month)
Hexane	1.0 – 2.0 (drums per month)
Benzene	4.0 (drums per month)
Perchlo (surfactants)	1.25 (tons per month)
Trichlor (Toluene)	1.0 – 2.0 (drums per month)
Methanol	0.2 (kilolitres per month)
White Spirits	2.0 (kilolitres per month)
Butyl oxitol	0.6 (kilolitres per month)
Methylene Chloride	3.0 (tons per month)

Petroleum-based waste is produced at 0.42 kilolitres per month.

3.1.2 Hazardous waste stream handling

Multiple Company A
There are no hazardous waste streams produced as all raw materials are mixed into product, re-used or re-blended back into products. All non-hazardous waste is taken to a waste facility for disposal by an approved contractor who provides a certificate of safe disposal.

Multiple Company B
The small amount of white spirits that is discharged is deemed hazardous. Since this is discharged with water and cleaning agents, the entire waste stream becomes hazardous. The effluent stream is treated by means of a settling tank to remove the suspended solids before being discharged into the municipal sewer system.

The sludge that collects at the bottom of the settling tank is the only other waste that is generated from this facility. The sludge is removed by an external contractor who provides a certificate of safe disposal after the disposal of each batch.

This facility does not have a formal hazardous waste management plan.

Automotive Company E
This facility has a hazardous waste management plan in terms of the requirements of their ISO 9001 accreditation.

Hazardous waste consists of tank residue and contaminated shrink wrap. Currently, there is no on-site separation of hazardous and non-hazardous waste, with all waste being collected in a waste skip that is emptied by a waste contractor and disposed of as hazardous waste. The combined waste stream also includes un-usable containers that are shredded and compacted so that they can occupy a smaller volume. A certificate of safe disposal is provided for each disposed batch.

There are plans to separate effluent streams in order to remix appropriately for self-neutralisation or to treat appropriately. Currently, all the effluent streams run into the settling tank where its solids content is settled before being discharged to the municipal sewage system. The sludge that collects at the bottom of the settling tank is also removed and disposed of by a waste contractor.

Multiple Company C
No formal hazardous waste management plan exists. Solvent degreaser which is in spent drums is considered to be a hazardous waste stream and is separated from the non-hazardous waste. Hazardous waste is encapsulated and sent to a landfill using an approved contractor who provides a certificate of safe disposal while non-hazardous waste is either reworked or recycled.

3.1.3 Chemical inventory record

Multiple Company A
The facility uses a computer program to track chemicals and the status is very good. The facility is accredited with SABS (SANS) 1828 (food industry) and 1853 (detergents).

Multiple Company B
Multiple Company B uses an electronic system, “Alchemist”, for tracking chemical inventory. This system is updated by an annual stock check. Additionally, the facility is ISO 9001 accredited.

Automotive Company E
There is an electronic system that tracks chemical inventory. This system is updated regularly using a three-month stock check. The facility is ISO 9001 accredited and has embarked on a two-year process of obtaining accreditations in terms of the following:

- OHSA
- HACCP-2200
- ISO14000
- ISO 18000

The HACCP-2200 accreditation would be needed for the food warehouse that Automotive company E intends to construct.

Multiple Company C
The “Alchemist” computer program is used to track chemical inventory and the general status of these records is good. The facility is ISO 9001 accredited and is SABS 1828 (food industry) and SABS 1853 (detergents) approved.

3.1.4 Personnel competence and training

Multiple Company A
The staff is trained in sound operating procedures and a production card serves as a method of evaluating the operational skills. Refresher courses on safety and operational procedures are presented on an annual basis.

Multiple Company B
The site staff is trained in good housekeeping methods and there is a culture of safety and awareness that exists amongst the site staff who are urged to look out for the safety and well-being of their co-workers.

Additionally, there are permanent first aid staff as well as safety and fire marshals on the facility. Annually, during the month of April, five site staff are sent for fire training.

Management at the facility acknowledged that their induction course for new recruits was of a poor quality and needed improvement. The facility does not have regular refresher courses for safety and sound operational skills, instead there is continuous "on the job training".

Automotive Company E
The site staff is trained in good housekeeping techniques and a culture of safety exists amongst the staff members. Staff are trained to operate each individual operational unit, and each chemical has its own set of handling and operating instructions that the site staff is expected to abide by.

There are ongoing safety courses for each level of management and Automotive Company E aims to successfully deliver a total of 104 safety lectures in 2007.

Multiple Company C
A culture of safety awareness amongst staff exists and the wearing of personal protective clothing (PPC) is compulsory. Staff are trained in sound operational skills with regards to the usage of fork lifts and blenders with annual training courses being held in this regard.

3.1.5 Waste minimisation

Multiple Company A
Spilled raw material is collected in buckets and placed into containers for re-use. Plastic and metal drums are re-conditioned and carry deposits of R80 per drum and R200 per drum, respectively. Broken drums are collected by a waste contractor. The cost of land filling could not be established.

Multiple Company B
Failed batches of products are assessed and re-worked into new batches. The cost of land filling of sludges and waste was not known by the interviewee. Due to low effluent discharge rates, domestic rates were applied. The cost of land filling could not be established.

Automotive Company E
Usable wood pallets are sorted from those that are to be disposed of while plastic and metal scrap is sold for scrap. Money generated from these sales is used to fund soccer and other extra-mural activities for staff. This serves as a motivation for site staff to minimise waste by means of recycling.

Where possible, drums are re-used for refilling with the same raw material or are shredded when considered un-usable. Drums that are suitable for reconditioning are collected by a drum reconditioner.

Multiple Company C
In terms of waste minimisation, packaging is recycled and is shared amongst the staff. Landfill costs amount to R2500 per year.

3.1.6 Housekeeping and quality control

Multiple Company A
Materials Safety Datasheets are used, but there is no documented procedure for handling, transporting, storage and disposing of chemicals. The raw material analysis is done by the manufacturers and sold with a certificate of analysis.

Quality checks are only performed on the finished products. If losses are detected those are deducted from the inventory. In general, the facility follows SABS (SANS) methodology where housekeeping is concerned.

Multiple Company B
Materials Safety Datasheets are used for all raw materials while the handling, transportation, storage and disposing of chemicals is done in accordance with the requirements of the ISO 9001 accreditation.

There is an on-site laboratory that performs analysis on the quality of the raw materials and products. Additionally, the facility also uses the Certificate of Analysis that accompanies each incoming batch of raw material as a further quality check.

Inspectors from the local municipality routinely take samples of the facility's effluent to analyse for pH, COD and EC levels.

Automotive Company E
Materials Safety Datasheets are used for all raw materials which are available on a website. The handling, transportation, storage and disposing of chemicals is done in accordance with the requirements of the ISO 9001 accreditation.

There is an on-site laboratory that does analysis of raw material and finished products. If customers are dissatisfied with the products, then samples are sent to an external analytical laboratory for verification. Records are also kept of chemical losses due to packaging and containerisation.

Process operations are closely monitored, especially the production of sulphuric acid (H2SO4) used in the production of lead acetate batteries.

Multiple Company C
Material Safety Datasheets are used for all raw materials and the quality of raw materials is checked before usage. Quality control checks are performed on all streams while all losses incurred are recorded on blend sheets. The general state of housekeeping is good.

3.1.7 Risk profiling of facility

The criterion on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility.

Multiple Company A
Multiple Company A is situated in an industrial area. Thus far, no complaints have been filed with the relevant municipalities.

Multiple Company B
There are no residential areas in close proximity to the facility and currently no complaints have been laid by neighbouring communities, local municipalities, NGOs or environmental groups.

Automotive Company E
In the past, there were no residential areas in close proximity to the facility. Recently, however, an informal settlement called Da Noon has encroached to within 20 meters of the facility boundary and this development changes the entire risk profiling situation of the facility. Automotive Company E aims to mitigate the problem by building a wall, 1.8m high, on the boundary of the facility.

The facility has a clear record and no complaints have been laid by neighbouring communities, local municipalities, NGOs or environmental groups

Multiple Company C
The facility is situated in an industrial area. No complaints have been filed with the relevant municipalities or with the facility. Hazardous waste is encapsulated and disposed of in a high hazardous landfill by an approved contractor. The disposal of waste has no affect on the rural and urban-poor.

3.1.8 Emergency planning and safety

Multiple Company A
There is no formal or informal emergency plan at the facility.

Multiple Company B
The facility possesses updated evacuation plans and a plan of action in the event of a fire. There are three emergency/fire escapes and a flammable store for listed chemicals. A fire alarm was in the process of being installed. The facility also possesses a fire permit for a flammable store and a permit for industrial effluent discharge.

Automotive Company E
The facility possesses a full emergency plan which includes fire response, disaster management and an emergency response unit. The facility has underground flammable storage.

The staff is always alert for possible uncontrolled fires that could originate from the encroaching informal settlement such as shack fires or from the uncontrolled burning of tyres (and other wastes) for the recovery of scrap metal.

Multiple Company C
In terms of emergency planning and safety, emergency planning is divided into two protocols, namely “serious” and “non-serious”. The facility is compliant with legislation from the Department of Labour, with regard to basic skills, Aids awareness and budgeting. The company also has a fire permit for the listed flammable chemicals on site.

3.1.9 Barriers to implementation of waste management planning

Multiple Company A
A financial barrier exists for the construction of a fireproof store to house a 0.2 kilo-litres flammable drum.

Multiple Company B
Possible barriers to the successful implementation of a hazardous waste management plan were identified as follows:

- Financial
- Technical
- Training
- Morale
- Cultural

Automotive Company E
The encroachment of the informal settlement is seen as a barrier to the implementation of an effective hazardous waste management plan.

Multiple Company C
No barrier exists for the implementation of a waste management plan at Multiple Company C.

3. RESULTS OF THE SURVEY (CLEANING SECTOR)

3.2.1 CHEMICAL USAGE AND PRODUCTION

CLEANING COMPANY A

It was evident from a site visit to the factory that the process of manufacturing products consisted of blending various raw materials on a batch basis. The list of major raw materials as well as the quantities of these is shown in **TABLE 9**. The quantity of raw materials used varied substantially on a monthly basis as the business was very seasonal. It was, however, established that the highest demand for cleaning chemical products was during summer months.

TABLE 9: MAJOR RAW MATERIALS USED AT CLEANING COMPANY A

RAW MATERIAL USED	QUANTITY
Sodium Hypochloride	1.25 (tons per month) (average)
Caustic Soda	1.5 (tons per month)
Benzene	Could not be established
Turpentine	Could not be established
Paraffins	Could not be established
Iso and N-Propanol	Could not be established
Butoxy-Ethanol	Could not be established
Lpg Gas	Could not be established
Sulphuric Acid	Could not be established
Hydrochloric Acid	Could not be established
Hydrofluoric Acid	Could not be established

A wide range of products are produced at Cleaning Company A. The list of products produced as well as the quantities is shown in **TABLE 10**.

TABLE 10: MAJOR PRODUCTS PRODUCED AT CLEANING COMPANY A

PRODUCTS	QUANTITY *(tons per month)*
Dishwashing liquid	3.0
Bleach	3.5
Washing powder	2.0

Solvent based chemicals, emulsifier and water are used for cleaning. All of the solvents are re-used and virtually no effluent leaves the plant. Waste streams are unused products and are generated as a result of the cleaning of mixing tanks and are discharged via the sewer system without treatment.

No by-products are produced during the process.

MULTIPLE COMPANY D

The facility uses a broad range of raw materials. The materials in **TABLE 11** were identified as those that are used in large quantities or are considered hazardous.

TABLE 11: MAJOR RAW MATERIALS USED AT MULTIPLE COMPANY D

RAW MATERIALS	QUANTITY
Solvents (diesel, paraffin)	Could not be established
Caustic Soda and Potash	Could not be established
Lubricants	Could not be established
Sulphuric Acid (98%)	Could not be established
Hydrochloric Acid (33%)	Could not be established
Nitric Acid	Could not be established
Chromic Acid	Could not be established
Methyline Chlorite	Could not be established
Trichloro-Ethylene	Could not be established
Ammonia	Could not be established
Calcium Hyperchloride	Could not be established
Sodium Hyperchloride	Could not be established
Xylol	Could not be established

The facility produces a broad range of products which are depicted in **TABLE 12**.

TABLE 12: QUANTITIES OF PRODUCTS PRODUCED AT MULTIPLE COMPANY D

PRODUCT	QUANTITY
Enzyme based products	Could not be established
Sulphuric acid drain cleaner	Could not be established
Miracle man (Diesel based)	Could not be established
Miracle tool (Diesel based)	Could not be established
Bleaches	Could not be established
Disinfectants	Could not be established
Hand cleaners (liquid, gel, paste)	Could not be established
Brass and Copper cleaner	Could not be established

Cleaning chemicals at Multiple Company D are taken from the raw materials stock.

Multiple Company D claims to produce minimal amounts of waste products which includes solid waste that is stored in waste drums and then collected by an approved hazardous waste collector. A certificate of safe disposal is provided after removal of each batch of hazardous chemical waste.

The facility generates a wash-water effluent stream that has its pH buffered before it is discharged into the municipal sewer system. No by-products are produced because this facility only carries out blending operations and the yield of the products is close to 100% of the raw material. Pot-washing of vessels does occur after the mixing of a batch and the waste stream generated in this process will essentially be a diluted form of the product.

CLEANING COMPANY B

The raw materials used at the facility are as listed in **TABLE 13**. The product manufacturing rate varies from day to day and hence only storage quantities of raw materials were provided.

TABLE 13: MAJOR RAW MATERIAL USED AT CLEANING COMPANY B

RAW MATERIAL	QUANTITY
Soda ash	25 kg (bags)
Sodium Meta-Silicate (additive)	25 kg (bags)
Propanol	210 litres (drum)
Engine degreaser (Paraffin based)	25 litres (drum)
Powdered chlorine	21 tons (container)
Caustic	4 tons (flowbin)

According to the facility no waste or by-products are produced. Effluent resulting from the cleaning of mixing tanks can contribute to the volume of industrial effluent discharged to the municipal sewer system.

3.2.2 Hazardous waste stream handling

Cleaning Company A
The facility does not produce any hazardous effluent streams. All failed batches are reworked while all the products are inherently safe. All the chemicals used in the facility are stored in appropriate areas and are clearly marked. A flammable store is also used for listed flammable products. The cleaning of mixing units results in the only effluent discharge from the facility but this is essentially diluted product which is discharged. Solid waste is removed by an approved contractor who provides a certificate of safe disposal after the removal of each batch.

The factory is ISO 9000 accredited and therefore has to comply with strict requirements in terms of the disposal of hazardous waste.

Multiple Company D
Chemical spills are absorbed with cloth's or absorbents and then shovelled up before being placed in waste drums. This procedure is not documented, but the staff has been trained in this approach. Hazardous and Non-Hazardous waste are produced in very small quantities and are currently not separated. These are all disposed of into the waste drums for collection by an approved waste management contractor. A certificate of safe disposal is provided for each batch of hazardous material removed.

The water used in cleaning the blending tanks is treated in a settling tank to neutralise the pH and to remove solids before discharging to the municipal sewers. Additionally, the facility has a flammable store for listed chemicals.

Cleaning Company B
The facility only produces non-hazardous waste. The cost of solid waste disposal amounts to approximately R900/month waste is removed twice a month.

3.2.3 Chemical inventory records

Cleaning Company A
The factory uses both physical and electronic methods to track its chemicals. A monthly physical stock-taking takes place to verify the electronically indicated amounts.

Multiple Company D
Multiple Company D uses an electronic system to track its chemical inventory. The system holds the formulae for the combination of raw materials in order to manufacture certain products and as products are produced, the amount of raw materials is reduced by the appropriate quantities. The electronic records are backed up by manual records and are updated by physical stock-checks.

Cleaning Company B
A computer program, ERP, is used to track chemical inventory. The status of this inventory is of a high-quality and it is further supported with monthly stock-takes. The facility is also ISO 9001 accredited.

3.2.4 Personnel competence and training

Cleaning Company A
The staff receives in-house training. The forklift drivers are being tested for competence biannually. There are regular fire drills, first aid training and refresher courses in correct chemical handling techniques. A good culture of safety awareness exists as well as training in operational skills. New workers are required to attend an induction course.

Cleaning Company B
The staff are trained in good house keeping practices and operational skills. Training occurs on a monthly basis. A culture of safety awareness amongst staff also exists.

Multiple Company D
The facility has a formal induction programme for new staff which focuses on good housekeeping practices and sound operational skills. The staff receive regular in-house training in terms of meeting the safety requirements of the ISO 9002 accreditation. All training courses are refreshed on a quarterly basis. Additionally, there is a St. John accredited first-aid officer on site who is sent for the required refresher courses. Generally, a culture of safety awareness exists amongst all staff.

3.2.5 Waste minimisation

Cleaning Company A
At present, there is no waste minimisation procedures employed, as all raw materials are used and no by products are formed. All out-of-specification products are reworked to meet the required specification of the final product.

Multiple Company D
No waste minimisation techniques are currently employed. The cost of land filling could not be established.

Cleaning Company B
In terms of waste minimisation, paper and cardboard are taken by staff and re-used. Drums and plastics are recycled. The effluent costs amount to approximately R2 000/month due to current discharges to the sewer.

3.2.6 Housekeeping and quality control

Cleaning Company A
Materials Safety Datasheets are used and documented procedures for handling, transporting, storage and disposing of chemicals is performed in accordance with the requirements of the ISO 9000 accreditation. Only raw materials accompanied with a Certificate of Analysis are accepted for use.

Recipes for the blending of various products have built-in warnings or checks relevant to the chemicals being used, to alert the operator to possible dangers relating to the usage of the chemical. The housekeeping techniques used are excellent, before and during the manufacturing processes.

Multiple Company D
Materials Safety Datasheets are used for all raw materials while the handling, transportation, storage and disposing of chemicals is done in accordance with the requirements of the ISO 9002 accreditation.

In terms of housekeeping and quality control, Material Safety Datasheets are used. There are documented systems and procedures for handling, transporting, storage and disposing of chemicals. Raw material quality is monitored by in-house analysis and should also be accompanied by a Certificate of Analysis when purchased. Process conditions are monitored and quality control checks are performed on all streams. Records of losses are kept by checking the yields of products produced. The general state of housekeeping is satisfactory.

Cleaning Company B
In terms of housekeeping and quality control, Material Safety Datasheets are used. There are documented systems and procedures for handling, transporting, storage and disposing of chemicals. Raw material quality is monitored by in-house analysis and should also be accompanied by a Certificate of Analysis when purchased. Process conditions are monitored and quality control checks are performed on all streams. Records of losses are kept by checking the yields of products produced. The general state of housekeeping is satisfactory.

3.2.7 Risk profiling of facility

The criterion on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility.

Cleaning Company A
The criteria on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility

There are no residential areas in close proximity to the facility and currently no complaints have be laid by neighbouring communities, Local Municipalities, NGO's or environmental groups.

Multiple Company D
There are no residential areas in close proximity to the facility and currently no complaints have be laid by neighbouring communities, Local Municipalities, NGO's or environmental groups.

Cleaning Company B
There are no residential areas in close proximity to the facility and currently no complaints have be laid by neighbouring communities, Local Municipalities, NGO's or Environmental groups.

3.2.8 Emergency planning safety

Cleaning Company A
The facility has a first order emergency plan and is in possession of the required permits required in terms of the company's ISO 9000 accreditation.

Multiple Company D
The facility had in the past developed a documented procedure for evacuation in the event of an emergency. Three emergency exits are currently located on site. Storage, handling and transportation of chemicals is performed in accordance with the requirements of the company's ISO 9002 accreditation.

Cleaning Company B
Documented procedures for emergencies are available and the facility is compliant with legislation.

3.2.9 Barriers to implementation of waste management planning

Cleaning Company A
It is evident that there are no real barriers to implementing hazardous waste management planning. There is a constant self-development of procedures and techniques to handle chemicals.

Multiple Company D
Multiple Company D does not have any obvious barriers to implementing a hazardous waste management plan.

Cleaning Company B
The main barrier to the implementation of a waste management plan at Cleaning company B would be time.

3. RESULTS OF THE SURVEY

(CONSTRUCTION & ENGINEERING SECTOR)

3.3.1 CHEMICAL USAGE AND PRODUCTION

CONSTRUCTION COMPANY A

Construction company A manufacture all building and construction products. Due to the varying nature of raw materials, a few were selected as being the major ones, these are shown in **TABLE 14**.

TABLE 14: MAJOR RAW MATERIALS USED AT CONSTRUCTION COMPANY A

RAW MATERIAL	QUANTITY
Cement	(18 tons per month)
Sulphuric acid	Could not be established
Caustic	
Epoxy & Polyurethane	100 (litres per month)

The products produced are numerous and are categorised in **TABLE 15** below. The quantities of products were not specified.

TABLE 15: QUANTITIES OF PRODUCTS PRODUCED AT CONSTRUCTION COMPANY A

PRODUCT	QUANTITY
Building & construction products	Could not be established
Polyurethane flooring	Could not be established
Cementitions *(80%)*	Could not be established
Coatings *(20%)*	Could not be established

Approximately 0.3 kilolitres per month of a Xylene or Water mixture is used as service chemicals at the facility. No by-products are produced at the facility.

3.3.2 Hazardous waste stream handling

Construction Company A
The facility has a hazardous waste management plan. A fire store is in place for the storage of flammable material. The company is currently busy working on a fire and evacuation plan. Chemical waste and wastewater are seen as hazardous. These wastes are stored in drums and removed by a reputable waste management service provider to be land filled. Hazardous and non-hazardous waste is separated on-site. No treatment regimes are employed to effluent streams as no hazardous effluent exists.

3.3.3 Chemical inventory record

Construction Company A
A computer program, "Alchemist", is used to track chemical inventory and the condition is of a high standard. Manual stock-taking is performed once a month. The facility is ISO 9000 accredited.

3.3.4 Personnel competence and training

Construction Company A
The staff are trained in good housekeeping practices. A culture of safety awareness exists amongst staff. Workers are also trained in sound operational skills with regard to operating practices. Training is an on-going process at the facility.

3.3.5 Waste minimisation

Construction Company A
Powders that are spilt may be reworked. Liquid materials that are not re-usable or re-workable are disposed of in a landfill site using an approved waste contractor.

Cardboard boxes have a deposit on them and hence are returned to the supplier to recover the deposit. Flowbins (1m3) have a deposit of R100 on them and are also returned for the recovery of deposits.

The cost of land filling 16 drums of chemical waste and wastewater amounts to R3 000/month.

3.3.6 Housekeeping and quality control

Construction Company A
Material Safety Datasheets are used for all raw materials and there are documented systems and procedures for the disposal of wastes. The quality of raw material is monitored and is purchased with a certificate of analysis.

Additionally, process conditions are also monitored while quality control checks are done on products and on waste streams. Records of any losses incurred are kept and the state of housekeeping is of a high standard.

3.3.7 Risk profiling of facility

The criteria on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility

Construction Company A
The facility is situated in an industrial area and no complaints have been filed with the relevant municipalities or with the facility. Waste sludge from the process, which is hazardous, is containerised and disposed of in a high hazardous landfill by an approved contractor.

3.3.8 Emergency planning and safety

Construction Company A
The facility has no formal emergency plan and is compliant with the MSDS sheets with regard to chemicals handling, storage and transportation.

3.3.9 Barriers to implementation of waste management planning

Construction Company A
The successful implementation of a hazardous waste management plan is prevented by the following barriers:

- Financial
- Time
- Space

3. RESULTS OF THE SURVEY (PHARMACEUTICAL SECTOR)

3.4.1 CHEMICAL USAGE AND PRODUCTION

PHARMACEUTICAL COMPANY A

Pharmaceutical company A Corporation manufactures mainly pharmaceutical products and over 200 raw materials are used in various products. The major raw materials used at Pharmaceutical Company A are shown in **TABLE 16**.

TABLE 16: MAJOR RAW MATERIALS USED AT PHARMACEUTICAL COMPANY A

RAW MATERIAL	QUANTITIES *(tons per month)*
Acetic Anhydride	59
Glacial Acetic Acid	9
Hydrochloric Acid (35%)	5
Sulphuric Acid	2.5
Phosphorus Pentachloride	2.5
Phosphorus Oxychloride	1.7
Ethyl Acetate (Anhydrous)	1.7
Sodium Hydroxide Pearls	1.7
Mono-Methylamine	1.25
Di-Ethyl Oxalate	0.8
Hydrobromic Acid	0.8

Products produced cover a wide range for local consumption and the international market. **TABLE 17** shows the overall amount of pharmaceutical products produced.

TABLE 17: QUANTITIES OF PRODUCTS PRODUCED AT PHARMACEUTICAL COMPANY A

PRODUCT	QUANTITIES *(tons per month)*
Pharmaceuticals (overall)	50 – 83

A range of service chemicals used in cleaning processes is shown in **TABLE 18** below.

TABLE 18: SERVICE CHEMICALS USED AT PHARMACEUTICAL COMPANY A

SERVICE CHEMICAL	QUANTITY *(tons per month)*
Low Sulphur Oil	69
Sodium Hydroxide	61
Nitrogen	28
Methanol	15
Acetone	12
Ammonia	9.2
Chloroform	7.5
Toluene	5.8
Ethylene Glycol	3.75
Methylated Spirits	3.3
Heptane	2.5
Iso-Propanol	2.1
Sodium Hypochlorite	1.7
Dimethylformamide	11.7
Dichloromethane	1.25
Methyl Ethyl Ketone (*Mek*)	1.25
Sodium Chloride	0.83
Potassium Carbonate	0.83

Waste products formed during the processes are both hazardous and non-hazardous. Waste solvents are in the form of mixtures and aqueous waste which may contain up to 10% organic matter. These are shown in **TABLE 19**.

TABLE 19: WASTE PRODUCTS PRODUCED AT PHARMACEUTICAL COMPANY A

WASTE PRODUCTS	QUANTITIES *(tons per month)*
Aqueous waste (*10% organic*) (hazardous)	333
Solvents (hazardous)	6.25
Non-hazardous	16

By-products from the process are shown in **TABLE 20** below.

TABLE 20: BY-PRODUCTS PRODUCED AT PHARMACEUTICAL COMPANY A

BY-PRODUCT	QUANTITY *(tons per month)*
Sodium Acetate	190
Various solvents	160

PHARMACEUTICAL COMPANY B

The Pharmaceutical company B manufactures pharmaceutical products using a batch processing system. A list of raw materials and the quantities used are presented in **TABLE 21**.

TABLE 21: MAJOR RAW MATERIALS USED AT PHARMACEUTICAL COMPANY B

RAW MATERIAL	QUANTITY
Methanol	0.25 (kilolitres per month)
Ethanol	26 (litres per month)
Solvents	0.1 (kilolitres per month)
Acids	22 (kilolitres per month)
Powders	7 (kilogram per month)
Ammonia	2 (kilolitres per month)
Other (incl. Butane, Nitrogen and Alkalis)	2.5 (kilogram per month)

Specific products produced include headache tablets, influenza mixtures, antacids and bactericides.

Waste products generated would include out-of-specification products that are disposed of in high hazardous (H:H) landfill sites by an authorised waste service provider. No by-products are produced.

3.4.2 Hazardous waste stream handling

Pharmaceutical Company A
The facility has a hazardous waste management plan. The aqueous and solvent waste streams are considered to be hazardous. Hazardous and non-hazardous waste streams are separated on site.

The following treatment regimes are applied to the waste effluent streams:

- pH adjustment by caustic addition
- Neutralisation by chemical reaction (e.g. addition of water to acetic anhydride, followed by caustic addition)
- Purification by distillation
- Mixture separation and in-process washing (e.g. separation of non-polar and polar solvents)

Disposal of waste from waste streams are as follows:

- Landfill – at a H:H site for aqueous waste and lime treatment
- Solvents for recycling, drum burning or incineration (with scrubbing of flue gases)
- Incineration and landfill for pharmaceuticals
- Encapsulation
- Municipal sewer under permit for wastewater

Pharmaceutical Company B
A hazardous waste stream handling plan does exist with standard operating procedure. Staff are trained in appropriate waste management and handling.

Hazardous waste streams include hazardous pharmaceutical waste and bio-hazardous waste (medical waste) which are separated at the facility. Bio-hazardous waste from medical research is incinerated off-site. An approved waste contractor is used to remove all other hazardous waste and a certificate of safe disposal is provided after the disposal of each batch. The cost of land filling amounts to approximately R3 800/month.

Currently, industrial and domestic effluent is not separated. A plan for effecting this separation is scheduled for implementation by June 2007.

3.4.3 Chemical inventory records

Pharmaceutical Company A
The SYSPRO computer package is used to track chemical inventory and the status is of a high standard. In addition, monthly stock-takes are performed which are subjected to strict chemical movement controls and frequent audits. The facility is not ISO accredited as yet.

Pharmaceutical Company B
A computer program is used to track chemical inventory and the status of the system is of a high standard. The facility is not ISO accredited as yet, but is striving towards ISO 18001 accreditation by 2009.

3.4.4 Personnel competence and training

Pharmaceutical Company A
Site staff are trained in good housekeeping practices and a culture of safety exists amongst staff. Workers are equipped with sound operational skills with regard to regulatory requirements. Daily weekday training is typical across a range of disciplines while retraining is only encouraged if a problem occurs. Annual training of staff is undertaken when required.

Pharmaceutical Company B
Staff are trained in good housekeeping practices and safety awareness amongst staff does exist. Safety awareness training for all staff is monitored on a monthly basis with an annual external audit being conducted by staff from the head office in the United Kingdom (UK). Additionally, staff are trained in sound operational skills and refresher courses are held once a year.

3.4.5 Waste minimisation

Pharmaceutical Company A
Solvents, scrap metal, glass, paper and wood are recycled. Energy extraction from heat exchangers are utilised for other unit operations while solid waste is compacted on site to reduce landfill volumes. Wastewater from cooling towers is used to irrigate gardens. The cost of land filling amounts to approximately R1.8 million/year.

Pharmaceutical Company B
Paper, oil, metal drums and plastic bottles are recycled. No packaging or boxes are re-used internally while water from the cooling towers is recycled. The costs of effluent discharge could not be established.

3.4.6 Housekeeping and quality control

Pharmaceutical Company A
Material Safety Datasheets are used for all raw materials. There are documented systems and procedures for handling, transporting, storage and disposing of chemicals; hazardous and non-hazardous. Raw material quality and process conditions are monitored while quality control checks are performed on raw material and product streams. Waste stream checks are done by on-line pH instrumentation with additional detailed analysis by approved laboratories (e.g. SABS and CSIR) and a waste contractor on landfill site. A record of losses is kept and the general status of these records is of a high standard.

Pharmaceutical Company B
Materials Safety Datasheets are used for all raw materials. Raw material quality is not checked, but is supplied with a Certificate of Analysis. Process conditions are monitored as the product quality is sensitive to changes in these conditions. Quality control checks are performed on products but this programme will be extended to include monitoring of the liquid effluent as well. Records of losses are not kept.

3.4.7 Risk profiling of facility

The criteria on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility

Pharmaceutical Company A
The facility is situated in an industrial area. An expensive infrastructure namely Pharmaceutical company B is within 10m and Afrox within 25m of the facility. An incident involving a hydrogen sulphide release on 14 October 2004 caused a nuisance odour relating to a possible stalling of a scrubber system. This resulted in a neighbour complaining. The disposal of waste has no effect on the rural and urban-poor.

Pharmaceutical Company B
The facility is located in an industrial area and to date no complaints had been received from the surrounding communities or the local municipality.

3.4.8 Emergency planning and safety

Pharmaceutical Company A
Emergency planning at the facility is adequate. Immediate neighbours are aware, but rely on disaster management and emergency services to co-ordinate any evacuation. The facility is fully compliant with regard to chemical handling, storage and transportation.

Permits are available for the following:
- manufacturing permit by the Medicines Control Council
- wastewater permit for municipal sewerage
- flammable storage certificates

Pharmaceutical Company B
Regular evacuation drills are used to increase the level of preparedness of staff on the facility. An Occupational Health and Safety Officer (OHSO) is also present on site. The relevant permits for operations at the facility are up-to-date.

3.4.9 Barriers to implementation of waste management planning

Pharmaceutical Company A
There are no barriers to the successful implementation of a hazardous waste management plan.

Pharmaceutical Company B
The facility has no barrier to the implementation of a waste management plan. It was, however, felt that the perception that “waste is just waste” needed to be changed.

3. RESULTS OF THE SURVEY (HYGIENE SECTOR)

3.5.1 CHEMICAL USAGE AND PRODUCTION

HYGIENE COMPANY A

Hygiene Company A manufactures personal care products. The major raw materials used in the manufacturing of these products are shown in **TABLE 22** below. Products manufactured vary on a day to day basis and hence only storage quantities of raw material are provided.

TABLE 22: MAJOR RAW MATERIALS USED AT HYGIENE COMPANY A

RAW MATERIAL	QUANTITIES
Acetone	**Could not be established**
Additives (*fragrances*)	*minimal*
Ethanol (95%)	14 000 litres tank
Ethanol (100%)	23 000 litres tank
Butane (*propellant*)	23 m^3 tank
Propane (*propellant*)	44 m^3 tank
Nail varnish *(flammable)*	4 000 litres tank

The products manufactured can be categorised either as cosmetic or toiletries and the volume of each category could not be established. The facility uses a number of service chemicals for cleaning. This is shown in **TABLE 23** below.

TABLE 23: SERVICE CHEMICALS USED AT HYGIENE COMPANY A

SERVICE CHEMICALS	QUANTITIES *(tons per month)*
Coss Bleach	25
Coss Pine disinfectant	20
Sumabac	8
Coss Pink handsoap	150
J1500 floor polish	100
Shift floor stripper	75
Coss Handy andy	50
Coss dish liquid	30
Coss intensive	30
Sumakor	100
LSD washing powder	50
Coss auto washing powder	10
Traffic film remover	100
Auto floor stripper	100
Release	150
Jeyes fluid	5
Stainless Steel polish	25
Bronocide	100
Acid Flush	25
Sulphuric acid	25
Alkali Flush	25

The facility produces liquid and solid waste and this is shown in **TABLE 24** below. The quantity of waste produced was not specified.

TABLE 24: WASTE PRODUCTS PRODUCED AT HYGIENE COMPANY A

WASTE	QUANTITY
1st Liquid waste skip	Residues, contaminated batches, expired foundation oils (*crushed*), kitchen oil (*spent*) and cleaning agents.
2nd Solid waste skip	Paper (*compacted*)
3rd Solid waste skip	Glass and metals (*separated*)

No by-products are produced at the facility as this is mainly a blending operation.

HYGIENE COMPANY B

It was evident from a visit of the factory that the manufacturing process was performed on a batch basis. The list of major raw materials used at Hygiene company B is shown in **TABLE 25**.

TABLE 25: MAJOR RAW MATERIALS USED AT HYGIENE COMPANY B

RAW MATERIAL	QUANTITIES
MPcol - sodium laurel ethyl sulphate (27%)	Could not be established
Ammonium hydroxide (25%)	Could not be established
Utex	Could not be established
Thioglycolic acid	Could not be established
Hydrogen peroxide	Could not be established
Ethanol (99%)	Could not be established

Although **TABLE 25** shows only the list of major raw materials used, other raw materials were also used, but in far less quantities. Typical products produced are shampoos, conditioners, hair dyes, hair relaxers and hair sprays. Approximately 66% of the factory's output is shampoo with the balance consisting of conditioners, hair dyes, hair relaxers and hair sprays.

Service chemicals for cleaning included MPcol, NaOCl (bleach) diluted to 200 mg per litre and Divaclean. Waste products from the process occurred only as a result of pot washing (plastic and metal), cooling water and cardboard. No by-products were produced

The quality of raw materials were closely monitored as products are intended for intimate human use **(in-house laboratory analysis of raw materials)** and process conditions were closely monitored as all out-of-specification product had to be discarded and may not be re-used, recycled or reworked.

3.5.2 Hazardous waste stream handling

Hygiene Company A
The facility has a documented hazardous waste management plan. The waste effluent streams are treated with lime to control the pH. Waste may be separated as liquid and solid waste. The liquid and solid waste is land filled using an approved contractor who provides a certificate of safe disposal after each batch removed from site.

Hygiene Company B
All the effluent from the plant is fed to a gravity settling tank with an overflow to the municipal sewer system. All hazardous waste from the sludge of the tank is encapsulated and appropriately discarded using an approved contractor. A certificate of safe disposal is provided by the disposal contractor for each batch of waste removed from the site. Effluent generated during the washing of mixing vessels is disposed of as industrial effluent.

3.5.3 Chemical inventory records

Hygiene Company A
A "SAP" database is used to track chemical inventory and the status of the inventory is of a high standard with audits done on a monthly basis. The facility is ISO 9002 accredited.

Hygiene Company B
The factory uses a "SAP" database to track its chemicals as well as periodic manual auditing for management purposes. The system is in excellent condition and currently the facility exceeds the relevant chemical inventory requirements in terms of maintaining their ISO accreditation.

3.5.4 Personnel competence and training

Hygiene Company A
The staff is trained in good housekeeping practices and a culture of safety exists amongst staff. Workers are also trained in sound operational skills with regular (monthly) in-house courses being held.

Hygiene Company B
The staff at Hygiene Company B are trained in-house in good operational procedures by the production manager. There are regular fire drills as well as training in first aid and correct chemical handling techniques. A good culture of safety awareness also exists. Operational training is provided on a quarterly basis.

3.5.5 Waste minimisation

Hygiene Company A
Waste minimisation in terms of source reduction and recycling is a major focus area at the facility. Waste paper is compacted on site to reduce its volume before it goes to a landfill and glass and metal (tins) are recycled.

Landfill costs vary on a monthly basis. The various costs are listed below:

- In September 2006, the cost to remove paper amounted to approximately R16 000 and in November 2006, this amounted to approximately R7 500.
- The cost to remove hazardous waste also varies on a monthly basis. In November 2006, the cost was approximately R7 000 and in December 2006, this was approximately R2 250.
- The effluent from manufacturing processes amounted to approximately R126 111 last, year from June 2005 to July 2006.

Hygiene Company B
At present there are no waste minimisation techniques employed as all raw materials are used and no by products are formed. It was acknowledged by Hygiene company B that there was probably some room for improvement as unwanted product and product out of specification could not be reworked or recycled. It was estimated that 5% of the highly viscous product and 1% of the low viscosity product could be regarded as waste.

There is scope for rework of out-of-specification product with regard to viscosity or specific gravity. This would, however, require authorisation from the parent company and then only 20% may be used at a time. Steam at 50 kPa is used in the process.

3.5.6 Housekeeping and quality control

Hygiene Company A
Material Safety Datasheets are used for all raw materials while documented systems and procedures exist for handling and disposal of chemicals. Raw material quality is monitored and is purchased with a certificate of analysis. Process conditions are also monitored with quality control checks performed on raw, product and waste streams.

Records are kept of all accidents/spills emergencies that occur and are investigated under strict control after the event.

Hygiene Company B
Materials Safety Datasheets are used for all raw materials while documented procedures for handling, transporting, storage and disposing of chemicals exceeds the standards required in terms of maintaining an ISO accreditation. The quality of raw material as well as process conditions is closely monitored while traceability of chemicals with a SAP database is relatively accurate.

Quality control checks are performed on waste streams and in general, the housekeeping procedures at the facility are of a high standard which leads to improved quality control and a reduction in losses due to out-of-specification products.

3.5.7 Risk profiling of facility

The criteria on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility

Hygiene Company A
The facility is situated in an industrial area and no complaints have been lodged by the neighbouring companies. The disposal of waste has had no affect on the rural and urban-poor.

Hygiene Company B
The facility is situated in an industrial area and thus far no complaints have been filed with the relevant municipalities or with the facility. Solid waste is disposed of using an approved contractor while liquid effluent is treated before being discharged into the municipal sewer system.

3.5.8 Emergency planning and safety

Hygiene Company A
The status of emergency planning at the facility is of a high standard. The facility is compliant in terms of chemicals handling, storage and transportation. However, a suitable flammable store is required for flammable products. Permits are available for operations, storage of chemicals, and manufacturing of products and disposal of waste.

Hygiene Company B
There is a first order emergency planning procedure as well as a back-up. The required permits are in order as the facility is monitored according to the relevant EU standards. Permits are required for pressure vessels, ethanol storage, compressors as well as a flammable store. During the last audit the facility was found to be 96% compliant with operation procedures.

3.5.9 Barriers to implementation of waste management planning

Hygiene Company A
The successful implementation of a hazardous waste management plan is hampered by the following barrier:

- perception – company sees waste as waste not as a resource

Although basic measures are in place for waste management, there is still room for improvement.

Hygiene Company B
The only barriers to implementing hazardous waste management planning were financial and technical expertise.

3. RESULTS OF THE SURVEY (PRINTING SECTOR)

3.6.1 CHEMICAL USAGE AND PRODUCTION

PRINTING COMPANY A

The major raw materials used at the facility are shown in **TABLE 26**. Since the quantities of raw material used vary on a daily basis, only storage quantities were provided.

TABLE 26: MAJOR RAW MATERIALS USED AT PRINTING COMPANY A

RAW MATERIAL	QUANTITIES
Acetone	0.2
Ethyl Acetate	23
Ethyl Alcohol	23
Hexane	0.2
Isobutyl Acetate	2
Mek	0.8
Nitrocellulose Varnisher	16
Nitrocellulose/Polyamide Varnish	4.6
N-Propanol	4
Polyamide Varnish	0.6
Polyurethane Synthetic Resin	2.4
Toluene	60
Xylene	0.6

The products at the facility include liquid inks for newspapers and magasines. Paste inks and screen ink products for silkscreen printing/clothing. Waste products come from the washing of containers and include mainly consumables. No by-products are produced in the process. The types of waste products produced as well as the quantities are shown in **TABLE 27.**

TABLE 27: TYPES OF WASTE PRODUCTS PRODUCED AT PRINTING COMPANY A

PRODUCT	QUANTITIES
Water	8000 litres 3 times a year
Sludge-solvent/ink mix (pot washing)	Could not be established
Ink-samples/reject	Could not be established
Used solvent (cleaning)	Could not be established
Soiled rags-solvent (non-toxic & highly flammable)	Could not be established
Resin/pigment bags, drums-contaminated (flammable 200 litres container)	Could not be established
Kegs-contaminated (flammable 25 litres container)	Could not be established
Plastic wrapping	Could not be established
Fluorescent light bulbs (contain mercury)	Could not be established
Aluminium powder (screen grinding)	Could not be established
Contaminated PPE (gloves, respirators etc.)	Could not be established
Spill residue/clean-up waste	Could not be established
Pigment bags	Could not be established
General/office refuse (plastic and paper)	Could not be established

PRINTING COMPANY B

Printing company B recycles waste chemicals and also manufactures chemical products. Recycling of waste chemicals entails the following raw materials which are shown in **TABLE 28**.

TABLE 28: WASTE CHEMICALS AS RAW MATERIAL RECYCLED AT PRINTING COMPANY B

RAW MATERIAL	QUANTITY
Acetone	Could not be established
Chloroform	Could not be established
Dimethylformaldehyde	Could not be established
Ethyl acetate	Could not be established
Flexographic solvent	Could not be established
Lacquer thinners	Could not be established
Iso-propanol	Could not be established
Methanol	Could not be established
Tetrahydrofuran	Could not be established
Toluene	Could not be established
White Spirits	Could not be established

The manufactured products are shown in **TABLE 29** below. Quantities of products produced could not be established.

TABLE 29: PRODUCTS PRODUCED AT PRINTING COMPANY B

PRODUCTS	QUANTITIES
Disalicylidine Propylene Diamine (*Fuel Additives*)	Could not be established
Fatty Acid Diethanolamide (*Lubricant Additives*)	Could not be established
Butyl Stearate (*Fatty Esters*)	Could not be established
Iso-propylamine Sulphonate (*Surfactants*)	Could not be established
BAC 50 and BAC 80 (*Quaternary Ammonium Compounds*)	Could not be established
PVC Weld (*Adhesive*)	Could not be established

Products at the facility may either be products of chemical reaction, distillation or blending. The quantities of raw material processed using each of the unit operations are shown in **TABLE 30**.

TABLE 30: PROCESSING OF RAW MATERIAL AT PRINTING COMPANY B

RAW MATERIAL	QUANTITY
Reactions	180
Distilling	60
Blending	600

The sludge produced by each of the unit operations are considered hazardous.

PRINTING COMPANY C

Tech-Ink manufactures ink products. A list of raw materials used is shown in **TABLE 31** below.

TABLE 31: MAJOR RAW MATERIAL USED AT PRINTING COMPANY C

RAW MATERIAL	QUANTITY
BEA (*Benzene-Ethyl-Alcohol*)	284
Disperbyk 163	5
Vinnol E15/45	14

The total amount of ink products manufactured amounts to 300 tons per month.

The facility produces waste in the form of paper, packaging, cardboard and oil rags. The quantities of these are shown in **TABLE 32** below.

TABLE 32: WASTE PRODUCTS PRODUCED AT PRINTING COMPANY C

WASTE PRODUCTS	QUANTITY
Paper	10 tons/month
Packaging	
Cardboard	
Oil rags	

3.6.2 Hazardous waste stream handling

Printing Company A
Solid and liquid hazardous waste streams are collected and disposed of by a waste service provider while contaminated drums and kegs are reconditioned by drum re-conditioners.

The following streams are deemed hazardous:

- Sludge-solvent/ink mix from pot-washing stored in drums
- The ink-samples/rejects which are stored in drums are removed by an approved service provider
- Used solvents, soiled rags-solvent are stored in steel bins and removed by an approved service provider
- Contaminated drums and kegs are reconditioned by approved service provider
- Aluminium powder which is highly flammable
- Contaminated PPE and spill residue/ clean-up waste is stored in drums and removed by an approved service provider
- Pigment bags are treated as normal waste and removed by an approved service provider
- Resin or pigment bags are treated as normal waste and removed by an approved service provider
- Plastic wrapping is normal waste and removed by an approved service provider
- Fluorescent light bulbs all contain Hg and are treated as normal waste and removed by an approved service provider

Hazardous and non-hazardous waste streams are currently separated but an in-depth analysis of the facility will be undertaken in the near future to minimise waste. All hazardous wastes are taken to Vissershok waste facility for processing by an approved contractor and a certificate of safe disposal is issued for each batch.

Printing Company C
The facility does not have a hazardous waste management plan in place and hazardous and non-hazardous waste streams are not separated at the facility. No treatment regimes are employed on waste effluent streams as no effluent is generated. Waste such as used solvents, rags, oils, paper, cardboard, packaging, plastic drums from manufacturing processes is disposed of using an approved contractor.

Printing Company B
The facility has a formal hazardous waste management plan. All waste streams are considered hazardous and are tested for pH, standard gravity, odour and visibility. Sludge is containerised and sent to a high hazardous landfill site using an approved contractor who provides a certificate of safe disposal after the removal of each batch.

3.6.3 Chemical inventory records

Printing Company A
The facility uses an integral ERP system (Automotive Company) which is updated daily. An external audit together with stock counts is done three times a year. The facility is ISO 9001:2000 accredited and is a Sun Chemical-SunCare certified site.

Printing Company B
A computer program is used to track the chemical inventory and its status is of a high quality. The electronic system is supported with weekly stock takes. The facility presently has no ISO accreditation.

Printing Company C
A computer program is used to track the chemical inventory and the status is of a high standard. Manual stock-takes are performed on a monthly basis. The facility is ISO 9000 accredited and is striving towards ISO 14 000 and ISO 18 000 accreditation.

3.6.4 Personnel competence and training

Printing Company A
The staff is trained in sound operating procedures as well as safe handling of hazardous material. Training takes place throughout the year based on an annual training plan.

Printing Company B
Staff are trained in good housekeeping practices and a culture of safety awareness exists. Staff are also trained in sound operational skills with regard to operating practices. In-house training occurs on a monthly basis.

Printing Company C
Good housekeeping practices of staff and a culture of safety awareness amongst staff requires attention. Staff are, however, trained in sound operational skills and in-house training of workers occurs on a monthly basis.

3.6.5 Waste minimisation

Printing Company A
At present, a contractor is on-site to define discrete waste streams for separation. A need was expressed to measure emissions from the facility in terms of meeting the requirements of the air pollution act. No industrial effluent is discharged from the facility. The cost of land filling was not provided.

Printing Company B
The company recycles waste generated from industry. The company provides a very cost-effective service, in that the company re-sells recycled solvent back to the consumer at competitive rates. Sludge from the process is considered hazardous and is land filled using an approved contractor. The cost of land filling was not specified.

Printing Company C
The facility recycles used solvent, paper and packaging. Solid waste is removed by an approved contractor and the cost of land filling is approximately R240 000/year.

3.6.6 Housekeeping and quality control

Printing Company A
Materials Safety Datasheets are used for all raw materials. Waste products are disposed of by an approved contractor who provides a certificate of safe disposal. The raw material analysis is done by the Durban branch of Printing Company A who also manufactures the raw materials. Quality checks are performed on the product, but not on waste streams. Process conditions are closely monitored to reduce the occurrence of failed batches and out-of-specification products. Housekeeping is of great importance to the facility.

Printing Company B
Material Safety Datasheets are used for all raw materials and there are documented systems and procedures for handling of chemicals. Raw material quality is monitored by means of pH, standard gravity, and odour and visibility tests.

Additionally, process conditions are monitored with regard to temperature and pressure while quality control checks are done on all streams. No record of losses incurred with regard to containerisation are kept, however, the contents are decanted immediately and form part of the disposed waste. The state of housekeeping could possibly be improved.

Printing Company C
Material Safety Datasheets are used for all raw materials and there are documented systems and procedures for handling, transporting, storage and disposing of hazardous and non-hazardous chemicals. Raw material quality is monitored by in-house analysis and is only accepted if accompanied by a certificate of analysis when purchased.

Process conditions are monitored and quality control checks are performed on all streams. A record of any losses incurred is kept. The general state of housekeeping is poor and needs attention.

3.6.7 Risk profiling of facility

The criteria on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility

Printing Company A
The Printing Company A factory is situated in an industrial area. The residential areas of Maitland and Fractreton are situated slightly further away from the facility and thus far no complaints with regard to hazardous waste have been filed with the relevant municipalities or with the facility.

Printing Company B
The facility is situated in an industrial area and no complaints have been filed with the relevant municipalities or with the facility. Sludge waste which is hazardous is containerised and disposed of in a high hazardous landfill site by an approved contractor.

Printing Company C
The facility is situated in a light industrial area with a shopping complex (Pick ‘n Pay Hypermarket) to the north-east of the facility. The Big Lotus River Canal is situated east of the facility, approximately 20 meters away. This canal flows southwards and discharges into Zeekoei vlei. No complaints have been lodged by the facilities neighbours or the surrounding communities.

3.6.8 Emergency Planning and safety

Printing Company A
There is a formal emergency plan detailing the evacuation procedures in the event of a fire or spill. Additionally, the required permits for the facility are in order i.e. Flammables Substance Certificate 0263 – Community Fire Safety Bylaw. The Epping fire chief audits the site on a monthly basis while neighbouring industries are informed about developments in terms of emergency planning through regular meetings. Residential areas are considered too far away from the facility and are not included in these meetings.

The local fire department is supplied with a copy of both the emergency plan and contingency/disaster recovery plan.

Printing Company B
A documented evacuation plan is currently being followed. The company nevertheless has a R5 million public liability cover and R1 million liability cover to the landlord in case of a disaster. In an effort to improve the safety on the facility, the company is in the process of applying for a fire permit and installing two fire hydrants. With regard to Section 24G of NEMA, the company was granted amnesty for their environmental management plan.

Printing Company C
The status of emergency planning at the facility is very basic. Limited documentation regarding emergency planning is available. The company realises that there is a gap in terms of compliance with regard to chemicals handling, storage and transportation. They are making a concerted effort to improve their processes, such as the implementation of new management systems, compliance audits and so forth. A permit is available for the operations on site.

3.6.9 Barriers to implementation of waste management planning

Printing Company A

It was evident that a structured waste management plan already existed, but that there was room for improvement. Barriers to implementation of an improved waste management plan would be time and resources.

Printing Company B

The successful implementation of a hazardous waste management plan is prevented by the following barriers:

- legislation – in the process of obtaining a permit for fire and storage of chemicals
- financial – upgrading the facility

Printing Company C

The successful implementation of a hazardous waste management plan is prevented by the following barriers:

- administration
- culture
- morale

3. RESULTS OF THE SURVEY (SURFACE COATINGS SECTOR)

3.7.1 CHEMICAL USAGE AND PRODUCTION

COATING COMPANY A

The quantities of raw materials used and products produced at **Coating Company A** are shown in **TABLE 33** and **TABLE 34** respectively.

TABLE 33: MAJOR RAW MATERIALS USED AT COATING COMPANY A

RAW MATERIAL	QUANTITIES *(tons per month)*
± 420 raw materials	204

TABLE 34: PRODUCTS PRODUCED AT COATING COMPANY A

PRODUCT	QUANTITIES *(kilolitres per month)*
480 products or intermediates	450 – 900

Coating Company A purchases the following chemicals to use as detergents:

- Lakthin M 222 – 1500 litres per month
- floor cleaner
- aluminium sulphate, a flocculating agent

The waste streams and quantities generated at Coating company A are listed in **TABLE 35**.

TABLE 35: WASTE STREAMS GENERATED AT COATING COMPANY A

WASTE STREAM	QUANTITY
Water-based effluent	Could not be established
Dirty/used cleaning solvent	Could not be established
Solvent based sludge	5.8 (tons per month)
Water- based sludge	3.0 (tons per month)
Medical waste	Minimal
Contaminated packaging and shrink wrap	Minimal
Cooking oil	Minimal
Scrap metal	Minimal
Paper and cardboard	22.5 (tons per month)
Crushed fluorescent tubes	Minimal
Builder's rubble	Minimal
Broken pallets and domestic	Minimal

The **Coating Company A** produces no by-products because no chemical reactions take place at this facility.

COATING COMPANY B

The quantities of raw material used vary dramatically as the business is very seasonal and is driven by demand. The high-demand months are from September through to May and very few products are produced to be kept as stock. Typical winter values are roughly 20% of that of the summer.

The monthly usage of raw materials is shown in **TABLE 36**.

TABLE 36: MAJOR RAW MATERIALS USED AT COATING COMPANY B

RAW MATERIALS	QUANTITY
Polymers	3.0 (tons per month)
Calcium Carbonate	3.0 (tons per month)
Titanium Dioxide	2.0 (tons per month)
Iron Oxides	0.1 (tons per month)
Turpentine	1.0 (tons per month)
Toluene	0.4 (tons per month)
Ammonia	25 (kilograms per month)
Epoxies	0.15 (tons per month)
Iso-Cyanides	12.5 (kilograms per month)
Denatured Ethanol and Methanol	minimal

The paint products are produced on a demand basis and are listed in **TABLE 37**.

TABLE 37: PRODUCTS PRODUCED AT COATING COMPANY B

PRODUCTS	QUANTITY
Styrene Acrylic PVA	30 (kilolitres per month)
Pure Acrylic PVA	Could not be established
Roof Paints	Could not be established
Gas seal	Could not be established
Epoxy	Could not be established
Floor coating	Could not be established
Fire retardant (INTUMESCENT) coating	Could not be established
Fire retardant mastic	Could not be established
Cement modifier	Could not be established
Ink for highlighter pens	Could not be established

Solvent based chemicals, emulsifier and water are used as service chemicals for cleaning (0.2 kilolitres per month). Waste products come from the washing of containers and include solvents, pigments, and toluene and lacquer thinners. Residue solvent and solid residue are produced (0.2 tons per month) and disposed of using an approved contractor who provides a certificate of safe disposal. No by-products are produced.

COATING COMPANY C

Coating company C has a very broad range of raw materials.

The generic categories assigned to these raw materials as well as the quantities used are listed in **TABLE 38**.

TABLE 38: MAJOR RAW MATERIALS USED AT COATING COMPANY C

RAW MATERIAL	QUANTITY
Incan Preservative	1.4 (tons per month)
Aqueous Ammonia (supplied in 23 kg drums)	0.5 (tons per month)
Oil for De-foaming	3.0 (tons per month)
Binders: (Pure Acrylic; Emulsions; Styrene)	100 (tons per month)
Hydrocarbon Solvents (Paraffin and Turpentine)	16.5 (kilolitres per month)
Fillers (Clay Silica and $CaCO_3$)	300 (tons per month)
Methylene Chloride	2.0 (drums per month)
Pigments	40 (tons per month)
Solvents (Acrylic Based)	20 (tons per month)
HCC	1.4 (tons per month)
Liquid Pre-dispersed Colorants	1.2 - 1.8 (tons per month)

The facility produces one broad range of products called decorative paints at a production rate of 0.45 Kilolitres per month.

The company uses the cleaning chemicals as listed in **TABLE 39**.

TABLE 39: QUANTITY OF SERVICE CHEMICALS USED AT COATING COMPANY C

CLEANING CHEMICALS	QUANTITITIES
Mineral Turpentine	0.2 (kilolitres per month)
Thinners	0.1 (kilolitres per month)
Paint Removal	50 (litres per month)

The company produces a variety of wastes. If possible, the waste is sent for recycling, otherwise, it is sent for disposal as non-hazardous waste. **TABLE 40** displays the type of waste produced as well as the quantities of each stream.

TABLE 40: WASTE STREAMS PRODUCED AT COATING COMPANY C

WASTE MATERIAL	QUANTITY
Paper	84 (m^3 per month)
Plastic buckets and tins	126 (m^3 per month)
Dirty Solvent	0.6 (kilolitres per month)
Paint Residues	0.4 (kilolitres per month)

In addition, the facility also produces a waste effluent stream that is generated by the cleaning of the equipment and containers. This waste is removed by an approved contractor and disposed of as hazardous waste. The company produces no by-products.

3.7.2 Hazardous waste stream handling

Coating Company A

The facility has a documented hazardous waste management plan and the streams listed below are considered hazardous (see Table 35 for quantities generated):

- Crushed fluorescent tubes
- Dirty/used cleaning solvent
- Solvent based sludge
- Water- based sludge
- Medical waste
- Contaminated packaging and shrink wrap

Currently hazardous wastes are separated from non-hazardous wastes. Non-hazardous waste is treated as normal garbage that is land filled while the hazardous waste is collected by an approved waste management contractor and disposed of as hazardous waste at the landfill site. A certificate of safe disposal is provided for each batch of hazardous waste disposed of.

The sludge that collects at the bottom of the settling tank is also removed as hazardous waste by the same contractor.

Coating Company B

The facility does not have a waste management plan. Hazardous (solvent based) and non-hazardous (water based) streams are not separated. Should separation be implemented, treatment of the water-based stream would be required.

Coating Company C

The facility currently has an informal hazardous waste management plan.

The waste stream that is classified as hazardous is the dirty solvent stream and it is currently being separated from the rest of the waste.

Liquid effluent (from tank washing) is passed through a series of four sedimentation tanks to allow paint residues and particulates to settle. The sludge is then dug up and sent for disposal as hazardous waste by an approved contractor who provides a certificate of safe disposal for each batch disposed.

TABLE 41 displays the various types of wastes generated and the disposal regimes that are currently being applied to them.

TABLE 41: TREATMENT REGIMES FOR WASTE STREAMS AT COATING COMPANY C

WASTE MATERIAL	QUANTITY
Papers	Collected by Central Cartage Distributors
Plastic buckets and tins	Recycled by plastic manufactures and tins are taken by workers to the local scrap yard
Dirty Solvent	Sent to the Vissershok Disposal Facility
Paint Residues	Sent to the Vissershok Disposal Facility

3.7.3 Chemical inventory record

Coating Company A
The chemical inventory is tracked by "MRP" Computer generated records and is updated by four stock-takes a year. The facility has the following accreditations:

- ISO 9000
- ISO 14000 and
- OHSA 18001 (Stage 1)

Coating Company B
The software package COMPUCHEM is extensively used to track chemical usage. In addition, manual checking incorporating a double flagging system is also used. The facility has been SABS 9001 accredited for the past four years.

Coating Company C
The facility keeps records of all chemicals entering and leaving the premises by the commercial electronic package COMPUCHEM. The computer database is updated with a physical stock-check every month. Slight variances arise due to unaccounted for losses of materials.

3.7.4 Personnel competence and training

Coating Company A
The site staff at Coating company A are trained to use good housekeeping methods, in accordance with the MDWT Module 2. There is a culture of safety and awareness that exists amongst the site staff that are urged to look out for the safety and well-being of their co-workers. The new recruits receive induction courses and are instructed to attend refresher courses as required.

Coating Company B
The staff are trained in sound operating procedures as well as the safe handling of hazardous material. Training takes place throughout the year based on an annual training plan.

Coating Company C
The site staff is trained in good housekeeping practices and they are encouraged to promote a culture of safety amongst each other. The facility still has to implement safety signs and acknowledges that improvement in this regard is required.

Newcomers receive an induction course and refresher courses are repeated annually for all site staff. The staff is also trained in sound operational practices. They are also taught the logistics behind the operational practices so as to motivate them to implement these safe practices.

3.7.5 Waste minimisation

Coating Company A
The bulk of the non-hazardous waste materials are sent for land filling as general waste. Coating company A is, however, making a concerted effort to re-use materials where possible. For example, cleaning water is currently being re-used for low quality PVA, but this leads to huge contamination problems which need to be overcome. Additionally, mill washing solvent is added back to the batch while packaging drums are sent back to the supplier. Cleaning solvent paper, plastics and metal cans are sent for recycling. The disposal cost for waste was R186 368 for the 2006 financial year.

Coating Company B
At present, there are no waste minimisation procedures in place. Recycling and re-use of solvents are, however, implemented. A dust extraction system is envisaged in the future to prevent plumes of dust when mixing occurs.

The landfill cost of the solid waste (0.2 tons/month) amounts to R300/month. The cost associated with industrial effluent was not provided.

Coating Company C
The facility implements re-use and re-conditioning of products to minimise waste production. Out-of-specifications products that cannot be reconditioned are sold at reduced prices to the public. Plastics and tins are sent for recycling by volunteering site staff.

The current landfill charges are not available and the effluent waste discharge costs were approximately R700/month. The cost of land filling was not provided.

3.7.6 Housekeeping and quality control

Coating Company A
Materials Safety Datasheets are used for all raw materials. A copy of each Datasheet is kept on computer records in the Quality Control laboratory as well as in the safety control room.

The handling, transportation, storage and disposing of chemicals is done in accordance with the requirements of the facility's ISO 9001 accreditation. In addition to the Certificate of Analysis that accompanies each incoming batch of raw material from reliable suppliers, the facility also has an in-house quality control laboratory that analyses the quality of the raw materials, products and effluent. Impromptu audits are carried out for further quality assurance.

Process conditions on all major lines are monitored and the SC11 m /P 146 system is used to track chemical losses due to containerisation and packaging.

Coating Company B
Materials Safety Datasheets are used for all raw materials, but there are no documented procedures for storage, handling, transportation and disposal of hazardous waste. The raw material as well as process conditions are monitored. There are no quality control checks on waste and records are kept on losses. The good housekeeping methods need to be extended to the waste streams as well.

Coating Company C
The facility uses Material Safety Datasheets for all raw materials and the staff follows the ISO 9001 procedures and systems for storage, transportation and disposing of hazardous and non-hazardous chemicals.

The raw material quality is monitored using the Certificate of Analysis and by on-site sampling test in the facility's laboratory. Quality control checks are also performed on products, but not on waste streams and effluents.

3.7.7 Risk profiling of facility

The criteria on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility

Coating Company A
Bonteheuwel, Ruyterwacht and Elsies River are residential areas that are in close proximity to this facility. The facility is located in an industrial area and the distance to the nearest residential community exceeds 200 m. This distance provides a good buffering distance in terms of risk to the community.

No complaints have been laid by neighbouring communities, local municipalities, NGO's or environmental groups.

Coating Company B
Coating company B is situated in an industrial area and no complaints have been laid at the facility or with the local municipalities.

Coating Company C
The facility is situated in an industrial area. There have been complaints from the municipality regarding the effluent quality. No other complaints have, however been received from the residential community, local municipalities or environmental groups.

3.7.8 Emergency planning and safety

Coating Company A
Coating company A has a fully documented emergency plan available on the facility's intranet. The local Fire Department is well aware of the emergency status at the facility. The community has limited involvement in emergency planning at the facility.

The facility is compliant with all legal requirements due to their ISO 9000, ISO 14000, OHSA 18001 (Stage 1) accreditation.

Coating Company B
Coating company B has a first order emergency plan which is in need of improvement.

3.7.9 Barriers to implementation of waste management planning

Even though the interviewees believe that they have a good hazardous waste management plan, they acknowledge that the following areas could present barriers to successful hazardous waste management planning:

- Technical
- Financial
- Cultural

A cultural barrier means that the ground staff, who is low to semi-skilled labourers that have been raised in poor, disadvantaged communities such as townships and informal settlements, do not possess a sense of environmental awareness. This is because the environmental conditions of these areas are in an appalling state, and consequently, these people have been subjected to live in these conditions as part of everyday life.

Coating Company B
It is evident that a structured waste management system is required. Possible barriers to the successful implementation of such a plan were listed as:

- Manpower
- Financial
- Technical Expertise, And
- Space

Coating Company C
The facility has documented emergency and evacuation plans. Alarms and sirens are activated should these emergencies occur. The facility possesses a permit to discharge industrial effluent but it is currently in need of a flammable storage room, even though the City Council approved the building plans for a paint production factory when it was built.

The facility possesses the ISO 9001 accreditation. Permits for the manufacturing of the products are also up-to-date while certificates of safe disposal are provided by the contractors who dispose of the hazardous waste.

3. RESULTS OF THE SURVEY (SURFACE JOINING SECTOR)

3.8.1 CHEMICAL USAGE AND PRODUCTION

SURFACE JOINING COMPANY A

Approximately 600 raw materials are used on site of which 2% are hazardous. The list of major raw materials as well as the quantities of these is shown in **TABLE 42**.

TABLE 42: MAJOR RAW MATERIALS USED AT SURFACE JOINING COMPANY A

RAW MATERIAL	QUANTITIES *(tons per month)*
Butyl Acrylate monomer	13 - 17
Vinyl Acetate monomer	126 - 168
Toluene	84
Styrene monomer	8.0 - 13
Acetone	8.0
Methylene chloride	8.0
Ethanol	1.0
Methanol	1.0

The major products produced as well as their quantities are shown in **TABLE 43.**

TABLE 43: QUANTITIES OF PRODUCTS PRODUCED AT SURFACE JOINING COMPANY A

PRODUCT	QUANTITIES *(kilolitres per month)*
Vinyl Acetate emulsions (used in cold glues)	700 – 800
Solvent based contact adhesives (Bostik)	60
Styrene acrylate emulsions	100 – 200
Tile cement	400

The service chemicals used to clean the facility are soap and water. The liquid effluent stream generated on-site is treated at an effluent plant mainly to reduce the chemical oxygen demand (COD) content and to allow for the settling of solid material. Solid waste is disposed of using an approved contractor for land filling at the Vissershok landfill. No by-products are produced at the facility.

3.8.2 Hazardous waste stream handling

Surface Joining Company A
The plant has an informal waste management plan. The removal of waste is done by a contractor who provides a certificate of safe disposal. Hazardous and non-hazardous streams are separated on site. The solvent streams are classified as hazardous and are removed by an approved waste contractor.

3.8.3 Chemical inventory record

Surface Joining Company A
The chemical inventory on site is controlled by a computerised ERP system. Manual stock-taking is done four times a year. In addition, an integrated SHEQ system is present and a SHEQ co-ordinator is employed on site.

3.8.4 Personnel competence and training

Surface Joining Company A
In terms of personnel competence and training, the following are implemented;

- Teams to monitor production.
- Production is shut down 15 minutes before the end of each day and a general discussion with staff is done.
- Operation managers walk around for an hour on a daily basis to check operations.

Incentives are given to staff who comply with safety requirements and health and safety officers are permanently on site. Approximately one hundred and fifty workers are employed on a contract basis and are trained in plant operations on an ongoing basis, amounting to R400 000/year. An open channel of communication exists between operators and management.

3.8.5 Waste minimisation

Surface Joining Company A
Waste minimisation at this facility focuses on source reduction, re-use and energy extraction:

Source reduction: tanks have been installed with intermediates to avoid the usage of liners. Batch sizes have also increased and this decreases the losses relative to running a series of small batches. Additionally, energy efficiency also increases while water consumption (for pot-washing) decreases.

Re-use: dedicated pots for wood filling will be introduced thereby eliminating washing and loss in yield.

Energy reduction: a low sulphur oil (LSO) boiler was installed to reduce electricity consumption at the facility.

3.8.6 Housekeeping and quality control

Surface Joining Company A
Housekeeping on site is of a high standard and Material Safety Datasheets are used for all raw materials. In addition to the certificate of analysis, an on-site quality assurance laboratory checks raw materials, products and waste stream quality on a daily basis using pH and conductivity meters. A record of losses for spills over 25kg are also kept.

3.8.7 Risk profiling of facility

The criteria on which risk profiling was based on was the proximity of settlements (formal and informal) to the facility

Surface Joining Company A
To date no complaints have been lodged with the company or with the local municipalities concerning the operations at the facility. All hazardous waste is collected by an approved contractor and a certificate of safe disposal is presented for each batch of waste removed.

3.8.8 Emergency planning and safety

Surface Joining Company A
A documented emergency management plan exists for the facility. All staff on the site are trained in fire fighting and the site is currently fully compliant with legislation. An open channel of communication exists between the company and the local municipality.

3.8.9 Barriers to implementation of waste management planning

Surface Joining Company A
The plant experiences no barriers in the management of waste, however, the following concerns were expressed:

- New legislation should be communicated more readily.
- Legislation could be too complex to be enforced.
- Government does not provide incentives for environmental compliance.

4. POSSIBLE SCENARIOS IMPACTING ON THE RURAL AND URBAN-POOR

The evaluations of scenarios relating to the possible impacts of the Consumer-Formulated Chemical Sector on the rural and urban-poor are discussed in the ensuing sections. These scenarios are based on a qualitative life cycle analysis of the hazardous waste after leaving the facility and the possible points of contact with the rural and urban-poor.

SCENARIO 1: MANAGEMENT OF CONTAINERS

The management of containers should include inherent stringent measures to protect the rural and urban-poor. If informal settlements or sub-economic communities are in the vicinity of the facility, drums are always at risk from theft. Reasons for theft can either be for storage purposes, or for use as a container in which fires can be made. Irrespective of the intention for use, individuals are at high risk of being poisoned, which in some cases can be fatal.

According to the chemical datasheets on parathion toxicology of the World Health Organisation and Food and Agriculture Organisation, the total recorded death count due to parathion and malathion poisoning are as follows:

- 115 recorded deaths in Asian countries
- 117 recorded deaths in Americas
- (No statistics have been recorded for parathion related fatalities in Africa)

Bulk quantities of toxic fluids (e.g. parathion, insecticide or malathion) could be contained in metal drums. Once the drums are emptied, they should be sent back to the supplier for re-conditioning and re-use. If not, the facility should make sure that the drums are sent to a hazardous waste disposal site.

Drums to be reconditioned are either collected by the supplier at the time of stock delivery or the reconditioner itself. If the supplier collects it, reconditioning is either done on site or it is sent to dedicated drum reconditioners. The supplier should then also take the necessary measures to minimise possible risks to any informal settlements that might be encroaching.

Approved hazardous waste collectors however, will collect the drums periodically, which implies that the drums will, for a limited period, need to be stored on-site. Metal drums can be stored in the following way:

- The drums must be drip-dried of residue. The residue must either be used or it must be sent for hazardous waste disposal.
- The drums must then be washed using high pressure water so that a minimal amount of water is used. The waste effluent that is generated will be highly toxic. This effluent must be collected in a designated toxic effluent storage tank and it must be sent for hazardous waste disposal.
- The tanks should then be fire-blasted at a high flame temperature so that the contaminants undergo complete oxidation. If they are partially oxidised, they might be converted into dioxins and furans which are carcinogenic.

If the drums are plastic, then they need to drip-dried, washed and shredded. The shredded plastic should be stored in a hazardous skip before collection by an authorised hazardous waste collector.

SCENARIO 2: OFF-SPECIFICATION CONSUMER PRODUCTS

Consumer chemical products such as personal health care items that are sub-standard must be destroyed by incineration or must be immobilised and stabilised. It is not acceptable for these containers to be land filled because there is a risk of theft which may lead to possible use. There is a high risk that the individuals in turn, could be poisoned.

Hygiene Company B has very stringent regulations with regard to the disposal of off-specification products. When these products are collected for disposal, a high-level staff member is required to accompany the waste collector and photograph the destruction process of the product. The photographs are then sent to the Proctor and Gamble Headquarters in Germany for documentation.

SCENARIO 3: SPILLAGES AND THE STORM-WATER SYSTEM

Any toxic or hazardous chemicals must be cleaned-up promptly using the sound methods that are described in the **Upstream Cleaner Technologies section (Part 2)** of this report. This does not include flushing the area with water as this will only broaden the risk of exposure. There is also the risk of the toxic chemicals leaching into the storm-water system which means they may contaminate river systems and can eventually build up in inland water-bodies. Informal settlements are often established on banks of rivers and the communities in these settlements often draw water for consumption purposes or use it for recreational purposes. Consequently, these communities are at risk of being poisoned.

SCENARIO 4: MINIMISING DUST EMISSIONS

All efforts to minimise dust emissions should be implemented. While non-toxic dusts may seemingly be harmless to healthy humans, it can be very damaging to poor labourers whose respiratory systems have been weakened by tuberculosis or HIV.

SCENARIO 4: ILLEGAL DUMPING

Present efforts to prevent illegal dumping should be increased as a matter of urgency. This would also apply to more stringent access control to all dumping and landfill sites. The poor who peruse dump sites and landfill sites for opportunities are at risk of coming in contact with toxic and hazardous illegally dumped chemicals. These are further spread when they reach their abodes and transmit the toxins to others.

5. DISCUSSION

Based on the survey of chemical companies representing the consumer-formulated sectors it was established that a wide range of approaches in terms of dealing with hazardous waste existed. These ranged from "highly developed plans" to "uncoordinated" responses, which could present a risk to human health or to the environment. To address this lack of a uniformed approach in dealing with hazardous waste streams, a generic waste management planning guideline has been developed to assist the chemical sector in defining and implementing components for effective hazardous waste management planning.

In this study, the feedback received from the participating companies served as the primary source of input in developing the status quo of waste management for the consumer-formulated chemical sector. An overview of the various aspects relating to hazardous waste handling and specifically the alignment of observed practices with the Western Cape Hazardous Waste Management Plan will also be discussed.

The strategic goal of the Hazardous Waste Management Plan for the Western Cape Province is:

"*To ensure the safe and integrated management of hazardous waste in the Western Cape through integrated sustainable hazardous waste management planning."*

The plan further states that the objectives are:

1. Safe handling and disposal of hazardous waste
2. Information management
3. Effective compliance monitoring and enforcement
4. Reduction of the generation of hazardous waste
5. Provision of sufficient/adequate financial resources

Information obtained from the survey provided insight into the chemical handling practices which exist in the various consumer-formulated sectors and suggested that although certain companies within a particular sector could be used as a benchmark in terms of hazardous waste management, safe handling of chemicals, appropriate storage arrangements and internal transferring of chemicals, a uniform approach did not exist. This further implies that even closer interaction from all tiers of government would be required to ensure compliance across the spectrum of companies constituting a sector. It should be borne in mind that the main objectives of this study were to establish the status quo in terms of chemicals and hazardous waste handling and as such only present a first order estimate of the situation on the ground. The short-comings that can be identified at this stage relate to the following aspects of chemical handling:

STORAGE OF CHEMICAL RAW MATERIALS

Separate areas for the storage of chemicals of similar properties and are often not clearly demarcated and the signage indicating the potential hazards relating to the group of chemicals are either inconspicuous or non-existent. In certain cases highly corrosive substances (e.g. HF) were left in open storage, accessible to all members of staff. Ideally these types of substances should only be available from a chemical store with strict access control. In addition, flammable stores should be compulsory if any listed chemicals are used on the facility. All facilities should be able to provide an up-to-date floor plan to the local municipalities so that it may be used as a mechanism for monitoring compliance in terms of storage.

HANDLING OF CHEMICAL RAW MATERIALS

All companies claim to have Material Safety Datasheets (MSDS's) which provide critical information on chemical properties and safe handling procedures. To use these effectively would require the implementation of a compulsory and structured training programme which would highlight the information in the MSDS's. The auditing of the attendance at these courses would provide a useful mechanism for monitoring the compliance for the training component.

CHEMICAL INVENTORY RECORDS

All the participating companies had an electronic programme for tracking the usage of chemicals which was normally supported with manual stock-takes to verify the electronic data.

HAZARDOUS WASTE STREAM HANDLING

Certain companies have a structured approach to the handling of hazardous waste whereby hazardous and non-hazardous wastes are separated. Hazardous waste is normally disposed of using an appropriate contractor who provides a certificate of safe disposal for each batch of waste removed from the site. To exercise even more control over the waste disposal process a member of staff should specifically be assigned to this task.

Cleaning of product residue tanks should be undertaken in specific bays only and effluent from this process should be captured in a special tank which can allow for the settling of solid material and the possible treatment of overflow. Special bays should be used for the washing of tanks containing toxic material.

Regular analysis of the effluent quality should be undertaken and these should be kept on record to be used as a mechanism for the monitoring of compliance in terms of waste stream handling. Records of the certificate of safe disposal should also be available for auditing by the local municipalities.

Although hazardous waste is collected and disposed of using an approved contractor it should still be appropriately treated before disposal. This should be based on the physical and chemical characteristics of the waste viz.

- Explosives
- Gases
- Flammable liquids
- Flammable solids/substances
- Oxidising substances
- Poisonous and infectious substances
- Radioactive substances
- Corrosive substances
- Miscellaneous substances

The application of appropriate technologies for the treatment of this waste would require a more in-depth analysis of the facility's effluent before any designs can be undertaken.

HOUSEKEEPING AND QUALITY CONTROL

Maintaining an acceptable standard of housekeeping is potentially the major shortcoming in most of the industries interviewed. The application of these techniques in various industries have previously been evaluated and found to provide a high rate of return with limited capital investment. A list of appropriate housekeeping techniques is provided in **Appendix C**.

EMERGENCY PLANNING AND SAFETY

Most sectors seem to have an undocumented emergency plan. If the facility is in the process of obtaining ISO 18000 accreditation, this aspect of the business normally receives more attention. It is evident that companies, when prioritising the accreditation goals, assign a higher level of importance to Quality (ISO 9000) followed by Environmental Compliance (ISO 14000) and then Occupational Health and Safety (ISO 18000). An integrated approach for obtaining accreditation, whereby all aspects of responsible manufacturing are considered should be adopted.

WASTE MINIMISATION

Responses from the various facilities suggested that an unstructured approach to waste minimisation exists in most cases but that a first order attempt is usually made. Apart from the recycling of plastic, paper and cardboard few process-related approaches have been undertaken to minimise waste. This could possibly be attributed to the lack of technical expertise and financial constraints.

6. CONCLUSIONS

Based on the information obtained from the surveys and the preceding discussion, the following conclusions can be drawn:

- A non-uniformed approach in responsible chemicals management and disposal exists across all sectors of the consumer-formulated chemical industry which leads to a wide variety of approaches with differing efficiencies being applied.
- Training of staff is implemented but does not receive the level of importance that it deserves. This is particularly true for issues relating to hazardous waste management and occupational health and safety.
- Electronic chemical inventory records appear to be used throughout all the sectors. This is, however, to be expected as the loss of raw materials relates directly to the loss of profits.
- Generally, housekeeping is of a poor standard throughout most of the sectors and needs urgent attention. These changes could potentially result in high rates of return on investment because of the minimal capital input required.
- Quality control is of a high standard when performed on products produced. The monitoring of effluent water quality or of hazardous waste streams is seldom instituted considering that this information would be required when deciding on the treatment regime required for stabilisation of these streams prior to disposal.
- Emergency planning and safety does not receive the attention that it deserves mainly due to the lack of manpower and finances. This could, however, be very costly in the long run if a disaster should occur. All facilities should be able to provide an up-to-date floor plan to the Local Municipalities so that it may be used as a mechanism for monitoring compliance for the storage component.
- In most cases only first order waste minimisation is undertaken due to a lack of technical expertise and financial constraints.
- The effect of hazardous waste stream handling on the rural and urban-poor should receive high priority in the development of the facility's hazardous waste management plan. This is particularly necessary when the disposal of hazardous waste or the reconditioning of containers in which hazardous waste was stored is outsourced to external contractors.

7. RECOMMENDATIONS

Based on the discussion and conclusions the following recommendations can be made:

- A uniformed approach based on prescribed guidelines for the handling, storage and transportation of chemicals as well as hazardous waste stream handling should be implemented by all consumer-formulated chemical industries. This will require closer interaction between the DEA&DP, local municipalities and the private sector especially in terms of providing support to smaller companies which do not have the manpower, technical expertise or finances to design a programme for effectively dealing with chemicals and hazardous waste streams.
- Training of staff in waste management at the various facilities should be rewarded by the DEA&DP. Training is used as an indication of the level of compliance in terms of adequate training and to identify facilities which may require support in this issue. Monitoring of a proposed training programme for the staff at various facilities can be used as an additional measure of compliance for the training component.
- A list of good housekeeping techniques specific to a sector should be circulated to all companies and assessment should be undertaken to establish the needs in terms of manpower, technical expertise and financial investment required. This information would provide the basis for the level of intervention required to assist these facilities.
- The quality of all effluent streams and hazardous waste streams should be monitored to determine the treatment regime required for stabilisation before disposal to a hazardous landfill site. This, however, will require in-depth analysis of the exact composition of hazardous waste streams to ensure that the correct treatment regime is applied. The exact nature of this treatment regime will be facility and waste stream specific.
- All facilities should aim to have a documented emergency plan. This could be based on generic components of emergency plans that have successfully been implemented at other facilities which can then be made available to industries in need of assistance.
- Implementation of higher order waste minimisation techniques should be implemented to minimise waste production. Implementation of these initiatives may require specialist input and the DEA&DP or local municipalities should facilitate this process for the facilities that require this intervention.
- Facilities should ensure that the hazardous waste leaving their premises does not affect the rural and urban poor and is disposed of in an appropriate manner. The list of external contractors used by the facility should be provided to the DEA&DP so that a record of the lifecycle may be kept.

8. REFERENCES

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APPENDICES

APPENDIX A : FORMAT OF QUESTIONNAIRE USED

COMPANY INFORMATION	
Date	
Name of Company	
Address	
Person interviewed and position	
Contact Details	
Interviewer	

CHEMICALS USAGE & PRODUCTION	
List raw materials (chemicals) used	
Quantities of raw materials used (mass, volume per unit time)	
List of products produced (Specific conversion rates if available)	
Quantities of products produced (mass, volume per unit time)	
List of service chemicals used (For cleaning etc.)	
Quantities of service chemicals used (mass, volume per unit time)	
List of waste products produced	
Quantities of waste product produced (mass, volume per unit time)	
List of by-products produced	
Quantities of by-product produced (mass, volume per unit time)	

HAZARDOUS WASTE STREAM HANDLING	
Does the facility have a hazardous waste management plan?	
Which waste streams (listed above) on the facility are classified as hazardous?	
Are hazardous and non-hazardous waste streams separated on the facility?	
What treatment regimes are being applied to the waste effluent streams (hazardous and non-hazardous)?	
What disposal options are currently implemented for the waste streams (hazardous and non-hazardous)?	

CHEMICAL INVENTORY RECORDS	
What system is currently used to track chemicals usage?	
What is the general status/ condition of these chemical inventory records?	
Is the facility accredited? (ISO9000,14000,18000)	

PERSONNEL COMPETENCE & TRAINING	
Are site staff trained in good housekeeping practices?	
Does a culture of safety awareness exist amongst staff?	
Are staff trained in sound operational skills?	
What is the frequency of training courses?	

WASTE MINIMISATION	
What methods of waste minimisation are currently implemented? • Source reduction • Re-use • Recycling • Waste exchange • Energy extraction • Land filling	
Source reduction • Currently in place or potential for implementation • Quantities of chemicals that can be saved/reduced • Cost of implementation • Potential savings	
Re-use • Currently in place or potential for implementation • Quantities of chemicals that can be saved/re-used • Cost of implementation • Potential savings	
Recycling • Currently in place or potential for implementation • Quantities of chemicals that can be saved/re-used • Cost of implementation • Potential savings	
Waste Exchange • Currently in place or potential for implementation • Quantities of chemicals that can be saved/re-used • Cost of implementation • Potential savings	
Energy Extraction • Currently in place or potential for implementation • Quantities of chemicals that can be saved/re-used • Cost of implementation • Potential savings	
Landfill • Cost of landfill • Cost of chemicals not re-used/recycled	
Liquid Waste • Effluent Costs (from municipal account and related to contamination)	

HOUSE-KEEPING AND QUALITY CONTROL	
Are Materials Safety Datasheets being used? (Obtain example for record)	
Are there documented systems and procedures for handling, transporting, storage and disposing of chemicals (hazardous and non-hazardous)? (Obtain example for record)	
Is raw material quality monitored? (YES/NO)	
Are process conditions monitored? (YES/NO)	
Are quality control checks performed on raw materials, products and waste streams (liquid and solid)? (How are these check performed? And obtain copy of these records)	
Are records kept of losses due to containerisation, packaging? (If so, obtain these records)	
Comment of the state of housekeeping methods and implementation thereof	

RISK PROFILING OF FACILITY	
Which residential areas are in close proximity to the facility? (Obtain approximate distance)	
Which expensive infrastructure are in close proximity to the facility? (Obtain approximate distance)	
Have any complaints been received (in terms of pollution) from the neighbouring communities, Local Municipalities, NGOs or environmental groups? (Obtain records of these complaints)	

EMERGENCY PLANNING AND SAFETY	
What is the status of emergency planning at the facility? (Obtain any documented procedures)	
What is the level of awareness of the community in terms of of emergency planning at the facility?	
What level of involvement does the community have in emergency planning at the facility?	
What is the status in terms of the facility's legal compliance with • **National laws** • **Provincial laws** • **Local Government Laws** **w.r.t chemicals handling, storage and transportation**	
Are any permits required for the • **Operations – use or manufacturing of chemicals** • **Storage of chemicals** • **Transportation of chemicals** • **Products produced** • **Disposal** (Obtain copies of these permits) (OHSA; PPE; First Aid) (Safety Officer should be in place)	

BARRIERS TO IMPLEMENTATION OF HAZARDOUS WASTE MANAGEMENT PLANNING	
What are the potential barriers to the implementation of a successful hazardous waste management plan? • Legal/regulatory • Financial • Technical • Training • Morale • Markets • Administration • Cultural • Labour • Geographical • Competition	

APPENDIX B : CONTACT DETAILS OF PARTICIPATING COMPANIES

Confidential

APPENDIX C : LIST OF HOUSEKEEPING TECHNIQUES

There should be a concerted effort from management to see to the implementation of good housekeeping techniques. These techniques require very little capital investment and emphasize sound training in good operational procedures optimising the use of the existing equipment. Depending on the initial state of the facility, the implementation of good housekeeping techniques can contribute to immediate significant savings. The following are some of the generic good housekeeping techniques prevalent in the metals finishing and drum refurbishing industries:

- Monitor water usage.
- Constructing dikes or bund walls around storage areas to contain contaminated storm-water formed within the storage area and to prevent running storm-water from coming into contact with the drums.
- Paving or impervious storage areas are required to prevent infiltration of potentially contaminated stormwater.
- Prompt clean-up of minor spillages with absorbents must be undertaken immediately whenever there is a spill.
- Maintain inspections so as to detect early leaks or prevent them.
- Motivate employees to partake in the system by having their inputs implemented in the program.
- Optimise operations to reduce pollutant content of the emission gases from the furnaces.
- Stressing equipment maintenance to prevent damage and leaks.
- Recover residual materials in equipment and pipe lines during repair and shutdown.
- The separation of stormwater and effluents from different origins permits appropriate treatment options as well as re-use.
- Have a leak detection system under storage tanks.
- Use of high-pressure water cleaning rather than detergents or chemicals minimises water use and eliminates hazardous waste.
- Where practical, indirect cooling is to be used instead of direct cooling thereby preventing contamination with hazardous waste.
- Ensure the separation of clean storm water from contaminated bund waters.
- Storing all drums with bungs in place, and rings and lids on the drums.
- Cleaning tears from drum exterior surface.
- Substances in dust or powder form should be replaced with the equivalents in pellet or tablet form.
- Perpetually wet floors should have a non-slip surface or coating to prevent slipping.
- Sound management of the drum inventory to minimise drum deterioration. (EPA 821-R-02-011, USA).

APPENDIX D: BPEO UPSTREAM CLEANER TECHNOLOGIES AND APPLICABILITY TO VARIOUS SECTORS

Various upstream technologies have been implemented in the consumer-formulated industries. Some of these are discussed in more detail in the ensuing sections.

1.1 Upstream Cleaner Technologies relating to Tanks

1.1.1 Methods of draining of storage and operational tanks for liquid systems

There are two basic methods of draining storage tanks viz., manual and automatic. As far as possible, tanks should be manually drained. When carried out with proper procedures and appropriate training, manual draining is technically and environmentally superior to automated draining. This is because simple automated valves are subject to failure, either closing prematurely and leading to cross-contamination of batches or not closing completely, leading to leakage and subsequent loss of storage chemicals (BREF, 2006).

1.1.2 Using dedicated systems

Dedicated systems are storage tanks and pipes etc, which are manufactured for the use of specific products or raw materials. The material of construction for the dedicated system is usually determined by the chemical properties of the product or raw material. The usage of dedicated systems prevents cross-contamination and thus minimises emissions and disposal of contaminated products.

1.1.3 Optimum operation of mixing tanks to minimise sludge formation

Sludge formation depends on several factors, which are set by process design. These include:

- Temperature
- Product type
- Standing time
- Mixer capacity
- Type of tank bottom
- Method of receipt (tanker, pipeline)

Sludge formation also depends on the mixer inside the mixing tanks due to the shear that is exerted on the tank bottom. When the shear is high, the formation of sludge is low. Even though jet mixers tend to be more efficient, impeller mixers are more common. Optimisation techniques will therefore be provided for the most used type of mixer.

The common heuristics given for optimising impeller mixers are (BREF, 2006):

- Use impellers with adjustable swivel angles
- Use multiple impellers for larger tanks
- The separation angle between the blades of the impellers should be between 22˚ and 45˚

1.1.4 Sludge removal

Sludge is currently removed from a storage tank by withdrawing the stock from the tank and then purging the sludge into a treatment or incineration facility or it is sent for disposal. The problem associated with this is that some of the sludge can be re-suspended into the stock or some of the stock is lost through the sludge removal process. Methods that have been developed to mitigate these problems include (BREF, 2006):

- use of a suitable additive
- centrifugation to increase the efficiency of sludge removal, and
- product circulation

1.2 Cleaner Technologies Relating To Chemical Handling and Transporting

1.2.1 Reducing the number of flanges and gasket-seals

Flanges and gaskets are usually used to connect the components of a transporting system (i.e. pipes, pumps and valves). The problem is that thermal stress deforms the flanges and thus creates openings from which emissions can occur. Welded connections should therefore be used wherever possible to reduce these emissions.

Where welding is not an alternative, the selection of gaskets and flanges must be based on the following criteria (BREF, 2006):

- compatibility with the process fluid
- operating temperature and pressure
- variations of operating conditions, and
- type of joint involved and the characteristics of the gasket

In the consumer-formulated industry, many products are transported to the packaging sections via pipelines that require regular cleaning and maintenance. In order to reduce the waste generated by the cleaning of these pipelines, the pipelines should be purged with air pressure or a pipeline cleaning pig (California EPA, 1998).

1.2.2 Use of open piping

Wherever possible, open piping networks should be replaced with closed piping systems or the length of open piping should be minimised (BREF, 2006).

1.2.3 Clean-up techniques for spilled liquids

In-order to clean up chemical spills effectively to prevent them from entering the drainage system, the following equipment and procedures should be used:

- A spill dam to keep major spills from entering the drainage system. Contain the spill by building a dyke around the spill
- An appropriate solid absorbent to absorb liquids by covering the liquid with it. The soaked absorbent should then be swept up and disposed of in the appropriate manner
- In the case of an acid or base spillage, sodium bicarbonate should first be used to neutralise and then the spillage can be soaked up with a solid absorbent and then be disposed of in an appropriate manner (Pintar, 2006)

1.3 Techniques for Minimising Dust from The Storage of Solid Materials

The most hazardous effect resulting from the storing of solids is the formation of dust. Therefore, the focus of the following section is primarily on the approaches and precautions industry could take to minimise their dust formation. There are three general approaches to minimising the formation of dust. These are:

- organisational approaches: behaviour of operators
- constructional primary approaches: constructional measurements, and
- technical primary approaches: techniques which prevent dust formation

1.3.1 Organisational approach

Operators should be trained to do regular visual inspections of the dust that is emitted from the storage of solid material. This practice helps to assess the condition of any preventative measures that might be in place.

1.3.2 Constructional approach: silos and feed hoppers

Silos are containers in which dusty solids can be stored. These are closed containers and therefore abate dust emissions. The solid stock is discharged from the conical discharge section and can be drawn in the exact quantities that are needed with the aid of a weighing scale. Silos are equipped with a spreader, a telescopic pipe and a screw system in order to keep the solid material evenly distributed across the silos. Silos are used for stocks that are stored for days or weeks. Dust filters are usually installed to prevent dust emissions during filling. For smaller storage times, hoppers should be used.

1.3.3 Techniques for prevention of dust formation

Generally, the best way to prevent dust formation is to use enclosed storage systems. Wherever this is not applicable (e.g. due to financial constraints) the following techniques can be implemented (BREF, 2006):

- The surface of the stored material can be moistened with a dust binding additive or water, provided that the additive will not interfere with any of the downstream processes
- By covering the open surface with tarpaulins
- By solidifying the surface, or
- By grassing-over the surface

1.4 Minimising Dust Emissions from Transporting and Handling of Solids

1.4.1 Transporting and handling of solids

Another approach to minimise the formation of dust is the use of continuous transporting systems (conveyer belts) instead of manual transporting (trucking and shovel), but often this option is not economically viable. Therefore, the best way to minimise dust formation would be to train staff and operators in practices that would prevent excessive dust formation. Below are a few suggestions (BREF, 2006):

- When using a mechanical shovel, the dropping height should be kept as low as possible

- When solids are spread on the floor, a passing vehicle can swirl up dust. Therefore, the speed of passing vehicles should be regulated to avoid re-suspension of dust
- If the solid material is wettable, then it should be moistened in order to prevent dust from being emitted from transported quantities

1.4.2 Clean-up techniques for spilled solid materials

Often, solid materials are toxic and can potentially generate toxic dusts that are hazardous to humans and the environment. Thus, when cleaning up solid wastes and spills, caution needs to be practised in order to minimise the generation of dust. When the solid is un-reactive to water, the following clean-up guideline can be used:

- Use gloves, safety goggles and dust masks.
- The spilled powder can be dampened lightly with water using a spray bottle. When the powder is very fine and dusty, the mist should be sprayed above the spill and be allowed to settle on the powder. For coarser material, water can be sprayed directly onto the pile but for corrosive solids, more care needs to be taken to avoid skin contact.
- An alternative method is to cover the spill with a wet paper towel.
- The spilled solids must now be shifted gently into a plastic dust pan. The material may be wiped up using the wet towel. A brush can only be used if the material is not dust generating.
- The solid should be placed into a waste container and sent for the appropriate disposal.
- The area can now be cleaned with a detergent and water.

If the material in the spill is reactive to water or flammable, make sure that all ignition sources and flames are shut off. The spilled material can be dampened with cheap natural oil such as soy bean and cooking oil and must be protected from air. In addition, only plastic tools should be used.

1.5 General Practices and Techniques to be Considered For Pollution Abatement and Minimisation

1.5.1 Recycling of packaging material

Where applicable, the drums containing raw materials should be sent back to the supplier for recycling and re-use. The plastics and paper wrapping of raw materials can also be sent back to the supplier for recycling, or be incinerated (BREF, 2006).

1.5.2 Process operation modifications for pollution abatement

In the consumer-formulated chemical industry, improved operating practices can lead to a significant saving in water consumption and can significantly reduce emissions of pollutants.

Before tanks are cleaned with water, they should be vacuum sucked to capture any residue stock that is still useable to prevent it from being emitted into effluent water (BREF, 2003). Residue left on buckets and shovels that are used for manual transport and loading should be removed (by scraping and absorbing) and re-used or disposed of before they are washed. Timers can be used during machine and tank cleaning procedures to minimise water consumption (Wynne et al, 2000).

Statistical process control monitoring should be implemented to predict the life span of equipment so that operational planning can be implemented to prevent equipment from failing during operation. Equipment failures during operation may generate off-specification product (California EPA, 1998).

1.5.3 Equipment cleaning technologies for pollution abatement

Rinsing efficiency can be enhanced with the use of sprays. Vacuum slots and shut-off nozzles should be fitted onto manually held hosepipes and rinsing water should be under pressure to reduce the amount of water that is used (Wynne et al, 2000).

When process vessels are polished to a mirror finish they can be cleaned more efficiently. The use of Teflon liners on process vessels can also reduce the frequency at which tanks are washed (California EPA, 1998).

Often vessels are initially cleaned with solvents to remove organic residues (as in the paint manufacturing industries) producing hazardous effluent streams. Cleaning methods, including crushed walnut shell blasting and carbon dioxide pellet blasting could provide safer alternatives in this respect (California EPA, 1998).

1.5.4 Equipment modifications for pollution abatement

Where applicable, heat exchanges should be installed on hot effluent lines to recover the heat for

- Heating up a colder stream, and
- To cool it to prevent possible volatile substances from evaporating from the effluent.

Ideally, pumps should be reversible to pump unused material back through the pipes to the storage tanks.

In the consumer-formulated chemical industry, processes are usually batch operated, which reduces the possibility of recycling useable process water. If extra storage tanks are available these could be used for collecting batch process thus enabling the re-use and recycling of process water (BREF, 2003).

1.5.5 Automation of processes

Previously, processes such as preparation and dosing of chemicals were performed manually to minimise errors caused by incorrect proportioning. Recent technological advances in automated systems have enabled these processes to be completed faster and with higher efficiency. Therefore, processes can be carried out with less corrective measures than would have been required if manual preparation was used. More importantly, using automated systems would promote a healthier working environment because it would eliminate human contact with toxic and hazardous substances (BREF, 2003).

1.6 Control Measures for the Management of Hazardous Materials (International Labour Office, Geneva)

1.6.1 Classification of hazardous materials

Chemicals are classified as hazardous when their chemical properties are in one of the following categories:

- flammable liquids
- flammable gases
- corrosive liquids
- toxic liquid, gas or solid
- chemicals that emit highly toxic fumes in a fire
- chemicals that react with water to produce toxic gasses or fumes
- oxidising agents
- unstable chemicals
- explosives
- flammable solids
- compressed gases

1.6.2 Control Measures for the Storage of Hazardous materials

- Chemicals should be segregated when being stored and the criteria for segregation should be based on their reactivity. Chemicals which can exothermically react or react to produce an explosive compound should be kept far away from each other. Accordingly, flammable substances should not be stored near oxidising agents.
- In areas where chemicals are stored in small quantities, the chance of intermixing occurring increases, which could ignite a fire. Therefore stringent precautions should be attached to these areas.
- The access points to the storage areas should have adequate security and potential sources of ignition should be eradicated.
- The storage areas of hazardous chemicals should be completely separate from the processing area but should still be accessible.
- The material of construction of storage containers should be conducive to the chemical properties of materials being stored.
- The operating staff must have appropriate training as to the loading and unloading of containers. They must also be cautioned as to the chemical reactivity of the stock and how possible fires and explosions could arise from the chemical reactivity.
- Room temperature and humidity should be adequately monitored and controlled especially in regions where the natural humidity is high. Adequate ventilation to minimise the build-up of fumes, gases and vapours should also be implemented.
- Information relating to emergency procedures must be clearly visible for all staff.
- Chemicals must be properly labelled with the expiry date clearly noticeable. Chemicals must not be stored beyond the expiration date due to chemical changes that could occur.

1.6.3 Control measures for transporting of hazardous chemicals

Municipalities should establish criteria for the transporting of hazardous material for the personal well-being of the workers involved. These criteria should be in accordance with the following regulations:

- Properties and quantities of chemicals.
- The suitability of pipelines or packages in which the chemicals are transported.
- The specifications of transport vehicles.
- The transporting routes.
- The appropriate training and qualifications of the transport workers with respect to loading and off-loading procedures.
- The appropriate driver’s licenses of the drivers of the vehicles.
- Labelling requirements.
- Emergency procedures in the event of the spillage and fires during transport.

1.6.4 These criteria should be consistent with existing international criteria set by bodies such as:

- International Maritime Dangerous Goods Code
- Convention on International Civil Aviation
- European Agreement Concerning the International Carriage of Dangerous Goods by Road

These criteria should be complemented by other criteria that will protect workers and other persons in the event of an accident.

2. END-OF-PIPE TREATMENT OPTIONS

There are many chemical process technologies that are used for effluent water treatment. In the following section, these techniques will be described together with the Best Available Technique (BAT) descriptions.

2.1 Separation Process

Separation processes are techniques in which the contaminants are removed from the wastewater stream by means of a chemical or physical separation method.

Break-up of Emulsions	:	To agglomerate finely dispersed oily materials in a suspension for efficient oil-water separation by using an acid or a poly-electrolyte as the de-stabilisation agent.
BAT	:	The waste stream should be tested for the presence of cyanides. If these are present then the cyanide must first be destroyed before the process can be implemented. Waste acid streams, instead of fresh acids, should be used for destabilisation of emulsions.
Centrifugation	:	To de-water fine-particle sludges by rapidly rotating the sludge in a vessel. When particles are very fine and the specific gravity is less that that of water, separation cannot be done in sedimentation tanks.
Evaporation and Distillation	:	To thermally separate useful materials from oily sludge waste.
Liquid extraction	:	To extract pollutants from wastewater by firstly mixing the wastewater with an insoluble liquid that has a higher solvency for the pollutant than water, and then separating the two liquid phases by decanting.
Filtration	:	To produce clear water from water suspensions such as sludges and pastes by passing the suspension through a filter medium.
Sieving	:	This is a classification process where a mixture of particles with a broad size distribution is mechanically discretised into smaller mixtures with acute size distributions. This is essential for the life-span of minor processing units.
Membrane Filtration	:	The use of a synthetic semi-permeable membrane to separate water from oily or solid suspensions. Ultrafiltration can be used for the break-up of emulsions.
Flotation	:	Injecting and dispersing air bubbles into a suspension. The oil or solid particles can then attach to the bubbles floating on the water surface to form froth.
Ion Exchange	:	This is performed in a similar manner to liquid extraction. In this case, however, the pollutant is either a cation or an anion and will migrate from the water to the other phase, called the resin, where it can pair with a more suitable ion.
Oil Separation Processes	:	Gravity separation of soluble oils and oil/water mixtures that could possibly be preceded by emulsion break-up processes.
Acid Break-up of Emulsions	:	This process involves gathering finely dispersed oily materials in a suspension for efficient oil-water separation by the use of a poly-electrolyte agent.
Screening	:	This process involves the removal of bits of scrap from wastewater.
Gravity Sedimentation	:	Use of gravity to separate coarse to medium size particulates from wastewater.

Adsorption	:	Extraction of a contaminant from water onto an activated surface of a solid. This is usually done forcing wastewater through a bed of activated solids.
Stripping	:	Removal of volatile contaminants (such as H_2S, NH_3, and VOC's) with air or steam in a packed or tray column. When air is used, the gas is collected and treated in elemental recovery units. In the case where steam is used, it can also be sent to distillate to elemental recovery units.
BAT	:	Steam is preferred over air because the process operates at higher temperatures, consequently being more efficient in removing the contaminant. When air is used there is a potential risk of VOC oxidation due to the presence of oxygen.

2.2 Chemical Processes

These are processes where a chemical reaction is induced to destroy the contaminant or to convert it to a harmless form.

As with all chemical reactions, these reactions are optimised by optimising the yield, reaction and selectivity. Therefore, BAT's were developed for these processes as generic pre-optimisation steps.

Electrolysis	:	The recovery of metals from solutions using an electrical current to reduce the metal ions into elemental deposits.
BAT	:	The wastewater should be entered centrally into the electrolysis cell.
Neutralisation	:	Used to adjust the pH of wastewater. Some contaminants can be removed from wastewater by adjusting the pH of the water to a level in which they are not soluble. Neutralisation can either be achieved by the addition of an acid or an alkali salt.
BAT	:	Keep waste that is to be neutralised separate from other wastes containing metals and complexing agents (such as cyanide). This will prevent the formation of metal complexes that would be more difficult to remove.
Oxidation-Reduction	:	Redox reactions are used to treat wastewater by altering or destructing the contaminants. Nitriles and cyanide are destroyed by oxidation whereas toxic chromium compounds are destroyed by reduction.
BAT	:	Avoid the gaseous emissions from the Redox reactions into the atmosphere.
Precipitation –Flocculation	:	A two step process to remove metals from wastewater. The first step is precipitation where ionic metals are converted to a solid form or an insoluble salt, thus removing the metal from solution. These solid particles are normally very fine and dispersed. This process is then followed by flocculation in which the deposits are agglomerated by the use of a flocculating agent so that the deposits can settle.
BAT	:	As a first step, make sure all the metals are in solution by acidifying the waste. Then precipitate the wastes with the respective precipitating agent and adjust the pH to the level of lowest solubility. Avoid adding complexing agents and organic compounds because these chemicals disrupt the precipitating reactions. Only consider adding another precipitating agent when the target concentrations of metal solutions have not been met.
Wet Air oxidation	:	This process is used to destroy wastewater sludge. The solids are solubilised and oxidised under high pressure.

3. WASTE DISPOSAL TREATMENT TECHNOLOGIES

These are techniques that are applied at waste disposal facilities to convert incoming waste to a safe disposable form. Incoming industrial wastes will usually be hazardous, radioactive and it will be discharging a leachate.

3.1 Immobilisation, Solidification and Encapsulation

The purpose of these techniques is to convert hazardous waste into a chemically inert and physically stable mass (example: must not emit dust). Once treated, the waste must have a low emission of leachate and it must be strong enough to allow for land filling and reclamation.

Immobilisation is a process whereby waste is chemically converted to inert, insoluble and immobile forms. It is then followed by solidification, where immobile wastes are cemented together to form a rocklike material. The cementing agents include Portland cements, lime, fly-ash, gypsum mixtures and modified clays. The waste is then encapsulated by coating or closure of the solid masses of waste. Macro-encapsulation is the encapsulation of a large mass of varying waste while micro-encapsulation is the encapsulation of particles of waste.

In South Africa, waste is macro-encapsulated in specially designed cells and a variety is contained in drums.

3.2 Co-Disposal at Landfills

The purpose of co-disposal of general waste and hazardous waste is to absorb, dilute and neutralise any liquids and to encourage biological decomposition which will assist in the breakdown of hazardous wastes.

3.3 Landfill-Ash Blend, Neutralisation, Precipitation

The purpose of landfill-ash blending is to reduce the flammability of a waste by mixing it with ash and other approved material so that the flash point of the mixture exceeds 61˚C. The resulting mixture may then be disposed of with general waste in accordance with the hazard rating.

The waste must also be neutralised in order to adjust the pH in the region of 7. Lime is normally used to neutralise acidic waste while hydrochloric acid is normally used to neutralise alkaline waste.

Sometimes, waste containing solutions of metal ions is land filled. The metal ions can be precipitated to an insoluble form using lime or sodium sulphide.

3.4 Incineration

Incineration is the controlled combustion of hazardous waste to convert it to ash or residue and exhaust gasses, i.e., carbon dioxide and water. Incineration of chlorine and sulphur containing compounds is followed by scrubbing to remove the subsequent hydrogen chloride and sulphur dioxide that is formed in the incinerator.

The process units that serve as the most suitable for waste incineration are Rotary Kilns, Multiple Hearth and Fluidised bed furnaces. Incineration operations require temperatures exceeding 1250˚C and residence times of 2 seconds for the complete destruction of carcinogens such as PCB's and dioxins. The cost of incineration is high.

In the USA, selected hazardous waste is being burned as fuel for cement kilns and is being burnt with extreme efficiency. This is because cement kilns operate at temperatures of 1500˚C and the residence time for the kilns is approximately 6 seconds. The disadvantage is that the load of heavy metals, sulphur and chlorine in the wastes is limited because it can diminish the quality of the clinker product of the kiln and it can affect the operation of the kiln itself.

4. NEW EMERGING TECHNIQUES

These are new techniques that have been developed through intensive research for more effective treatment of waste. Some of these technologies are still being evaluated and others have been patented by the respective organisations.

These technologies have been divided into four classes and are briefly discussed below:

SEPARATION TECHNIQUES

These techniques were developed primarily to separate complex waste into components for easier and more effective chemical treatment. For example, separating organic contaminants from heavy metals and radionuclides.

CHEMICAL STABILISATION TECHNIQUES

These techniques were developed for the chemical stabilisation and immobilisation of heavy metals, radionuclides and inorganic material.

ORGANIC DESTRUCTION TECHNIQUES

These techniques were developed for robust destruction of organic contaminants.

COMBINATION TECHNOLOGIES

These are robust techniques that have been developed to carry out a variety of treatment actions in a single step.

SEPARATION TECHNIQUES

Low temperature thermal desorption

The purpose of this technology is to separate hazardous and radionuclides by means of the large difference between the boiling points of organic and inorganic materials. This enables more efficient and less complex treatment of each component. Organics generally will vaporise at temperatures below 149˚C, whereas boiling points of inorganics are in excess of 1000˚C. Thus, the organics in a waste mixture will evaporate at moderate temperatures, thus separating from the inorganics containing radionuclides that remains solid. The gaseous organics can then be drawn into an oxidation chamber to be destroyed.

This technology has been developed and patented by McLaren Hart. It is designed only to treat solid waste with no free liquids

Magnetic Separation (MAG*SEP process)

The purpose of this technology is to separate heavy metals and radionuclides from aqueous waste. Selective Environmental Technologies, Inc. (Selentec) has developed and patented a system called the MAG*SEP Process. The MAG*SEP particles are fine magnetite particles with acrylic coatings on the surface. The particles have a functionalised resin applied and the resin functions like ion exchange resins by selectively adsorbing heavy metals and radionuclides onto the acrylic surface. The contaminated particles are then magnetically filtered from the waste stream.

This process has been designed to treat aqueous waste streams and slurry streams with a maximum solid concentration of 50% by weight.

Supercritical carbon dioxide extraction (solvent extraction)

This process is a washing process where carbon dioxide that is heated above 32˚C and compressed to pressures exceeding 10342 KPa is used to extract organic contaminants from debris and waste. The carbon dioxide fluid along with its dissolved contaminants is separated from the waste, which remains in the solid phase. The carbon dioxide fluid is then decompressed in order to release the contaminants that are condensed.

This process is used to separate hazardous organic waste from radioisotopes so that each component can be treated separately. It has been designed to treat solid waste and debris.

Supercritical Carbon Dioxide Extraction of Metals and Radioisotopes

This process is similar to the Supercritical Carbon Dioxide Extraction (solvent extraction) process, but it extracts heavy metals and radio-isotopes. In this case, the waste is premixed with a non-polar chelating substance that bonds ferociously to surface of metals. The chelating substance is highly soluble in the supercritical carbon dioxide, and will therefore transport the heavy metals and radioisotopes from the waste/debris to the fluid. The fluid is then separated from the waste and decompressed to release the heavy metal from the carbon dioxide.

Bioprocessing

The Bioprocessing group at Pacific Northwest National Laboratory (PNNL) is assessing the use of microbes to precipitate metals in solution by reducing them to an insoluble form. Specifically, they are looking at the bioprecipitation of uranium from aqueous waste by reducing the soluble uranium (VI) to insoluble uranium (IV).

CHEMICAL STABILISATION TECHNIQUES

Maectite process

The patented Maectite process is a chemical stabilisation process that converts inorganic contaminants (including hazardous, non-hazardous metals and radionuclides) into minerals that are so hard that the metal ions have limited thermal motion. Additionally, the material is very insoluble and non-brittle i.e. does crush under physical force.

This technology has been patented by Sevenson who determines the reaction conditions and a suitable combination of reactants by analysis of the waste stream. This technology has been developed to treat soils contaminated with metals viz. Arsenic, Barium, Cadmium, Chromium, Lead, Mercury, Selenium and Silver.

Mercury Stabilisation (De-Merc)

The De-Merc process is a patented technology developed by Nuclear Fuel Services, Inc and its purpose is to use proprietary reagents to convert hazardous mercury to a non-hazardous form that is either a monolithic solid or a pressed cake. In the process, the wastes are shredded and mixed with water and the propriety reagents to immobilise and make the mercury non-hazardous.

This process has been designed to treat liquid and solid waste.

Microwave Melting

Microwave melting is an in-drum process where inorganic waste is turned into a hard, non-leaching solid by the use of microwaves. The “reagents” in this process is a silica compound and inorganic material and is carried out in the container that should eventually serve as an encapsulating container.

During the process, the container is half-filled with inorganic material and the silica compound. The mixture is then melted by direct microwave exposure thereafter more waste material and more silica compound is added. The addition of material and heating is alternated until the container is full. Once full, the microwave radiation is shut-off completely and the molten mixture solidifies into the desired disposable solid.

This process has been designed to treat inorganic waste containing radionuclides and is not suitable to treat organic waste.

Phosphate Ceramic final waste forms (Ceramicrete)

The purpose of this process is to immobilise and encapsulate inorganics in the insoluble phosphate network of a monolithic ceramic. The ceramic has a very dense network which encapsulates the waste inorganics.

During the process, solid waste, magnesium oxide, phosphate acids and water is mixed to form a thick slurry which is then poured into a waste container and left for two hours at room temperature to solidify into the phosphate ceramic.

This process is a proprietary process of the Argonne National Laboratory and is mostly suitable for immobilising ash waste.

ORGANIC DESTRUCTION TECHNIQUES

Catalysed Chemical Oxidation (DETOX)

The purpose of this process is to catalytically oxidise and destroy organic compounds to form water and carbon dioxide. The catalyst is ferric ions in an acidic solution (3-4%HCl) which are reduced to ferrous ions and are therefore regenerated by dissolving oxygen into the acidic solution.

The reaction takes place in a pressurised stirred tank reactor that is equipped with solid, liquid and oxygen feeding systems. It also has a condenser through which gaseous emissions pass to be treated.

The DETOX process has been developed and patented by Delphi Research, Inc which has also developed a co-catalyst for further acceleration of the oxidation reactions. The efficiency of this process can be altered by changing the feed waste. The feed waste has the following limitations:

- <10% by weight basicity
- <10% by weight reactive metals
- <5% by weight fluoride, sulphur, phosphorus, calcium and cyanide

Electrochemical Oxidation

This process takes place in an electrolytic cell. When a current passes through the solution, an oxidising species is generated at the anode and it is this species that consecutively, will oxidise and destroy the organic compounds.

The process is still under research in the Pacific Northwest National Laboratory (PNNL) and the Los Alamos National Laboratory (LANL). The PNNL is suggesting that Cerium in its nitrate form should be the mediating species. The LANL are assessing cobalt as the mediating species.

This process is not highly sensitive to the characteristics of a waste stream and can effectively treat waste with a water content of less than 20%.

Electron Beam Treatment Technology

The purpose of this species is to destroy organic contaminants by extremely reactive radical species. The radical species are created by firing a beam of highly energetic electrons onto thin sheets of water flowing over a weir.

In the process, the electrons will collide with the water to generate the three radical forms of the water molecules, which are, aqueous electrons, hydroxyl radicals, and hydrogen radicals. The aqueous electrons and hydrogen radicals destroys organics by reducing them, and the hydroxyl radical, which is a strong oxidising agent, destroys these organics by oxidation.

This process has been developed and patented by HVEA and is meant for aqueous streams with a suspended solid content not exceeding 10%.

Gas Phase Reduction/Eco Logic Process

This process breaks down organics by a hydrogenolysis reaction and the result is a methane rich stream that can be used for energy supply purposes. In the reaction, alkyl and halide groups are replaced with hydrogen groups, which mean that long chains are broken up.

Additionally, liquid waste is separated from solids and then vaporised. The vapour is then mixed with hydrogen as it enters a reaction vessel where it is heated to temperatures exceeding 850˚C, at which temperature hydrogenolysis will begin.

This process has been developed and patented by ELI Eco Logic International, Inc and is suitable for liquid/aqueous waste feeds. If the waste feed is in the solid phase, the organics will need to be separated from the solids prior to treatment.

Steam Reforming

In this process, organic contaminants in waste are destroyed in a two step process. In the first step, organics are separated from solid waste by exposing the waste batch to steam which evaporates the organics. The gas stream then enters a reaction vessel where it is exposed to super-heated steam that destroys the organic compound.

There are two organisations researching this technology viz. ThermoChem/Manufacturing and Technology Conversion International as well as Scientific Ecology Group (SEG). This process can effectively treat liquid and solid waste.

Super Critical Water Oxidation

Supercritical water describes the phase of water where gas and liquid phases are indistinguishable from each other. This occurs at pressures exceeding 22100 KPa and temperatures exceeding 374˚C. Under these conditions water is capable of dissolving organics and oxygen, enabling a singular phase oxidation reaction, which is much faster than multiphase reactions because there is no need for prior inter-phase mass transfer. The process is amendable for aqueous waste with organic waste concentrations of 10% or less.

Combination Technologies

Quantum-Catalytic Extraction Processing (Q-CEP)

The purpose of this process is to catalytically destroy waste (gas, liquid or solid) into its elements. This is done by injecting waste into the bottom of a bath of molten iron or nickel at temperatures around 1649˚C so that the waste can dissolve into the molten metal. The molten metal then catalytically destructs the waste into its elements. Gaseous elements are emitted and collected (and treated appropriately) while liquid elements, including radioactive waste, will either float on the surface of the molten phase or remain dissolved in the molten phase. Once solidified, the iron/nickel phase is a stable waste form.

This technology has been patented by Molten Metal Technology. This is the most robust process and can treat almost all waste forms.

Plasma Vitrification

Plasma is an electrically neutral state of matter that consists of highly ionised gas, electrons and neutral particles. This state of matter can only exist at temperatures exceeding 1000˚C and is created by forcing an electrical current through an inert gas. Plasma can then be used to destroy organic contaminants, melts inorganics and other non-combustibles into a molten slag, which then solidifies into a stable waste form. The creation of the slag can be aided by adding ceramic materials to the waste prior to treatment. This process is still under research by several research organisations.

Appendix E

APPENDIX E: SUMMARY OF UPSTREAM CLEANER TECHNOLOGIES AND APPLICABILITY TO VARIOUS SECTORS

	ESTIMATED ECONOMIC IMPLICATIONS	AGRICULTURAL SECTOR	AUTOMOTIVE SECTOR	CLEANING SECTOR	PERSONAL CARE SECTOR	PRINTING SECTOR	SURFACE COATING SECTOR
Manual drainage of storage and operational tanks for liquid systems	Low cost. Staff training cost	Uses solid- liquid systems	Possibility of precipitation occurring	Possibility of precipitation occurring	No. Quick usage of stock	Applicable various sludges formed	Applicable many powders are used
Using dedicated systems	High. But improves process efficiency and allows for implementation of further pollution prevention	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Optimum impeller design to minimize sludge formation	Low	Applicable	Applicable	Applicable	Minimal Sludge	Applicable	Applicable
OPTIMIZE SLUDGE REMOVAL BY: **-the use of a suitable additive**	Depends on chemistry						
-centrifugation to increase the efficiency of sludge removal	High	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
-product circulation instead of stirring	Medium	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Reducing the number of flanges and gaskets –seals with welded connections	Low	Applicable. Many gasses and VOCs transported	Applicable. aerosols transported to packaging	Applicable. aerosols transported to packaging	Applicable. Volatile products transported	Applicable many gasses and VOCs transported	minimal
Purging of product pipelines with compressed air| leakage pig to reduce the waste generated by cleaning	Low, if compressed Air is available	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Replacing open piping with closed piping	Low	Applicable	Applicable	Applicable	Stocks transported in closed piping to prevent contamination	Applicable	Applicable
Clean- up techniques for spilled liquids	Low. Immediate implementation	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Silos and feed hopers for bulk storage of fine solids to reduce dust generation	Depends on the required storage volume	Applicable	Minimal	Applicable	Minimal	Applicable	Applicable
<u>TECHNIQUES WHICH PREVENT DUST FORMATION FROM OPEN STORAGE PILES</u> **-the surface to be moistened with an inert liquid** **-to cover the open surface with tarpaulins** **-solidify the surface –** **-or to grass-over the surface**	 Low Low Low Low	 Applicable Applicable Applicable applicable	 No No No No	 Applicable Applicable Applicable applicable	 No No No No	 Applicable Applicable Applicable applicable	 Applicable Applicable Applicable Applicable

	ESTIMATED ECONOMIC IMPLICATIONS	AGRICULTURAL SECTOR	AUTOMOTIVE SECTOR	CLEANING SECTOR	PERSONAL CARE SECTOR	PRINTING SECTOR	SURFACE COATING SECTOR
Clean- up techniques for spilled solid materials	Low	applicable	applicable	applicable	applicable	applicable	applicable
Recycling of packaging material	Low	applicable	applicable	applicable	applicable	applicable	applicable
Tanks to be vacuum sucked to capture any residue stock that is still useable	Low. Will lead to higher sales and profits	applicable	applicable	applicable	applicable	applicable	applicable
Mechanical cleaning of bucket s and shovels prior to washing to improve effluent quality	Low	Minimal. Process largely automated	Stocks are mainly light solvents and liquids, though powders are present	Applicable. Many powders transported in buckets	Applicable. Blending of viscous materials from buckets	Applicable sticky residue present	Applicable sticky residue present
Implementation of statistical process control monitoring to prevent equipment from failing during operation	High, but highly beneficial	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Improving rising efficiency using pressurized water, vacuum slots and shut-off nozzles	Low. Immediate implementation	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Polishing process vessels to a mirror finish for more effective cleaning	Low. Immediate implementation	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
The use of Teflon liners on process vessels reduces the frequency of washing	High	Applicable	Applicable	Applicable	Vessels must be regularly cleansed	Applicable	Applicable
Using crushed walnut shell blasting and carbon dioxide pellet blasting as superior alternatives to solvent cleaning to prevent the generation of hazardous effluent streams	Crushed nuts are cheaply available, pressure blaster might be expensive	Applicable	Applicable	Applicable	Most chemicals are cleaned with water	Applicable	Applicable
Installing heat exchangers on hot effluent lines to recover heat and to prevent VOC's from evaporating.	High capital costs, but will increase profit returns	Minimal: Low temperature operations	Minimal: Low temperature operations	Minimal: Low temperature operations	Minimal.: Low temperature operations	Minimal: Low temperature operations	Minimal. . Low temperature operations
Using reversible pumps to pump back unused material to the storage tanks	Low cost	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable
Using extra storage tanks for collecting batch process water to enable the process water to be reused and recycled	Low cost. Clean metal and plastic drums can be used for storage	Applicable: collection of rinsing water	Applicable: collection of rinsing water	Applicable: collection of rinsing water	Applicable: collection of rinsing water and cooling water	Applicable: collection of rinsing water	Applicable: collection of rinsing water
Using technological advanced PROCESS AUTOMATION for process speed and efficiency	Can be expensive, but improves productivity	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable

APPENDIX F : COST OF IMPLEMENTATION OF TECHNOLOGIES THAT ARE CLASSIFIED AS HIGH COST

The techniques that were classified as “high” in **Appendix D** can be very effective in pollution abatement and will eventually provide high profit returns and thus a payback on the capital expenditure. Therefore it is imperative to produce a cost estimate of the capital expenditure as a first order indication of the economic implications of implementing cleaner production techniques.

Dedicated Systems

A dedicated system would typically consist of a storage vessel, tubing and a pump. The price of such a system would vary considerably, depending on the material that is used for construction, which is ultimately dependant on the chemicals. Typical materials for construction would be stainless steel, mild steel and plastic. **Table A** provides a guide as to the minimum capital cost for implementing a dedicated system with reference to the components and materials.

TABLE A: COMPARATIVE PRICES

COMPONENTS	MATERIAL FOR CONSTRUCTION		
	Stainless steel	Mild steel	Poly-vinyl-chloride
1 m^3 storage vessel	14 000	4 000	900
2 bar piston pump	2 000	2 000	2 000
Tubes (price per meter)	80	9	5

As an example, the cost of a dedicated system consisting entirely of stainless steel with a 20 meter pipe would have a minimum capital cost of R18000.

Process Monitoring for Life-Span Prediction of Equipment

In order to achieve this objective, a variety of process variables such as conductivity, pH, flow, level and temperature would be measured. These variables can then be correlated with the current ware and tear of the equipment, and as a result, statistical prediction can be made. Average prices for these measuring devices for March 2007 are given in **Table B**.

TABLE B: COST OF MONITORING EQUIPMENT

PROCESS VARIABLE	MEASURING DEVICE	PRICE
Fluid flow	½ inch tube flow meter	R7 000
pH (acidity, alkalinity)	Electronic pH meter	R8 000
Electrical conductivity	Conductivity meter	R9 220
Liquid level	Ultra-sonic level meter	R7 510
Temperature	Electronic thermometer	R350

From the above table, the minimum capital cost of a complete measuring system would be estimated at R35 000.

Installing Heat Exchangers on Effluent Lines

The price of heat exchangers varies drastically with the exchange area. Typically, consumer related industries would use small tube-in-tube exchangers that would cost R2 000, or more pressure intensive tube-in-shell exchangers that would cost about R15 000.

Using Teflon Liners to Reduce Internal TANK Washing, Polishing and Corrosion

Implementing this technique can be expensive or cheap, depending on the size of the internal processing area and thickness of Teflon lining. The estimated price of Teflon sheets that are 1.2 m wide, 2 mm thick, is R1 725 per meter, and the price of sheets that are 1 mm thick, 1.2 m wide is R840 per meter.

Bulk Storage of Powders in Silos

The average usage rate of powders in the consumer related industries would be 5 tons per month. It would be far more environmentally viable to store these powders in bulk storage in silos or feed hoppers. The silos are either corrugated or smooth-walled. The corrugated silos with a storage capacity of 5 m^3 would have a capital and installation cost of R15 000-R20 000 and that of the smooth-walled storage with the same capacity, would be R25 000-R30 000.

Automated Processes And Controllers

Automated processes and controllers would require the measuring devices, signal transmitters and actuators. The measuring devices that are listed in table **Table B** would be incorporated into a full control system.

Individual automated processes for adequate mixing would be less complex and cheaper. A hypothetical automated mixing unit is given in **Figure A.**

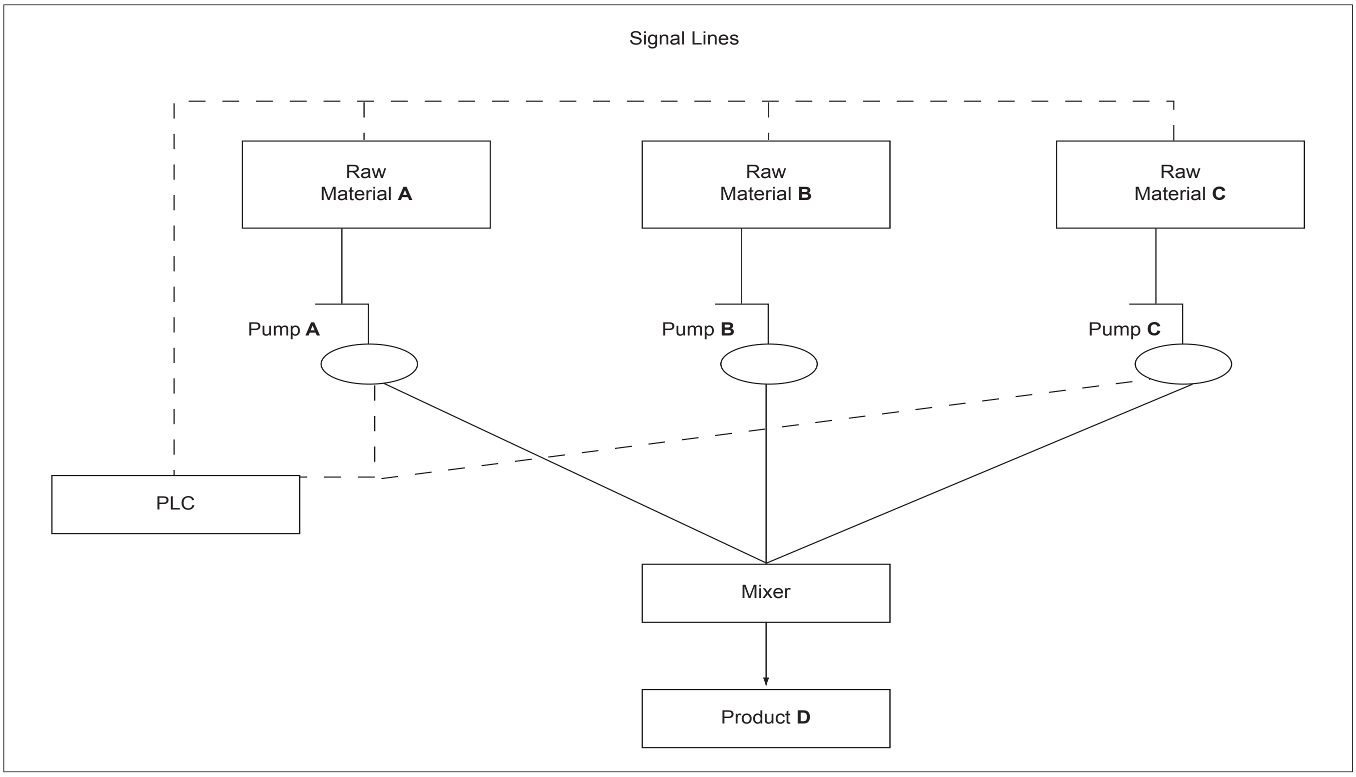

Figure A: Hypothetical automated process

Raw materials A, B and C must be mixed in specific proportions to produce Product D. The proportions are 500 kg of A, 300 kg of B and 200 kg of C to produce 1000 kg of Product D. The raw materials are stored in 1000 litre containers.

Electronic scale balances are inserted under the containers of the raw materials, and these scale balances continuously transmit signals to a controller (PLC). This controller will then shut off pumps A, B and C when the required mass of raw materials has been withdrawn.