APPENDIX 5: WASTE MANAGEMENT REPORT

WASTE MANAGEMENT REPORT:

PROPOSED CHROME CHEMICALS PLANT, MIDDELBURG

FOR:
SAMANCOR CHROME (PTY) LTD

November 2007

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WASTE MANAGEMENT REPORT FOR PROPOSED CHROME CHEMICALS PLANT, MIDDELBURG

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1. EXECUTIVE SUMMARY

As part of the Environmental Impact Assessment process for a proposed chrome chemicals plant at Middelburg, Mpumalanga, an assessment of the expected waste to be generated and the subsequent management thereof has been undertaken.

The following major waste streams have been considered in terms of handling, storage, treatment, reuse and disposal options:

- electrostatic precipitator and bag filter dusts
- post treatment frit residue filter cake
- aluminium oxide slag from chrome metal plant

The composition of the wastes was predicted from literature review, experience from the plant engineers and a laboratory test sample. The presence of hexavalent chromium (Cr^{6+}) is critical to the hazardousness of the wastes.

Classification and hazard rating of these waste streams has been undertaken in terms of the Department of Water Affairs and Forestry Minimum Requirements for the Handling, Classification & Disposal of Hazardous Waste. It was assumed that Ch^{6+} would be present in all three wastes listed above and therefore it has been concluded that these wastes fit into Class 6.1 Toxic Substances, and have a hazard rating of 1 (HR1) by virtue of the likely presence of Cr^{6+} in the waste.

The dust wastes will be recycled into the process. The frit residue will be partially recycled to extract chromium and then treated to convert Cr^{6+} to Cr^{3+} that is considerably less toxic. The best opportunities for recycling of the aluminium oxide slag and final frit residue are incorporation into cement or clay fired bricks, but these options can only be properly investigated once the plant is operational and the exact composition and quantity of the wastes is known.

Provided that the wastes are stored, handled, transported and disposed of in compliance with the DWAF Minimum Requirements, it is expected that there will not be an unacceptably significant impact on the environment.

It is anticipated that numerous other waste streams will be generated at the plant as can be expected from any industrial venture. These are office waste, engineering waste, and general domestic-type waste for instance. These waste streams are not addressed in detail in this report, as they define a substantially lesser environmental risk to those listed above.

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2. BACKGROUND

It is the intention of Samancor Chrome (SamancorCr) to establish at its Middelburg site a world class chrome chemicals production facility utilising its advanced technologies, raw material and market position. The facility will broaden its production scope and increase its beneficiation capability. This will be achieved by utilizing existing equipment, to be augmented with new ancillary equipment, in the construction of a facility for the production of a range of chrome chemicals and chrome metal at the Middelburg Site of SamancorCr. The company will take advantage of existing infrastructure and the site's proximity to SamancorCr Mines.

The objective of this waste management report is to inform the Environmental Impact Assessment process for the aforementioned plant. This report gives an account of assessment of the risks associated with potentially hazardous waste that will be generated on site, the associated treatment strategies proposed and a brief evaluation of potential means for the reuse or recycling of this waste.

3. LIST OF ACRONYMS

ARL Acceptable Risk Limit

DWAF Department of Water Affairs & Forestry

HR Hazard Rating

MRHW Minimum Requirements for the Handling, Classification & Disposal of Hazardous Waste

TCLP Toxicity Characteristic Leach Potential

USEPA United States Environmental Protection Agency

4. LEGAL AND POLICY FRAMEWORK

In terms of the Environment Conservation Act of 1989 Section 20(1) & (6) "Waste", is defined as including:

Any matter (whether gaseous, liquid or solid or any combination thereof) which is an undesirable or superfluous by-product, emission, residue or remainder of any process which originates from any residential, commercial or industrial area and which is:

a) discarded by any person; or

b) is, accumulated and stored by any person with the purpose of eventually discarding it, with or without prior treatment connected with the discarding thereof; or

c) is stored by any person with the purpose of recycling, re-using or extracting a useable product from such matter and

d) building rubble used for filling or levelling purposes."

Excluded from the definition is (other laws regulate the excluded categories) -

a) waste water disposed of in accordance with the National Water Act;

b) French drains and septic tanks;

c) minerals, tailings, waste-rock or slimes produced by or resulting from activities at a mine or works as defined in section 1 of the Mines and Works Act, 1956; and

d) radio-active waste.

Furthermore a "disposal site" is defined as a site used for the accumulation of waste with the purpose of disposing or treatment of such waste;

Waste generated from various processes will be accumulated on site. Storage of waste material derived from the process qualifies as a waste disposal activity as referred to in Section 1 of the Environment Conservation Act of 1989. By strict interpretation of the law this means that the area where waste is being stored, treated, or from which a valuable constituent is recovered, is regarded as a waste handling facility which should be permitted, or exempted from permitting, in terms of Section 20(1) of the same Act.

According to Section 20(1) of the ECA, ***"no person shall establish, provide or operate any disposal site without a permit issued by the Minister of Water Affairs..."***, the process of which is in turn informed by the DWAF Minimum Requirements Waste Management Series (DWAF 1998a, DWAF 1998b, DWAF 1998c) documents (with the draft 3rd edition having been released). Provision is made for the Minister to grant exemptions from the permitting requirements. As such SamancorCr will need to apply for:

- a waste disposal site permit in terms of Section 20(1) of the ECA; or
- an exemption from the provisions of Section 20(1) of the ECA.

4.1 WASTE DISPOSAL SITE PERMIT APPLICATION

The hazardous waste generated onsite will be treated and accumulated in storage facilities on the site before final disposal. It such it is envisaged that an exemption from the provisions of Section 20(1) of the ECA may be applied for. The permitting process will be informed by this Environmental Impact Assessment.

5. PROJECT DESCRIPTION

5.1 DESCRIPTION OF ACTIVITY TO BE UNDERTAKEN

Chromium chemicals are produced through the alkaline roasting of chromite ore in a rotary kiln where it is oxidized from its trivalent state (Cr^{3+}) to its hexavalent state (Cr^{6+}) in the form of Sodium Monochromate, which is the precursor to production of Sodium Dichromate. Sodium Dichromate is the starting point for a broad range of downstream products which include chrome sulphate, chromic acid, chrome oxide and chrome metal amongst others.

The plant will produce the following range and tonnages of product:

- Sodium Dichromate 70,000 tonnes per annum (tpa)
- Chrome Oxide 19,000 tpa
- Chrome Sulphate 14,000 tpa
- Chrome Metal 10,000 tpa
- Potassium Dichromate 2000 tpa
- Sodium Sulphate 60,000 tpa

A more detailed description of the project is given the Environmental Impact Assessment Report, and is summarised in Figure 5-1: Project Description.

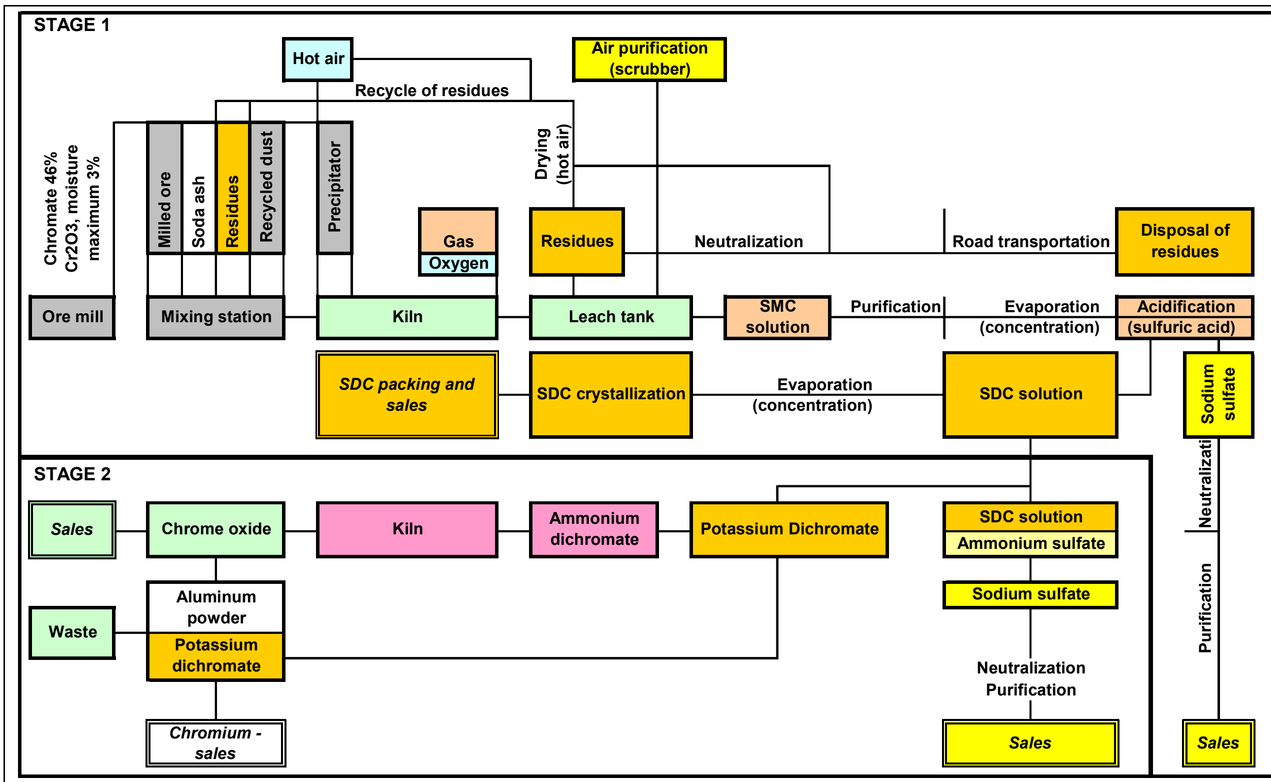

Figure 5-1: Project Description

6. METHODOLOGY

A plan of study was formulated to meet the requirements for Plan of Study for Environmental Impact Assessment as set out in regulation 29.1(i) of GNR 385 promulgated in terms of chapter 5 of the National Environmental Management Act (Act No. 107 of 1998), reproduced below:

"29.1(i)a plan of study for environmental impact assessment which sets out the proposed approach to the environmental impact assessment of the application, which must include

(i) a description of the tasks that will be undertaken as part of the environmental impact assessment process, including any specialist reports or specialised processes, and the manner in which such tasks will be undertaken;

(ii) an indication of the stages at which the competent authority will be consulted;

(iii) a description of the proposed method of assessing the environmental issues and alternatives, including the option of not proceeding with the activity; and

(iv) particulars of the public participation process that will be conducted during the environmental impact assessment process;"

The waste management assessment is comprised of the following activities:

- review of literature
- waste classification and hazard rating
- discussion of waste treatment alternatives
- identification and evaluation of reuse and disposal alternatives.

The Minimum Requirements for the Handling, Classification & Disposal of Hazardous Waste (MRHW) (DWAF 1998a) will further be used as a point of departure for discussion of storage, handling, treatment and disposal procedures for hazardous waste.

6.1 REVIEW OF LITERATURE

Due to an absence of actual samples, waste streams will be considered on a theoretical basis. Literature on wastes arising from chrome chemicals facilities worldwide will be reviewed and a preliminary classification and hazard rating in terms of the DWAF-MRHW will be undertaken. Information on the wastes from chrome chemicals production has also been compiled by the US EPA so as to inform regulation of mineral processing wastes in the United States (EPA 1990, Chapter 4, Sodium Dichromate production).

6.2 WASTE CLASSIFICATION AND HAZARD RATING

The appropriate disposal method for hazardous waste cannot be determined without information on the Class and Rating of the waste, as outlined in the DWAF-MRHW.

The DWAF-MRHW considers any waste that contains, or that can leach a potentially hazardous component, as "probably" or potentially hazardous. The document contains an approach for the classification of these wastes either as hazardous (see below) or non-hazardous. A non-hazardous waste is one that has a similar or even lower pollution potential than a general waste such as household waste.

Potentially hazardous wastes are identified by:

- the industrial sector that generates the waste: e.g. chemical and related industries, power generation, foundries, etc
- the process that generates the waste: e.g. petroleum production, production of primary chemicals or feedstocks, etc
- the waste stream: e.g. oily wastes, organic wastes, etc
- the hazardous characteristics of the waste: e.g. corrosivity, flammability, reactivity and toxicity.

In South Africa, the primary classification of wastes in terms of their hazardous characteristics is accomplished by using the International Maritime Dangerous Goods (IMDG) code, or SABS code 0228, i.e:

- Class 1: Explosives
- Class 2: Gases
- Class 3: Flammable liquids
- Class 4: Flammable solids
- Class 5: Oxidising Substances and Organic Peroxides
- Class 6: Toxic and Infectious Substances
- Class 7: Radioactive Substances
- Class 8: Corrosive Substances and,
- Class 9: Miscellaneous Dangerous substances

The above code was primarily developed as a code for the transport of hazardous materials. Therefore, the, approach used to classify Class 6: Toxic and Infectious Substances in this code is not adequate for the determination of the impact of hazardous waste on the environment. The DWAF-MRHW outlines a comprehensive approach to the classification of the toxic or poisonous characteristics of a hazardous waste.

The DWAF-MRHW classifies waste streams in terms of their chronic toxicity (teratogenicity, mutagenicity, carcinogenicity), acute toxicity in terms of mammalian toxicity as measured by the LD50 mg/kg (oral, rat), and ecotoxicity in terms of its LD50 mg/l/96hr for fish, preferably trout. It also takes into account the biodegradability of the specific component, its persistency, bioaccumulation and mobility in the environment. Waste is then rated according to a Hazard Rating Group (HR) depending on chronic toxixcity, acute toxicity and Acceptable Risk Limit (ARL). The ARL is defined as equal to one tenth of the LD50.

In simple terms, the ARL is: "That concentration, which when added to a body of water will provide no risk or at least an acceptable risk, if consumed by a population."

The hazard groups are defined as:

- Hazard Rating Group 1, (HR1): Extreme Hazard, e.g. Hg and PCBs
- Hazard Rating Group 2, (HR2): High Hazard, e.g. Mn and Zn

- Hazard Rating Group 3, (HR3): Moderate Hazard, e.g. Ni and phenol
- Hazard Rating Group 4, (HR4): Low Hazard, e.g. Ethanol
- Non-hazardous or Non-toxic, e.g. fresh general/ domestic waste

The assessment of a waste can be done on a number of risk levels where the primary risk assessment level includes the risk based classification system for waste as used above for the non-magnetic waste as given in the DWAF-MRHW. This considers waste specific issues, essentially chemical nature and hazardous characteristics. The procedures to be followed are well defined and very conservative and include the specification of the leaching methods, i.e. the US EPA TCLP (Toxicity Characteristic Leach Potential) or South African Acid Rain tests that are used to evaluate the potential risk associated with leaching of inorganic or organic components.

Hazardous waste is defined by the DWAF-MRHW as waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill health or increase mortality in humans, fauna and flora, or adversely affect the environment when improperly treated, stored, transported or disposed of. From this definition it can be seen that many variables determine whether a waste is hazardous or not. Classification of all potentially hazardous wastes is therefore necessary because of the presumption that all industrial wastes are hazardous unless proven otherwise.

6.3 WASTE TREATMENT ALTERNATIVES

The results of compositional analyses and the literature review will be used to identify treatment strategies to reduce the hazard presented by components of the waste so as to minimise the potential impact of the waste on the environment, as far as practicably possible.

6.4 IDENTIFICATION AND EVALUATION OF REUSE AND DISPOSAL ALTERNATIVES

Identification and evaluation of treatment methods follows a generic gate process whereby wastes are considered for reuse (refer to Figure 6-1: Waste Treatment and Reuse Stage Gate Decision Process).

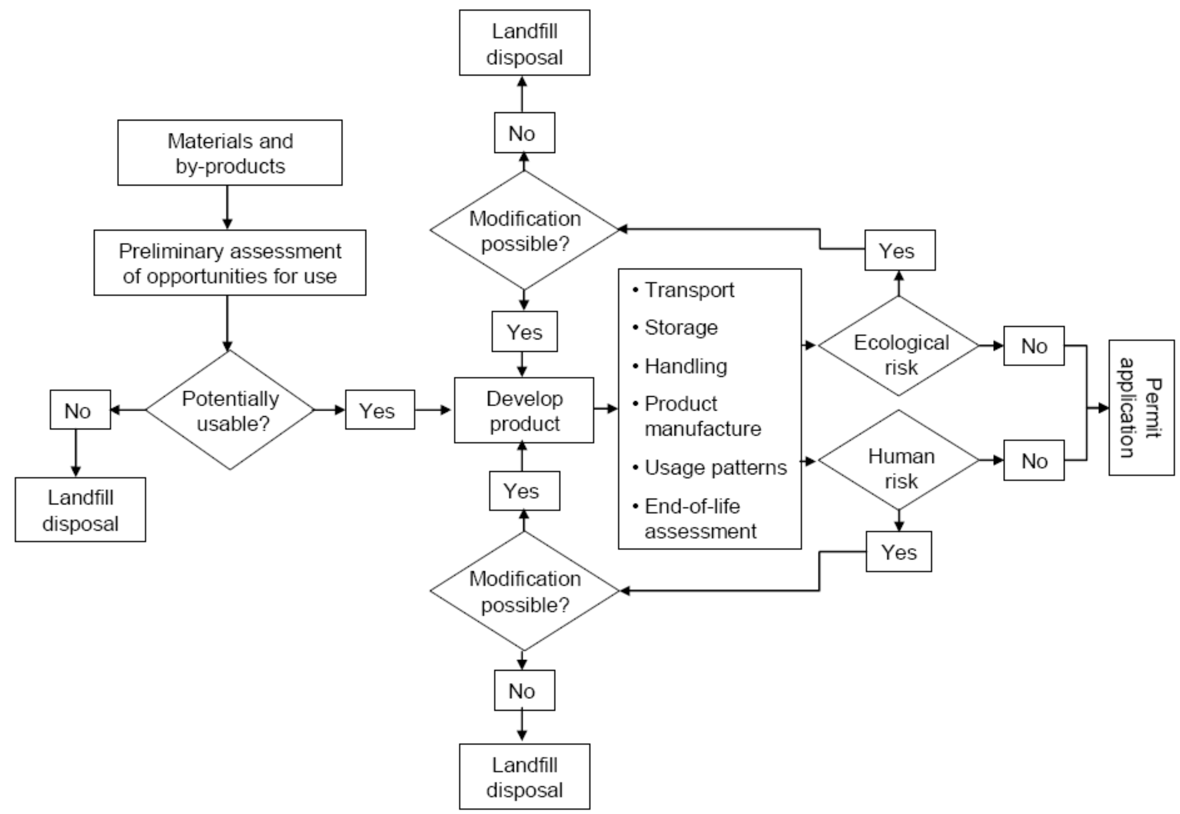

Figure 6-1: Waste Treatment and Reuse Stage Gate Decision Process.

The following options for hazardous waste reuse have been identified and investigated:

- treatment with mud or sludge dredged from salty or brackish water to form a hardened sedentary mass having load supportive properties suitable as landfill (Kapland et al 1985)
- pelletising and smelting / direct charge to DC furnace
- incorporation in cement aggregates
- incorporation in clay fired brick.

The disposal of treated frit residue to a suitably permitted waste disposal site will be assessed based on the outcomes of the classification and hazard rating exercise. When products from such wastes are disposed of, re-introduced into society, or when direct use of such materials for useful applications is allowed, the potential for exposure of a wide spectrum of members of the community has to be considered. The disposal and reuse options have been evaluated against each other in terms of:

- environmental Impact
- exposure risk assessment
- economic feasibility.

7. WASTE GENERATION AT THE PROPOSED PLANT

The following major waste streams need to be considered in terms of handling, storage, treatment, reuse and disposal options:

- electrostatic precipitator and bag filter dusts: generated as a result of emissions abatement - this is recycled into the plant but must to be accumulated and handled before re-feeding
- post treatment frit residue filter cake: following the leaching of chromium product, frit residue is treated to reduce Cr^{6+} - this waste stream needs to be stored, handled and disposed
- aluminium oxide slag from chrome metal plant: this results from the aluminothermic reduction of chrome - this waste stream needs to be stored, handled and disposed.

These are all potentially hazardous wastes due to the presence of aluminium, chrome (potentially containing Cr^{6+}), presence of trace amounts of other heavy metals, as well as presence of sodium and its salts (as a result of stochiometric excess of soda ash used in the kiln). The frit residue cake is the waste of primary concern due to quantity.

A generic representation of waste frit residue produced from such chrome chemicals manufacturing plants is shown Figure 7-1: Generic Waste Treatment and Generation Processes. A more representative scheme of waste generation and recycling at the proposed plant are shown in Figure 7-2: Residue Generation and Recycling.

It is anticipated that numerous other waste streams will be generated at the plant as can be expected from any industrial commercial operation; these will include office waste, engineering waste, and general domestic-type waste for instance. These waste streams will not be addressed in detail in this report, as they are of substantially lesser significance in comparison to those listed above.

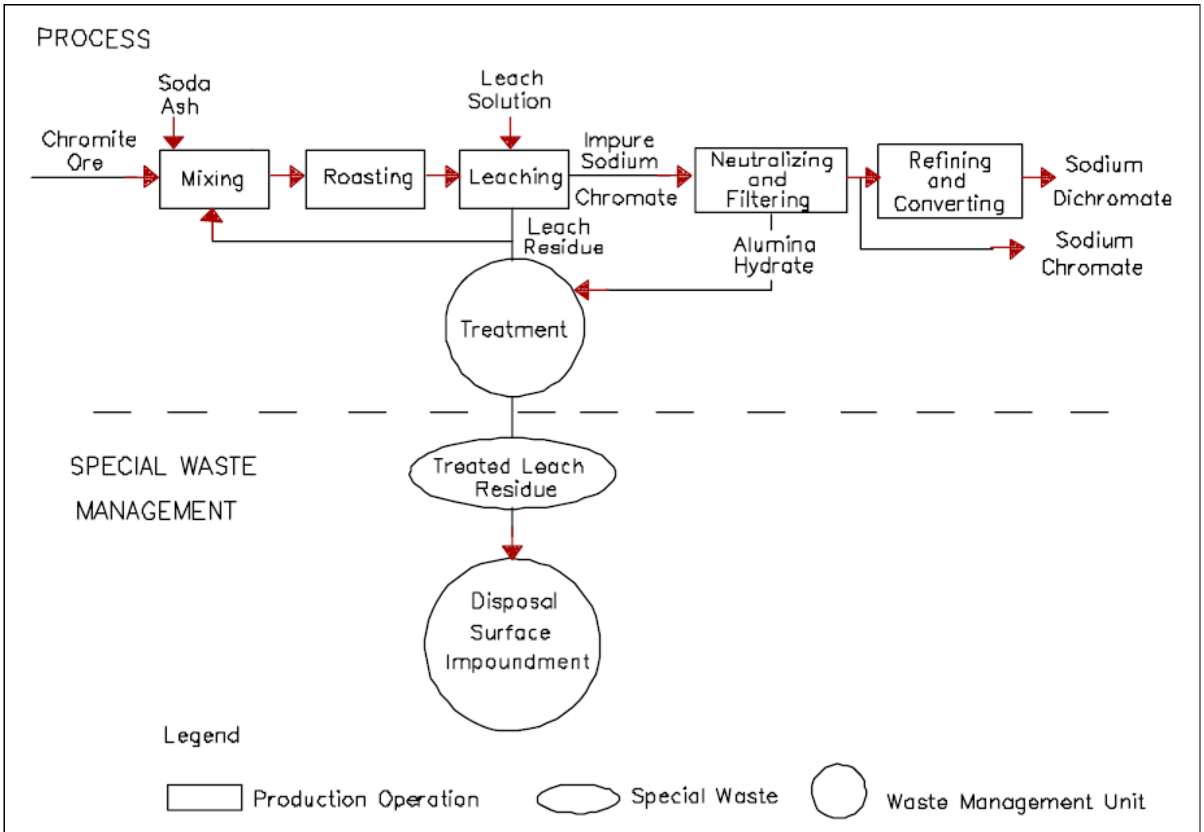

Figure 7-1: Generic Waste Treatment and Generation Processes

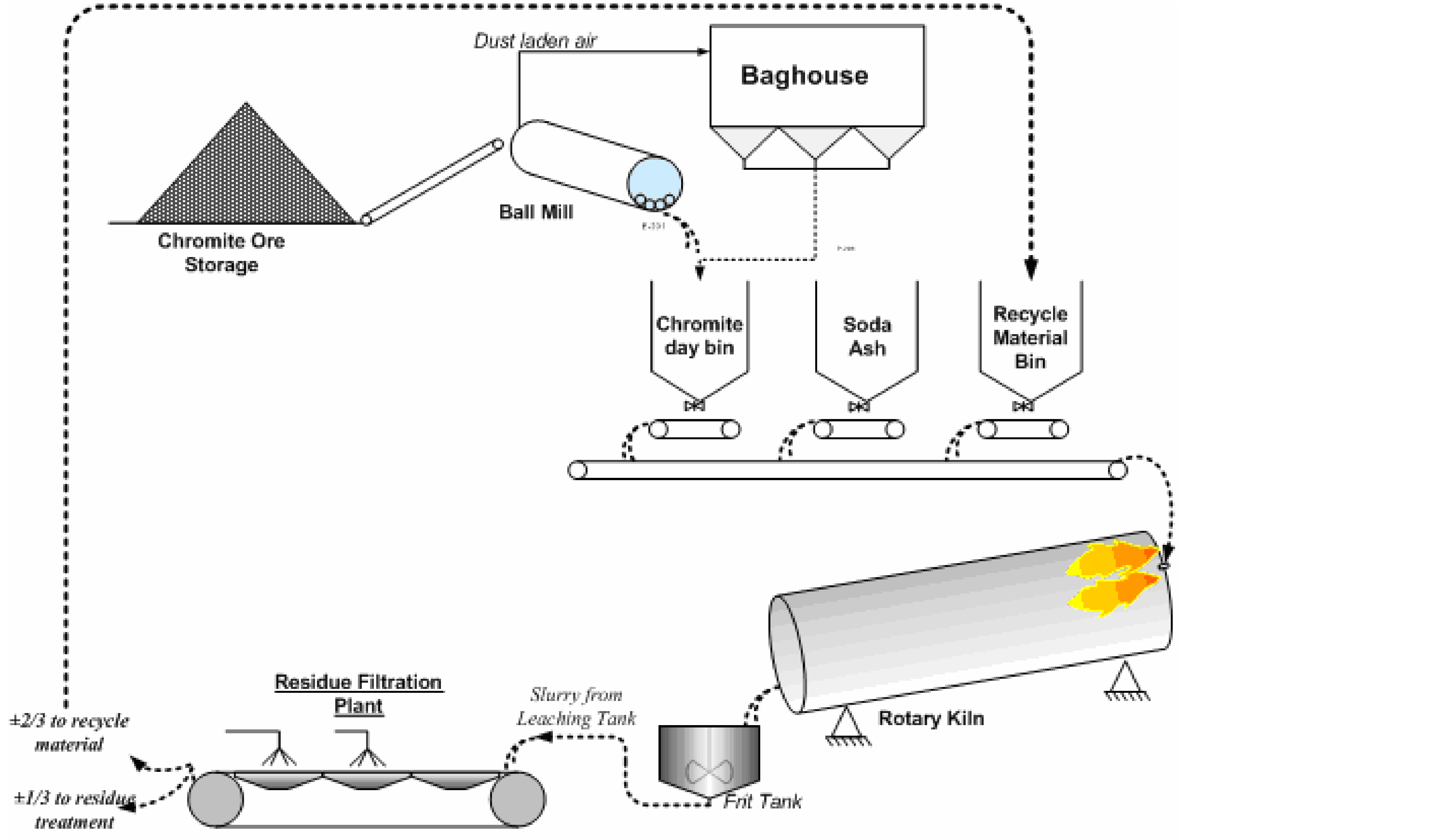

Figure 7-2: Residue Generation and Recycling

8. FINDINGS

8.1 LITERATURE REVIEW

Due to an absence of actual samples, with the exception of a laboratory test sample, waste streams will be considered on a theoretical basis. Literature on wastes arising from other chrome chemicals facilities will be reviewed and a preliminary classification and hazard rating will be undertaken in terms of the DWAF-MRHW. Information is also gleaned from a study of the wastes from chrome chemicals production compiled by the US EPA so as to inform regulation of mineral processing wastes (EPA 1990, Chapter, 4 Sodium Dichromate production).

8.2 WASTE CLASSIFICATION AND HAZARD RATING

The waste hazard characterisation process requires full chemical analysis of the by-products, which allows the risk assessment to focus on chemicals of potential concern. Ideally pre-treatment and post-treatment frit residue filter cake samples should be subjected to compositional analyses as well as to TCLP or acid rain tests to empirically determine and quantify the nature of the hazardous components that may leach. Due to the absence of such samples the analyses reported are provided by the project chemical engineering experts (Table 8-1 and Table 8-8) and a laboratory test sample (Table 8-4). These are used as the waste composition for the assessment.

8.2.1 WASTE COMPOSITION

It must be noted that the actual composition of the frit residue will only be known when an actual sample of the residue can be taken. This is of course not possible without the plant in operation. It is expected that the residue will be similar in composition to the analyses given below, but the source of ore and process efficiency will determine the actual composition.

Table 8-1: Residue Initial Chemical Composition (provided by Samancor Cr)

Waste Component	Composition Before Treatment
CrO_3	0.6 - 0.7 %
TOTAL Cr_2O_3:	8%
H_2O:	18 - 20 %
AL_2O_3:	21 - 24%
Fe_2O_3:	30 - 35%
MgO:	12 -18%
Others:	negligible

Table 8-2 Residue Particle Size Distribution (provided by Samancor Cr)	
Particle size in µm	**Percentage**
Greater than 700	2%
50-700	45%
Less than 50	53%

Table 8-3: Waste Composition [Kapland et al]	
Waste Component	**% Composition by Mass Before Treatment**
CaO	38
Fe_2O_3	23
Al_2O_3	15
MgO	10
SiO_2	3
Na_2O	2
CrO_3	2
Cr_2O_3	3
Loss on Ignition	5
Mn	0.2
Pb	-
Ni	0.2
Co	-
Cu	0.002
V	0.08
Ti	0.08
Zn	-
Ba	0.006
Sr	0.02
As	-
Cd	-
Mo	-
Sn	0.02

The compositional analysis in Table 8-3 is of a typical chromium ore waste sample following drying and calcining at 100°C (Kapland et al).

Table 8-4 shows the analysis of a laboratory sample of calcined frit waste. This is the expected trace and minor elements of the waste residue.

Table 8-4: Waste Composition Laboratory Sample	
Element	**Measured value in ppm**
As	<4
Ba	21
Bi	<3
Br	<2
Ce	<10
Co	382
Cr	88000
Cs	<5
Cu	11
Ga	85
Ge	<1
Hf	<3
La	<10
Mo	<2
Nb	1.2
Nd	<10
Ni	1469
Pb	<2
Rb	<2
Sc	21
Se	1.4
Sm	<10
Sr	<2
Ta	<2
Th	<3
Tl	<3
U	<2
V	325
W	3.4
Y	<1
Yb	<2
Zn	1170
Zr	2.4

The EPA states the following as constituents of potential concern (EPA 1990):

- Chromium
- Vanadium
- Aluminium
- Manganese
- Arsenic.

The compositions obtained from international sources must be considered with caution as the compositions of the wastes are related the compositions of the parent ore, that in some cases will be different from that for the proposed plant.

The compositions of the electrostatic precipitator and bagfilter dusts, as well as aluminium oxide slag from the chrome metal plant, will contain some or all of the same constituents in varying quantities. The aluminium oxide slag from the chrome metal plant is expected to have an elevated aluminium content.

8.2.2 ASSUMPTIONS

Due to the absence of an actual sample, a conservative approach is taken in classifying and hazard rating the waste. The following assumptions are made:

1. It is assumed that the waste will be disposed at a landfill containing other wastes and that the disposal site will be acidic, as is generally the case for such sites due to the presence of organic waste, which produces ethanoic acid during decomposition.
2. It is assumed that the entire amount of each constituent will leach from the waste body when disposed of in an acidic environment (equivalent to the entire set of constituents leaching from a sample subjected to the TCLP test).
3. It is assumed that hexavalent chrome will remain in the hexavalent state despite the assumed low pH.

8.2.3 CLASSIFICATION

The wastes produced fall into class 6 in the DWAF-MRHW.

Under the current guidelines (EPA, 1986), Cr(VI) is classified as Group A - known human carcinogen by the inhalation route of exposure. Carcinogenicity by the oral route of exposure is classified as Group D, which implies carcinogenicity by the oral route of exposure cannot be determined (EPA 2007).

The waste also contains several other heavy metals which have the potential to leach in quantities which will result in concentrations exceeding their respective acceptable risk levels.

The wastes are thus assigned to Class 6.1. Toxic Substances.

Table 8-5: Waste Classification

Waste	Class
Frit residue	6.1. Toxic Substances.
Electrostatic precipitator and bag filter dusts	6.1. Toxic Substances.
Aluminium oxide slag from chrome metal plant	6.1. Toxic Substances.

8.2.4 HAZARD RATING BEFORE TREATMENT

In accordance with assumption 2, the hazard rating is estimated based on the entire metallic component of the waste leaching during a TCLP test. The leachate concentrations are calculated in accordance with 100g:2000ml (waste to leaching solution ratio) as per the TCLP detailed in the DWAF-MRHW.

Although the full characteristics and dimensions of potential waste disposals sites for this waste are unknown, an Estimated Environmental Concentration (EEC) can be calculated based on a disposal facility of a certain area as per Section 8.4.1 of the

DWAF-MRHW. In line with the conservative approach taken, the ARLs have instead been directly compared to the estimated leachate concentrations to determine the hazard rating of the waste as opposed to calculating an EEC.

Table 8-6: Waste Composition & Hazard Analysis

Element	ppm	mg/L	Acceptable Environmental Risk (mg/L)	Hazard Rating
As	<4	<0.2	0.38	
Ba	21	1.0	7.8	
Bi	<3	<0.2	500	
Br	<2	<0.1	0.031	HR1
Ce	<10	<0.5	[1]	
Co	382	19.1	0.97	**HR2**
Cr	88000	4400.0	4.7	**HR1**[2]
Cs	<5	<0.3		
Cu	11	0.6	0.13	**HR2**
Ga	85	4.3	351	
Ge	<1	<0.1	5	
Hf	<3	<0.2		
La	<10	<0.5	2	
Mo	<2	<0.1	106	
Nb	1.2	0.1		
Nd	<10	<0.5		
Ni	1469	73.5	0.49	**HR2**
Pb	<2	<0.1	0.12	
Rb	<2	<0.1		
Sc	21	1.0		
Se	1.4	0.1	1.2	
Sm	<10	<0.5		
Sr	<2	<0.1	42	
Ta	<2	<0.1		
Th	<3	<0.2		
Tl	<3	<0.2	17	
U	<2	<0.1		
V	325	16.2	1.3	**HR3**
W	3.4	0.2	1561	
Y	<1	<0.1		
Yb	<2	<0.1		
Zn	1170	58.5	0.83	**HR2**
Zr	2.4	0.1	2	

1 - Some elements reported at levels below the detection limit of the tests conducted. In cases where it is highly unlikely that appreciable amounts of these elements will occur, because of their natural scarcity in South African chrome ores, the ARL's and subsequent hazard ratings are omitted.

2 - It is conservatively assumed here that the chromium composition will contain a fraction of hexavalent chrome exceeding the ARL, as can be deduced from Table 8-1.

The frit residue waste is given a hazard rating of 1 (HR1) as a result of the potential hexavalent chromium content. It is expected that the aluminium oxide slag from the chrome metal plant, as well as the electrostatic precipitator and bag filter dusts will also have a hazard rating of 1 (HR1) due to the presence of hexavalent chromium.

Table 8-7: Waste Hazard Rating

Waste	Hazard rating
Frit residue	1
Electrostatic precipitator and bag filter dusts	1
Aluminium oxide slag from chrome metal plant	1

8.3 WASTE TREATMENT

The Plant will produce 92 000 tpa of frit residue at maximum capacity. 67% of this residue will be recycled to optimise chrome recovery, while the remaining 33% is bled off into a residue treatment system which reduces the hexavalent chrome to the less hazardous trivalent species.

The frit residue treatment process is schematically represented in Figure 8-1 below.

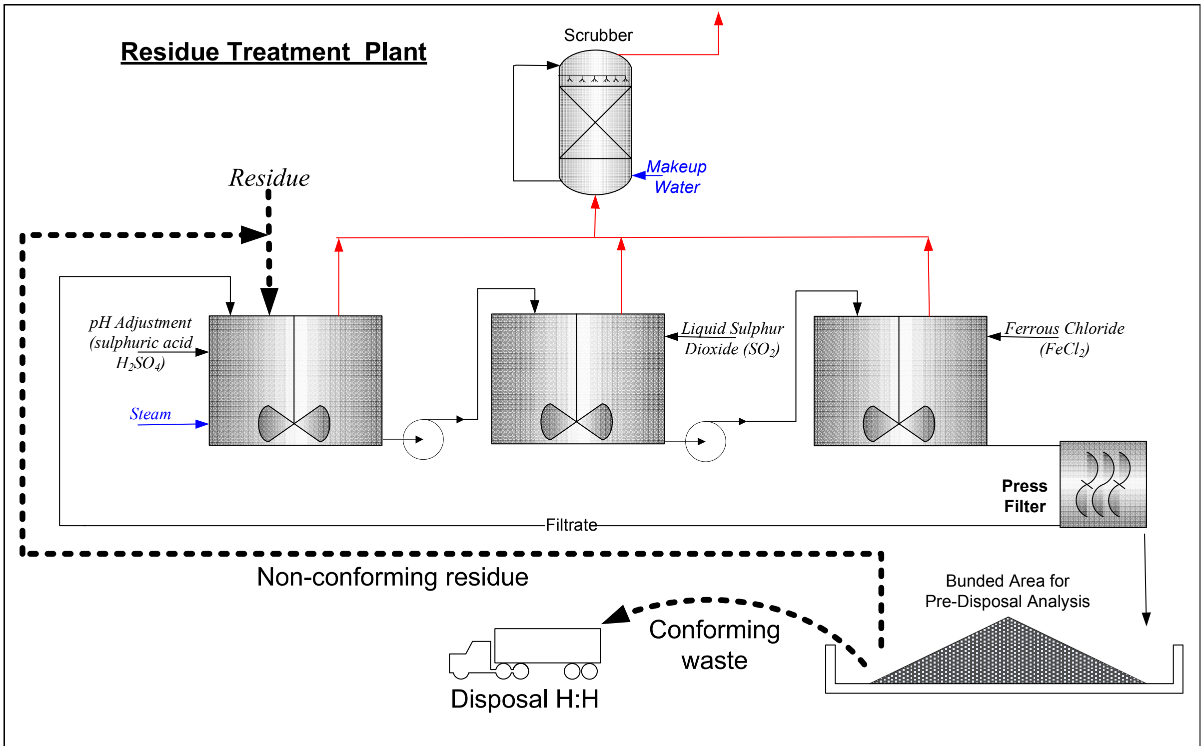

Figure 8-1: Residue Treatment Diagram

The solid residue produced is expected to contain approximately 7000ppm CrO_3 before treatment and approximately 5ppm after treatment. Treated frit residue will be accumulated in a bunded bay, where it will be sampled and analysed for hexavalent chromium. Non-conforming residue will be reprocessed.

Table 8-8: Comparison of Residue Before and After Treatment		
	Before Treatment	**After Treatment**
CrO_3:	6000-7000 ppm	typical: 5 ppm maximum: 10 ppm
Total Cr_2O_3:	8%	8%
H_2O:	18-20 %	18-20 %
Al_2O_3:	21 - 24%	21 - 24%
Fe_2O_3:	30 - 35%	30 - 35%
MgO:	12 -18%	12 -18%

The primary constituents of the waste remain substantially the same, while the hexavalent content is largely reduced to a trivalent state.

8.3.1 HAZARD RATING AFTER TREATMENT

The final residue waste will be treated before disposal to reduce its hazardousness in line with the philosophy of the waste management hierarchy, using the methodology outlined. The waste treatment process primarily seeks to reduce the hexavalent chrome to a less hazardous trivalent state, however the fundamental constituency remains largely the same. The presence of other potentially toxic components such as aluminium, and possibly manganese (depending on the ore used) imply that the waste will remain in a high hazard rating category, but will now have a hazard rating of 2 (HR2). The actual hazard rating can only be confidently arrived at with actual samples from the process.

8.4 WASTE HANDLING

In order to avoid dust generation, residue is transported with a moisture content of 20%. From Table 8-2 Residue Particle Size Distribution, it can be seen that a substantial proportion of the waste is less than 50µm and has the potential to become entrained by wind during handling, transfer and transportation.

The plant will formulate an environmental management system in accordance with the requirements of the ISO4001 Environmental Management System Standard. A procedure for the handling of waste will be produced and applied to ensure that waste is handled and transported in compliance with SANS 10231 for Transportation of Dangerous Goods.

8.5 REUSE AND RECYCLING OF TREATED WASTE

Electrostatic precipitator and bag filter dusts will be recycled into the process without treatment. Reuse and recycling methods considered for treated frit residue cake include the following:

- treatment with mud or sludge dredged from salty or brackish water to form a hardened sedentary mass having load supporting properties suitable as landfill (Kapland et al 1985)
- pelletising and smelting or direct charge to DC furnace
- incorporation in cement aggregates
- incorporation in clay fired brick.

Treatment with mud or sludge to produce a hardened mass that will prevent leachate of the hazardous components of the waste as proposed by Kapland et al requires the use of sediment from coastal or brackish waters. This option does not appear to be feasible given the distance of the proposed plant from such a sediment source. In addition the potential environmental implications of the dredging must be considered in identifying a suitable source.

Smelting of the waste in the DC furnace will negatively affect the final chrome content of the ferrochrome produced by virtue of the relatively small quantity of chrome in the waste.

The incorporation of the wastes in cement aggregates and clay fired bricks presents a potential use which will encapsulate the waste in a manner that will prevent leaching while providing structural strength and volume in the end use.

Of the options listed it would appear that the incorporation of the treated waste into clay fired bricks is likely to be the most feasible option for reuse of the waste.

Actual samples of the treated waste are required in order to conduct more detailed studies of the potential use of this waste in clay fired brick making. It is thus recommended that such feasibility studies be undertaken in the event that the plant is brought into operation.

8.6 DISPOSAL OF HAZARDOUS WASTE

Until suitable reuse technologies can be proven and put into action, the wastes must be disposed of in an environmentally sound manner. The treated frit residue waste will still have a high hazard rating, HR2, and must therefore be disposed of to a permitted H:H facility in line with the DWAF-MRHW. The aluminium oxide slag is also expected to have a hazard rating HR2, and will also go to an H:H disposal site.

The closest and most economically feasible H:H facility is the Holfontein facility. This will be the likely place of final disposal if the treated waste cannot be further reused or recycled in an environmentally acceptable manner.

9. CONCLUSIONS

It is expected that the frit residue produced will be hazardous waste both before and after treatment, as detailed in Section 8.2.4 Hazard Rating Before Treatment and Section 8.3.1 Hazard Rating After Treatment. Approximately 67% of the residue from the leaching process will be recycled back into the process to maximise chromium yield, while the remainder will be treated to reduce the hazardousness of the waste. This is in line with the waste management hierarchy as presented in the DWAF Minimum Requirements for the Handling, Classification & Disposal of Hazardous Waste. The hazard rating of the residue is expected to be HR1 before treatment and likely to be HR2 after treatment. The hazard rating for the aluminium oxide slag waste is expected to be HR1. The bag filter and electrostatic precipitator dust are also rated HR1, but will be recycled into the process. These hazard ratings are influenced primarily by the likely presence of hexavalent chromium in the waste streams.

The actual classification and rating of the waste can only be determined once a sample of the waste produced is analysed. A precautionary approach should thus be taken, and the waste must be assumed to be HR1 until proven otherwise.

Work may be undertaken to ascertain the possible recycling of the wastes into either cement or clay brick products. This work may commence once the plant is established and the exact composition and quantities of the wastes are known.

Provided that the wastes are stored, handled, transported and disposed of in compliance with the DWAF Minimum Requirements, it is expected that there will be not be an unacceptably significant impact on the environment.

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