Information Report

January 1997

Regulation of Dioxin releases from the Runcorn operations of ICI and EVC

ENVIRONMENT AGENCY

REGULATION OF DIOXIN RELEASES FROM THE RUNCORN OPERATIONS OF ICI AND EVC

Executive Summary

ICI and EVC at Runcorn operate processes for the production of the chemicals Vinyl Chloride, Perchloroethylene, Trichloroethylene, CTF and chlorine. All these processes form very small quantities of dioxins as unwanted by-products.

At present, the site's largest dioxin arising (some 500 grams Toxic Equivalent (TEQ)/year) is in heavy organic residues which are sent to the Holford brine cavities for secure containment. There are relatively minor releases to the air and water environments. Dioxins may also have been released to the local environment from historical operations.

Major environmental improvements are being made on the site through the installation of three incinerators. Local air quality, the ozone layer and global warming will all benefit from a 90% reduction in the emission of chlorinated hydrocarbons to air. Discharges to water will be cut by 80% and this will enable the Weston Canal to comply with water quality standards. The incinerators will also provide for the discontinuation of waste disposal at Weston Marsh Lagoons and Holford brine cavities.

These significant environmental improvements are balanced against a small release of dioxins to atmosphere (an estimated maximum of 0.244 grams TEQ/year). However, future dioxin releases are not considered to have any major environmental impact. The Environment Agency considers that there will be a net environmental benefit from the incinerators and supports their installation.

The levels of dioxin in local air and soil are typical of an urban environment and do not give cause for concern. Sediments in the Weston Canal show elevated dioxin levels due to site releases, but these sediments are periodically dredged for disposal in Frodsham Marsh Lagoon where they are effectively isolated from the environment. Dioxins found in River Weaver sediments and local soils do not appear to have a significant contribution from process releases.

The Ministry of Agriculture Fisheries and Food have been made aware of dioxin releases from the Runcorn site and have concluded that there are unlikely to be any unacceptable effects on the human food chain. This has been supported by a recent survey of local farms which found dioxin levels in cow's milk to be well within acceptable limits.

The Environment Agency is satisfied that there is sufficient regulatory control on dioxin releases to protect the local environment

Cover photograph reproduced courtesy of ICI Chemicals & Polymers Limited

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1. INTRODUCTION

ICI Chemicals & Polymers Limited (ICI) and, to a lesser extent, European Vinyls Corporation (UK) Limited (EVC) operate a large manufacturing site in Runcorn, Cheshire which produces chlorine, chlorinated organics and a number of other chemicals.

In March 1994, Her Majesty's Inspectorate of Pollution (HMIP) issued an Integrated Pollution Control (IPC) Authorisation to ICI for operation of the vinyl chloride process at Runcorn. The Authorisation included an Improvement Requirement on ICI to assess dioxin releases from the process. An assessment report[1] was submitted to HMIP and its subsequent distribution to other interested bodies provoked widespread discussion and media coverage, including a Channel 4 Dispatches programme on the 6th December 1995.

Discussion has also surrounded dioxin releases from the incinerator which forms part of ICI's Environmental Improvement Project. More recently, proposals by ICI and EVC to build two further incinerators on the site have lead to renewed interest in dioxins.

The environmental significance of dioxin releases is a complex and topical issue which has generated strong opinions from interest groups. Further confusion may have been perceived by the involvement of three separate environmental regulators on the site - HMIP, the National Rivers Authority (NRA) and Cheshire Waste Regulation Authority (Cheshire WRA).

So when the Environment Agency was formed on 1 April 1996 we took the opportunity to adopt a fully integrated approach to dioxin releases and set up a Project Team with representatives from the former HMIP, NRA and WRA. The Project Team was tasked with objectively considering the adequacy of controls on dioxin releases from the Runcorn site, and ensuring that the air, water and land environments were all adequately protected.

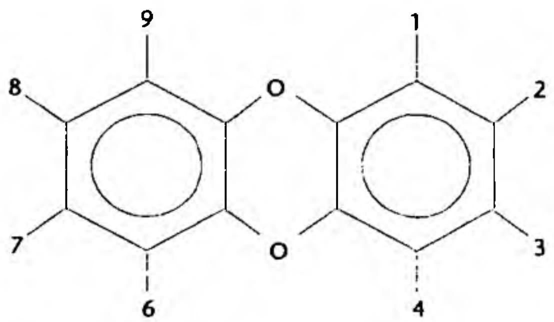
The Project Team was also required to prepare a summary of its work in the form of an "Information Report" which would provide a clear overview of dioxin releases from the Runcorn site. This document represents the Information Report. The Report strikes a balance between technical detail and readability by a wide audience. Diagrams and tables have been used to aid explanation, and scientific details have been simplified wherever possible. The Glossary near the end of this report gives simple descriptions of some of the key terms used in the text.

Our objective is that the Report clarifies the issue of dioxin releases from the Runcorn site and leads to a better understanding of the implications. The Report does not deal with the release of other substances from the Runcorn site, nor does it deal with dioxin releases from other sites.

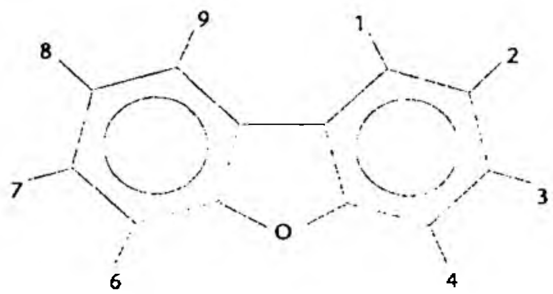
2. WHAT ARE DIOXINS ?

2.1 Chemistry of Dioxins

The common name Dioxins is often used to describe the group of chemicals known as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). All dioxins have the same basic structure of chlorine atoms attached to two carbon rings, which are in turn joined by one or two oxygen atoms.



Dibenzo-para-dioxin



Dibenzofuran

Figure 1 : Structure of dioxins/furans

The numbered positions on the rings may be occupied by hydrogen or chlorine atoms. There is a standard naming system for dioxins which indicates the chlorine content and location. So, for example the following dioxin compound:

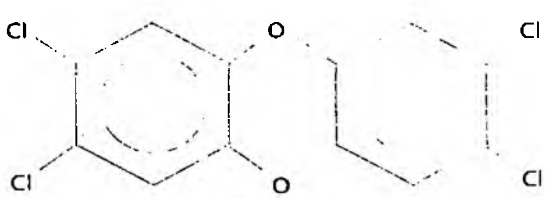


Figure 2 : 2,3,7,8-TCDD

- has two oxygen atoms, so is a dioxin (rather than a furan);
- has four chlorine atoms, so will have the prefix "tetra"; and
- the chlorine atoms are in the 2, 3, 7, and 8 locations.

This compound is therefore known as 2,3,7,8 tetra chloro dibenzo-p-dioxin, which can be abbreviated to 2,3,7,8-TCDD.

The other prefixes indicating the number of chlorine atoms are : mono (1 chlorine atom), di (2), tri (3), penta (5), hexa (6), hepta (7) and octa (8).

There are many combinations for the number and location of chlorine atoms, and it is possible for 210 different dioxin compounds (or 'congeners') to exist. Most of the 210 dioxin congeners are thought to pose no risk to human health, and only 17 congeners with chlorine atoms in the 2,3,7,8 locations are reported to have potential health effects.

For the sake of simplicity this report uses the general term Dioxins as a collective term to describe the dioxin and furan congeners. Specific congeners are referred to as and where necessary.

2.2 Reporting Units

Dioxin concentrations in the environment are usually very low and are present in fractions of a gram. Dioxin concentrations are typically expressed per kilogram of soil, per cubic metre of air, and per litre of water. To avoid confusion, concentrations are expressed in the units that minimise the number of zeros and so the following units are used widely in this report.

Table 1 : Reporting Units

1 milligram (mg) =	0.001 g
1 microgram (μg) =	0.000001 g
1 nanogram (ng) =	0.000000001 g
1 picogram (pg) =	0.000000000001 g
1 femtogram (fg) =	0.000000000000001 g

Table 2 : Toxic Equivalent Factors (TEF) for the 17 "toxic" congeners

Dioxins	Factor	Furans	Factor
2,3,7,8-TCDD 1,2,3,7,8-PeCDD	1 0.5	2,3,7,8-TCDF 2,3,4,7,8-PeCDF 1,2,3,7,8-PeCDF	0.1 0.5 0.05
1,2,3,4,7,8-HxCDD) 1,2,3,6,7,8-HxCDD) 1,2,3,7,8,9-HxCDD)	0.1	1,2,3,4,7,8-HxCDF) 1,2,3,7,8,9-HxCDF) 1,2,3,6,7,8-HxCDF) 2,3,4,6,7,8-HxCDF)	0.1
1,2,3,4,6,7,8-HpCDD OCDD	0.01 0.001	1,2,3,4,6,7,8-HpCDF) 1,2,3,4,7,8,9-HpCDF) OCDF	0.01 0.001

2.3 Sampling and Analysis

Since dioxins are present at such low concentrations in the environment they are very difficult to sample and analyse. Sophisticated analytical controls are required to ensure reliable results, and even so it is possible to obtain very different figures from different laboratories.

In general, the accuracy of results declines with reducing concentrations and with increasing sample interferences. However, recent improvements to analytical techniques mean that dioxins can be detected at lower and lower levels. Dioxin sampling and analysis is very specialised and costs will depend on the sample nature and the desired level of detection. Sample analysis would typically cost between £500 and £700, but the cost of collecting that sample will vary from a few pounds (for a soil sample) up to £1,500 (for an accurate gas sample from a process vent).

2.4 The Relative Toxicity of Dioxins

Dioxins occur in the environment in complex mixtures of the 210 congeners. Since the congeners have different toxicities it is difficult to determine the overall toxicity of any mixture. An international system has therefore been developed which assigns toxicities to each congener relative to the most toxic form (namely 2,3,7,8-TCDD). Seventeen dioxin congeners have been identified as having significant toxicity and have been assigned the Toxic Equivalent Factors (TEF) in Table 2.

The TEF is effectively a weighting factor which if multiplied by the known concentration of a congener gives a Toxic Equivalent (TEQ). The toxicity of any mixture is given by the sum of the TEQs. For example, Table 3 shows a soil sample containing three dioxin congeners at different concentrations. If these concentrations were simply summed together, then the sample would be reported as containing 60 ng/kg of dioxin.

However, this ignores the fact that 1,2,3,4,7,8-HxCDF is ten times less toxic than 2,3,7,8-TCDD. By applying the toxicity factors to each congener and summing the results it can be seen that the Toxic Equivalent (TEQ) is 23 ng/kg. The TEQ figure therefore takes account of the relative strengths of dioxins and enables comparison with other results.

Table 3 : A worked example of a TEQ calculation

Dioxin Congener	Sample Concentration (ng/kg)	Toxic Equivalent Factor (TEF)	Toxic Equivalent (TEQ)
2,3,7,8-TCDD	10	1	10
1,2,3,7,8-PeCDD	20	0.5	10
1,2,3,4,7,8-HxCDF	30	0.1	3
Total concentration = 60 ng/kg		Total TEQ = 23 ng/kg	

Table 4 : Dioxin properties

Characteristic of dioxins	Implication
Occur as solids at ambient temperatures and are slow to evaporate	Releases will mainly be in solid form, rather than as liquid or gas. Environmental occurrence will be mainly in soil and this restricts continued movement of dioxins once in the environment.
Very stable to chemical and biological breakdown.	Dioxins will persist in the environment and may be detectable long after a release has ceased.
Very low solubility in water.	Very low levels of dioxin in river water, but higher concentrations in sediments and soils. Plants will not tend to take up dioxins from soils through their roots.
Strong affinity to organic & particulate matter.	Dioxins will collect in the fatty tissues of animals and will build up in the food chain. Dioxins will not tend to move through soil with the movement of ground water.

2.5 Properties of Dioxins

The occurrence and fate of dioxins in the environment is partly a function of their physical and chemical properties and so it is worth highlighting some key characteristics (Table 4).

Many releases of dioxin have a characteristic profile of the dioxin congeners and this can sometimes act as a "fingerprint" to identify their source. Since dioxins are slow to degrade in the environment their congener profile will also tend to remain and this can be useful for identifying historical sources of dioxins. Unfortunately fingerprint data does not exist for many historical sources because analysis for dioxins is comparatively recent.

2.6 Sources of Dioxins

Dioxins are not produced intentionally and have no known use, but they are widely distributed around the world and can be found in the air, land and water environments. Dioxins do occur as a result of natural processes, although these sources are relatively unimportant when compared to the amounts released from man's activities. Interest in dioxins has increased over the last 20 years due to an awareness of the contribution that man has made to their formation, and also due to improved techniques for the measurement and detection of dioxins at extremely low levels. Table 5 gives some activities which represent the most significant sources of dioxins.

Public interest in dioxins is usually associated with the 1976 incident at Seveso, Italy when a phenol/dioxin mixture was released after an explosion at a trichlorophenol manufacturing plant. Dioxins also gained notoriety as a contaminant in 'Agent Orange' which was used as a leaf defoliant in Vietnam. More recently concern has surrounded the discovery of dioxin contaminated cow's milk in the Bolsover area of Derbyshire. Following a lengthy investigation, Coalite Products Ltd were prosecuted by HMIP for failing to use best practicable means to prevent emissions of dioxins from their chemical incinerator.

Table 5 : Dioxin sources

	EMISSIONS TO AIR	RELEASES TO WATER	SOLID WASTES
INDUSTRIAL	Waste incinerators; coal combustion; metal smelting	Production of chlorinated aromatic compounds	Combustion ashes; chlorinated organic process residues.
NON-INDUSTRIAL	Traffic; domestic fires	Deposition and run-off from combustion	Combustion ashes
NATURAL	Forest fires; volcanoes.	Deposition and run-off from combustion	Combustion ashes

2.7 Health Effects

Of the 210 known dioxins, there are 17 which are considered to pose a risk to human health. The majority of animal toxicity studies have been based on the most toxic 2,3,7,8-TCDD congener. Relatively low doses of 2,3,7,8-TCDD have been shown to be fatal to some species (eg. guinea pigs), although it is less toxic in other species. Acute exposure to 2,3,7,8-TCDD will also cause toxicity to the skin which is seen in humans as the skin eruption known as "chloracne".

The greater concern to human health is probably long term exposure to lower concentrations (ie. chronic effects). Work on species such as rabbits, mice and monkeys has shown the potential for liver damage, tumour formation, immune system suppression, and damage to reproductive systems.

The UK Department of Health considers that *"although there is insufficient evidence for a causal link between exposure to 2,3,7,8-TCDD and cancer in humans, it would be prudent at present to regard 2,3,7,8-TCDD as a possible human carcinogen"*[(2)]. The United States Environmental Protection Agency has suggested that the levels of dioxin in the human population are close to those which might cause changes to enzymes, male reproductive hormones and the immune system. There is still some scientific debate on the impact of dioxins and studies on health effects are on-going.

3. WHY ARE DIOXINS PRODUCED ON THE RUNCORN SITE ?

Dioxins are not intentionally produced on the Runcorn site, but some processes have been identified as forming, or having the potential to form, dioxins. In very general terms, dioxins can form wherever carbon, oxygen and chlorine come into contact at high temperatures. A number of processes on the site fulfil these requirements.

The processes of interest are those for the production of vinyl chloride (VC), perchloroethylene (Per), trichloroethylene (Tri), chloro trifluoromethyl pyridine (CTF) and chlorine.

Formation could also occur in the incinerator which forms part of the site's Environmental Improvement Project (EIP) and in the two further incinerators which are planned to serve the VC and fluorochemical processes. The EIP is currently being commissioned and has received operational approval. The VC and fluorochemical incinerators are being designed and are the subject of planning applications.

Figure 3 shows the location of these processes and other features which are mentioned in this report.

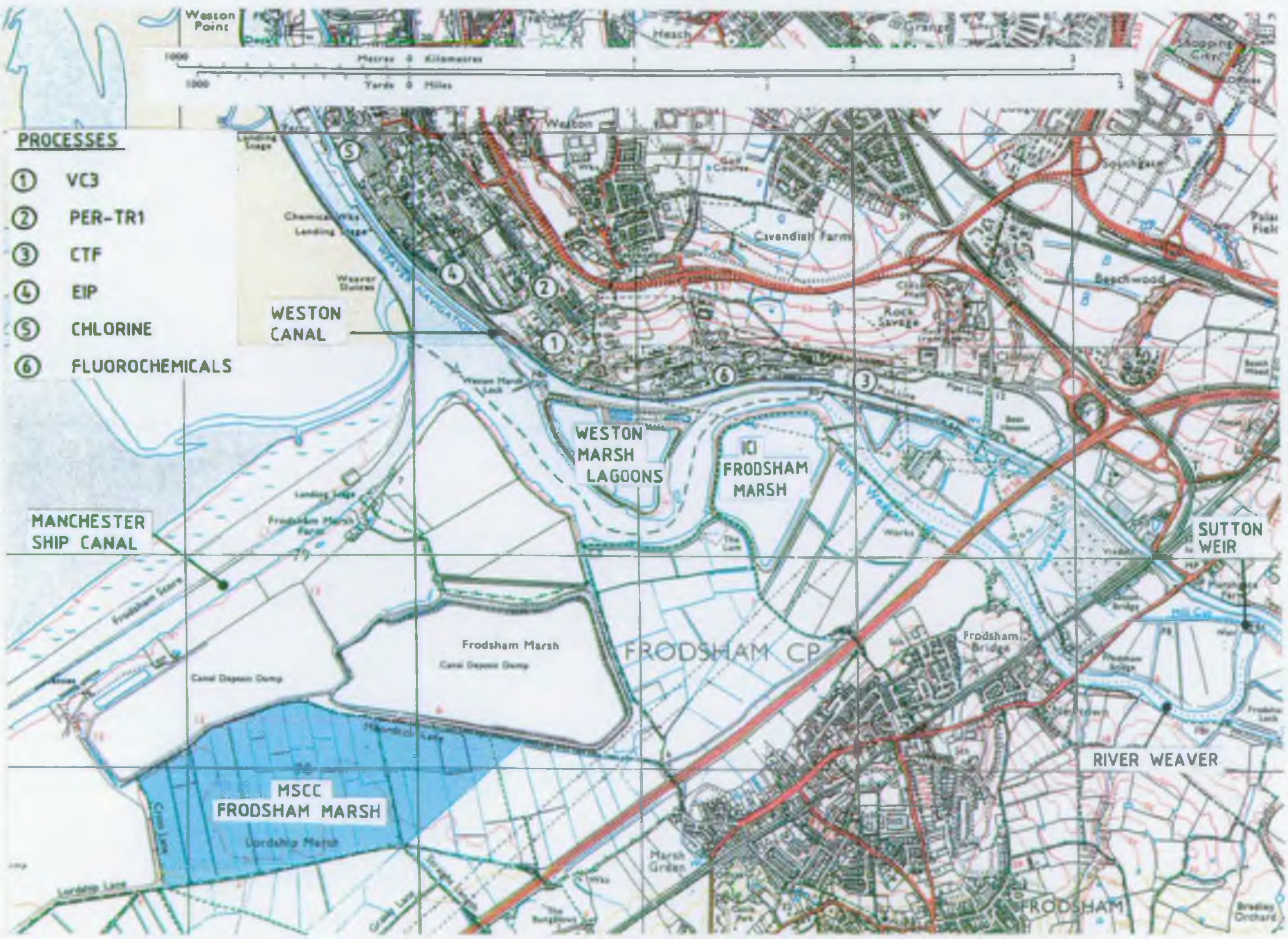


Figure 3 : The Runcorn site and surrounding area

The following sections give brief details of how dioxins could arise in each process and where they are released to. The term "releases" is used to describe any transfer beyond the site boundary, although some of the solid waste releases will undergo further treatment (eg. incineration or secure containment), which will minimise their environmental impact. The following sections also describe some of the efforts that have been taken to minimise dioxin releases; much of which is part of ongoing process optimisation.

3.1 Vinyl Chloride (VC) Process

VC manufacture is dependent on the production of the chemical intermediate ethylene dichloride (EDC). Up to 200,000 tonnes per annum of EDC is produced on the VC3 plant by a combination of two integrated reaction routes - direct chlorination and oxychlorination. Figure 4 is a simplified diagram of the relevant components of VC3 and is annotated with some estimated dioxin "flux rates" (ie. the annual amount of dioxin formed or released).

The **Oxychlorination** route produces EDC by reacting ethylene with oxygen and hydrogen chloride over a copper based catalyst. Under these reaction conditions a small quantity of mixed chlorinated hydrocarbons (in addition to EDC) are produced and must be removed before the EDC can be used to make VC. The oxychlorinator brings together hydrocarbons, oxygen and chlorine at high temperature in the presence of a catalyst and this provides the precursor conditions for dioxin formation. Dioxins exist in process effluents from the quenching of oxychlorinator product gases, and these effluents currently pass to Weston Marsh Lagoons.

It has been known for several years that oxychlorination can form dioxins, but oxychlorinators continue to be used because they consume the hydrogen chloride by-product that arises from the cracking of EDC to produce VC. This is a good example of how releases have been minimised by process optimisation.

In the **EDC purification** unit, EDC product is "boiled" off from the mixture or organics in a distillation column, whilst heavier compounds (including very small quantities of dioxins) collect at the base. The so called "heavy residues" from the base of the column have been historically sent to the Per-Tri plant to recover the useable organics. However, in June 1996 ICI advised that these residues would in future be sent for direct disposal at the Holford brine cavities.

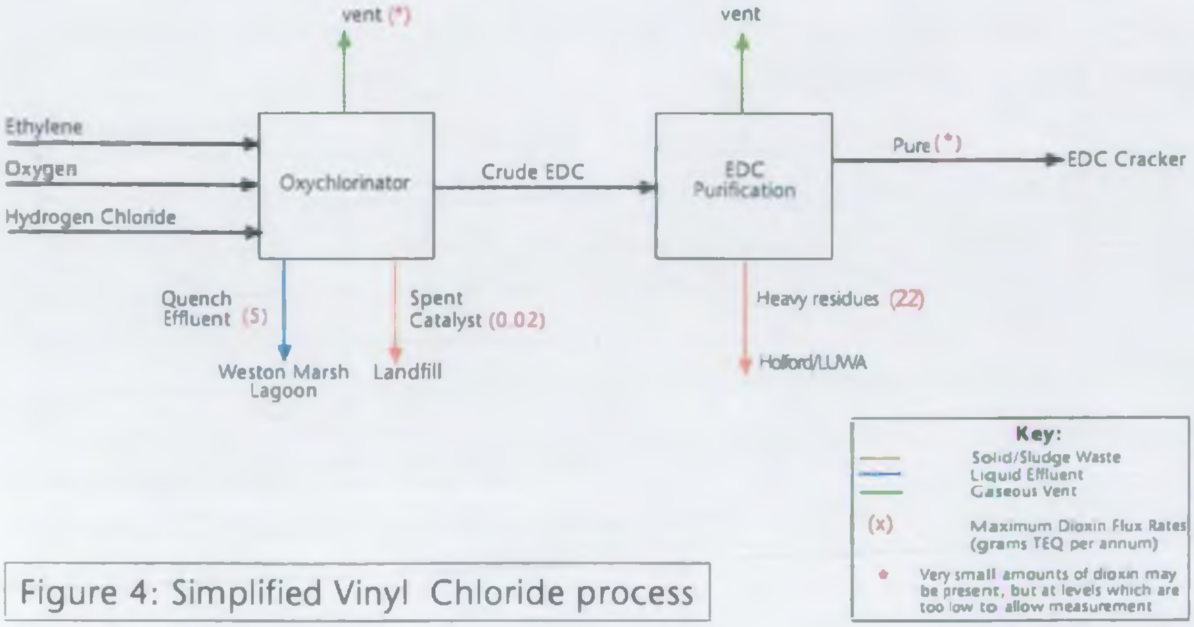


Figure 4: Simplified Vinyl Chloride process

Dioxins are virtually absent from the oxychlorinator and EDC purification gaseous vents because the temperatures are much below the boiling point of dioxins. However, the reactor is fluidised (suspended by air) and so the product gases prior to the quench contain some catalyst particles (with associated dioxins). Fresh catalyst is periodically added to the reactor to make good this loss.

Every two years the oxychlorinator is shut down for maintenance and, after putting the catalyst aside, the reactor is washed out. The reactor wash results in loss of catalyst to Weston Marsh Lagoons and some captured solids are sent to Randle Island landfill. However, the bulk of the catalyst is put back into the reactor for reuse and, by careful control of reactor conditions, the need for disposal of catalyst (and hence dioxins) can be minimised.

European Vinyls Corporation (UK) Limited (EVC) have recently announced that they are considering plans to purchase and uprate the VC3 plant by 50%, thus increasing the production capacity to 300,000 tonnes per annum. This 'Rejuvenation Project' includes features which will further reduce the release of dioxins to the environment, most notably :

- An incinerator for gaseous vents and heavy residues (which will remove the need to send wastes to Holford brine cavities) and
- A move from fluidised bed to fixed bed reactors (which will reduce the loss of catalyst to the canal)

The uprate will require approval from the Environment Agency and Halton Borough Council (as the planning authority). It is anticipated that these changes will have the following impact on dioxin releases (Table 6).

3.2 Perchloroethylene-Trichloroethylene (Per-Tri) Process

The production of Perchloroethylene (Per) and Trichloroethylene (Tri) has been identified as having the potential to form dioxins because it involves an oxychlorination reactor which takes a variety of chlorinated hydrocarbons (CHCs) as feedstock. The production of Per-Tri is another large scale chemical process and can produce up to 125,000 tonnes per annum of products. Figure 5 shows the key components of the Per-Tri plant and some estimated dioxin flux rates.

Table 6 : Estimated dioxin releases from VC3 plant before and after the uprate

MEDIUM	PROCESS STREAM DESCRIPTION	DIOXIN RELEASE	
		NOW (g TEQ/year)	FUTURE (g TEQ/year)
AIR	Process vents	*	*
	Incinerator	N/A	0.02
WATER	Weston Marsh Lagoon overflow	0.1	N/A
	EIP effluent treatment	N/A	0.1
LAND	Catalyst deposit on Weston Marsh Lagoon	5	N/A
	Spent catalyst to landfill	0.02	0.12
	Heavy residues to Holford	22	N/A
	Solids removed by EIP effluent treatment	N/A	4.9
	TOTAL	**27.12**	**5.14**

N/A = Not Applicable
* = Very small amounts of dioxin may be present, but at levels that are too low to allow measurement.

The "**LUWA**" thin film evaporators take organic residues from other plants and boil off light CHCs for reuse as a Per-Tri feedstock. Heavy residues from VC3 were fed to the LUWAs but concerns about the creation of brominated impurities in the Per and Tri products led to this being stopped in June 1996. Heavy residues have also been imported to the LUWA from EVC's Vinyl Chloride (VC4) plant at Hillhouse, near Blackpool, but this stopped in about 1992.

The LUWA's main function is now the processing of 4,500 tonnes of heavy residues which remain from a batch imported from VC6 (in Wilhelmshaven, Germany) several years ago.

In the **oxychlorinator**, a mixed feed of EDC and recovered CHCs are reacted with oxygen, chlorine and/or hydrogen chloride over a copper catalyst at 400-500°C. In a similar way to the VC process, this oxychlorination reaction does not just produce the desired Per and Tri, but also allows the formation of a range of lighter and heavier CHC's. Products are separated from unwanted CHCs in a series of **distillation columns**. The resulting heavy residues contain small traces of dioxins. Heavy residues from the distillation columns pass to the "**DOPP**" kettles which, like the LUWA evaporators, recover light CHCs for reuse in the oxychlorinator.

Heavies remaining in the DOPP and LUWA contain the bulk of dioxins from this process. These residues are considered unusable and are currently sent to Holford salt cavities for secure containment.

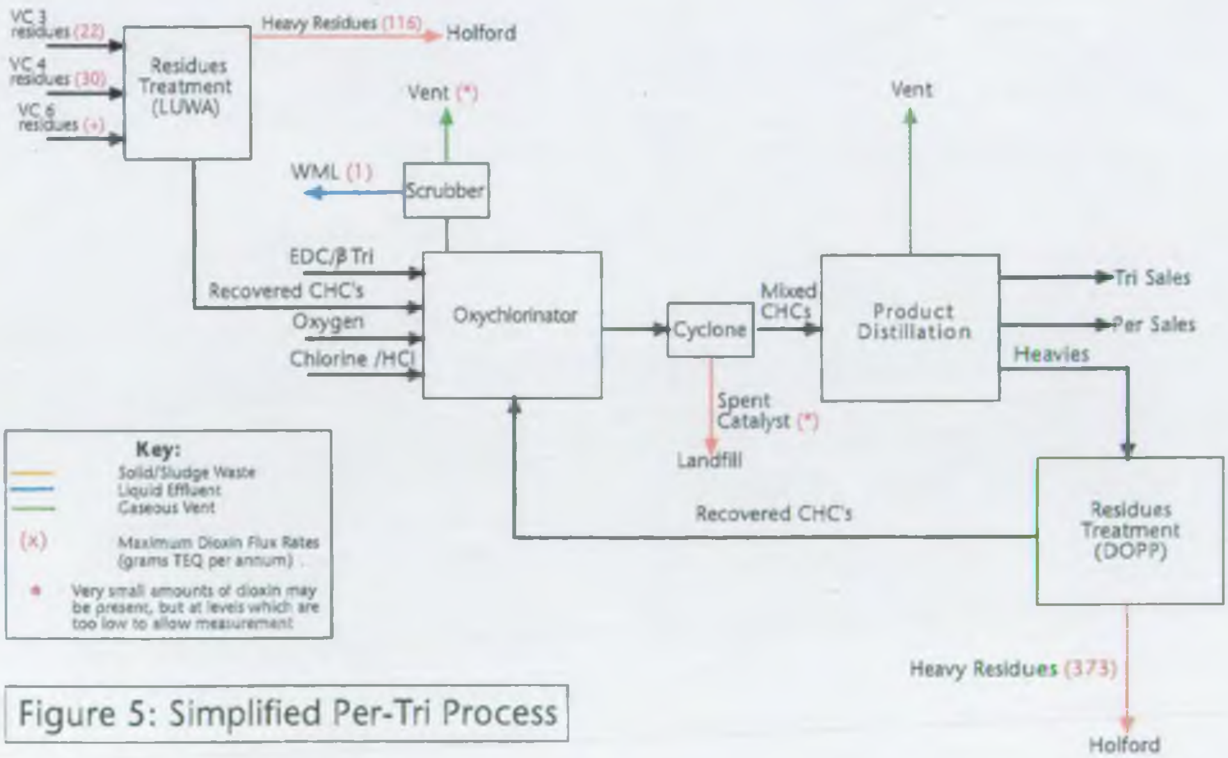


Figure 5: Simplified Per-Tri Process

3.3 CTF Process

On this relatively small plant, up to 1000 tonnes per annum of CTF (2-chloro, 5-trifluoromethyl pyridine) is made by ICI as a chemical intermediate for use by Zeneca plc. Figure 6 shows the key components of the CTF plant and some estimated dioxin flux rates.

In the **reactor** an organic compound (beta picoline) is chlorinated and fluorinated at elevated temperature over a catalyst. The reaction is not very selective and a wide range of unwanted chlorinated / fluorinated organics result. During the reaction a small quantity of organics decompose and contaminate the catalyst.

Catalyst activity needs to be continuously maintained in a **regenerator** by burning off organic build-ups with heated air. It is the presence of chlorinated organics in this combustion zone which gives the potential for dioxin formation.

3.4 Chlorine Process

The Runcorn site's fundamental process is the large scale production of chlorine, hydrogen, sodium hydroxide, sodium hypochlorite and potassium hydroxide. These products are mainly used around the site in a variety of integrated processes, although there is some product export. The process involves the passage of an electric current ("electrolysis") through sodium chloride brine in 262 mercury cells. This is a low temperature operation (which restricts the potential for dioxin formation) but chlorine and oxygen do come into contact with traces off carbon (e.g rubber lining of cells).

There is no hot emission of gas from the process and, because of the high boiling point of dioxins, there is no credible release route to atmosphere.

Aqueous effluents from chlorine production pass to the Waste Brine Treatment Plant (WBTP) for mercury recovery, chlorine destruction and pH adjustment. Solid precipitates are removed from the brine in filters and the filter deposits are dewatered before disposal at Randle Island landfill. Because of their affinity to particulates, the dioxins will be present in the filter solids. It has been estimated that the 80 tonnes / year of solids sent to Randle Island contain about 1.5 grams of dioxin.

3.5 Environmental Improvement Project (EIP)

The EIP is a centralised treatment facility for chlorinated hydrocarbons (CHCs) that arise from certain processes on the site. The EIP includes an incinerator which is fed with CHC gases from a number of site processes. The incinerator is also supplied with volatile organic compounds (VOCs) which are steam stripped from process sludges and VOCs which are air stripped from process effluents.

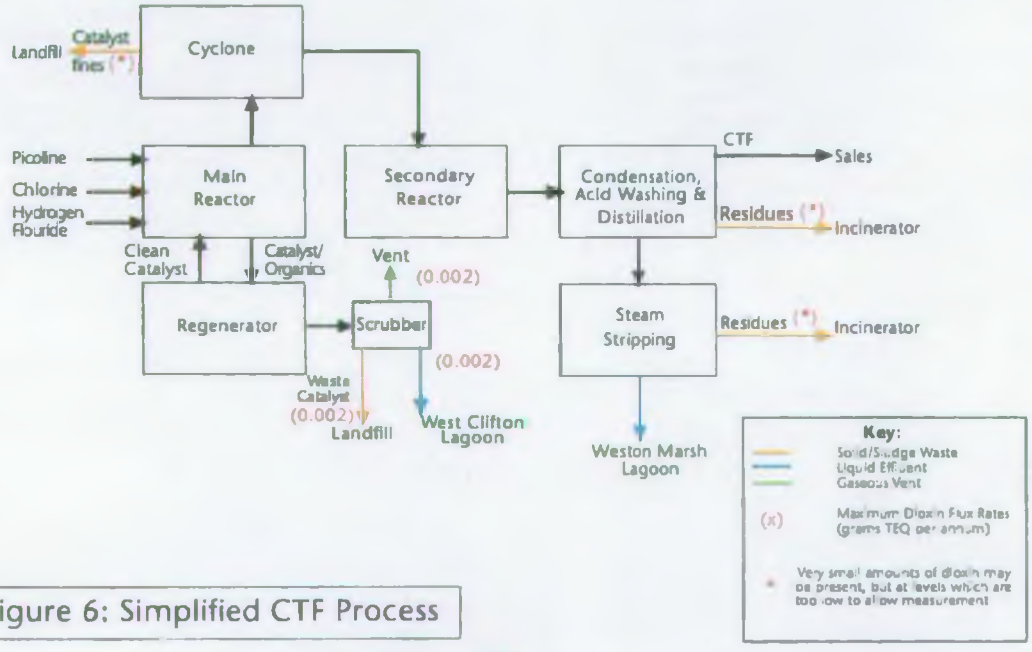


Figure 6: Simplified CTF Process

It is not a production plant in the same way as VC, Per-Tri and CTF, although hydrogen chloride will be recovered for sale. Its completion will bring a significant reduction in the emission of VOCs to atmosphere and of CHCs to the Weston Canal. It will also allow the disposal of waste at Weston Marsh Lagoon to be discontinued.

Figure 7 shows the key components of the EIP plant. The EIP is currently being commissioned and, since the final phase will not be complete for some years, the dioxin flux rates still need to be quantified by monitoring.

The **steam stripper** takes organics collected in interception pits on the site's production plants and removes CHCs by direct contact with steam. The CHC gases that are driven off are fed through to the incinerator, although there is provision for local venting in the event of incinerator unavailability. Any condensate from the CHC gases passes to the air stripper. The remaining sludge (comprising of non-volatile organics and inorganics) is drummed and sent off-site for destruction in a merchant incinerator.

CHC effluents from the Per-Tri plant, West End Effluent Plant and the steam stripper are pre-treated and then pass to the **air strippers**. Effluent and clean air flow in opposite directions and this results in the CHCs passing from the effluent into the air stream. The CHC/air mixture passes forward to the incinerator, except in the event of incinerator unavailability when there is provision for local venting for up to 25 days per year.

Effluent from the air stripper will pass to **sand filters** for suspended solids removal. Treated effluent will discharge to the Weston Canal whilst solids collected on the filters will be sent to landfill. The sand filters represent Phase II of the EIP project and, until mid 1997, solids removal from the effluent will be performed by Weston Marsh Lagoons.

The **incinerator** burns CHC gases which have originated either directly from site processes or from the effluent and sludge strippers. With the aid of a natural gas support fuel, incinerator gas stream temperatures are raised to 1200°C for at least two seconds. The CHC gases are combusted into carbon dioxide, hydrogen chloride and water. The hot combustion gases feed a boiler to raise steam for use on site and then pass through a water quench (to recover hydrogen chloride) and a final caustic scrubber (to remove residual acid gases) before venting to atmosphere.

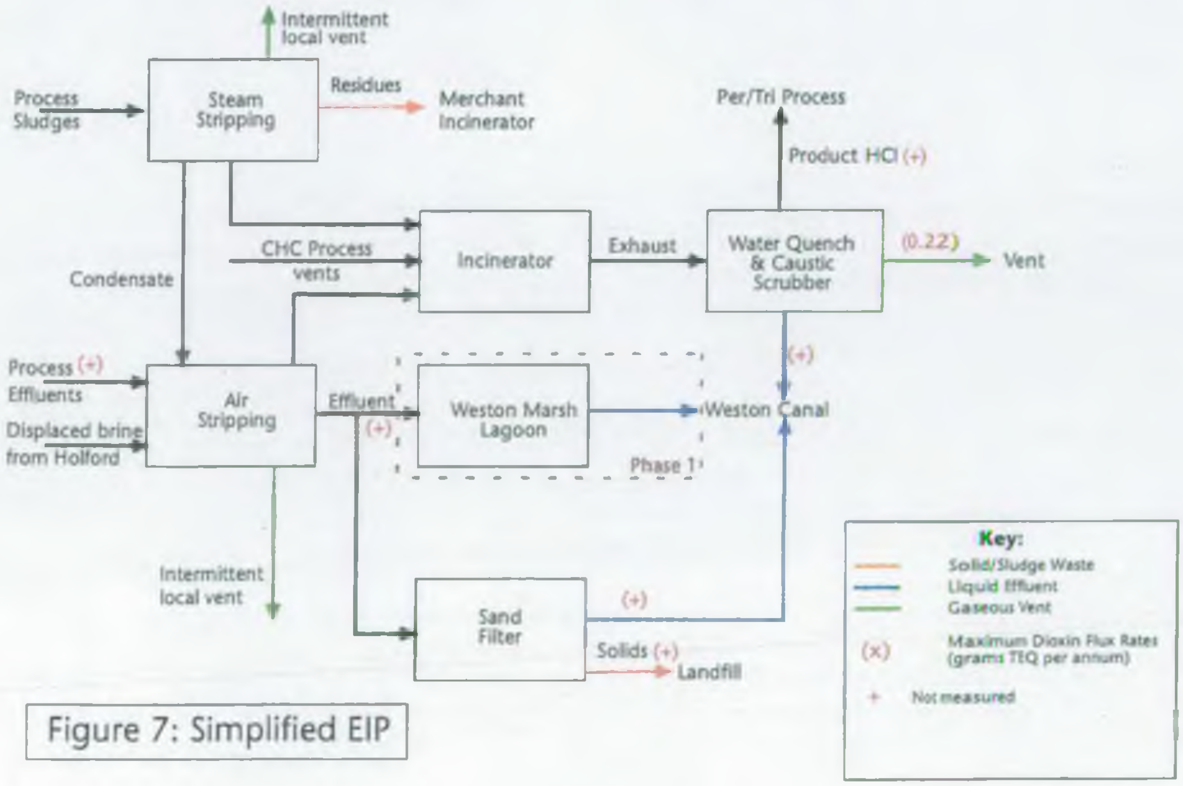


Figure 7: Simplified EIP

Dioxins are known to re-form after the incineration of chlorinated compounds because the hydrocarbon, chlorine and oxygen precursors are present as the exhaust gas cools from elevated temperatures in the presence of solid particles. However, this potential has been reduced by a number of design features, including :

- the incinerator's operational controls are designed to ensure that the highly destructive combustion conditions of 1200°C are maintained for at least 2 seconds;
- all the incinerator inputs are gaseous and have very low levels of solid particles which means fewer sites where dioxins can form;
- incinerator exhaust gases are rapidly cooled to below 250°C with a water quench and this minimises the re-formation of dioxins (so called *`de novo'* synthesis).

3.6 Fluorochemicals Vents Treatment Unit (VTU)

A third incinerator, in addition to the EIP and that proposed for VC3, is planned on the Rocksavage site for the destruction of fluorinated hydrocarbon gases arising from the Arcton 22 and KLEA plants. The current emissions of about 1400 tonnes per annum of halogenated organics will be reduced to about 100 tonnes per annum. Of particular importance is the 92% reduction in emissions of Arcton 23 (trifluoromethane) since it has a Global Warming Potential 11,700 times that of carbon dioxide.

Dissolved organics in effluents from the Arcton 22, KLEA 134a and CTF plants will also be air stripped and the resulting gases passed to the VTU.

This separate incinerator is necessary because the presence of hydrogen fluoride dictates the need for corrosion resistant materials. A separate incinerator also allows the EIP's saleable hydrochloric acid to be kept free from hydrogen fluoride contamination.

The VTU will be fitted with similar controls to the EIP for preventing the re-formation of dioxins. The VTU stack will be limited to releasing 0.1 ng TEQ/m^3, and this will equate to an estimated annual release of 0.002 grams.

3.7 Historical Sources

In addition to the above sources of dioxin it has been recognised that a number of historical processes on the site probably had the potential to form dioxins. These processes are no longer running and since they were operated before dioxins had been identified as a pollutant there are no records of dioxin releases. Table 7 identifies some of the processes which involved the dioxin precursors (carbon, chlorine, oxygen and high temperatures), and might have released dioxins.

Table 7 : Possible historical sources of dioxins

Process	Process description	Closure date
Le Blanc process	Production of Soda Ash from Saltcake (sodium sulphate & sodium chloride), limestone and coal.	Pre 1930
Carbide	Calcium carbide was produced on site for the preparation of acetylene. The carbide was formed by burning coke and lime at about 2000°C.	ca. 1968
Coal combustion	Coal was burnt in the site power station, and steam engines were used for transportation.	ca. 1968
Chlorine production on graphite anodes	Presence of the dioxin precursors carbon, chlorine and oxygen	ca. 1980
Mercury retorts	Carbon filters are used to remove traces of mercury from caustic soda product. Spent filters were sent to the mercury retorts and heated to 500°C to recover the mercury.	ca. 1992

4. HOW MUCH DIOXIN IS RELEASED INTO THE ENVIRONMENT?

In can be seen that dioxins in solid wastes represent the majority of releases from the site and this reflects the physical and chemical properties of dioxins. Solid wastes are generally sent to facilities which offer secure containment or destruction, and this restricts the potential for dioxins to reach the food chain. Dioxin releases to watercourses and atmosphere are relatively minor, but have the potential to enter the food chain.

The following six routes have been identified as allowing dioxin release into the environment and are described in more detail in the following sections.

1. Deposition in worked-out brine cavities at Holford;
2. Settlement of solids in the Weston Marsh Lagoons;
3. Spent catalyst disposal at Randle Island landfill;
4. Disposal of canal silt to dredging Lagoons;
5. Gaseous emissions;
6. Use of site products.

4.1 Holford Brine Cavities

The Holford Brinefield is located near Northwich in Cheshire and covers an area of approximately 10 square kilometres. It forms part of the Cheshire-Shropshire saltfield which was laid down during the Triassic period about 200 million years ago. The salt deposits are found some 200 to 300 metres below the surface and are approximately 200 metres thick.

ICI have extracted salt from the Holford Brinefield since 1926 using controlled solution mining. Water is pumped down a sleeve tube to dissolve the salt and the resultant brine is forced to the surface through an uptake tube. High pressure air is injected into the cavity to control the shape and rate of development of the roof space. Once the cavity has reached its desired size, water injection is stopped and the cavity is left full of saturated brine to prevent surface subsidence.

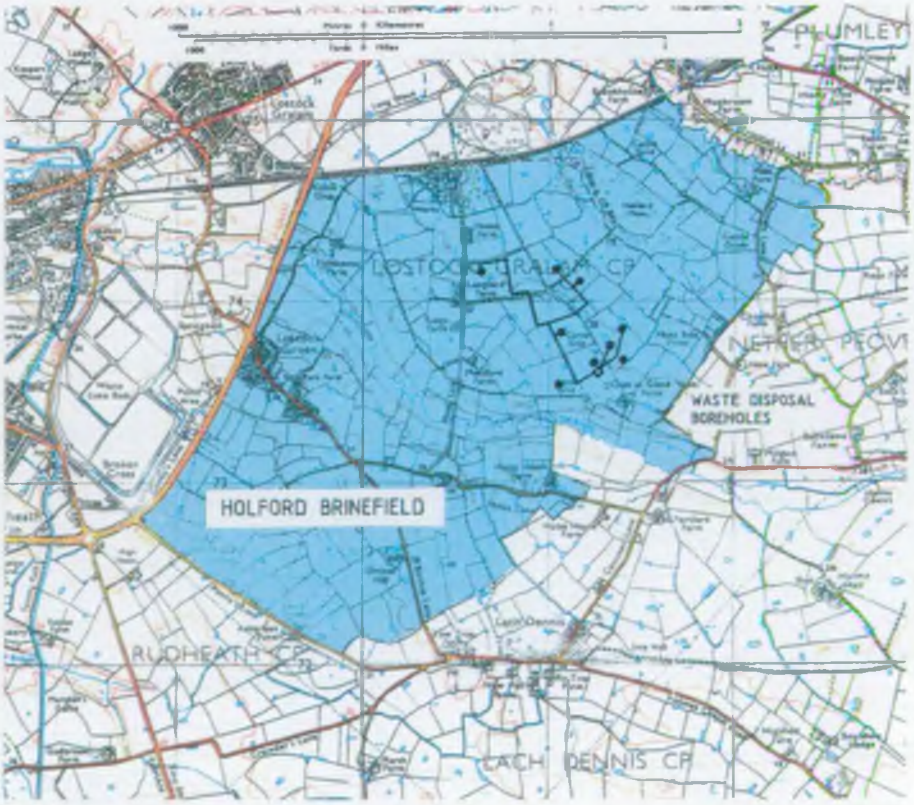
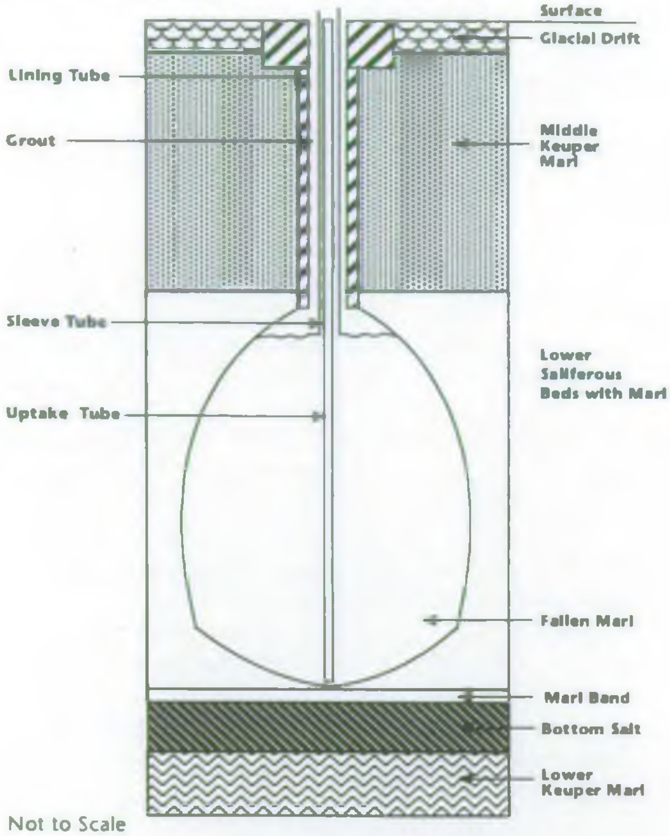


Figure 8 : Holford brinefield and waste disposal boreholes

Figure 9: Brine Cavity Cross Section



Not to Scale

The presence of underground salt shows that groundwater is absent and so the cavities are seen as high integrity storage facilities which are isolated from the foodchain. For instance, ethylene gas is stored in two specially formed cavities, and natural gas in another. During the past 35 years, many of the 200 cavities have been converted to depositories for wastes arising from ICI and Brunner Mond processes. Nine disused cavities have been licensed to receive up to 35,000 tonnes per annum of halogenated organic wastes. Wastes from the VC and Per-Tri processes are sent here and contain about 500 grams TEQ per annum of dioxins. Halogenated organic wastes are also received from EVC's Vinyl Chloride plant (VC4) at Hillhouse, near Blackpool and this will have a similar composition.

The density and temperature of each waste load is measured at the source works, and restrictions are placed on the minimum density (to ensure mixing with alkali waste) and maximum temperature (to minimise heat load in the cavity). The wastes are pumped into a cavity and the equivalent volume of displaced brine is returned to Runcorn by road tanker for discharge onto Weston Marsh Lagoons. In future displaced brine will pass to the air stripper unit on the EIP.

Each receiver is regularly monitored to check the integrity of containment and any chemical changes which may be occurring. Precise surface level surveys are carried out on a regular basis to look for signs of subsidence. The cavities are pressure tested every two years to confirm the integrity of the cavity. Cavity temperatures are monitored annually as a check on possible heat release from the chemical breakdown of organic residues. Surface water monitoring is undertaken quarterly to detect any loss of organic compounds from the waste handling facilities into the local watercourses.

In the absence of a credible release route from the cavities into the air and water environments, it is reasonable to assume that the ambient dioxin levels will be unaffected.

4.2 Weston Marsh Lagoons

The Weston Marsh Lagoons (WML) occupy a total area of 16 hectares (40 acres) adjacent to the Runcorn site (see Figure 3). Fly ash pits were constructed in 1958-1960 to serve the coal fired Weston Point Power Station. Lagoon walls were then constructed from fly ash and used for the deposit of lime wastes from the carbide processes. In the early 1970's chlorinated hydrocarbon manufacture switched from acetylene to an ethylene based process, thus eliminating large quantities of solid lime wastes. Since then the lagoons have been mainly used for the settlement of suspended solids from aqueous effluents and for the evaporation to atmosphere of chlorinated hydrocarbons. They are currently licensed to receive up to 2,800,000 tonnes per annum of effluent which contains about 300 tonnes of suspended solids.

Effluent discharges onto WML contain inorganic contaminants (mainly catalyst residues of copper and iron salts, sodium carbonate and hydroxide, calcium sulphate and brine) as well as organic contaminants from the production plants (eg. Per-Tri, Vinyl Chloride, Vinylidene Chloride and Cereclor). The lagoons also receive brine which is displaced from the Holford waste disposal cavities. Dioxin input from the VC and Per-Tri plants was originally estimated at between 1 and 12 grams per annum (TEQ). More recent monitoring by ICI suggests that the value is at the lower end of this range.

The slow flow of effluent across the lagoons allows suspended solids to settle out before discharging into the Weston Canal via Outfall 55. Many of the heavier organics (including dioxins) have low solubility in water and will settle out with the solids to become part of the lagoon deposits. Only 0.2 gTEQ/year. was originally estimated to reach the Weston Canal, but on the basis of more recent data this figure has been revised to 0.04 g TEQ. Solids will continue to settle out in the Weston Canal and an even smaller proportion will flow over Sutton Weir into the River Weaver.

With the introduction of the site's EIP, the discharge of effluents to WML will initially be restricted to solids settlement (Phase I), and then during 1997 (Phase II) their use will be discontinued. The lagoons will then be remediated to a plan which will be agreed with the Environment Agency.

4.3 Randle Island Landfill

Randle Island landfill has been licensed since 1977 for the disposal of wastes arising from ICI's Merseyside operations. The site is licensed to accept up to 30 tonnes per month of spent catalyst, including the copper catalyst used on the VC3 and Per-Tri plants. Up to 0.5 grams per annum of dioxin will be associated with the spent catalyst.

The disposal does not have any specific restrictions on the level of dioxins, but containment is provided by the landfill design and operation. The spent catalyst is bagged or drummed prior to deposition in prepared disposal areas and is encapsulated under waste calcium sulphate. The calcium sulphate powder hardens in the presence of atmospheric moisture to form a low permeability barrier which minimises the movement of groundwater. Since dioxins have very low solubility in water and there is minimal ground water movement, the landfill is considered to give satisfactory containment.

4.4 Dredging Lagoons

Silt accumulates in the Weston Canal and Manchester Ship Canal (MSC) as a result of effluent discharges and silt from river catchments. The canal silt contains dioxins which have arisen from current industrial sources, historical discharges, and from atmospheric deposition.

Dioxin arisings in the Weston Canal (also known as the Weaver Navigation Canal) can be attributed to the activities of ICI and its predecessors on the site. Dioxin in Weston Canal silt also comes from MSC water (which is used to cool the site power station) and the River Weaver.

The Weston Canal is periodically dredged by ICI to maintain boat access. Up to 175,000 m^3 per year of dredgings are pumped onto Frodsham Marsh Lagoon for solids settlement and the water overflow discharges to the River Weaver via Outfall 63. If Weston Canal silt is assumed to contain 400 ng TEQ / kg of dry solids, then the 12,000 tonnes (dry solids) per annum disposed of to Frodsham Marsh Lagoon will contain about 5 grams of dioxin.

The Manchester Ship Canal Company (MSCC) similarly dredge the Manchester Ship Canal and settle solids in their own lagoon (Frodsham Marsh Dredging Grounds) with an overflow discharge into Hoolpool Gutter. The facility is licensed to receive up to 950,000 m^3 per year. If the Manchester Ship Canal silt is assumed to contain 200 ng dioxins TEQ / kg of dry solids, then the 57,000 tonnes (dry solids) per annum disposed of to Frodsham Marsh Dredging Grounds will contain about 11 grams of dioxin.

4.5 Gaseous Emissions

Dioxin emissions to the atmosphere are relatively minor when compared with releases to other media. A maximum of 0.244 grams TEQ per annum is expected when all three incinerators have been completed. However, it is anticipated that EIP incinerator performance will be better than the authorised limit of 1 ng/m^3 and so the authorisation includes an improvement requirement to assess the feasibility of reducing emissions to 0.1 ng/m^3. Mass emissions of dioxins will be correspondingly lower.

The VC and Fluorochemicals incinerators will be automatically set emission limits of 0.1ng/m^3 as this is now considered to be an achievable standard. Since these incinerators are smaller and are operating to tighter limits, the anticipated mass release of dioxin is much lower than from the EIP.

Despite the small emissions, the atmosphere does play an important role in the environmental distribution of dioxins because emissions will deposit on soil, vegetation and rivers. Deposits onto vegetation and soil are of particular interest because they may be ingested by livestock and enter the human foodchain.

4.6 Use of Site Products

The dioxin flux of product aqueous hydrogen chloride from the Per-Tri process has been calculated at 0.14 g TEQ / year. Product vinyl chloride monomer has also been analysed, but no dioxins were detected above the analytical limit of detection.

CTF, Perchloroethylene and Trichloroethylene products have not been analysed for dioxins. However, their dioxin content can be expected to be negligible because these products are all subject to purification by distillation and heavier organic components will be retained in distillation residues.

4.7 Site Releases in the UK Context

The above sections indicate the source and magnitude of dioxin releases from the Runcorn operations of ICI and EVC, but it is worth considering these in the context of overall UK releases.

An HMIP report[3] established an inventory of dioxin emissions to the UK atmosphere from industrial and non-industrial sources and estimated that between 560 and 1100 grams TEQ are emitted to atmosphere per year. By far the majority arises from Municipal Solid Waste Incinerators, and only 0.02 g TEQ/year was estimated to arise from the production of "halogenated chemicals". The production of EDC by oxychlorination was identified by name in the report, but on the basis of measurements made in a German plant it was concluded that "very low concentrations (of dioxins) are detected in emissions (to atmosphere)". These emissions arise from a heavy residues incinerator which is similar to the one proposed by EVC.

The site's main atmospheric releases will arise from the three incinerators that are being installed to effect environmental improvements. These incinerators will reduce the site's current emission of some 10,000 tonnes/year chlorinated hydrocarbons by 90%. This will provide significant benefits to local air quality, protection of the ozone layer and the reduction of global warming. The incinerator projects will also cut discharges of chlorinated hydrocarbons to water by 80% and this will enable the Weston Canal to comply with water quality standards. The incinerator projects will further allow the discontinuation of waste disposal of Weston Marsh Lagoons and Holford brine cavities.

Table 8 : Potential site releases of dioxin to atmosphere (grams TEQ / year)

SOURCE	PROGRESS DATE			
	Now	Post ICI's EIP	Post EVC's Incinerator	Post ICI's Fluorochemicals Incinerator
Vinyl chloride	*	*	*	*
Per-Tri	*	*	*	*
CTF	0.002	0.002	0.002	0.002
Chlorine	*	*	*	*
EIP (ICI)	-	0.22	0.22	0.22
VC3 Incinerator (EVC)	-	-	0.02	0.02
Fluorochemicals incinerator (ICI)	-	-	-	0.002
TOTAL	**0.002**	**0.222**	**0.242**	**0.244**

Note * : Very small amounts of dioxin may be present, but at levels that are too low to allow measurement.
Note 1 : Release figures for the EVC and ICI (Fluorochemicals) incinerators are indicative only and do not prejudice the imposition of limits in the IPC authorisations.

Table 8 indicates how the site releases to atmosphere will change as the three incinerators are installed. Although the trend is for increasing releases of dioxins to atmosphere, this should be viewed in the overall site context of significantly reduced CHC releases and reduced dioxins in solid wastes. These factors have already been considered in granting IPC authorisation for the EIP and have received approval form the numerous IPC consultees.

Note should also be taken that the EIP mass release of 0.22g TEQ/year is based on an authorised dioxin limit of 1ng/m^3. The incinerator design may allow operation at a much better level and so the IPC authorisation requires a feasibility study on achieving a dioxin limit of 0.1ng/m^3. This would have an equivalent reduction on mass releases.

Care should be taken in interpreting the figures in Table 8 because the mass releases have been calculated from the average of a limited number of analytical results and the incinerator figures have yet to be confirmed by analysis.

Chemical processes were in fact identified[3] as more likely to release dioxins to water or land, and equivalent inventories for releases to these media are being prepared by the Environment Agency. An early draft report[4], indicates that dioxin releases to land are between 1,500 and 12,000 grams TEQ per year. This reflects both the nature of the sources and the tendency for dioxins to bind to solids. The principal sources of dioxin releases to land appear to be the manufacture of pesticides, non-ferrous metal operations, and the incineration of municipal solid waste in old plants. Data availability was very poor in many of these industries and the dioxin quantification undertaken by ICI represents one of the more detailed studies. Many of the solid wastes are incinerated or landfilled and this reduces their potential for environmental impact.

The Runcorn site releases of solid wastes (ie. going to Weston Marsh Lagoons, Randle Island landfill, Holford brine cavities and off-site merchant incinerators) are given in Table 9. Care should again be taken in interpreting the results because the mass releases have been calculated from the average of a limited number of analytical results and the incinerator figures are yet to be determined.

The total UK release of dioxins to the water environment have not been calculated but some estimates are expected to be included in the forthcoming Environment Agency report [4]. The Runcorn site releases to water (ie Weston Canal and River Weaver) are given in Table 10. Care should again be taken in interpreting the results because the mass releases have been calculated from the average of a limited number of analytical results and the incinerator figures have yet to be confirmed by analysis.

Table 9 : Site releases of dioxin in solid wastes (grams TEQ / year)

SOURCE	PROGRESS DATE			
	Now	**Post ICI's EIP**	**Post EVC's Incinerator**	**Post ICI's Fluorochemicals Incinerator**
Vinyl chloride	22.02	22.02	0.12	0.12
Per-Tri	489	489		
CTF	0.004	0.004	0.004	0.004
Chlorine	1.5	1.5	1.5	1.5
EIP (ICI)	-	4.9	4.9	4.9
VC3 Incinerator (EVC)	-	-	TBD	TBD
Fluorochemicals incinerator (ICI)	-	-	-	TBD
TOTAL	**512.524**	**517.424**	**6.524**	**6.524**

TBD = To Be Determined (once the plant is operational)
Note * : Very small amounts of dioxin may be present, but at levels that are too low to allow measurement.

Table 10 : Site releases of dioxin to water (grams TEQ / year)

SOURCE	PROGRESS DATE			
	Now	Post ICI's EIP	Post EVC's Incinerator	Post ICI's Fluorochemicals Incinerator
Vinyl chloride[(1)]	0.2	0.1	0.1	0.1
Per-Tri[(1)]		*	*	*
CTF	*	*	*	*
Chlorine	*	*	*	*
EIP (ICI)	-	TBD	TBD	TBD
VC3 Incinerator (EVC)	-	-	TBD	TBD
Fluorochemicals incinerator (ICI)	-	-	-	TBD
TOTAL	**0.2**	**0.1**	**0.1**	**0.1**

TBD = To Be Determined (once the plant is operational)
Note * : Very small amounts of dioxin may be present, but at levels that are too low to allow measurement.
Note 1 : VC and Per-Tri both currently discharge into Weston Marsh Lagoons.

It can be seen that the site currently makes a major contribution to the overall arisings of dioxin in UK solid wastes, although this will reduce significantly when EVC's incinerator is installed. The site contribution to overall dioxin releases into the UK atmosphere is comparatively minor.

5. HOW ARE DIOXIN RELEASES REGULATED ?

Releases from the site into the environment are controlled through three main pieces of legislation; namely the Environmental Protection Act 1990 (Parts I and II), and the Water Resources Act 1991. The separate enforcement of these acts by HMIP, the NRA and Cheshire WRA may have caused some confusion to members of the public. However, since 1 April 1996 all enforcement has been by the Environment Agency and it is hoped that this will improve the clarity of environmental control. The scope of the legislation is shown schematically in Figure 10 and details of the legislative controls are described in the following sections.

5.1 Integrated Pollution Control (IPC)

Integrated Pollution Control (IPC) was introduced by the Environmental Protection Act 1990 (Part I) and was enforced by HMIP until 1 April 1996. IPC applies to the most potentially polluting, or technologically complex, industrial processes in England & Wales. This relatively new approach to pollution control considers releases to all environmental media so as to minimise the overall effect (ie. having regard to the Best Practicable Environmental Option - BPEO). This is achieved by setting operating controls which prevent and minimise releases at source, before rendering harmless any unavoidable releases. Operators are required to use the Best Available Techniques Not Entailing Excessive Costs (BATNEEC) and this involves not only the process equipment, but also how it is operated.

ICI has made IPC applications for the processes which have the potential to form dioxins. The applications commit ICI to the manner in which the processes will be operated and the frequency of check monitoring that ICI will carry out. The processes of interest were issued IPC Authorisations on the dates shown in Table 11.

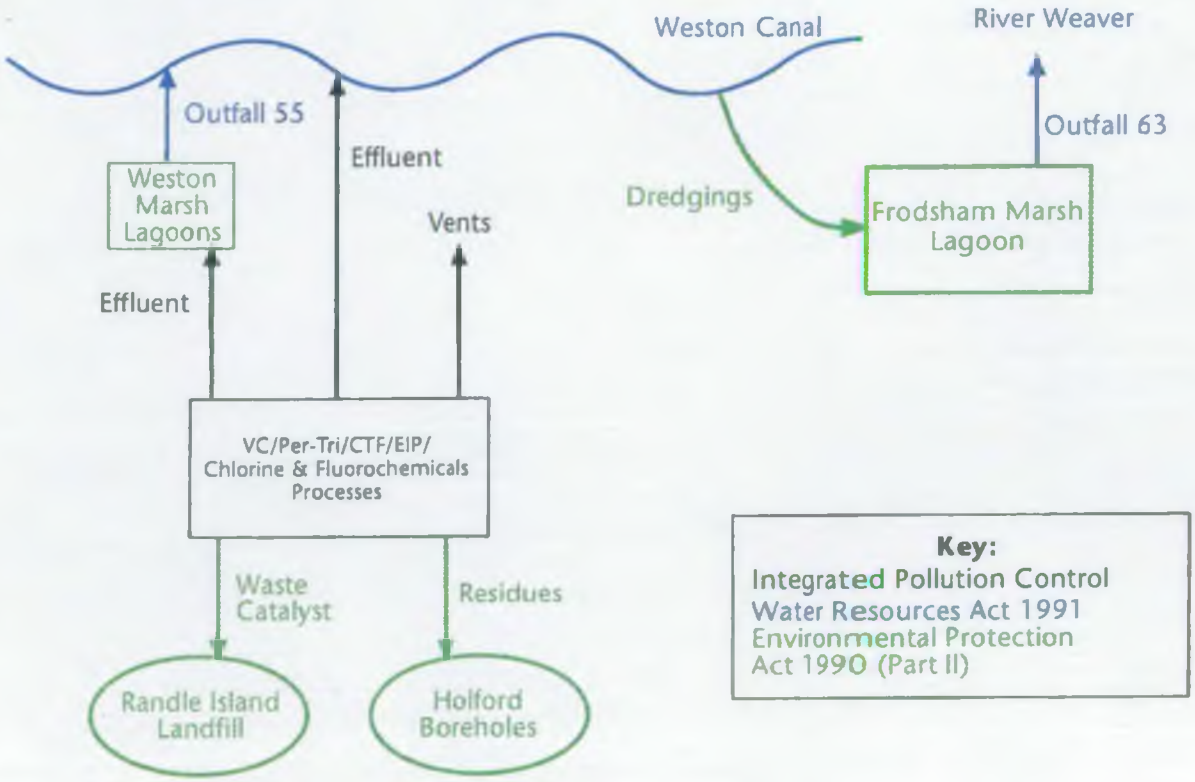


Figure 10: Legislative Controls

Table 11 : IPC authorisations

Process (& Reference Number)	Authorisation Issue
Incinerator (AI5162)	26/11/93
Vinyl chloride (AP8993)	30/03/94
Chlorine (AL7294)	06/01/95
CTF (AL7332)	12/04/95
Per-Tri (AL7421)	30/08/95

The Authorisations have set limits on the release of pollutants into the environment and, where necessary, include limits for dioxin releases. Limits take account of the achievable performance of a plant as well as the BATNEEC guidance levels given in Environment Agency 'Process Guidance Notes'. Even where specific limits have not been set in authorisations there is an implied general condition that BATNEEC will be used in operating the process. This so called 'residual BATNEEC duty' is a powerful tool in improving the environmental performance of IPC regulated processes.

The EIP incinerator has already been subjected to the full public consultation that is associated with IPC and approval for the releases has been given by the Statutory Consultees. The VC and fluorochemical incinerators are the subject of current applications and will be set conditions of operation in accordance with BATNEEC and BPEO.

The authorised dioxin limits, dioxin monitoring frequencies, and dioxin monitoring results for the VC, Per-Tri and EIP processes are detailed in Appendix A. The dioxin releases to air and water are small and two limits have been set. Both limits relate to the uncompleted EIP incinerator vent, so there are currently no monitoring results. However, in the absence of specific limits, dioxin monitoring is still carried out on some 15 process streams and the analytical results are submitted to the Environment Agency

Table 12 : Authorisation Improvement Requirements

Authorisation & Improvement Requirement	Submission date
VC[(2)] : " Submit to the Chief Inspector a report on : a) the evaluation of dioxin formation in the oxychlorinators; b) the associated risk to human health; and c) the proposed monitoring regime for any dioxin emissions".	30/04/94 [(1)]
CTF : " The Operator shall carry out a study and representative sampling to establish the concentration level of dioxins emitted from the regenerator off gas scrubber vent (Release Point A3). The study, its findings and any future proposals shall be submitted to the Chief Inspector".	31/01/96
EIP : " Submit to the Chief Inspector a programme for the monitoring of soil dioxin concentrations in the locality of the incinerator". " Submit to the Chief Inspector a feasibility study on reducing dioxin emissions to 0.1 ng/m³".	30/06/94 30/06/98
Chlorine : "Submit to the Chief Inspector a report on the evaluation of dioxin formation in the process".	01/01/97

Note 1 : Only those reports submitted after 01/04/96 can be found on the Public Registers, although this report was voluntarily released under the Environmental Information Regulations and ICI gave permission for it to be placed on the public registers.
Note 2 : The VC report also addressed dioxin formation in the Per-Tri oxychlorinator and so no improvement requirement was included in the Per-Tri Authorisation when issued on 30/08/95.

Results of monitoring undertaken by ICI and the Environment Agency can be found on the IPC Public Registers along with copies of ICI's applications and the Authorisations. The Public Registers are located at the Environment Agency's office in Warrington and at the Widnes office of Halton Borough Council. Both Registers can be viewed during normal working hours.

Five of ICI's applications were identified as providing inadequate information on the potential for dioxin formation and release, and so improvement requirements were set within the IPC authorisations. The content of these requirements are given in Table 12. ICI's responses to these Improvement Requirements have been submitted on time and have been widely used in preparing this Information Report.

5.2 Water Resources Act 1991 (WRA 1991)

Prior to the implementation of IPC, all effluent discharges from the site were consented under the WRA 1991 and were enforced by the NRA. The WRA 1991 now only has relevance to discharges from Weston Marsh Lagoons, Frodsham Marsh Lagoon and MSCC's Frodsham Marsh Dredging Grounds. Discharges from the lagoons have been set consents which reflect good operation and the need to protect the Weston Canal. No specific discharge limits have been set on dioxins, but they are controlled indirectly by regulating the concentration of suspended solids. This approach has been adopted because :-

- the dioxin levels are very small within large volumes of discharge and are thus difficult to measure;
- the analytical methods for dioxin measurement are complex, time consuming, costly, and can be difficult to replicate between laboratories;
- dioxins in effluents are preferentially adsorbed onto solids and so strict control of suspended solid levels controls dioxin concentrations.

Table 13 details the limits which have been set on these outfalls, and also indicates the monitoring frequencies and typical analytical results. In the period January 1991 to January 1996 there was only one breach of the suspended solids limit set on Outfall 55.

5.3 Environmental Protection Act 1990, Part II

The disposal of waste to Holford Brinefields, Randle Island, Weston Marsh Lagoons and Frodsham Marsh Lagoons is controlled under EPA 1990, Part II and the associated Waste Management Licensing Regulations 1994 (Table 14). The objective of the waste management licensing system is to ensure that waste management facilities do not cause pollution of the environment, harm to human health and do not cause detriment to local amenities. Up until 1 April 1996 these were enforced by Cheshire Waste Regulation Authority, but are now covered by the Environment Agency.

Table 13 : Monitoring under the Water Resources Act 1991

Process stream description	Limit	Monitoring frequency	Dioxin monitoring results (as TEQ)
Overflow from Weston Marsh Lagoons to Weston Canal (Outfall 55)	None for dioxin, but suspended solids = 300 mg/l	ICI = 52 times per annum for suspended solids, and a six monthly composite sample for dioxins composed of weekly sample contributions EA = 12 times per annum for solids	Jul-Dec 1994 = 0.1 ng/l Jan-Jun 1995 = 0.02 ng/l Jul-Dec 1995 = 0.06 ng/l Jan-Jun 1996 = 0.02 ng/l
Overflow from Frodsham Marsh Lagoons to River Weaver (Outfall 63)	Suspended solids = 100 mg/l	ICI = 52 times per annum EA = 12 times per annum	None

Table 14 : Environmental Protection Act 1990 - Waste Management Licences

Disposal Route	Waste Management Licence
Holford Brinefields	60357
Weston Marsh Lagoons	60532
Frodsham Marsh Dredging Grounds (MSCC)	61754
Frodsham Marsh Lagoons (ICI)	60531
Randle Island Landfill	60547

The EC Ground water Directive (80/68/EEC) aims to prevent the pollution of ground water by specified dangerous substances and is implemented by Regulation 15 of the Waste Management Licensing Regulations 1994. The existing Waste Management licenses for Holford Brinefields and Frodsham Marsh Lagoons are currently being reviewed in accordance with Regulation 15.

An application for a waste management licence which might result in direct or indirect discharge to ground water of dangerous substances must be subject to prior investigation. This investigation includes examination of the hydrogeology, the possible purifying powers of the soil, and the risk of ground water pollution.

Waste Management licences authorise the deposit of specific waste types and there are no individual restrictions on the disposal of dioxins. Monitoring information is submitted in accordance with the licence requirements and are available for public viewing at Commerce House, Hunter Street, Chester. There has been full compliance with the deposit restrictions.

Discharges onto Weston Marsh Lagoons will cease during 1997 with the completion of Phase II of ICI's EIP. A closure plan for the lagoons is currently being agreed with ICI, as a prelude to agreeing a restoration plan.

5.4 Self Regulation

The European Council of Vinyl Manufacturers (ECVM) is a trade association which aims to reduce the environmental impacts of PVC manufacture by sharing knowledge between members and the promotion of good practices. In 1995, ECVM set voluntary emission targets as a means of promoting environmental performance. European Vinyls Corporation (EVC) is a member of ECVM and their current application of the charter to the PVC8 plant will be extended to the VC3 if the purchase is successful. ICI does not produce PVC and cannot therefore be a member of ECVM, although it does aim to meet the targets on its VC3 plant.

The ECVM Charter[5] includes dioxin emission guidelines which are based on Best Available Techniques.

For the emission of vent gases to atmosphere the ECVM guideline for dioxin-like components is 0.1 ng TEQ/m^3. Emissions are already below this limit and the proposed EVC incinerator will be set an emission limit of 0.1 ng TEQ/mg^3.

The guideline for discharges of effluent to the water environment is $<$ 1 µg TEQ / ton of oxychlorination capacity. VC3 is operated within this guideline and a rate of 0.45 µg TEQ /ton of oxychlorination capacity has been estimated (Note : This is based on most recent data assuming a dioxin release of 0.045 g/year (0.04 from Weston Marsh Lagoon overflow and 0.005 from outfall 49) and an oxychlorination capacity of 100,000 tonnes/year.)

ECVM have prepared a report on the environmental performance of their member companies and it is believed that most companies meet the ECVM Charter requirements on dioxin releases. The report is expected to be available in early 1997.

Per-Tri and CTF are produced in lower volumes and on fewer plants (compared with PVC) and so they have no equivalent industry charters.

6. ARE THE RELEASES HARMFUL ?

Dioxin has been described in some quarters as the "perfect poison", but it does not live up to such an emotive label. However, it is known that dioxins are very resistant to breakdown, can accumulate in the food chain, and can have adverse health effects, so it is right that they are treated with caution and subject to the most strenuous control.

The following sections summarise available data on the levels of dioxin in air, water and soil environments in the vicinity of the Runcorn site. Comparison is made with dioxin limits and guidelines and also with data from other sites. There is also discussion of the food chain effects in the Runcorn area and comparison with tolerable dioxin intakes. Although much of the analytical work has been carried out by ICI contracted analysts, the Agency is satisfied that the results are reliable.

6.1 Air Quality

The UK does not have any statutory limits on dioxin concentrations in the atmosphere. Dioxin chemistry dictates very low atmospheric levels of dioxins and, since direct inhalation is not significant, atmospheric dioxin represents a low risk for potential human exposure.

Despite the analytical problems of detecting very low concentrations, there have been a number of studies on ambient dioxin levels in the UK atmosphere. Table 15 summarises some data presented in an HMIP report[6] .

The results for nearby Widnes demonstrate that atmospheric levels of dioxin are fairly typical of those found in urban areas.

The EIP authorisation includes a requirement to monitor soil dioxin concentrations before and after incinerator construction. This will provide an indicator of atmospheric deposition from the incinerators

6.2 Water Quality

Again, there are no statutory limits on dioxins in the water environment. There is also a paucity of information on background levels of dioxins in rivers because the NRA previously restricted its testing to rivers where problems were thought to exist.

Table 15 : Ambient dioxin concentrations in air

Site description	Location	Dioxin concentration (fg TEQ / m^3)
Rural	Hazelrigg, Lancaster	Range = Not detected to 22
Semi-Urban	Stevenage	83, 151
Urban	London	Range = Not detected to 654
Urban	Manchester	Range = 1.4 to 1813
Urban	Cardiff	Range = Not detected to 856
Urban	Panteg, Gwent[1] : 3 sites	A. 14,800; B. Range 23 to 449; C. Range 159 to 201
Urban	Belfast	178, 120, 72, 37
Urban	Wigan	280, 300, 500, 110
Urban	Widnes	233, 319, 164, 98

Note 1 : In the vicinity of Rechem chemical waste incinerator.

Table 16 : Suggested pollution categories for dioxins in river sediments

Category	Dioxin concentration (ng / kg dry weight)	
	TEQ	Total dioxins/furans
Remote	-	< 200
Background	about 6	200 - 1000
Slightly polluted	-	1000 - 2000
Polluted	-	2000 - 10,000
Heavily polluted	-	10,000 - 100,000
Very heavily polluted	-	> 100,000

The NRA did carry out a fairly comprehensive study in 1994[7] on river water and river sediments at 40 locations in England & Wales. Dioxin concentrations in river water were found to be very low with a maximum detected level of <0.08 ng TEQ/l (<6 ng/l as total dioxins). There is no information on the level of dioxins in water from the River Weaver or Weston Canal to compare against this yardstick.

However, of far greater importance are the levels in river sediments because these provide an historical record of dioxin discharges, as well as a reservoir for future release into the aqueous environment. Table 16 is based on the NRA report[7] and suggests some pollution categories for dioxin levels in the sediment of English and Welsh Rivers.

The highest UK sediment concentrations were found in the River Doe Lea downstream of Coalite's chemical works at Bolsover, Derbyshire (Table 17). The NRA identified these levels as very heavily polluted and potentially harmful to aquatic life[8]. Dioxin discharges have since fallen considerably and levels in the river have been greatly reduced.

Table 17 : Dioxins in river sediments near the Coalite works at Bolsover

Location	Dioxin concentration (ng / kg dry weight)	
	TEQ	Total dioxins
Upstream of Coalite site	7	1,050
Downstream of Coalite site	43,500	20,269,000

Table 18 : Dioxins in river sediments near the Runcorn site

Location	Dioxin concentration (ng / kg dry weight)	
	TEQ	Total dioxins
Upstream :		
- River Weaver at Acton Bridge	18[1]	1,527[1]
	127	8,836
Downstream :		
- Weston Canal near discharge from Weston Marsh Lagoons (Outfall 55)	125	74,680
- Weston Canal near Outfall 56	2,964	547,039
- Manchester Ship Canal at Eastham Lock	225	6,498
- Church Cut (Runcorn Docks)	1,168	76,430
- River Weaver near M56	42	2,583

Note 1 : Sampled by NRA; all other samples collected by ICI.

Table 18 shows the dioxin sediment levels taken from locations around the Runcorn site. Although dioxin levels rise significantly downstream of the site, they do not reach the extremely high levels observed at Bolsover. The highest result (near Outfall 56) represents a "very heavily polluted river" according to the above definition. Levels fall along the watercourse, and by Eastham Lock (where the Manchester Ship Canal enters the River Mersey) sediments are still "polluted", but are typical of the area. These sediments are periodically dredged and sent to settling lagoons.

6.3 Soil Quality

The bulk of the UK dioxin burden resides in soils, and this reflects the affinity of dioxins for organic matter. There are no statutory limits on dioxin levels in UK soils, and there do not appear to be legal limits in other countries. However, a large number of soil analyses have been undertaken in the UK and there is good knowledge of ambient concentrations.

A study by HMIP in 1989(9) found that dioxins are ubiquitous in the soil environment and are found in significantly higher concentrations in urban areas. The analytical method did not distinguish between all the dioxin and furan congeners (so it is not possible to calculate TEQ concentrations), but background total dioxin concentrations were in the order of 400 ng/kg dry weight. Urban soils were found to have an average total dioxin concentration of 2,000 ng/kg dry weight, whilst one sample had in excess of 10,000 ng/kg. A second HMIP report(10) was issued after international agreement of the dioxin Toxic Equivalent Factors, and soil samples were analysed for all congeners so that TEQ values could be derived. Table 19 gives average results for urban soils, rural soils and an historical sample collected in 1927.

ICI have taken soil samples at nine locations around the site, and four samples were also taken by Brenda Rowe Productions whilst researching the Dispatches programme which was broadcast on 6 December 1995. The results of all these analyses are summarised in Table 19 and fuller results are given in Appendix B. Bearing in mind the different sampling techniques and the analytical variability when testing for dioxins, it appears that the soil dioxin concentrations in the Runcorn area are typical of those found in urban soils.

In Germany recommended actions for different levels of dioxin in soil have been set on the basis of land use (Table 20). It should be noted that the German samples were taken from the surface to 20 cm deep, whereas HMIP samples were taken to 5 cm and ICI samples to 3 cm. Although this does not allow for direct comparison of data (because deeper soils will tend to contain less dioxin), it does provide a useful yardstick. On the basis of the German action levels, none of the Runcorn soil samples indicate the need for remediation of playgrounds or residential areas. A small number of the soil samples exceed the 40 ng TEQ/kg threshold for "limitations on the cultivation of certain foodstuffs", but this can be attributed partly to the different sampling methods. Any controls on cultivation would be set by MAFF and none have been imposed.

Table 19 : Dioxin concentration in UK soils

Location	Dioxin concentration (ng / kg dry weight)	
	TEQ	Total dioxins
Historical soil - archived 1927 sample	-	50
Rural soil - average of 11 UK locations	5.2	292
Urban soil - average of 5 UK locations	28.4	3519
Runcorn soil : A. ICI results (average of 18 samples from 9 locations) B. Brenda Rowe Productions results (average of 3 samples from 3 locations)	 34.9 8.3	 941 483

Table 20 : German action levels for dioxin in soil [11]

Land use	Soil dioxin concentration (ng TEQ/kg)	Recommended action
Agriculture & horticulture	< 5	Target value
	5 - 40	Unrestricted cultivation of foodstuffs
	> 40	Limitations on the cultivation of certain foodstuffs
Playgrounds & residential areas	> 100	Remediation of contaminated soil in playgrounds
	> 1,000	Remediation of contaminated soil in urban areas
	> 10,000	Remediation of contaminated soil in industrial areas

6.4 Dioxin Origin

Dioxins are very persistent in the environment and the profile of dioxin congeners can therefore assist in the identification of where they come from. It has been established that dioxins arising from the VC3 and Per-Tri oxychlorinators have high absolute levels of the OCDF congener although most of the TEQ comes from the 1,2,3,4,7,8 HxCDF congener. If environmental samples are examined for the presence of this tell-tale "fingerprint", then we can assess whether local arisings of dioxin are due to releases from VC3 and Per-Tri.

Soils : UK soils generally contain the OCDD congener at the highest concentrations and the largest TEQ contribution tends to come from 1,2,3,7,8 PeCDF. By comparison, local soils show high absolute levels of OCDF and OCDD, and most of the TEQ comes from the 2,3,4,7,8 PeCDF congener.

The local soil profile is therefore different to the VC3/Per-Tri process congener profile and is atypical of UK soils. Local soils are not considered to be significantly affected by process releases.

It is also worth noting that dioxin concentrations do not appear to decrease with distance from the site. It can be therefore surmised that the majority of dioxins in local soils derive from atmospheric deposition by an historical source.

Sediments : Sediments from the Weston Canal contain high absolute levels of OCDF and most of their TEQ comes from the 1,2,3,4,7,8 HxCDF congener. This pattern reflects the process fingerprint and it is apparent that the dioxin comes from the site.

River Weaver sediments from upstream of the site (Acton Bridge) and downstream (M56 road bridge) show high absolute levels of OCDF (as with process releases), but most of the TEQ contribution comes from 2,3,4,7,8 PeCDF (unlike process releases). This does not appear to indicate a significant contribution from process releases.

Sediments in the Manchester Ship Canal at Eastham Lock show high absolute levels of OCDD (unlike process releases) although most of the TEQ comes from the 1,2,3,4,7,8 HxCDF congener (like process releases). This does not appear to indicate a significant contribution from process releases.

6.5 Food Chain Effects

The Ministry of Agriculture, Fisheries and Food (MAFF) and the department of Health are best informed to comment on the medical effects of dioxin exposure and so this section draws heavily on their expertise.

Plants do not tend to take up dioxins from soil because this would involve dissolving dioxins in water. This is precluded by the low solubility of dioxins and their affinity for the organic matter in soil. However, dioxins will be deposited directly onto foliage and may be retained[12].

Vegetation and soil may be eaten by animals and the associated dioxins will have a tendency to accumulate in the fatty tissues of those animals. This attraction to "fats" means that dioxins will tend to "bio-concentrate" through the food chain so that highest concentrations appear in the top predator species (eg. birds of prey, man).

Over 95% of human exposure to dioxins is thought to come from the consumption of food, with only minor contributions from inhalation, skin contact and water consumption[12]. The World Health Organisation's Regional Office for Europe has set a recommended Tolerable Daily Intake (TDI) of 10 pg TEQ/kg body weight/day and this has also been adopted by the UK Department of Health. The Department of Health's Committee on Toxicity has recently reviewed the TDI in light of the United States Environmental Protection Agency's (USEPA) comprehensive draft health assessment of dioxins, and concluded that the TDI is still appropriate[2].

MAFF have estimated the UK dietary intake of dioxins[13,14] and have concluded that :

- UK dietary intakes are below the TDI of 600 pg TEQ for a 60 kg reference person; and

- UK dietary intakes of dioxin are comparable with other industrialised countries; and

- dioxin intakes in the UK have reduced significantly in recent years (Table 21)

MAFF found the highest dioxin concentrations in samples of cow's milk and meat, especially in urban / industrial areas. The relative contributions to the average 1992 intake of 88 pg TEQ/person/day are shown in Figure 11.

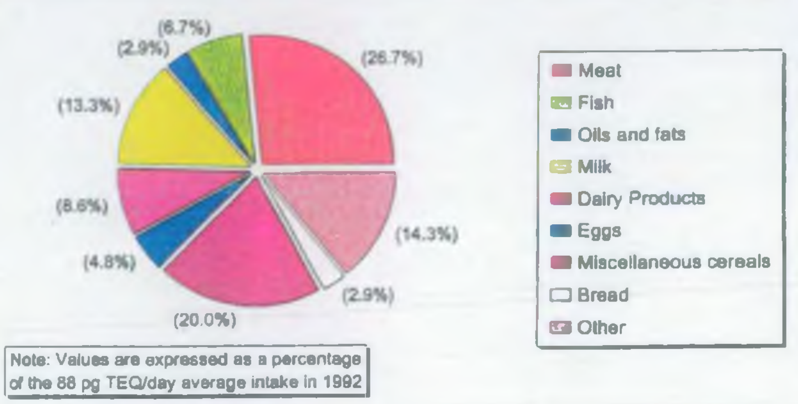
Dioxins are found mainly in fatty foods (eg. cow's milk) because dioxins are lipophilic ("fat loving"). Milk is a relatively easy matrix to analyse for dioxins and, because it is consumed by a large proportion of the population, milk is a useful environmental monitor for the presence of dioxins. It has been established that the background range for dioxins in cow's milk is 0.04 to 0.06 ng TEQ/kg fresh weight in rural areas and 0.12 to 0.27 ng TEQ/kg fresh weight in urban areas. This compares with a UK Maximum Tolerable Concentration of 0.7 ng TEQ/kg fresh weight.

The highest UK concentrations of dioxins in cow's milk for human consumption (1.8 and 1.3 ng TEQ/kg fresh weight) were found in samples taken in 1990 from two farms near the Coalite site in Bolsover, Derbyshire. The former Milk Marketing Board stopped accepting milk from these farms as it did not meet their standard conditions of sale. The concentration of dioxins in milk from these farms has subsequently fallen to background levels.

Table 21 : Change in dietary intake of dioxins from 1982 to 1992

	Average (pg TEQ/person/day)	High level (pg TEQ/person/day)
1982	250	442
1988	125	-
1992	88	156

Figure 11: Estimated UK dietary intake of dioxins



MAFF have continued a national programme of surveillance of dioxins in cow's milk from farms in the vicinity of 29 industrial sources. This survey ran from 1993 to 1995 and included farms near to Runcorn and Northwich. MAFF have not yet published the full survey results, but have indicated that :

"... the levels of dioxins in all samples are well within the Maximum Tolerable Concentration set by MAFF and the Department of Health. These results give no cause for concern over the safety of milk and milk products from these farms."[15]

MAFF have indicated that the survey is continuing and more samples are being taken for analysis. The results of the full survey will be published in a Food Safety Information Bulletin when this further work has been completed.

Just as dioxins may accumulate in cow's milk, there is potential for accumulation in human milk. Although dioxin levels in human milk have fallen by 35% over the period 1987/8 to 1993/4, MAFF has estimated that breast-fed babies have an average dioxin intake of 110 pg TEQ/kg/day at 2 months, falling to 26 pg TEQ /kg/day at 10 months[16]. This exceeds the Department of Health's TDI of 10 pg/kg/day, but the Department of Health considers that the risk is outweighed by the benefits of breast feeding and its comparatively short duration.

MAFF have reviewed ICI's report[1] on the 'Formation of dioxins in oxychlorination; Significance for human health' and concluded that the potential formation and release of dioxins were adequately assessed. MAFF agreed that the most significant route for entry of dioxins into the food chain would be atmospheric deposition on agricultural land and subsequent uptake by grazing animals. Since atmospheric releases are minor, MAFF was satisfied that the releases were "..*unlikely to result in any unacceptable effects on the human food chain..*". The dioxin releases to Holford brine cavities and Weston Marsh Lagoons were "..*expected to have minimal potential for subsequent entry into the human food chain..*".

When consulted on the increased dioxin emissions from ICI's EIP, MAFF replied that "..*provided the plant in question complies with the Chief Inspector's Process Guidance Note IPR 5/1...then it is unlikely that there will be any unacceptable effects on the human food chain..*".

This requirement was met when emission limits on the EIP were in accordance with IPR 5/1.

On a more general level, the University of Liverpool carried out an epidemiological study in 1990 of health and pollution in the Mersey Basin[17]. The study concluded that there was a wide variation of ill-health in the study area and, in general, electoral wards with a lot of industry were inhabited by lower income groups and showed more ill-health. About 5-10% of the variation in mortality rates could be explained by variations in industrial land use, but a more significant 55-60% could be attributed to the level of deprivation of inhabitants. However, four electoral wards were singled out as having high mortality, high deprivation, and high industrial land use (ie. maybe demonstrating adverse health effects due to pollution). One of these four wards was Heath (Runcorn) and was identified as worthy of closer scrutiny.

A methodology was also developed by HMIP[6] for determining the risk to human health from municipal waste incinerator dioxin emissions. Although municipal waste incinerators contribute about 70% of the industrial dioxin emissions to the UK atmosphere, the study found that incinerator emissions added less than 1% to background levels of dioxin exposure.

Halton Borough Council have recently appointed the environmental consultants DNV Technica Limited to study the 'cumulative effects of incinerators in Halton Borough'. This study has been initiated because two incinerators have been granted planning approval in the last three years and there have been recent planning applications for incinerators from EVC (VC3 plant upgrade) and ICI (Fluorochemicals). Planning applications tend to be considered individually and so this study aims to give an overview of cumulative environmental impacts.

7. CONCLUSIONS

The Department of the Environment has produced a good text on dioxins[18] and, although it is now a little dated, an extract from the Foreword provides a sound overview of the issue :

"*Dioxins have always been present in the environment. In a sense, they represent a risk in everyday life which we have lived with, albeit unknowingly, until recently. The release of dioxins probably reached a peak in post war years and is now declining. However, because dioxins are so persistent, there is a legacy of contamination from activities in the past. This legacy means that actions which we take now will only gradually show up as reduced levels of environmental contamination. This underlines the need to identify and take those actions which will be most effective in reducing such contamination.*"

Dioxins are formed by ICI and EVC on the Runcorn site as unwanted by-products in the manufacture of vinyl chloride, perchloroethylene, trichloroethylene, CTF and chlorine, and will also arise from the incineration of process wastes. The current total release of dioxins from these sources is given in Table 22 and put in the context of the UK's overall releases.

The Table also shows how dioxin releases will change with the installation of the three incinerators which are being built to effect other environmental improvements. The incinerators will bring major reductions in the release of chlorinated hydrocarbons to air and water, and of dioxins in solid waste. There will be an increase in the release of dioxins to atmosphere, but this is not considered to have a significant environmental impact. Any atmospheric deposition of dioxins will be assessed by monitoring soil dioxin concentrations before and after incinerator construction. The net benefit of the incinerator is considered to be positive.

Dioxin releases from the Runcorn site do not appear to have any deleterious effect on the local environment and ambient concentrations are as expected for an industrial/urban area. Air quality is typical of an urban environment. Canal sediments are polluted with dioxins in the immediate vicinity of outfalls, although sediments further from the site do not show any significant influence from process releases. Soil concentrations of dioxin are typical of an urban environment and show limited influence from process releases.

MAFF have considered ICI's dioxin releases and concluded that they are "*unlikely to result in any unacceptable effects on the human food chain*". This has been supported by MAFF's own survey of cow's milk which found "*no cause for concern over the safety of milk and milk products from (local) farms*".

Dioxins have been shown to be highly toxic but the existing environmental controls on operations at the Runcorn site are considered satisfactory. The Environment Agency is satisfied that the current restrictions contained in authorisations and licences exert sufficient control to protect the air, water and land environments.

Table 22 : Estimated site releases of dioxin and total UK releases

	UK total release in 1996	**Site Release**			
		Now	**Post ICI's EIP**	**Post EVC's Incinerator**	**Post ICI's Fluorochemicals Incinerator**
To atmosphere (grams TEQ/year)	560 - 1100	0.002	0.222	0.242	0.244
To water (grams TEQ/year)	Unknown	0.2	0.1	0.1	0.1
Solid wastes (grams TEQ/year)	1,500 - 12,000	512	517	6.5	6.5

There is ongoing scientific research into the effects of dioxins and the Environment Agency will keep informed of developments. The Environment Agency will review its environmental controls on the Runcorn operations of ICI and EVC in the light of any new evidence and will impose new controls as necessary.

On an internal level, the Environment Agency has found much benefit in the creation of the Project Team which prepared this report. The Team has been able to consider the subject in an integrated manner and this is a direct result of the Environment Agency's formation.

8. FUTURE ACTIONS

This report demonstrates the actions which have been implemented to minimise the formation and release of dioxins from operations on the Runcorn site. It also demonstrates the extensive monitoring which has been undertaken by the Environment Agency, MAFF, ICI and EVC.

The Environment Agency will continue to seek improvements in the environmental performance of all plants on the Runcorn site, and will pay close attention to the dioxins issue. The Agency will continue to cooperate with ICI, EVC, other regulators, interest groups and the public to attain these improvements. However, the nature of dioxins means that there is no room for complacency and there are a number of actions which still need to be completed. These actions include :

Remediation of Weston Marsh Lagoons :

ICI have submitted closure and restoration proposals to the Environment Agency in accordance with the requirements of the Waste Management Licence. The proposals involve a five stage site assessment programme :

Stage I - Historical desk top review
Stage II - Site investigation
Stage III - Data evaluation and risk assessment
Stage IV - Planning
Stage V - Implementation

Stage I has been completed. Stage II can only commence upon the cessation of the discharges onto the lagoon (in 1997) and a drying out period to allow access for sampling. It is too early to confirm what remedial actions will be taken, but this will be the subject of agreement between ICI and the Environment Agency. Options for lagoon remediation may include some form of encapsulation system, and the on-site treatment of the wastes will also be considered.

Wind blown dust from the drying surface of the lagoons following the cessation of discharges has been identified as a potential problem. A dust monitoring programme will establish background dust levels prior to closure. The Environment Agency views dust losses as an important issue and will assess the need for natural or synthetic cover materials.

Residues Disposal at Holford Brine Cavities :

The UK's strategy for sustainable development of the waste management industry has been refined by the white paper 'Making Waste Work' [19]. The strategy requires that the present generation should deal with the wastes that it produces and not leave the problems to be dealt with by future generations. The Environment Agency does not consider that the permanent storage of hazardous wastes in the brine cavities is sustainable and will be seeking an alternative solution to disposal. The Environment Agency therefore welcomes EVC's proposal to install an incinerator as part of the VC3 rejuvenation project as this will provide a more acceptable route for the disposal of heavy organic residues.

The use of Holford Brine Cavities for the storage of historical wastes will also be discussed with ICI.

Further Monitoring :

The Environment Agency believes that the current monitoring regime provides a satisfactory level of knowledge on the dioxin releases and ongoing work will generate more information. However, we will periodically review this position and implement additional monitoring as appropriate.

It is apparent from this study that sediments in rivers and canals provide a sink for dioxins that are released to water and air. The Environment Agency already has in its possession a number of radiometrically dated sediment cores taken from the Mersey Estuary and our intention is to let a contract to assess the dioxin content of these samples. This will provide a historical profile of dioxin releases from the Mersey catchment. The results will enable a comparison of current and past discharges both with respect to quantities and congener profile. This may be useful in providing further information on the source of dioxins that have been measured around the site.

GLOSSARY OF TERMS

Carcinogen	Any agent (a chemical or some forms of radiation) capable of inducing abnormal tissue growth which may lead to cancer.
CHC	Chlorinated Hydrocarbon
Chloracne	Skin eruption which resembles acne. Caused by exposure to various chlorinated organic compounds.
Congener	A general term used to describe an individual PCDD or PCDF. The 2,3,7,8 congener group refers to all those PCDDs and PCDFs which have the 2,3,7 and 8 positions as a common pattern of substitution.
Dioxins	Collective name for the chemicals known as polychlorinated dibenzo-p-dioxins or polychlorinated dibenzofurans.
EA	Environment Agency
EDC	Ethylene dichloride (also known as 1,2 dichloroethane)
EIP	Environmental Improvement Project
EVC	European Vinyls Corporation (UK) Limited
Flux rate	The amount of a substance passing a certain point in a given unit of time (eg. grams of dioxin per year).
Halogenated	Containing a halogen element (eg. chlorine, fluorine, bromine)
HMIP	Her Majesty's Inspectorate of Pollution
Hydrocarbon	An organic compound containing only the elements carbon and hydrogen.
ICI	ICI Chemicals & Polymers Limited
MAFF	Ministry of Agriculture, Fisheries and Food
MSC/MSCC	Manchester Ship Canal / Manchester Ship Canal Company
NRA	National Rivers Authority
PCDD	Polychlorinated dibenzodioxin, the series of compounds popularly known as dioxins.
PCDF	Polychlorinated dibenzofuran, the series of compounds popularly known as furans.
PER	Perchloroethylene (tetrachloroethylene)
TDI	Tolerable Daily Intake
TEF	Toxic Equivalent Factor, the weighting factor expressing the toxicity of a particular dioxin or furan relative to 2,3,7,8-TCDD.
TEQ	Toxic Equivalent is the sum of the toxicities of a mixture of PCDDs and PCDFs, the toxicity of each component being expressed by the product of the concentration and the TEF.
TRI	Trichloroethylene
USEPA	United States Environmental Protection Agency
VC	Vinyl Chloride (chloroethene) - as produced on the VC3 plant
VOC	Volatile Organic Compound
VTU	Vents Treatment Unit
WML	Weston Marsh Lagoons
WRA	Waste Regulation Authority
WRA91	Water Resources Act, 1991
$<$	Less than

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Appendix A : Dioxin Monitoring under the Environmental Protection Act 1990 - Part I (Integrated Pollution Control)

A1 : Vinyl Chloride process

Process stream description [1]	Dioxin limit	Monitoring frequency (ICI & Environment Agency)	Monitoring returns by ICI	Monitoring results (as TEQ)	
				Concentration	Mass
Process effluent to Weston Canal (W49)	None	ICI = six monthly composite sample for dioxins composed of weekly sample contributions	Six monthly concentration & annual mass from February 1995	Jan-Jun 1995 = 0.03 ng/l Jul-Dec 1995 = 0.05 ng/l Jan-Jun 1996 = 0.06 ng/l	1995 = 0.005 g
Clean process effluent to WML (E1)	None	ICI = six monthly composite sample for dioxins composed of weekly sample contributions	Six monthly concentration & annual mass from February 1995	March 1995 = 0.4 ng/l Jan-Jun 1995 = 0.5 ng/l Jul-Dec 1995 = 0.23 ng/l Jan-Jun 1996 = 0.04 ng/l	1995 = 0.015 g
Contaminated process effluent to WML (E2)	None	ICI = six monthly composite sample for dioxins composed of weekly sample contributions	Six monthly concentration & annual mass from February 1995	Jul-Dec 1994 = 14.6 ng/l Jan-Jun 1995 = 9 ng/l Jul-Dec 1995 = 0.1 ng/l Jan-Jun 1996 = 17 ng/l	1995 = 1.4 g
Spent catalyst to landfill	None	ICI = annual test on composition	Annual concentration & mass	25.5 parts per billion, none disposed to landfill	1995 = none
Heavies to Per-Tri	None	ICI = annual test on composition	Annual concentration & mass	6.2 parts per billion	1995 = 22
Oxychlorinator vent to atmosphere (VC3-14)	None	ICI by calculation	Annual mass	Below limit of detection in EDC condensed from vent, so presumed even lower in vent	1995 = < 0.001 g

A2 : Per-Tri Process

Process stream description [1]	Dioxin limit	Monitoring frequency (ICI & Environment Agency)	Monitoring returns by ICI	Monitoring results (as TEQ) [2]	
				Concentration	Mass
Neutralised effluent to Weston Marsh Lagoon (E1)	None	ICI = six monthly composite sample for dioxins composed of weekly sample contributions	Six monthly concentration & annual mass	Jan-Jun 1996 = 0.1 ng/l	0.04 g

Appendix A (cont'd) : Dioxin Monitoring under the Environmental Protection Act 1990 - Part I (Integrated Pollution Control)

A3 : Environmental Improvement Project (EIP)

Process stream description [1]	Dioxin limit	Monitoring frequency (ICI & Environment Agency)	Monitoring returns by ICI[5]	Monitoring results (as TEQ) [4]	
				Concentration	Mass
Sand filter effluent to Weston Canal (Outfall 65a)	None for dioxins, but 45 mg/l suspended solids	ICI = 100 times per annum for solids, and a six monthly composite sample for dioxins composed of weekly sample contributions. EA = 4 times per annum for solids.	Six monthly (starting in 1997 when Phase II of project is completed)	-	-
Incinerator main vent at 60 metres	1 ng/m^3 [3] 0.22 g/annum	ICI = 6 tests during commissioning and then 4 times per annum. EA = once per annum.	Quarterly concentration and annual mass	-	-
Product hydrochloric acid to Per-Tri	None	ICI = one off test	One off report in early 1997	-	-
Soil dioxin concentrations in the locality of the incinerator	None	ICI = 3 soil samples on each of 7 occasions (2 occasions prior to start-up and 5 more occasions during first 11 years of operation)	As and when results available	Pre-start up : A. Feb 94 = 34, 31 & 19 ng/kg (duplicate results of 14, 18 & 15 ng/kg by another laboratory on the same sample) B. July 96 = 52, 45, 30	-
Sand filter solids	None	ICI = annual composite sample	Annual	-	-
Air stripper	None	ICI = one off test on aqueous feed, aqueous effluent, and knock out pot liquor.	One off report in early 1997	-	-

Note 1 : Reference numbers are those given in the IPC Authorisation.
Note 2 : Process was only authorised on 30/08/95 and so monitoring returns are limited.
Note 3 : By 30/06/98 ICI are required to submit a feasibility study on reducing dioxin emissions to 0.1 ng/m^3.
Note 4 : Although the process was authorised on 26/11/93, the plant is only just being commissioned and so monitoring returns are limited.
Note 5 : Some monitoring requirements have only recently been agreed and may not yet appear in the authorisation conditions.

Appendix B : Dioxins in soils around Runcorn

B1 : SAMPLES TAKEN BY ICI Location (& National Grid Reference)	Dioxin concentration (ng/kg dry weight)		Principal congener (absolute)
	TEQ	Total dioxins	
1. off Cheshyres Lane (SJ 5024 8098)	53	1157	OCDD
2. Frodsham Marsh Lagoon (SJ 5160 7890)	18	660	OCDD
3. Brine Reservoirs, Weston Hill (SJ 5068 8095) - 1993 Brine Reservoirs, Weston Hill (SJ 5068 8095) - Feb 94 : Lab 1 (3 samples) Brine Reservoirs, Weston Hill (SJ 5068 8095) - Feb 94 : Lab 2 (3 samples) Brine Reservoirs, Weston Hill (SJ 5068 8095) - July 96 : Lab 1 (3 samples)	53 34 / 31 / 19 14 / 18 / 15 52 / 45 / 30	1167 612 / 741 / 386 326 / 394 / 370 1011/999 / 716	OCDF OCDF OCDF OCDF
4. West Road, Weston Point (SJ 4961 8138)	72	3572	OCDD
5. nr Salt Union, Weston Point (SJ 4992 8150)	41	986	OCDF
6. Recreation Ground Club, Picow Farm Road (SJ 5015 8166)	17	484	OCDD
7. off Cheshyres Lane (SJ 5011 8107)	45	1051	OCDF
8. Runcorn Hill (SJ 5066 8137)	23	772	OCDD
9. off Moughland Lane, Higher Runcorn (SJ 5112 8180)	48	1526	OCDF
Average	34.9	941	-

B2 : SAMPLES TAKEN BY BRENDA ROWE PRODUCTIONS FOR CHANNEL 4 Location (& approximate National Grid Reference)	Dioxin concentration (ng/kg dry weight)		Principal congener (absolute)
	TEQ	Total dioxins	
1. MSCC Frodsham Marsh Dredging Ground - embankment (SJ 507790)[1]	115	6,462	OCDF
2. Field between Frodsham Marsh Lagoons (SJ 509790)	10	620	OCDF
3. Field between Frodsham Marsh Lagoons (SJ 514790)	8	443	OCDF
4. ICI Frodsham Marsh Lagoon - embankment (SJ 514796) [2]	405	84,763	OCDF
5. Field between Frodsham and M56 (SJ 523787)	7	387	OCDD
Average	8.3	483	-

Note 1 : Sample collected from lagoon embankment which was constructed of previously settled dredgings from the Manchester Ship Canal, and has therefore been excluded from calculation of average concentrations.

Note 2 : Sample collected from lagoon embankment which was constructed of previously settled dredgings from the Weston Canal, and has therefore been excluded from calculation of average concentrations.

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For general enquiries please call your local Environment Agency office. If you are unsure who to contact, or which is your local office, please call our general enquiry line.

ENVIRONMENT AGENCY GENERAL ENQUIRY LINE
0645 333 111

The 24-hour emergency hotline number for reporting all environmental incidents relating to air, land and water.

ENVIRONMENT AGENCY EMERGENCY HOTLINE
0800 80 70 60

ENVIRONMENT AGENCY