Risk Prioritisation Methodology for Hazardous & Noxious Substances for Public Health

Activity 3

3.1: HNS Prioritisation Methodology & List

ARCOPOL

The Atlantic Regions' Coastal Pollution Response

Version:	Final
Author:	Paul Harold, David Russell – Health Protection Agency Pauline Louchart – Pembrokeshire County Council
Responsible partner:	Pembrokeshire County Council & Health Protection Agency
Contributing partners:	Conseil Régional de Bretagne, Conseil Régional d'aquitaine, CEDRE, CIIMAR, CETMAR, EGMASA, Marine Institute

1 Introduction

Hazardous and Noxious Substance is defined in the OPRC-HNS Protocol 2000 as "*Any substance other than oil, which if introduced into the marine environment is likely to create hazards for human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.*"

Estimates indicate some 2200 Hazardous and Noxious Substances (HNS) carried regularly by sea with bulk trade of 165 million tonnes per year worldwide (ITOPF[1], International Tanker Owners Pollution Federation Limited). By 2015, maritime chemical trade is expected to grow by 30% (Ocean Shipping Consultants Ltd) especially as the next generation of container ships are 12,000 TEU compared to the "MSC Napoli" (UK, 2007) which transported 2318 containers.

With projections of increased transport of chemicals on ships, some increase in the number of HNS incidents may be expected. Incidents involving HNS have occurred regularly with over 100 incidents involving HNS reported in EU waters between 1987–2007 (HASREP Project[1]).

A conclusion of the White Paper[2] for the Interspill Conference & 4th IMO R&D forum entitled "*Are HNS spills more dangerous than Oil?"* stated that it would seem sensible to invest in efforts to better understand the risk of HNS spills occurring in different regions of the world". This is specifically relevant as incidents occurring in a port or in coastal areas can have both potential and actual public health implications as reported in several studies (Public Health Wales, 2010[3]).

This information combined with the prioritisation of those HNS substances posing the highest risk in terms of public health assist the preparedness and emergency response planning to a potential incident.

The prioritisation of risks from HNS is key to emergency planning and preparedness. In preparing for and responding to spills of HNS, responders need to evaluate the risks posed along their coastline, ensure the suitability of existing arrangements and the availability of up to date data on specific chemicals of concern.

Risk assessment provides a structured and evidence based process to address and evaluate the hazards posed by the maritime transport of chemicals to responders, public health and marine life.

A methodology has been developed to prioritise HNS based upon potential public health risks. The work, undertaken as part of the Atlantic Region Coastal POLlution response project (ARCOPOL), aims to provide information for use by operators, regulators and responders to incidents, enhancing the efficiency of the response and therefore reducing the overall risks to public health.

2 Desktop Study

A desktop study was carried out to review the relevant sources of information to feed into the risk assessment as well as a review of methodologies used to prioritise HNS in maritime

[1] HASREP "RESponse to Harmful Substances spilled at sea". Project carried out in the Community framework for co-operation in the field of accidental or deliberate marine pollution.

[2] White Paper for the Interspill Conference and 4th IMO R&D forum, Dr Karen Purnell, Managing Director, ITOPF. http://www.itopf.com/information-services/publications/papers/HNSPapers.html

[3] Systematic review of public health impacts from maritime HNS incidents, Sikha Dhar, Public Health Wales Paper

2.1 Review of statistical data

Estimates indicate some 2200 Hazardous and Noxious Substances (HNS) carried regularly by sea with bulk trade of 165 million tonnes per year worldwide (ITOPF[1], International Tanker Owners Pollution Federation Limited).

The identification of the most frequently transported Hazardous and Noxious Substances (HNS) may indicate those substances most likely to be spilt during an incident. Therefore research was undertaken to evaluate the maritime transport of HNS in the Atlantic Area. However the research has proven extremely difficult and the data is not readily available. This fact is recognised in the industry.

- Literature review of annual tonnage, frequency and incident data for the UK (HASREP, UK trade statistics, …)
- Enquiry made with ports and harbours have returned unsuccessful throughout the partnership area or the data provided was not specific enough, i.e. for individual HNS.
- Enquiry with EMSA – access to statistical data very limited.

The appropriate prioritisation of risks will only be possible with the appropriate level of statistical data on maritime transport and handling of HNS.

2.2 Review of past incidents

The table below summarises some of the major HNS incidents which have occurred at an international level over the past 10 years. The list does not take into account some minor incidents at a national level nor lost containers reported along the shoreline.

Sulphuric acid is one the most commonly transported and there seems to be a correlation between tonnage/transport frequency and incidents occurrence. However, it is difficult to establish a strong link with other HNS.

As is presented in the report later on, some research was undertaken to assess the correlation between incidents involving HNS and statistical data of maritime transport of substances in the UK based on the Maritime Coastguard Agency (MCA) incidents' database.

Date	Name of Ship	Location	HNS involved
August 09	GULSER ANA	Madagascar	Phosphorite
March 09	PACIFIC ADVENTURER	Australia	Ammonium nitrate
June 08	PRINCESS OF THE STARS	Philippines	Pesticides, Solvent
Feb 07	ANNABELLA	Baltic Sea	Butylene
Jan 07	GOLDEN SKY	Latvia	Potash – Potassium Hydroxide
Jan 07	MSC NAPOLI	UK	Various containers
31 Jan 06	ECE	Cherbourg, France	phosphoric acid
10 Oct 05	SAMHO BROTHER	Hsinchu, Taiwan	benzene
Aug 05	MGM 3030	USA	Sulphuric acid
Aug 05	KERIMA	USA	Sulphuric acid
8 April 05	GG CHEMIST	Off Shanghai, China	toluene
21 Jan 05	KASCO	Ho Chi Minh, Vietnam	gas oil
15 Nov 04	VICUNA	Paranagua, Brazil	methanol
Aug 04	GOLDEN GLORY	Egypt	Sulphuric acid
June 04	ENA 2	Germany	Sulphuric acid
28 Feb 04	BOW MARINER	Virginia, USA	methyl tertiary butyl ether / crude industrial ethanol / Methanol
Jan 04	PANAM SERRENA	Italy	Benzene
Jan 04	METIN KA	Oman	Ethanol
June 03	JAMBO	UK	Zinc concentrate and Cadmium
Dec 02	METIN KA	Turkey	Sulphuric acid
Aug 02	BOW EAGLE	UK	Ethyl acetate
July 02	IRINA 2	Papua New Guinea	Palm oil
19 Oct 02	ACCORD	Yangtze River, China	Poly-glycol mono-methyl 300, 950 ether acetate, methyl methacrylate
10 Sept 02	JOLLY RUBINO	Richards Bay, S- Africa	Packaged class 3 hazard
Oct 01	NORMA	Paranagua, Brazil	Naphtha
31 Oct 00	IEVOLI SUN,	France	Styrene, isopropyl alcohol, methyl ethyl ketone

2.3 Review of prioritisation tools & research projects

2.3.1 GESAMP List

The GESAMP 'hazard profile' approach appears to be one of the most appropriate sources of HNS data, providing a simplified summary of the chemical in question that can be used by field operatives and primary advisors in the first instance. It also has the added advantage of being focussed on the marine environment and on regularly shipped chemical cargoes.

The GESAMP hazard evaluation procedure is concerned with chemicals transported by ships and with the protection of the marine environment, personnel at sea and people using coastal amenities. The hazard profiles of substances carried by ships that have been reviewed by the EHS Working Group of GESAMP are published at regular intervals and a "composite list" is published on the IMO website.

The GESAMP toxicity profile considers the following principal aspects, namely:

- A: bio-accumulation and bio-degradation
- B: aquatic toxicity (acute-category B1; chronic B2)
- C: acute mammalian toxicity (oral toxicity C1, dermal C2, inhalation C3)
- D: irritation, corrosion and chronic mammalian toxicity (D1 Skin irritation and corrosion; D2 eye irritation and corrosion; D3 Long term health effects)

Within each category, except for the long term effects, each chemical is scored using a hazard rating based on 0-4 for acute toxicity and 0-3 for irritancy.

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2.4 Review of previous studies and research projects

A number of projects and research papers, notably those submitted for the INTERSPILL conference in Marseille in 2009, were reviewed as part of the desktop study. CEDRE provided key documents and reference to scientific papers and research projects too, which have been taken into account in the prioritisation process.

Hasrep project

The HASREP project stands for "RESponse to Harmful Substances spilled at sea". Project carried out in the Community framework for co-operation in the field of accidental or deliberate marine pollution.

The project produced a number of reports notably one identifying the top 100 priority chemicals being transported and handled in and along European waters.

Maritime & Coastguard Agency

As part of the MCA's implementation of the HNS protocol with respect to Ports and Harbours, the MCA is responsible for leading in the response to HNS incidents at sea, therefore its current available toolbox for the determination of fate and behaviour, and the potential and real environmental impact needed to be refined.

The MCA commissioned a report entitled RP 593 - UK Risk Assessment for Hazardous and Noxious Substances, which had for outcomes the following:

i. A full literature review including; relevant data sources for HNS, hazard assessment options and existing HNS fate and effects models (including confidence assessments).

ii. A gap analysis of HNS hazard assessment data and modelling approaches. Prioritisation of HNS to identify the substances or chemical groups of most concern.

iii. A review of the chemical spill models ChemSIS and CHEMMAP.

iv. Development of a Decision Support System to include HNS prioritisation

The prioritisation of HNS was found to be based on environmental criteria and also is restricted to the English Channel as opposed to the whole of the UK Pollution Control Zones.

3 Prioritisation Matrix

3.1 Introduction and caveat

A methodology has been developed to prioritise potential acute public health risks associated with incidents involving maritime transport of hazardous and noxious substances (HNS).

The methodology does not provide a process for assessing risks for specific incidents but instead aims to provide strategic risk information for public health planning and preparedness.

Whilst chronic effects are important public health considerations, acute health impacts have been used as the risk driver for this assessment. This decision has been taken in order to reflect the type of incident scenario envisaged, i.e. associated with large chemical releases, and additionally because of the inherent difficulties associated with attributing chronic effects such as excess cancers to specific events / agents.

3.2 Methodology

There is clearly a vast amount of chemicals transported by sea which makes the prioritisation of potential risks posed to coastline all the more difficult. However the process is simplified by the approach of classifying chemicals according to their physicochemical properties, which in turn dictate their fate and behaviour in the environment, thus pathways and then receptors.

Accordingly, following release at sea, chemical can be divided into 4 principal groups, namely evaporators, floaters, sinkers and dissolvers, reflecting their tendency to become air borne, remain on the surface, sink to the bottom or to solubilise in sea water respectively. Within these four groups, some chemicals will have properties consistent with more than one group and may be classified as a floater/evaporator, floater/evaporator/dissolver, dissolver/evaporator or sinker/dissolver.

These 4 cardinal properties dictate the environmental medium/media likely to be contaminated and hence the receptors likely to be exposed. Therefore, an evaporator is likely to contaminate air, may form a toxic cloud or plume and expose wildlife and human beings, principally through inhalation exposure. Floaters on the other hand are likely to cause surface contamination and thus may expose aquatic organism and wildlife at the surface, with also the potential of dermal exposure for human beings.

Dissolvers readily solubilise in sea water and the steady state concentration will reflect amount released, solubility, volume of water, dispersion, currents and wind velocity. This principally affects aquatic organisms. Sinkers are not readily soluble being lipophilic and being denser than sea water, sink to the bottom, affecting benthic organisms.

The Revised GESAMP hazard evaluation Procedure states that the “principal mode of exposure after spillage is expected to be through vapours”. Therefore community exposure is likely to occur predominantly from air-borne contamination and thus inhalation exposure. From the community aspect, the chemicals of priority concern are those that have some capacity for evaporation and which may induce a health effect.

Additionally, based on data for the actual quantities of HNS transported between EU ports and through the English Channel 2002 -2004 those that evaporate and also dissolve in or float on

seawater may each represent up to 20% of the total bulk of transported chemicals and therefore are likely to be encountered in an emergency incident (HASREP, 2005).

The list of HNS was therefore reduced to around 350 chemicals based on the GESAMP criteria.

3.3 Risk Prioritisation procedure

In generic terms, the risk of exposure and subsequent health effects is the product of hazard and probability. Hence the risk prioritisation procedure has been undertaken using conventional risk assessment methodology, as below:

Risk = Severity x Likelihood

The matrix developed provides a score for each criterion and the product of the scores reflects the considered risk in a relative manner.

As previously stated the major pathway of exposure following maritime incidents is air and subsequently inhalation exposure. Therefore the hazard posed by GESAMP identified HNS that are volatile or gaseous i.e. targeting the substances which are gas (G), evaporators (E), evaporator floaters (EF) or evaporator/ floater/dissolver (EFD).

3.3.1 Severity

Severity has been estimated as a measure of acute human health effects by determination of the toxicity of the chemicals under investigation together with their potential to reach a target receptor as below:

Toxicity

Chemicals of potential concern were identified from the GESAMP / EHS Composite List [4] and initially screened based upon their **acute** toxicity, with particular emphasis on inhalational exposure as this is considered to pose the major route for widespread exposure of the public (Appendix 3). For this purpose toxicity hazards were allotted scores as follows:

Toxicity Scores

Hazard Route	Score	Source
Inhalation	2 to 4	GESAMP
Irritant	2	(if score 3 on GESAMP)
Non Threshold	Not Scored	(if on GESAMP as C or R)

Inhalation and Irritant effects were considered as being of equally high significance due to their potential to cause acute effects and impact large numbers of people. Inhalation effects were scored as per the GESAMP List. Irritant effects were allocated an individual score of 2 so as to provide a similar range as that for inhalation, reflecting their potential to impact large numbers and the potential to lead to more severe effects.

[4] Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP) Working Group on the Environmental Hazards of Substances Carried by Ships (EHS) (GESAMP Reports and Studies No 64)
http://www.imo.org/includes/blastDataOnly.asp/data_id%3D25672/Report-BLGCirc.29annex6doc.pdf

Non-Threshold effects were considered of lower significance, with acute risks being considered as the key driver for this assessment. Whilst genotoxic carcinogens do in theory possess the potential for irreversible effects from a single exposure, in practise the risk is extremely small and influenced by many other factors. For this reason, non-threshold effects were omitted from the assessment

Some chemicals considered relevant did not appear on the GESAMP List, namely chlorine, phosgene, vinyl chloride and hydrofluoric acid. Whilst these chemicals do not appear on the GESAMP HNS List, there is evidence that they are transported by sea to varying extents. These chemicals were assessed using peer reviewed data (Toxnet Hazardous Substances Database[5]) applied to the GESAMP assessment process to provide indicative severity scores.

Behaviour

Chemical hazards were further refined by incorporating behaviour characteristics as an indicator of potential for exposure.

Characteristics	Score	VP (kPa)	Solubility (mg/l)	Density (kg/l)
Gas	10	>101.3	<100,000	na
Gas-Dissolver	9	>101.3	>100,000	na
Evaporator	8	>3	<10,000	<1.025
Evaporator-Floater	7	>0.3	<1000	<1.025
Evap-Dissolver-Floater	6	>0.3	1000 - 50,000	<1.025
Evap-Dissolver	5	>3	10,000 - 50,000	<1.025
Floater	4	<0.3	<1000	<1.025
Floater-Dissolver	3	<0.3	<1000	<1.025
Dissolver	2	<10	>50,000	na
Sinker	1	<0.3	<1,000	>1.025

Characteristics (physico-chemical properties) were based upon the European Behaviour Classification System for accidentally spilled chemicals6. Scores were allotted based upon potential for exposure via inhalation / airborne pathways and to a lesser extent their potential for direct contact. This was adapted from other assessment studies of HNS spills.7

Reactivity of chemicals was also considered in respect of the potential to react with water and / or air to produce toxic products. Again, several non-GESAMP chemicals were included in the assessment. Details are presented in Appendix 1.

Severity Calculation

Severity of potential acute health effects was subsequently calculated as the product of the scores for toxicity (GESAMP list) and characteristics (EU Behaviour) (Appendix 3). This was chosen as the preferred option as it gives the greatest range of scores thus highlighting the differences in severity between chemicals and likely impact.

[5] http://toxnet.nlm.nih.gov/
[6] http://www.gesamp.org/data/gesamp/files/file_element/ffc2bb7eb105382ff11ac5769dae1707/pbl_7_en_1.pdf

[7] Hasrep 2004 Task 2 Risk Assessment Methodology For The Transport Of Hazardous And Harmful Substances In The European Union Maritime Waters R.05.75a.C/4235

[An alternative option would be to calculate severity as the sum of toxicity and behaviour (i.e. adding the 2 scores). Overall this option reduces the severity scores but does not greatly change the standings of the highest scoring chemicals.]

3.3.2 Likelihood

The Likelihood was defined as the probability of occurrence of a spill within European Atlantic waters. Tonnage transported by sea was used as a proxy for likelihood of an incident. Site specific aspects such as shipping frequency could also increase likelihood but data was not readily available.

The likelihood could also consider the number of chemical incidents involving a given chemical or group of chemicals. However reported incident numbers are very low and not really applicable to be used to draw conclusions in respect of likelihood of specific HNS accidents

Likelihood was scored to reflect the amounts of HNS transported by sea (Appendix 3). Research undertaken by ITOPF, IMO and EMSA[6] states that there is reason to suggest that the most commonly transported chemicals are the ones most likely to be involved in an incident.

Information was obtained via a hierarchy of sources. UK import and export data were used in the first instance (Government Statistics office[8]), which although not specific for shipping are considered to provide representative values for comparison in view of the limited options for road, rail and air transport of bulk HNS. This information was supplemented by EU shipping data for Atlantic and English Channel routes (HASREP)[9] where UK data was unavailable. The ultimate aim of the process is to provide data to cover European Atlantic region shipping of HNS, however at this stage, the datasets are still under construction. In view of this, the data presented are UK focussed and thus only provides an illustration of the methodology.

A review of EU statistics using the Eurostat New Cronos database[10] appears to support the use of UK data as an indicator of European Atlantic region HNS trade demonstrating similar maritime trade and chemical import / export ratios for UK and other EU Atlantic states.

Annual Tonnage	Score
>1,000,000	5
100,000 - 1,000,000	4
10,000 - 100,000	3
1000 - 10,000	2
<1000 or no data	1

Scores were allotted in line with those used for assessments undertaken for the European project HASREP, although in this case due to the paucity of data it was decided to only include scores for annual tonnages and not include frequency of shipping data. A default score of 1 was applied where no quantitative data were available.

[8] UK Office of National Statistics PRA Reports (organic, inorganic chemicals, plastics, fertilisers, pharmaceuticals, Dyes http://www.statistics.gov.uk/CCI/SearchRes.asp?term=chemicals

[9] HASREP 2005. Report on Task 1: Monitoring of the flow of chemicals transported by sea in bulk

[10] http://www.esds.ac.uk/international/support/user_guides/eurostat/cronos.asp

Incidents were similarly reviewed in respect of likelihood but also not considered to be a relevant indicator in view of the small number that occur, limiting the ability to identify any trends in respect of specific HNS.

3.4 Risk Prioritised chemicals

The final risk assessment score was calculated as the product of the severity score and the corresponding likelihood score. 356 HNS have been ranked and the highest proportion has a score lower than 20.

The results of the risk prioritisation are presented in Appendix 2.

Number of HNS	Final Risk Scores	Cumulative total
31	0	31
45	1<x<9	76
85	10<x<19	161
59	20<x<29	220
35	30<x<39	255
36	40<x<49	291
47	50<x<100	338
16	100<x<200	354
2	200<x	356

The results identify several of the most toxic HNS as high priority and show many of the highest priority chemicals as those which are volatile / gaseous. This however is based upon the weightings currently given for each parameter assessed. Whilst weightings have been justified, these are draft values and are open to review. In addition, limited transportation data may artificially reduce potential risks associated with some chemicals.

3.5 Areas for Further Consideration

The analysis has identified areas for further consideration, specifically in respect of weightings. Weightings currently give a bias to the severity aspect of the risk assessment.

This has been done as it is considered that toxicity and behaviour of HNS are the key risk drivers, in view of the strength of these data and the limited number of incidents that actually occur (according to current reports).

It is felt that both tonnage and frequency data would be more representative of likelihood of incidents rather than tonnage alone. Whilst it can be assumed that high tonnage will equate to high shipping frequency this may not always be the case. For example crude chemicals are often carried in very large quantities at low frequency. In contrast refined products are often carried in smaller quantities at higher frequencies, reflecting customer demand and usage. It is accepted however

that at present the data set for UK shipping of HNS limits the ability of including frequency within this current assessment.

Other aspects could also be considered to refine the assessment for specific areas / ports. These could include a weighting for severity based upon proximity to population bases by incorporating a score for ports / lanes where urban centres fall within certain radii e.g. within 1 km, 3km, 5km, whilst likelihood could be refined by including a weighting for the general density of local shipping traffic.

With this in mind it is felt that the approach should only be used taking account of best available data and with regard to local positions which may differ from the national position. In addition, the process should be revisited from time to time to ensure that the risk assessment and subsequent prioritisation remains valid.

3.6 Data Gaps

A review of the literature has highlighted a paucity of data in respect of HNS shipping. The current assessment has used UK Import / Export data and EU data (Hasrep). UK data are not transport specific, whilst European data are limited to Atlantic coast and English Channel traffic and do not include the Irish Sea, Bristol Channel or North Sea. Data for these UK and European shipping areas would help to provide more accurate estimations for likelihood calculations.

Reported incident numbers are very low and not really applicable to be used to draw conclusions in respect of likelihood of specific HNS accidents. However reported incidents tend to relate to those where large volumes have been spilled. Data on smaller incidents could provide a useful likelihood indicator.

A review of MCA data has identified a number of recorded small UK incidents in respect of HNS as below and suggests a weak association between incident frequency and shipping tonnage estimates.

Group	Annual Tonnage	Incidents 2000 - 2007
Methanol	>1,000,000	32
Ethylene Glycols	>100,000	32
Alcohols	>10,000	2
Amines	>1,000	6
BTEX	>100,000	3
Acetates	>100,000	1
Inorganics (as Ammonia)	>100,000	13
Acids	>100,000	3

4 Identification of chemical of concerns

The table below lists all the chemicals which have a final risk score above 100. The chemicals of concerns identified as part of the project ARCOPOL have been selected as the first 10 priority substances. 10 is an arbitrary number chosen based on the time available under the project to develop datasheets and to research/collate data on each of the HNS.

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
CHLORINE GAS	7	10	4	280
ETHYLENE OXIDE	7	10	4	280
METHYL AMINE SOLN	7	9	3	189
AMMONIA	5	9	4	180
2-(2-AMINOETHOXY) ETHANOL	7	8	3	168
VINYL CHLORIDE	4	10	4	160
2-AMINO-2-METHYL-1-PROPANOL	7	7	3	147
3-METHYL PYRIDINE	6	7	3	126
FORMALDEHYDE	7	9	2	126
DIMETHYLAMINE	6	9	2	108
HYDROFLUORIC ACID	6	9	2	108
METHYLAMINE ACID	4	9	3	108
TRIMETHYLAMINE	6	9	2	108
ALUMINIUM CHLORIDE	7	5	3	105
ZINC BROMIDE	7	5	3	105
ZINC CHLORIDE	7	5	3	105
ANILINE	5	5	4	100
METHANOL	4	5	5	100

An HNS datasheet template has been developed based on published safety datasheets (SDS) template, datasheets produced by the Health Protection Agency but also on work undertaken by partners under ARCOPOL and contractors such as CEDRE.

A datasheet aimed specifically at incident response with a focus on public health and the maritime environment will be developed for each of the 10 substances if possible.

During the course of the project, EMSA has commissioned the development of datasheets for over 100 chemicals. The datasheets developed under ARCOPOL have been submitted as an example.

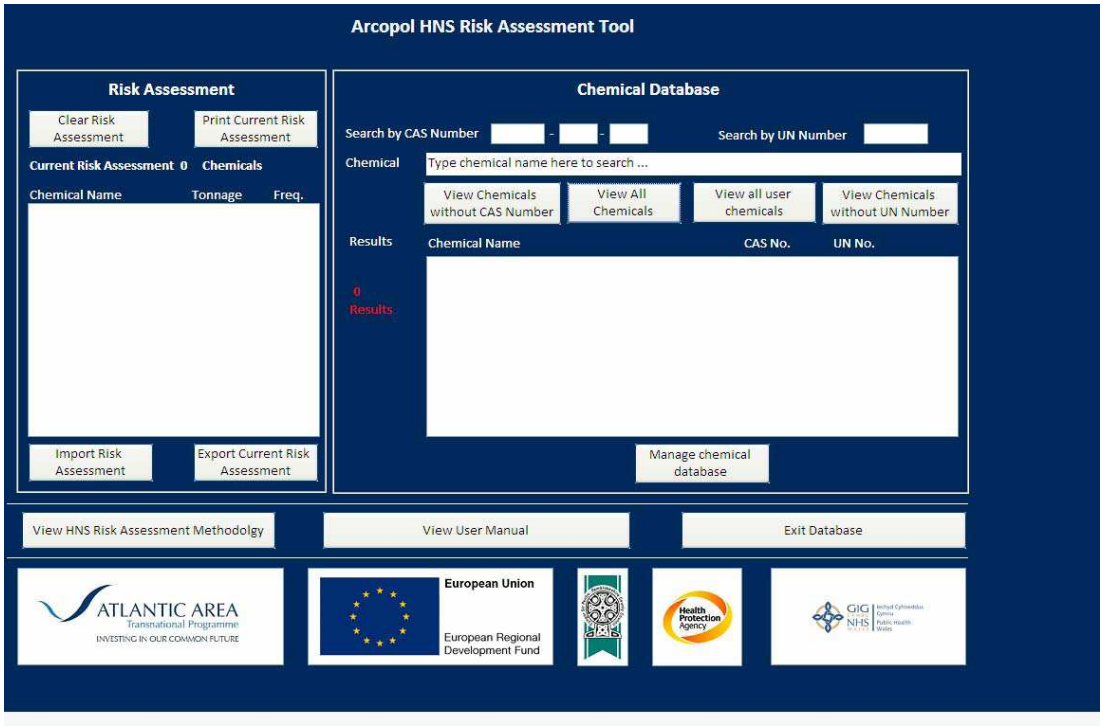
5 Geographical Inventory

Due to the lack of statistical data on specific Hazardous & Noxious Substances being transported along the Atlantic Area it was not possible to carry out a comparative study or a specific geographical register for each member states.

However, a database tool was developed which allows partner to enter area specific data on tonnage and frequency for a range of 350 chemicals selected under the prioritisation matrix.

Additionally users can enter new chemicals into the database if specific to their geographical area. For any new chemical entered, toxicity and behaviour values must be defined and backed by scientific data and source.

A screen print of the database is shown below:



APPENDIX 1: HNS Reacting with Air & Water

A list of the main chemicals and chemical groups that react with air and water was reviewed against the GESAMP list. Reaction products were assessed for acute inhalation toxicity / irritant effects and compared to the parent compound.

Where the effects of the product were more severe, the corresponding score for that product was used for the parent compound e.g. Aluminium Chloride reacts with water to produce hydrochloric acid. The severity score for Aluminium chloride of 4 was replaced with the score for hydrochloric acid of 35. Where the parent compound severity was higher than any products, then this was retained.

GESAMP chemicals listed as water / air reactants were as follows:

- Sodium Borohydride – produces sodium hydroxide and hydrogen
- Acetic anhydride – acetic acid
- Propionic anhydride – propionic acid
- Phthalic anhydride – Phthalic acid
- Aluminium Chloride – Hydrochloric Acid
- Ammonium Chloride - Hydrochloric Acid
- Zinc Chloride - Hydrochloric Acid
- Zinc Bromide - Hydrobromic Acid

Of these only Aluminium Chloride, Zinc Chloride and Zinc Bromide resulted in increased severity from the reaction products. All of the others remained unchanged (ammonium chloride reaction products were potentially more severe but it is present as a solution on the GESAMP list and therefore already exposed to water.)

A range of chemicals and groups that can react with water and air were not included in the GESAMP List including alkali metals and alkali earth metals which react violently with water, other metals which react with water, phosphides (which produce phosphine gas), carbides (which produce methane and other hydrocarbon gases), silicides and nitrides.

Conclusion

From this review Aluminium Chloride, Zinc Chloride and Zinc Bromide would fall within the top 20 priority chemicals based upon the severity score of their reaction products. A range of potentially reactive chemicals not included on the GESAMP list were assessed separately. None fell within the current top 20 priority list, although this did not consider risks from fire and explosion, which were considered outside the remit of this assessment.

APPENDIX 2: List of Risk Prioritised HNS

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
CHLORINE GAS	7	10	4	280
ETHYLENE OXIDE	7	10	4	280
METHYL AMINE SOLN	7	9	3	189
AMMONIA	5	9	4	180
2-(2-AMINOETHOXY) ETHANOL	7	8	3	168
VINYL CHLORIDE	4	10	4	160
2-AMINO-2-METHYL-1-PROPANOL	7	7	3	147
3-METHYL PYRIDINE	6	7	3	126
FORMALDEHYDE	7	9	2	126
DIMETHYLAMINE	6	9	2	108
HYDROFLUORIC ACID	6	9	2	108
METHYLAMINE ACID	4	9	3	108
TRIMETHYLAMINE	6	9	2	108
ALUMINIUM CHLORIDE	7	5	3	105
ZINC BROMIDE	7	5	3	105
ZINC CHLORIDE	7	5	3	105
ANILINE	5	5	4	100
METHANOL	4	5	5	100
CYCLOHEXYLAMINE	7	7	2	98
OLEYLAMINE	7	7	2	98
1,3-CYCLOPENTADIENE	3	8	4	96
ALCOHOLS	6	3	5	90
DICYCLOPENTADIENE	3	7	4	84
DI-N-BUTYLAMINE	7	6	2	84
ETHYLENE GLYCOL ACRYLATE	7	3	4	84
FATTY ACIDS, SATURATED	7	4	3	84
NONYL PHENOL	7	4	3	84
OCTANOIC ACID	7	4	3	84
PENTAETHYLENE HEXAMINE	7	4	3	84
PYRIDINE	4	7	3	84
PYRIDINE BASES	7	4	3	84
VINYL NEODECANOATE	7	4	3	84
CARBON DISULPHIDE	8	5	2	80
PHOSGENE	8	10	1	80
PYROLOYSIS GASOLINES	2	8	5	80

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
DIISOBUTYLAMINE	6	6	2	72
DI-N-PROPYLAMINE	6	6	2	72
ETHYLAMINE	4	9	2	72
DIETHYLAMINE	7	5	2	70
HYDROCHLORIC ACID	7	5	2	70
PROPYLAMINE	7	5	2	70
SULPHURIC ACID	8	2	4	64
2-METHYL-5-ETHYLPYRIDINE	7	3	3	63
HEPTANOIC ACID	7	3	3	63
HEXANOIC ACID	7	3	3	63
PENTANOIC ACID	7	3	3	63
PROPANOLAMINE	7	3	3	63
SODIUM ALUMINATE	7	3	3	63
SODIUM BOROHYDRIDE	7	3	3	63
SODIUM SILICATE	7	3	3	63
ACETONE CYANOHYDRIN	5	4	3	60
ACRYLONITRILE	3	5	4	60
DIISOPROPYLAMINE	6	5	2	60
N-ETHYL BUTYLAMINE	6	5	2	60
POLYETHYLENE POLYAMINES	5	4	3	60
POLYGLYCERINE	5	4	3	60
PROPYLENE OXIDE	4	5	3	60
ALKYL BENZENE MIXTURES (Xylenes)	2	7	4	56
ISOPHORONE DIAMINE	7	4	2	56
METHYLCYCLOPENTADIENE	2	7	4	56
N,N-DIMETHYLDODECYLAMINE	7	4	2	56
PHOSPHORIC ACID	7	2	4	56
POLYALKYL ACRYLATE IN XYLENE	2	7	4	56
SODIUM HYDROXIDE	7	2	4	56
STYRENE MONOMER	2	7	4	56
1,3 DICHLOROPROPENE	6	8	1	48
2-METHYL PENTANE	2	8	3	48
CHLOROACETIC ACID	8	2	3	48
FLUOROSILICIC ACID	8	2	3	48
ISO-OCTYLENE	2	8	3	48

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
METHYL AMYL ALCOHOL	4	3	4	48
METHYL ISOBUTYL KETONE	4	6	2	48
N-ETHYL CYCLOHEXYLAMINE	6	4	2	48
N-ETHYL-2-METHALLYLAMINE	6	4	2	48
NITRIC ACID	8	2	3	48
1-HEXANOL	5	3	3	45
ALCOHOL ETHOXYLATES	5	3	3	45
ALKYL POLYGLUCOSIDE	5	3	3	45
2,2-DICHLOROPROPIONIC ACID	7	2	3	42
ALKYLTOLUENESULFONIC ACID	7	2	3	42
CRESOLS	7	2	3	42
DIBUTYL HYDROGEN PHOSPHONATE	7	3	2	42
DIMETHYLFORMAMIDE	2	7	3	42
HEPTYL ACETATE	2	7	3	42
ISOBUTYRIC ACID	7	2	3	42
MALEIC ANHYDRIDE	7	2	3	42
PHENOL	7	2	3	42
POLYFERRIC SULPHATE SOLN	7	2	3	42
SODIUM SULPHIDE	7	3	2	42
XYLENOLS	7	2	3	42
2,4,4-TRIMETHYL HEXAMETHYLEN DIAMINE	5	4	2	40
ACETONITRILE	2	5	4	40
BUTYL ACETATE	2	5	4	40
ETHYL PROPIONATE	2	5	4	40
ETHYLENE GLYCOL MONOACETATE	5	2	4	40
GLYOXAL	4	5	2	40
ISOPROPYLAMINE	4	5	2	40
METHYL BUTYRATE	2	5	4	40
METHYL NAPHTHALENES	2	4	5	40
PROPYLENE CARBONATE	5	2	4	40
TETRAHYDRONAPTAHLENE	2	4	5	40
2-CHLOROPROPIONIC ACID	6	2	3	36
3-METHYL 1-BUTANOL	2	6	3	36
ACETIC ANHYDRIDE	6	2	3	36
DICHLORODIETHYL ETHER	6	2	3	36

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
DIMETHYLETHANOLAMINE	6	2	3	36
ETHYL BUTYRATE	2	6	3	36
ETHYLENE CHLOROHYDRIN	6	2	3	36
ETHYLENE GLYCOL MONOALKYL ETHERS	2	6	3	36
GLYCOLIC ACID	6	2	3	36
HYDROGEN PEROXIDE	6	2	3	36
2-ETHYL-3-PROPYL ACROLEIN	4	4	2	32
3-CHLOROPROPYLENE	4	8	1	32
ADIPONITRILE	4	2	4	32
DECYL ACRYLATE	2	4	4	32
DIMETHYL GLUTARATE	4	2	4	32
DITRIDECYL ADIPATE	2	4	4	32
DODECYL BENZENE	2	4	4	32
HEXAMETHYLENE DIISOCYANATE	8	2	2	32
ISONONANOL	2	4	4	32
LACTONITRILE SOLUTION	4	2	4	32
LAURIC ACID	2	4	4	32
N-ETHYL-3-PROPYL ACROLEIN	4	4	2	32
PALM NUT OIL	2	4	4	32
PROPIONITRILE	4	2	4	32
VINYL TOLUENE	2	4	4	32
1-PENTANOL	5	3	2	30
ALUMINIUM SULPHATE SOLUTIONS	5	2	3	30
DODECYL DIPHENYL OXIDEDISULPHONATE SOLUTIONS	5	2	3	30
DODECYL PHENOL	5	2	3	30
FERRIC CHLORIDE	5	2	3	30
LACTIC ACID	5	2	3	30
METHYL PROPYL KETONE	2	5	3	30
PROPIONIC ANHYDRIDE	5	2	3	30
TERT-AMYL METHYL ETHER	2	5	3	30
VINYL ACETATE	2	5	3	30
DIETHYLENE TRIAMINE	7	2	2	28
DODECYLAMINE	7	4	1	28

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
ETHANOLAMINE	7	1	4	28
FERRIC NITRATE	7	2	2	28
HEXAMETHYL DIAMINE	7	2	2	28
HEXAMETHYLENEDIAMINE	7	2	2	28
ISOOCTYLAMINE	7	4	1	28
POTASSIUM HYDROXIDE	7	2	2	28
TETRAETHYLENE PENTAMINE	7	2	2	28
TRIETHYL PHOSPHITE	2	7	2	28
TRIETHYLENETETRAMINE	7	2	2	28
WHITE SPIRIT	2	7	2	28
1-HEPTANOL	2	4	3	24
1-NITROPROPANE	2	6	2	24
1-OCTANOL	2	4	3	24
1-UNDECANOL	2	4	3	24
2-METHYLPYRIDINE	4	2	3	24
ALKARYL POLYETHER	2	4	3	24
ALKENYL SUCCINIC ANHYDRIDE	2	4	3	24
BUTYRIC ACID	4	2	3	24
CASHEW NUT SHELL OIL	2	4	3	24
DECANOIC ACID	2	4	3	24
DI-(2-ETHYLHEXYL)PHOSPHORIC ACID	2	4	3	24
DIETHYLETHANOLAMINE	4	2	3	24
DIISOBUTYL KETONE	2	4	3	24
DIISOPROPYL BENZENE	2	4	3	24
DODECYL DIMETHYLAMINE	2	4	3	24
ETHYL DIBROMIDE	6	2	2	24
ETHYLENE VINYL ACETATE AND COPOLYMER	2	4	3	24
FATTY ACID METHYL ESTERS	2	4	3	24
HEXAMETHYLENEIMINE	2	6	2	24
HYDROCARBON WAXES	2	4	3	24
ISONONYLALDEHYDE	2	4	3	24
ISO-OCTANOL	2	4	3	24
ISOPHORONE	4	3	2	24

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
ISOPROPANOLAMINE	4	2	3	24
LINEAR ALKYL PROPOXYAMINE ETHOXYLATE	2	4	3	24
LONG CHAIN ALAKRYL POLYETHER	2	4	3	24
METHACRYLIC ACID	6	2	2	24
MORPHOLINE	6	2	2	24
N,N-BIS(2-HYDROXYETHYL)OLEAMIDE	2	4	3	24
NEODECANOIC ACID	2	4	3	24
ROSIN	2	4	3	24
TRIETHYLAMINE	4	2	3	24
UNDECANOIC ACID	2	4	3	24
2-2(AMINOETHOXY) ETHANOL	7	1	3	21
EPICHLORHYDRIN	7	1	3	21
POLYOXYPROPYLENE DIAMINE	7	1	3	21
AMMONIUM SULPHIDE	2	5	2	20
BUTYLAMINE	2	5	2	20
BUTYRALDEHYDE	4	5	1	20
ETHYLENE GLYCOL MONOACETATE	5	1	4	20
GLYOXYLIC ACID	5	2	2	20
METHYL ACRYLATE	4	5	1	20
METHYL FORMATE	2	5	2	20
NAPTHALENE	4	1	5	20
N-METHYLGLUCAMINE	5	2	2	20
NONANOIC ACID	5	4	1	20
SODIUM PERBORATE	5	4	1	20
1,6-HEXANEDIOL	2	3	3	18
2-PENTANOL	2	3	3	18
ALKYL PROPOXYAMINE ETHOXYLATES	3	2	3	18
AMINOETHANOLETHANOLAMINE	3	2	3	18
DIETHYL SULPHATE	3	2	3	18
ETHYL AMYL KETONE	2	3	3	18
FORMIC ACID	6	1	3	18

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
FURFURAL	3	2	3	18
SODIUM CARBONATE	3	2	3	18
TRIMETHYL ACETIC ACID	2	3	3	18
1, 5-PENTANEDIAL SOLUTION	8	1	2	16
2,4-TOLYLENEDIAMINE	4	2	2	16
2,6-DIETHYLANILINE	2	4	2	16
2-ETHYLHEXANOIC ACID	2	4	2	16
AMMONIUM NITRATE SOLUTIONS	2	2	4	16
CALCIUM HYPOCHLORITE SOLUTIONS	4	2	2	16
CAPROLACTAM	4	2	2	16
CROTONALDEHYDE	4	2	2	16
DIETHYL BENZENE	2	4	2	16
DIPENTENE	2	4	2	16
DIPHENYL METHANE-4,4'-DIISOCYANATE	4	1	4	16
ETHYLENE DIBROMIDE	4	2	2	16
ISOPHORONE DIISOCYANATE	8	1	2	16
METHACRYLONITRILE	4	1	4	16
METHYLENE DI-ISOCYANATE	4	1	4	16
MOLYBDENUM POLYSULFIDE LONG CHAIN ALKYL DITHIOCARBAMIDE	2	4	2	16
MONONITROBENZENE	2	2	4	16
OLEIC ACID	2	4	2	16
TOLUENE DIAMINE	4	2	2	16
TOLUENE DIISOCYANATE	8	1	2	16
2-HYDROXY-4-METHYL THIO BUTANOIC ACID	5	1	3	15
CARBOLIC ACID - phenol	5	1	3	15
PHTHALIC ANHYDRIDE	5	1	3	15
2, 4 DICHLOROPHENOL	7	1	2	14
5-ETHYLIDENE-2-NORBORNENE	2	7	1	14
ALPHA-OLEFINS	2	7	1	14

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
ETHOXYLATED LONG CHAIN ALKYLOXYALKANAMINE	7	1	2	14
N-AMINOETHYLPIPERAZINE	7	2	1	14
OLEFIN MIXTURES	2	7	1	14
PROPIONIC ACID	7	2	1	14
1,2,3 TRICHLOROPROPANE	3	2	2	12
2-METHYL -2-BUTANOL	2	2	3	12
3-METHYL-3-METHOXY BUTANOL	2	2	3	12
ACETIC ACID	2	2	3	12
ACRYLAMIDE	2	2	3	12
ALKYLATED PHENOLS	2	2	3	12
ALLYL ALCOHOL	6	2	1	12
BENZENE TRICARBOXYLIC ACID	2	2	3	12
BENZYL ACETATE	2	2	3	12
BUTANOL	2	2	3	12
CHLOROHYDRINS	2	2	3	12
CITRIC ACID	2	2	3	12
DI(2-CHLORO-ISO-PROPYL) ETHER	2	2	3	12
DIACETONE ALCOHOL	2	2	3	12
DIETHYLENE GLYCOL	4	1	3	12
DIETHYLENE GLYCOL DIETHYLENE ETHER	2	2	3	12
DIETHYLSULPHATE	2	2	3	12
DIMETHYL ACETAMIDE	2	2	3	12
DIPHENYLOL PROPANE-EPICHLORHYDRIN RESINS	2	2	3	12
ETHYL TERT –BUTYL ETHER	2	2	3	12
ETHYLENE CARBONATE	2	2	3	12
ETHYLENE DIAMINE	2	2	3	12
ETHYLENE GLYCOL METHYL ETHER ACETATE	2	2	3	12
GLUCITOL	2	2	3	12
GLYCEROL PROPOXYLATED	2	2	3	12
HEXYLENE GLYCOL	2	2	3	12
MESITYL OXIDE	2	6	1	12

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
METHYL ACETOACETATE	2	2	3	12
N-METHYL ANILINE	2	3	2	12
N-METHYL PYRROLIDONE	2	2	3	12
N-METHYLDIETHANOLAMINE	2	2	3	12
NONYL (C6-C12) PHENOL POLY(4-12) ETHOXYLATE	2	2	3	12
PARALDEHYDE	2	2	3	12
POLYISOBUTENAMINE	2	2	3	12
POLYOLEFINAMINE	2	2	3	12
PROPYLAMINE GLYCOL MONOALKYL ETHER	2	2	3	12
SODIUM DICHROMATE	6	2	1	12
UREA/AMMONIUM NITRATE SOLUTION	2	2	3	12
2,4 –DICHLOROPHENOXYACETIC ACID	5	1	2	10
ALKYL ACRYLATE	2	5	1	10
BENZENE SULPHONYL CHLORIDE	5	1	2	10
DICHLOROPHENOL	5	1	2	10
ETHYL ACRYLATE	2	5	1	10
GLYPHOSATE	5	2	1	10
POLY-CYCLIC AROMATICS	2	1	5	10
1,2 DICHLOROPROPANE	2	2	2	8
1,2-BUTYLENE OXIDE	2	2	2	8
2-METHYL-6-ETHYLANILINE	2	2	2	8
3-(METHYLTHIO) PROPIONALDEHYDE	4	2	1	8
ALKYL BENZENE SULPHONATES	2	2	2	8
AMMONIUM CHLORIDE SOLUTION	2	2	2	8
BARIUM ALKARYL SULPHATE	2	2	2	8
BENZYL ALCOHOL	2	2	2	8
BETA-PROPIOLACTONE	8	1	1	8
DICHLOROPROPANE	2	2	2	8
DIETHANOLAMINE	2	2	2	8
DIMETHYL ADIPATE	2	1	4	8
DIPHENYL	2	1	4	8

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
DODECYL DIPHENYL OXIDE	2	2	2	8
EPTC	2	4	1	8
MAGNESIUM LONG CHAIN ALKARYL SULPHONATE	2	2	2	8
METAM-SODIUM	2	2	2	8
METHYL BUTENOL	2	4	1	8
METHYL SALICYLATE	2	2	2	8
NITROETHANE	2	2	2	8
POTASSIUM FORMATE	2	2	2	8
PROPIOLACTONE	8	1	1	8
TETRA-ETHYL LEAD	4	1	2	8
TOLUIDINES	2	2	2	8
1,2 DICHLOROETHANE	2	1	3	6
BENZYL CHLORIDE	3	1	2	6
CREOSOTE	2	1	3	6
DIMETHYL DISULPHIDE	2	1	3	6
DIMETHYL SULPHIDE	2	1	3	6
ETHYLENE GLYCOL PHENYL ETHER	2	1	3	6
FURFURYL ALCOHOL	3	2	1	6
METHYLBUTYNOL	3	2	1	6
TRIXYLENYL PHOSPHATE	2	1	3	6
ALACHLOR	4	1	1	4
BISPHENOL A	2	1	2	4
BISPHENOL A AND F	2	1	2	4
CHLORINATED PARAFFINS	2	1	2	4
CHLOROBENZENE	2	1	2	4
NITROTOLUENES	2	1	2	4
P-NITROTOLUENE	2	1	2	4
SHALE OIL	2	1	2	4
TOLYL TRIAZOLE	2	1	2	4
TRICHLOROBENZENES & ETHANES	2	1	2	4
3,4-DICHLOROBUT-1-ENE	2	1	1	2
DITHIOPHOSPHATE SALTS	2	1	1	2
1,3,5 TRIOXANE	0	1	2	0
2-ETHOXYETHANOL	0		3	0
2-ETHOXYETHYL ACETATE	0		3	0

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk (Product)
ALPHA-METHYLBENZYL ALCOHOL WITH ACETOPHENONE	0		2	0
BENZENE	0		4	0
BUTYL BENZYL PTHALALTE	0		3	0
BUTYROLALCTONE	0		1	0
COAL TAR NAPTHALENE	0		5	0
COAL TARS	0		5	0
COBALT NAPTHENATE	0		2	0
CYCLOHEXANONE	0		3	0
DIALKYLTHALATES	0		3	0
DICHLOROBENZENE	0		2	0
DICHLOROMETHANE	0		2	0
DICHLOROPANE	0		1	0
DIMETHYL GLUTAMATE	0		3	0
DI-N-BUTYL PTHALATE	0		3	0
DINITROTOLUENE	0		2	0
DI-N-PROPYL PTHALATE	0		3	0
DIPHENYLAMINE	0		2	0
ETHYL BENZENE	0		4	0
ETHYLENE GLYCOL	0		4	0
ISOPRENE	0		2	0
METHACRYLIC RESIN	0		2	0
METHYL BUTYL KETONE	0		3	0
METHYLBUTYNYL	0		1	0
NITRILOACETIC ACID	0		3	0
PENTACHLOROETHANE	0		2	0
PERCHLOROETHYLENE	0		2	0
TETRACHLOROMETHANE	0		1	0
TOLUENE	0		4	0

APPENDIX 3:
Extract from
Risk Prioritisation Tables

Extract from Behaviour Spreadsheet

CHEMICAL NAME	Behaviour Category	Behaviour score
PHOSGENE	GAS	10
ETHYLENE OXIDE	GAS	10
CHLORINE GAS	GAS	10
VINYL CHLORIDE	GAS	10
FORMALDEHYDE	GAS-DISSOLVER	9
METHYL AMINE SOLN	GAS-DISSOLVER	9
HYDROFLUORIC ACID	GAS-DISSOLVER	9
DIMETHYLAMINE	GAS-DISSOLVER	9
TRIMETHYLAMAINE	GAS-DISSOLVER	9
AMMONIA	GAS-DISSOLVER	9
METHYLAMINE ACID	GAS-DISSOLVER	9
ETHYLAMINE and its solutions	GAS-DISSOLVER	9
2-(2-AMINOETHOXY) ETHANOL	EVAPORATOR	8
1,3 DICHLOROPROPENE	EVAPORATOR	8
3-CHLOROPROPYLENE	EVAPORATOR	8
1,3-CYCLOPENTADIENE	EVAPORATOR	8
PYROLOYSIS GASOLINES	EVAPORATOR	8
2-METHYL PENTANE	EVAPORATOR	8
ISO-OCTYLENE	EVAPORATOR	8
BENZENE	EVAPORATOR	8
TOLUENE	EVAPORATOR	8
ETHYL BENZENE	EVAPORATOR	8
ISOPRENE	EVAPORATOR	8
PYRIDINE	EVAPORATOR-FLOATER	7
ALKYL BENZENE MIXTURES (Xylenes)	EVAPORATOR-FLOATER	7
5-ETHYLIDENE-2-NORBORNENE	EVAPORATOR-FLOATER	7
ALPHA-OLEFINS	EVAPORATOR-FLOATER	7
HEPTYL ACETATE	EVAPORATOR-FLOATER	7
METHYLCYCLOPENTADIENE	EVAPORATOR-FLOATER	7
OLEFIN MIXTURES	EVAPORATOR-FLOATER	7
POLYALKYL ACRYLATE IN XYLENE	EVAPORATOR-FLOATER	7
TRIETHYL PHOSPHITE	EVAPORATOR-FLOATER	7
WHITE SPIRIT	EVAPORATOR-FLOATER	7
CYCLOHEXYLAMINE	EVAPORATOR-FLOATER	7
OLEYLAMINE	EVAPORATOR-FLOATER	7

Extract From Toxicity Table

CHEMICAL NAME	INHALATIONAL TOXICITY,C3 L2-4	EYE IRRITATION D2,3	IRRITATION AND CORROSION D1,3	D3 CMR	TOTAL
BETA-PROPIOLACTONE	4	2	2	Y	8
PROPIOLACTONE	4	2	2	Y	8
SULPHURIC ACID	4	2	2	Y	8
TOLUENE DIISOCYANATE	4	2	2	Y	8
1, 5-PENTANEDIAL SOLUTION	4	2	2		8
CARBON DISULPHIDE	4	2	2		8
CHLOROACETIC ACID	4	2	2		8
FLUOROSILICIC ACID	4	2	2		8
HEXAMETHYLENE DIISOCYANATE	4	2	2		8
ISOPHORONE DIISOCYANATE	4	2	2		8
NITRIC ACID	4	2	2		8
PHOSGENE (Non GESAMP)	4	2	2		8
EPICHLORHYDRIN	3	2	2	Y	7
ETHYLENE OXIDE	3	2	2	Y	7
FORMALDEHYDE	3	2	2	Y	7
HEXAMETHYL DIAMINE	3	2	2	Y	7
2-(2-AMINOETHOXY) ETHANOL	3	2	2		7
2, 4 DICHLOROPHENOL	3	2	2		7
2,2-DICHLOROPROPIONIC ACID	3	2	2		7
2-2(AMINOETHOXY) ETHANOL	3	2	2		7
2-AMINO-2-METHYL-1-PROPANOL	3	2	2		7
2-METHYL-5-ETHYLPYRIDINE	3	2	2		7
ALKYLTOLUENESULFONIC ACID	3	2	2		7
CRESOLS	3	2	2		7
CYCLOHEXYLAMINE	3	2	2		7
DIBUTYL HYDROGEN PHOSPHONATE	3	2	2		7
DIETHYLAMINE	3	2	2		7
DIETHYLENE TRIAMINE	3	2	2		7
DI-N-BUTYLAMINE	3	2	2		7
DODECYLAMINE	3	2	2		7
ETHANOLAMINE	3	2	2		7
ETHOXYLATED LONG CHAIN ALKYLOXYALKANAMINE	3	2	2		7
ETHYLENE GLYCOL ACRYLATE	3	2	2		7
FATTY ACIDS, SATURATED	3	2	2		7

Extract From Severity Table

CHEMICAL NAME	Toxicity	Behaviour score	Severity
PHOSGENE	8	10	80
ETHYLENE OXIDE	7	10	70
CHLORINE GAS	7	10	70
FORMALDEHYDE	7	9	63
METHYL AMINE SOLN	7	9	63
2-(2-AMINOETHOXY) ETHANOL	7	8	56
HYDROFLUORIC ACID	6	9	54
DIMETHYLAMINE	6	9	54
TRIMETHYLAMAINE	6	9	54
CYCLOHEXYLAMINE	7	7	49
OLEYLAMINE	7	7	49
2-AMINO-2-METHYL-1-PROPANOL	7	7	49
1,3 DICHLOROPROPENE	6	8	48
AMMONIA	5	9	45
DI-N-BUTYLAMINE	7	6	42
3-METHYL PYRIDINE	6	7	42
VINYL CHLORIDE	4	10	40
CARBON DISULPHIDE	8	5	40
METHYLAMINE ACID	4	9	36
ETHYLAMINE	4	9	36
DIISOBUTYLAMINE	6	6	36
DI-N-PROPYLAMINE	6	6	36
DIETHYLAMINE	7	5	35
HYDROCHLORIC ACID	7	5	35
PROPYLAMINE	7	5	35
ZINC BROMIDE	7	5	35
ZINC CHLORIDE	7	5	35
ALUMINIUM CHLORIDE	7	5	35
3-CHLOROPROPYLENE	4	8	32
DIISOPROPYLAMINE	6	5	30
N-ETHYL BUTYLAMINE	6	5	30

Extract From Likelihood Table

		Likelihood Score (UK and EU Data)	
CHEMICAL NAME	Annual Tonnage (UK 2007)*	UK**	EU (HASREP)
1,2 DICHLOROETHANE	26,000	3	4
1,3-CYCLOPENTADIENE	NA		4
2-ETHYLHEXANOIC ACID	NA		3
2-METHYL PENTANE	NA		3
ACETIC ACID	50,000	3	4
ACETONE CYANOHYDRIN	NA		3
ACRYLONITRILE	160,000	4	4
ADIPONITRILE	NA		4
ALKYL BENZENE MIXTURES	As Toluene & ethyl benzene	4	4
ALLYL ALCOHOLS	<1000	1	
AMMONIA	350,000	4	5
ANILINE	300,000	4	4
BENZENE	300,000	4	5
BUTANOL	20,000	3	4
BUTYL ACETATE	NA		3
BUTYLAMINE	<10,000	2	
CARBON DISULPHIDE	3,000	2	
CHLORINE GAS	<1000***	4	
CHLOROACETIC ACID	40,000	3	

Table Continued - Tonnage Scores for all GESAMP List

CHEMICAL NAME	Tonnage Score
2-(2-AMINOETHOXY) ETHANOL	3
2-AMINO-2-METHYL-1-PROPANOL	3
1,3 DICHLOROPROPENE	1
3-METHYL PYRIDINE	3
DI-N-BUTYLAMINE	2
3-CHLOROPROPYLENE	1
NONYL PHENOL	3
OCTANOIC ACID	3
PYRIDINE BASES	3
VINYL NEODECANOATE	3
DODECYLAMINE	2
ISOOCTYLAMINE	2
N,N-DIMETHYLDODECYLAMINE	2
ETHYLENE GLYCOL ACRYLATE	4
HEPTANOIC ACID	3