

THE UK APPROACH TO LAND USE PLANNING IN THE VICINITY OF CHEMICAL MAJOR HAZARD INSTALLATIONS

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1. BACKGROUND

In the UK arrangements have existed since 1972 for local planning authorities (PAs) to obtain advice from the HSE about the safety implications for developments from risks associated with chemical major hazards.

The HSE's approach to advice originates from a strategy described in the recommendations of the UK Advisory Committee on Major Hazards (ACMH, 1976-84), set up by the Health and Safety Commission in 1974 in the aftermath of the Flixborough chemical disaster, namely:

- identification - establishing where major hazards exist;
- prevention and control - reducing the risk of a major accident using controls on-site; and,
- mitigation - reducing the impact of a major accident, if one should occur, through emergency planning and land use planning control.

Land-use planning is an important element of that strategy because even on a properly regulated site, risk cannot be eliminated i.e. there is always a residual risk, even if it is a very small one.

Following the UK Flixborough disaster in 1974, the Advisory Committee on Major Hazards in its second report (Para 109, (ACMH, 1976-84)) stated: 'The overall objective should always be to reduce the number of people at risk' and in its third report (Para 80, (ACMH, 1976-84)) said 'it is wise to avoid a substantial growth in population near an existing installation'.

This is now taken into account throughout the EU in Article 12 of the EC Seveso II Directive (EC, 1996) which requires that 'Member States shall ensure that the objectives of preventing major accidents and limiting the consequences of such accidents are taken into account in the land use planning...'¹

¹ Member States shall ensure that the objectives of preventing major accidents and limiting the consequences of such accidents are taken into account in their land use policies and/or other relevant policies. They shall pursue those objectives through controls on:

- the siting of new establishments,
- modifications to existing establishments covered by Article 10
- new developments such as transport links, locations frequented by the public and residential areas in the vicinity of existing establishments, where the siting or developments are such as to increase the risk or consequences of a major accident.

Member States shall ensure that their land use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, buildings and areas of public use, major transport routes as far as possible, recreational areas and areas of particular natural sensitivity or interest... so as not to increase the risks to people.

The Health and Safety Executive (HSE) advises Planning Authorities (PAs) on applications for development in the vicinity of major hazard sites and major accident hazard pipelines. HSE also advises PAs on applications for Hazardous Substances Consent to create a new major hazard site, or for Consent to modify an existing major hazard site. HSE is also consulted on the routing of new major accident hazard pipelines.

To improve the service to local Planning Authorities and to increase the transparency of the HSE's advice, a policy decision was taken to codify the process and experience obtained over 30 years whilst continuing the HSE's policy of giving clear advice for or against a proposed development.

Following this decision, the previous scheme has been replaced with a new scheme known as PADHI + (Planning Advice for Developments near Hazardous Installations (1)). This has now been provided to PAs as a computer programme which they can use themselves to obtain advice. The codified scheme does not represent the true situation of a gradual change in risk with distance but is a pragmatic way to generate timely advice: it is intended to give broadly similar decisions to the previous system that are consistent across the UK and allows a more effective use of the HSE resources. Thus the scheme may be seen as a development of the previous system rather than a replacement.

It must be stressed that, in this context, HSE's role is purely advisory. It is for the PA to weigh all of the different factors in the balance and decide whether or not permission should be granted. However HSE has the right of appeal to a Government Minister if it believes sufficient weight has not been given to the safety aspects.

This advisory function is distinct from HSE's role as a regulator of major hazard sites.

2. HSE'S APPROACH TO RISK ASSESSMENT

Residual risk

HSE's advice is based on an assessment of the residual risks to people presented by the major hazard site. Residual risk is the risk that remains after the site operator has done all that they need to do to comply with the law (noting that the law does not require the risks to be zero). The residual risk concept also recognises that a lapse in vigilance at a site that normally complies with the law can lead to an accident.

Essentially the assessment of risk comprises two components:

An estimation of the outcome, including consideration of the types of accident events which could take place at a major hazard, the scale of these accidents and how far away their impacts could be felt. This is termed an estimation of the scale of the consequences.

An estimation of how likely it is that these events will take place, and therefore how likely it is that certain consequences could be experienced around the major hazard. This is termed an estimation of the frequency (since the likelihood is usually expressed as a frequency) and may be either qualitative or quantitative in nature.

HSE's assessment of the risk may be either protection based or risk based, depending on the specific features of the major hazard site under consideration (and particularly on the nature of the dangerous substances present).

The protection based approach relies upon a consequence based assessment, where only the potential effects of selected accidents are quantified. The likelihood of particular accident events happening is considered in a qualitative way. This approach is used for the majority of major hazard sites storing or handling flammable substances especially liquefied petroleum gas (LPG).

The risk based approach involves quantification of both accident consequences and frequencies, enabling numerical estimates of risk to be calculated. This method is known as quantified risk assessment (QRA). For major hazards where the dangerous substances present are toxic (e.g. chlorine or ammonia), and for some hazards arising from flammable materials (e.g. flash fires resulting from accidental releases of liquefied natural gas), HSE's advice is based on risk, using QRA.

The estimates of risk produced by a risk assessment, like any prediction, are subject to uncertainty and it is important that this is recognised when establishing the criteria used for giving advice.

3. HARM CRITERION

It has often been assumed that risk criteria for major hazards should relate to the likelihood of death. This seems straightforward and easy to compare with risks from other hazards in life. However there are two important problems with a criterion based on the risk of death in the present context:

- (a) society is concerned about risks of serious injury or other damage as well as death;
- (b) there are technical difficulties in calculating the risks of death from a hazard to which individual members of a population may have widely differing vulnerabilities using an injury criterion other than death.

It is possible to avoid some of these problems by using an injury criterion other than death. For example, it is possible to define a dose of toxic gas, or heat, or explosion overpressure which gives all the following effects:

- Severe distress to almost everyone;
- A substantial fraction requires medical attention;

- Some people are seriously injured, requiring prolonged treatment;
- any highly susceptible people might be killed.

HSE describes this as a 'dangerous' dose because it has the potential to cause death but it will not necessarily do so. Then the risk assessed is that an individual at a particular place will be exposed to such a dangerous dose or worse. For more information on this see ref (9).

4. RISK CRITERIA AND INDIVIDUAL RISK

HSE's Reducing Risks, Protecting People⁽²⁾ document indicates that an individual risk of death of less than 1 in a million per year would be regarded as broadly acceptable, for the purposes of judging if the risks from an existing major hazard site to an existing population are acceptable. For the purpose of giving land use planning advice HSE uses the figure of 1 in a million per year for the lower bound, but in relation to the risk of receiving a 'dangerous' dose or worse, for a typical pattern of user behaviour in a development.

For developments where there would clearly be a high proportion of highly susceptible people, a more stringent criterion is judged to be appropriate. HSE considers that a level of 1/3 in a million per year of a dangerous dose or worse would be trivial even for such cases as homes for the elderly, caring institutions, long-stay hospitals etc. This provides a lower bound, below which advice on land use planning on the basis of individual risk is not warranted.

In terms of an upper limit, the Reducing Risks, Protecting People document indicates that, where members of the public have a risk imposed upon them, then an individual risk of death in excess of 100 in a million per year would be considered unacceptable. This criterion would apply when considering the risk presented by an existing major hazard site to the existing surrounding population, and whether HSE should take enforcement action against the operator of the site to ensure that the risk is reduced. However, in the context of a proposal to introduce additional population into the vicinity of an existing major hazard site, HSE considers that a more stringent criterion is appropriate. Hence HSE uses an upper limit of 10 in a million per year of a dangerous dose or worse, depending on development size and type.

5. LAND USE PLANNING ZONES

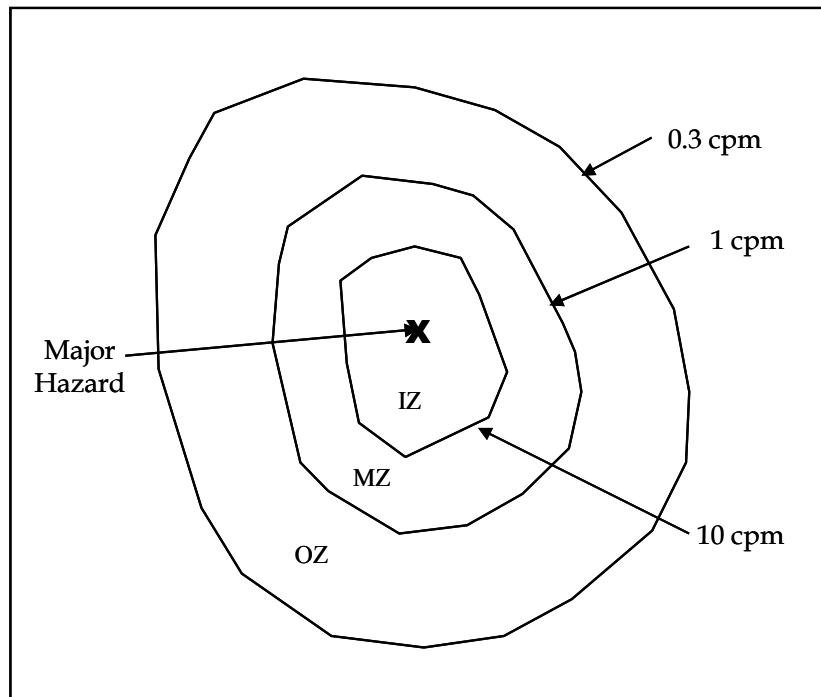
For the purposes of delivering land use planning advice, HSE defines a Consultation Distance, within which are usually three zones (Inner, Middle and Outer) around the major hazard. When using a risk-based approach, the zone boundaries correspond to levels of individual risk of dangerous dose or worse, as follows:

- Inner Zone (IZ): 10 chances per million per year (cpm) or greater individual risk of dangerous dose or worse;

- Middle Zone (MZ): Between 10 cpm and 1 cpm individual risk of dangerous dose or worse;
- Outer Zone (OZ): Between 1 cpm and 0.3 cpm individual risk of dangerous dose or worse.

Individual risk results are commonly presented as a set of contours drawn on a map, where the contours join together points at which the individual risk is the same.

Fig 1 - Example Individual Risk Contours



6. ZONES FOR PROTECTION BASED ASSESSMENTS

The numerical risk criteria can only be applied where a QRA is undertaken. For protection based assessment of fire and explosion hazards HSE has developed a set of criteria which relate to the nature of the hazard presented under various different accident scenarios. These criteria define zones within which the following levels of harm are experienced.

Inner Zone (IZ): exposure to the effects of a major accident would lead to a significant proportion of the population being fatally injured.

Middle Zone (MZ): exposure to the effects of a major accident would lead to a very low proportion (a few %) of a normal population being fatally injured.

Outer Zone (OZ): exposure to the effects of a major accident would lead to a very low proportion (a few %) of a vulnerable population being fatally injured.

Vulnerable populations would include the elderly and the sick (e.g. hospital patients).

7. PROPOSALS FOR DEVELOPMENT IN THE VICINITY OF EXISTING MAJOR HAZARD SITES

Once the details of the development are known and its location within the zones then the PADHI+ software can be used by the PA to generate advice (1). The figure below shows the overall process for provision of HSE's advice to PAs on applications for development in the vicinity of existing major hazard sites.

7.1 PADHI Process

The PADHI+ software (provided to PAs by HSE) receives inputs describing the development and which land use planning zone the development is in, and then generates the appropriate HSE advice. The advice given depends upon the size and nature of the development and the zone in which it is located (IZ, MZ or OZ). The advice generated by PADHI+ is either that HSE 'advises against' or 'does not advise against' the proposed development on the grounds of safety.

The size and nature of the development is taken into account by assigning the proposed development to a Sensitivity Level. Essentially there are four Sensitivity Levels:

Sensitivity Level 1: Based on normal working population;

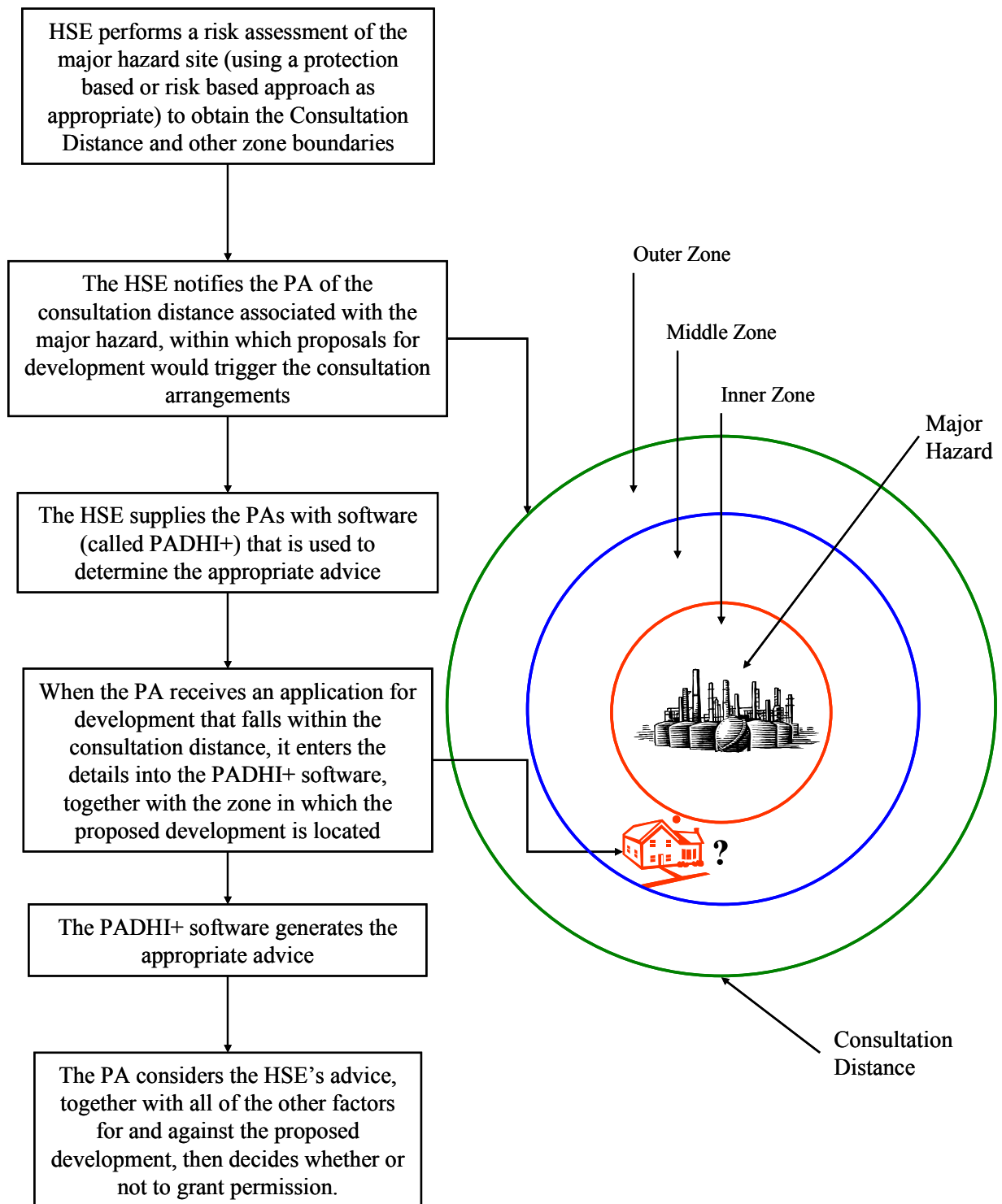
Sensitivity Level 2: Based on the general public – at home and involved in normal activities;

Sensitivity Level 3: Based on sensitive or vulnerable members of the public (e.g. children, those with mobility difficulties, those with certain health conditions or those unable to recognise physical danger);

Sensitivity Level 4: Large examples of Level 3 and large outdoor examples of Level 2.

Within each Sensitivity Level are a number of Development Types, which are used as a direct indicator of the sensitivity of the population at the proposed development. Exceptions are made for some very large or very small developments by assigning them a higher or lower Sensitivity Level than normal for their Development Type. As a general principle the Sensitivity Level is decreased by one for small examples of a type of development, and increased for large and very large examples of a type of development or where particular features of the development increase the risk to the population.

Fig 2 – Overall land use planning process



Within PADHI+, a decision table is used to generate the advice, in conjunction with a set of rules. The decision table is displayed in Table.1

Land Use Planning Advice Decision Table

Sensitivity Level	Development Inner Zone	in Development Middle Zone	in Development Outer Zone
1	DAA	DAA	DAA
2	AA	DAA	DAA
3	AA	AA	DAA
4	AA	AA	AA

Notes:

AA: Advise Against

DAA: Don't Advise Against

It should be noted that, as a result of the accident at Buncefield in December 2005, HSE has introduced particular arrangements for large scale petroleum storage depots which differ from those described above.

Generally speaking this system has worked reasonably well in the UK and for most of the time Planning Authorities have complied with our advice. However the UK is a very crowded island and some problems have started to emerge with giving advice mainly based on individual risk.

8. PROBLEMS WITH THIS APPROACH AND NEW PROPOSALS

The main problem is that planning applications are dealt with on an individual basis and cannot take into account the piecemeal or incremental growth of the total population near to a major hazard site. Eventually, a situation is reached whereby the risks from the MH establishment are no longer reduced as far as is reasonably practicable. (ALARP) and the HSE may then require the operator to implement measures to reduce the risks. This problem arises because the HSE's current system considers each new development proposal on its own merits, with no consideration of the change in overall societal risk from the MH site. (See an illustration of this in Figs 3, 4 and 5)

Another difficulty arises from proposals for new large scale development in the vicinity of MH sites that are beyond the CD but still sufficiently close to be affected by some of the events at the site. Although the individual risk associated with the location is low, the societal risk generated is significant. Furthermore, since the proposed location is beyond the CD, the LA is under no obligation to consult HSE and grants permission for the development.

Fig 3 Low level of Societal Risk

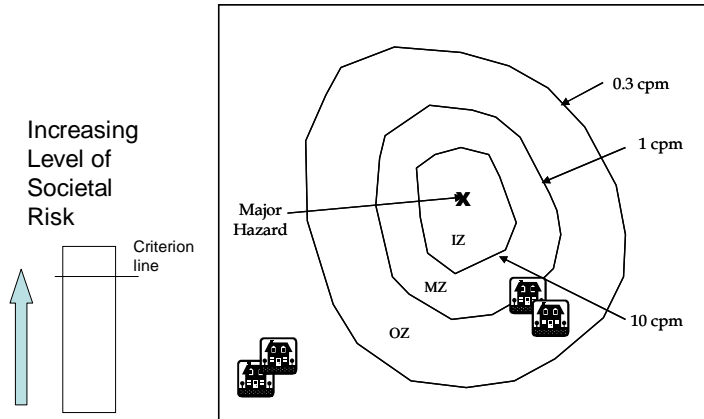


Fig 4 Incremental Development
Increased level of Societal Risk

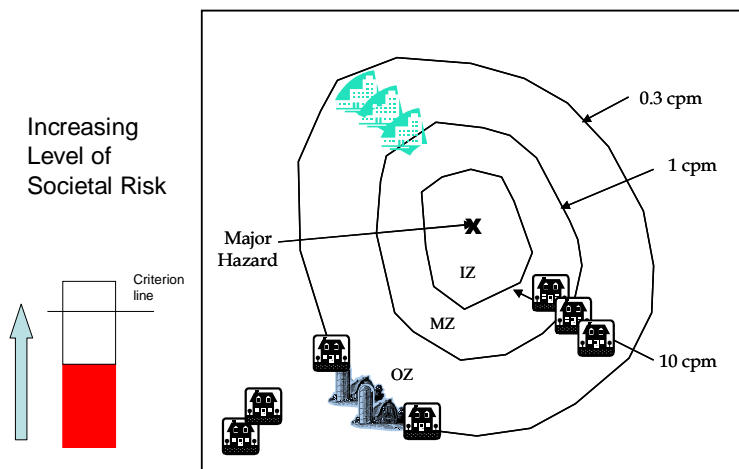
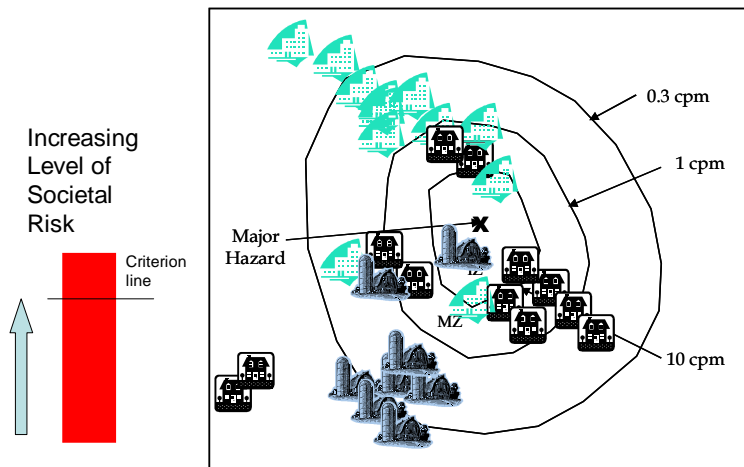


Fig5 Incremental Development
Societal Risk criterion is exceeded



9. DEALING WITH GROWTH IN SOCIETAL RISK

The risks from major hazards are of direct concern to the individual people who might be injured, but they are also of concern to society at large since there is the potential for large-scale disasters. It is generally recognised that these two aspects both require consideration in risk criteria for major hazards.

Individual risk is the likelihood that a particular person might be harmed. For the purpose of this document, the person may be, say, a typical inhabitant of a house at a particular location, or a typical user of a leisure facility at a particular location.

Whilst individual risk is a useful measure, it does not reflect one important feature of major accidents – their potential to affect large numbers of people at once. The societal risk addresses this aspect. Societal risk is usually expressed as the annual chance of harming a certain number of people. In simple terms, societal risk reflects the disaster potential of the major hazard site.

Broadly speaking, there are three types of societal risk:

National Societal Risk: The risk to the nation as a whole from a particular type of activity (e.g. nuclear power, or the transport of dangerous goods).

Local Societal Risk: The risk to a localised population from a particular type of activity (e.g. the risk to the population of a town near a heavily industrialised area where a number of major hazards are present).

Case Societal Risk: The risk at a particular location or from a particular activity (e.g. the risk to persons who would be present at a proposed shopping centre in the vicinity of an existing major hazard, or the risks to an existing population from a proposed major hazard).

The principal means of dealing with **case** societal risk (the societal risk of individual developments) is through the PADHI+ system, where Sensitivity Levels are used to represent increasing scale of the development and vulnerability of the associated population, but this does not deal with **local** societal risk which is the risk of harming a large number of the total population around a site.

For the majority of major hazard sites in the UK, HSE's advice is based principally on an assessment of individual risk, with case societal risk being addressed semi-quantitatively by classifying proposed developments into different Sensitivity Levels. However, there is a small proportion of major hazard sites where it is the view of Government Ministers that the local societal risk has reached a level where it is worthy of explicit consideration alongside individual risk and case societal risk.

In view of this a new approach is being developed which will take into account local societal risk. (3)

10. APPROACH USED FOR SOCIETAL RISK ATTENTION ZONES

Within societal risk attention zones, the principal means of advising PAs on local societal risk is through consultation on the **development plan or local development framework (LDF)**. This advice supplements that given by HSE with respect to individual applications for development.

The process of consultation on the major hazard risk implications of a development plan or framework involves not just the PA and HSE, but also other stakeholders such as emergency planners, the emergency services and the operator of the major hazard site. The objective of this wider involvement is to enable a fuller exploration of all the public safety issues arising from the long-term plans for development in the vicinity of the major hazard site.

The proposal is that when consulted by a PA on a draft development plan or framework that is associated with a societal risk 'attention zone', HSE assesses the level of local societal risk currently arising from the major hazard site(s) affecting the plan area; Assesses the case societal risk associated with the site allocations or development proposals described in the plan / framework; and, assesses the overall change in local societal risk resulting from implementation of the plan / framework.

11. SOCIETAL RISK CRITERIA OR GUIDELINES

An Individual Risk criteria framework is well established in the UK (2) and is widely followed by industry and regulators. Societal Risk considerations are implicit to some degree in existing land use planning advice, but although Societal Risk is used in risk assessment there are, as yet, no widely agreed societal risk criteria. An indicative point is presented in (2) (50 deaths at 200 chances per million (cpm) per year). This was proposed by HSE as a basic criterion for the limit of tolerability, particularly for accidents where there is some choice whether to accept the hazard or not, e.g. the risk of such an event happening from a major chemical site or complex continuing to operate next to a housing estate.

There is a developing industry framework for Societal Risk criteria summarised in (8) and a possible approach could be based on the guidelines shown in Figure 6. It can be seen that these guidelines do not explicitly include scale aversion. This scheme is based on established reference criteria or anchor points, and proposes four guideline bands to use to initially assess the results of societal risk calculations.

Figure 6 Sample Societal Risk Comparison FN Lines

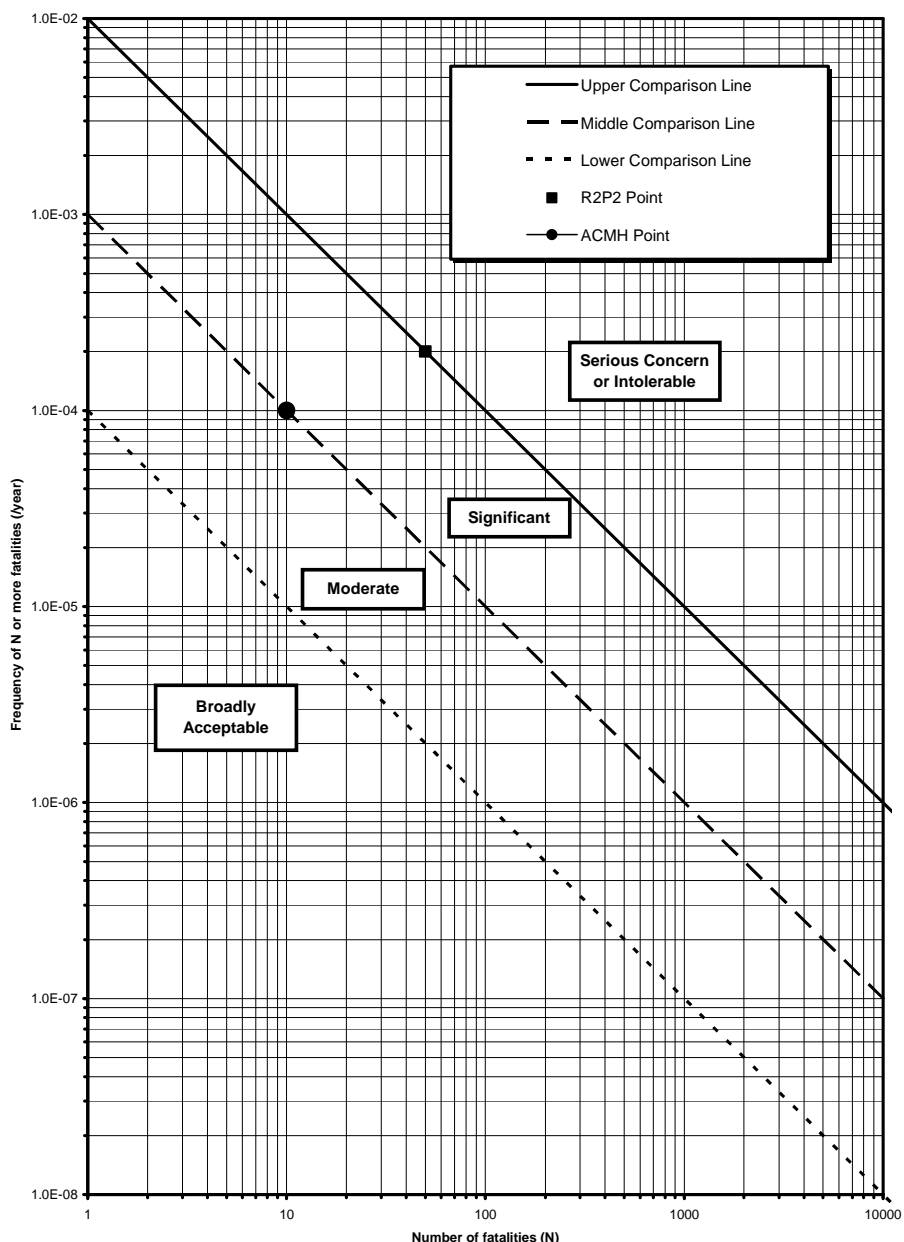


Figure 7 illustrates an FN curve for a sample hazardous installation plotted over the guidelines from Figure 6. Land use planning advice may initially be guided by the position of the FN curve in relation to the comparison lines. If the FN curve was substantially above the upper comparison line this would indicate significant societal risk and a high expectation value or EV (A measure of the potential number of people killed per year from an installation EV), and attract firm negative advice. (EV – Expectation Value is the sum of all the fN pairs for a defined situation. Also referred to as PLL – potential loss of life.)

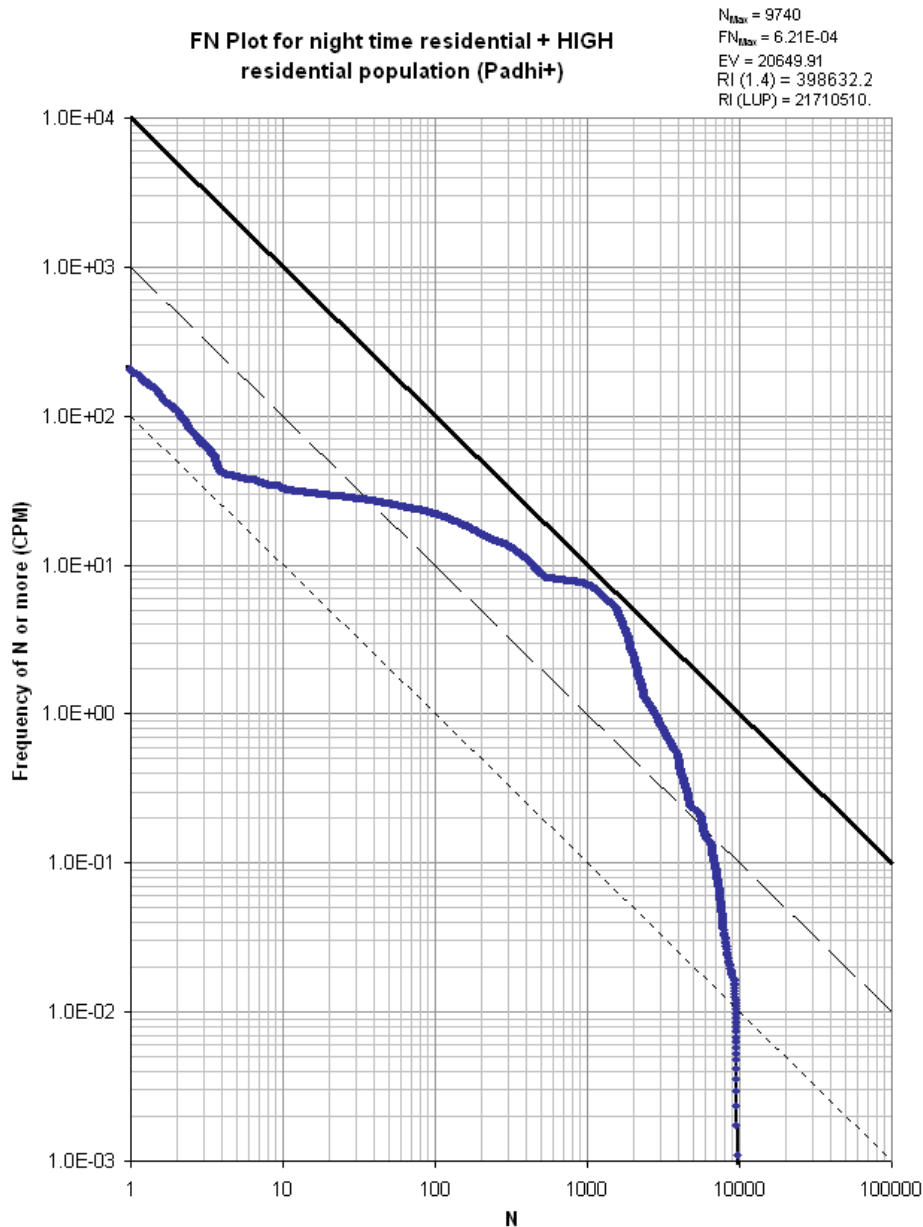


Figure 7 – FN curve for sample major hazard installation

An FN curve also shows the more dominant contributors to the EV, in terms of whether they are high or low frequency or high/low N, or a combination of the two. This could form the basis to review development plan proposals to reduce potential risks.

Figure 8 shows the individual risk contours for an installation, at 10, 1, 0.3 chances per million (cpm) of dangerous dose. These contours form the basis for existing land use planning advice, defining the inner, middle and outer zones. The outer contour defines the existing consultation distance for hazardous installations.

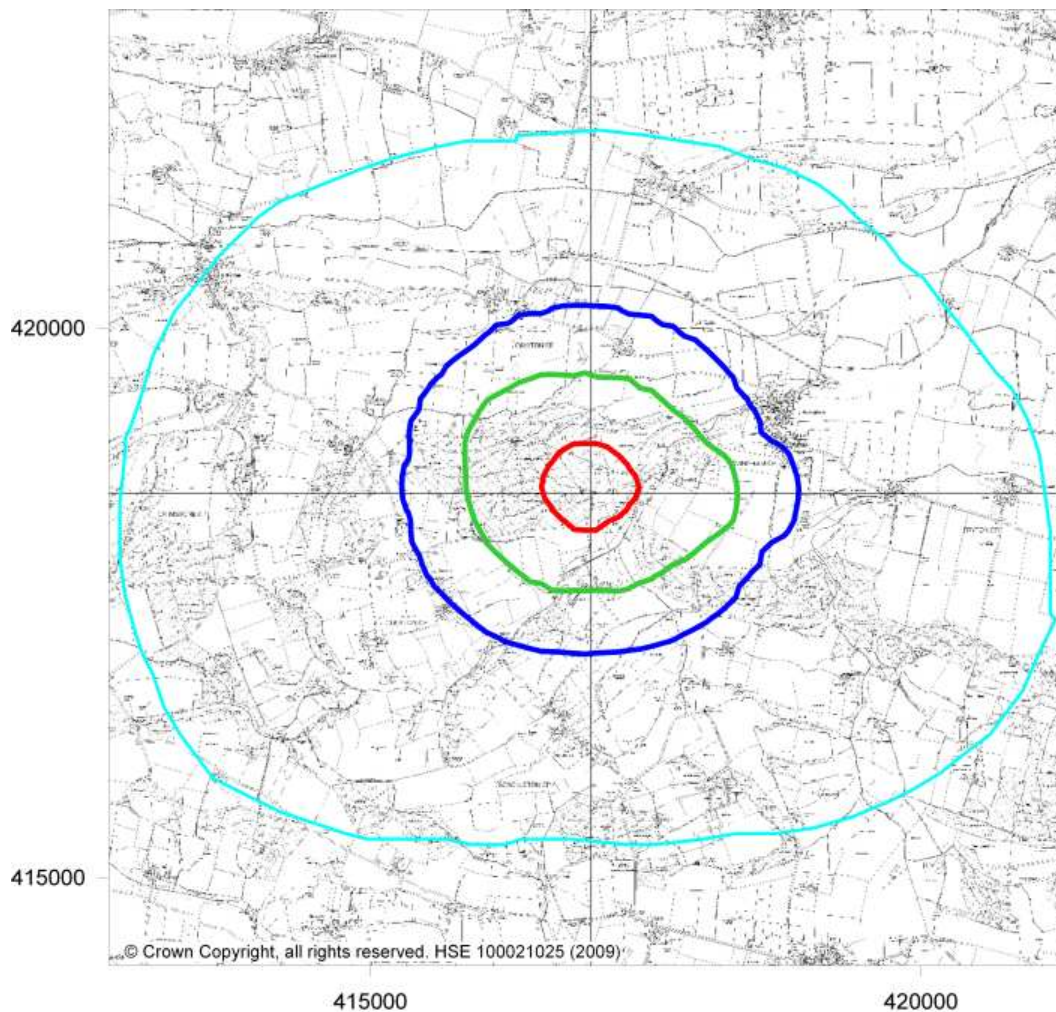


Figure 8 Individual Risk (Total Risk of Death) map

Figure 8 also shows a blue line that is plotted at a distance of twice the consultation distance. This is expected to be the outer boundary for most societal risk planning advice. The basis for this is that outside this distance individual risks are low and the EV from most developments is likely to be a very small proportion of the existing EV. Extremely large developments, located outside the blue line, where very large numbers of people may accumulate cannot be completely ignored, and may have to be included in a screening process.

Map based representations of risk assessment results could be more informative and useful to planners giving an indication of areas more suitable for development. For example map based representations of risk could help illustrate to planners preferred locations for new developments.

An example of a map based approach is shown in Figure 9, named an EV hotspots map. This shows the EV at each grid square used in the calculation process. A grid square is 100m x 100m (one hectare) and the EV for a grid location is a function of the population assigned to that grid square and the events that affect that location. Areas shown in amber and red indicate an EV greater than 0.01 fatalities per year and would indicate further development is inadvisable.

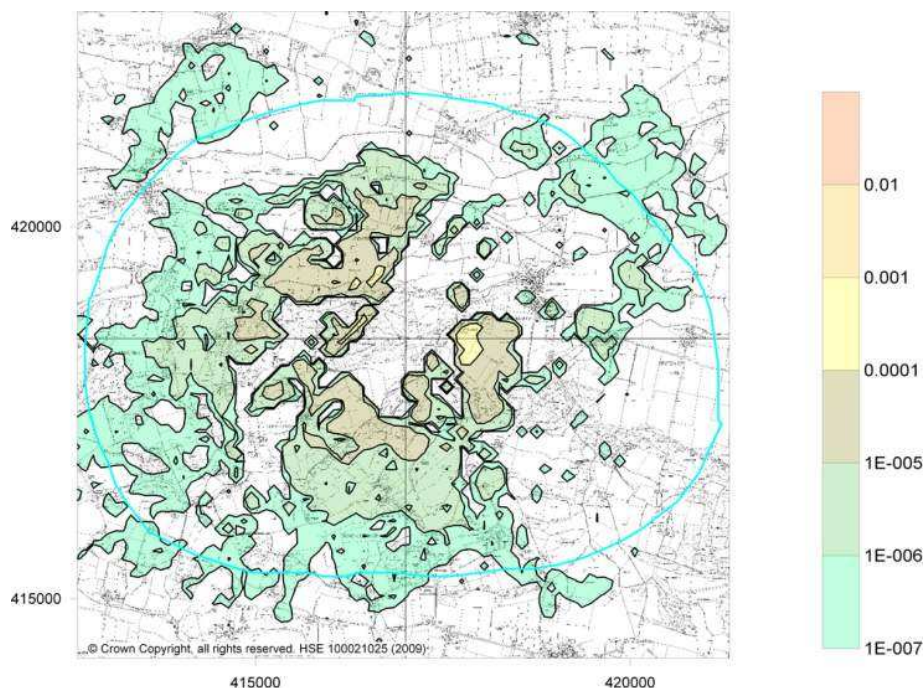


Figure 9 EV density (hot spots) map (night time residential population), colour scale numbers in fatalities per year per hectare.

HSE is looking at how these measures, and others, could be used to provide advice to local planning authorities. Conversely HSE is also consulted on proposals to construct and locate new major hazard sites.

12. PROPOSALS FOR NEW MAJOR HAZARD SITES, OR FOR MODIFICATIONS TO EXISTING MAJOR HAZARD SITES

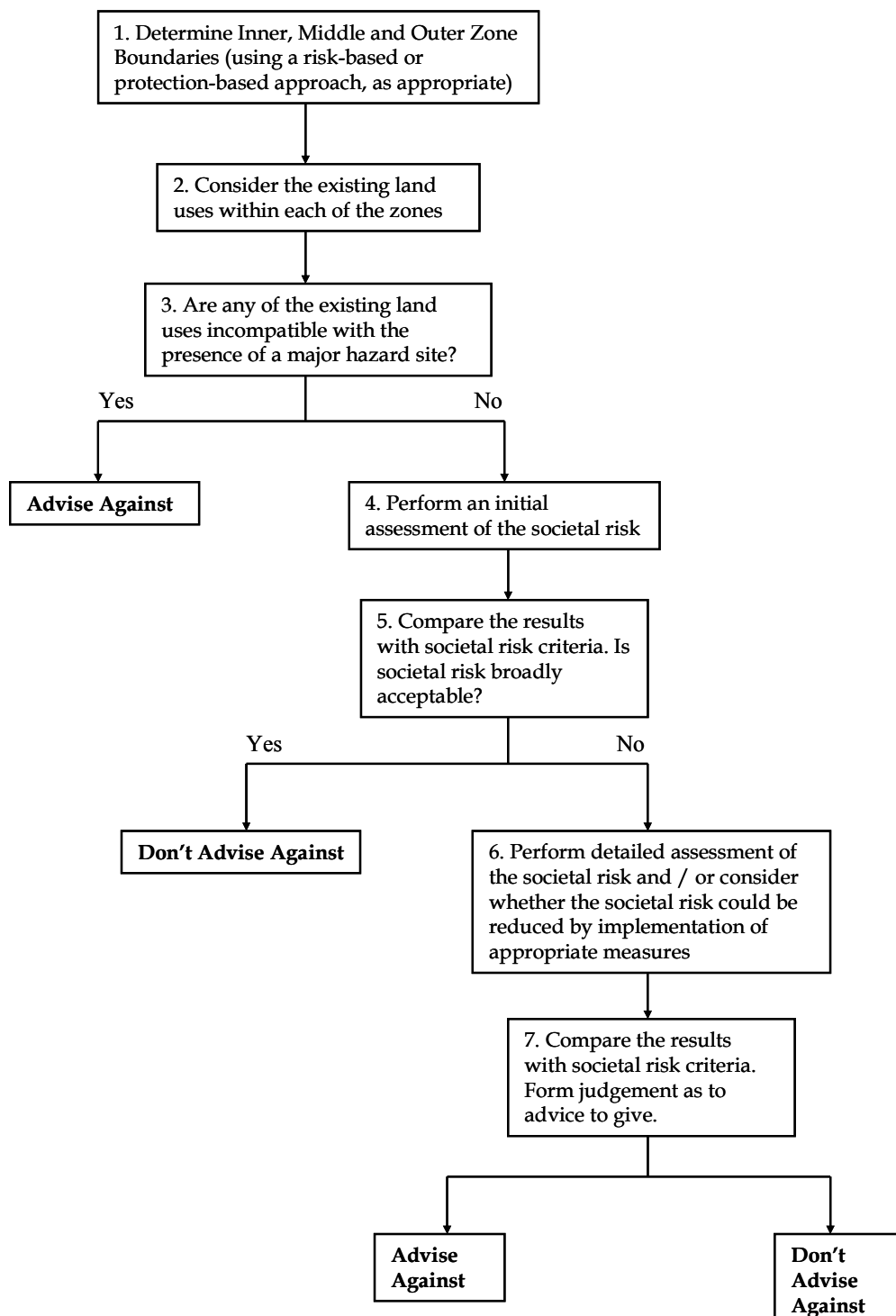
A company proposing to construct a new major hazard site would need to apply for Hazardous Substances Consent from the Hazardous Substances Authority. Where the operator of an existing major hazard site wanted to modify their site (for example, to increase the maximum quantities of dangerous substances present allowed), then they would need to apply for a variation to their Hazardous Substances Consent. In either case, HSE would be consulted by the Hazardous Substances Authority.

HSE's assessment of proposals for new major hazard sites (or changes at existing major hazard sites) involves consideration of both the individual risk and the societal risk to the people living in the surrounding area.

12.1 Proposals for New Major Hazard Sites

The overall approach involves a number of steps, as illustrated in Fig 10 below. The detailed methodology for a given situation differs according to whether the assessment of the proposed major hazard site is risk based or protection based.

Figure 10 - Deciding what Advice to Give for a Proposed Major Hazard Site



12.2 Incompatible Land Uses

In order to assess the significance of the individual risks from a new major hazard, estimates of the location of the inner, middle and outer zone boundaries are made, using a risk based or protection based approach as appropriate. This is Step 1 in Fig 8. Then, in Step 2, the pattern of existing land use within each of the three zones is then studied. The following land uses would be considered to be incompatible with the presence of a major hazard site:

- More than two houses in the Inner Zone;
- A workplace that is normally occupied (e.g. – offices) and where the number of people likely to be present is 100 or more, in the Inner Zone;
- Developments for use by vulnerable people in the Inner Zone;
- Any very large or sensitive developments in the Inner or Middle Zones.

If the zones encompass any existing land use that would be considered incompatible (Step 3), then the response from HSE will be to advise against the major hazard site as proposed. Where there are no incompatible land uses, the assessment proceeds to Step 4 (see below). In addition, HSE will advise against granting of Consent for a new major hazard site, or for alterations to an existing major hazard site which would increase the risks from that site, if any member of the public is subjected to a level of individual risk from all major hazards in the vicinity in excess of 100 chances per million per annum.

Initial Assessment of Societal Risk

Where no incompatibilities are detected, then HSE performs initial assessment of the societal risks (Step 4 in 8). The methodology used for this initial assessment depends on the nature of the proposed major hazard site, and particularly on whether the approach used is protection based or risk based.

The possible outcomes of this initial assessment are:

- The local societal risk is broadly acceptable, leading to a ‘don’t advise against’ response by HSE; or,
- The local societal risk is clearly so high that an ‘advise against’ response should be given; or,
- The result is not clear-cut and detailed analysis, possibly in conjunction with consideration of additional risk reduction measures at the proposed site, is necessary.

In the case of the last of these outcomes, the assessment proceeds to Step 6 in 8. For proposals to introduce new installations, activities or facilities at an existing major hazard site, or modifications to installations the process is similar.

REFERENCES

1. PADHI Planning Advice for Developments near Hazardous Installations – HSE’s Land Use Planning Methodology www.hse.gov.uk/landuseplanning/padhi.pdf
2. Reducing Risks Protecting People. HSE’s decision making process. ISBN 0 7176 2151 0 HSE Books, First published 2001.
3. CD 212 Proposals for revised policies to address societal risk around onshore non-nuclear major hazard installations. HSE Books. www.hse.gov.uk/consult/index.htm
4. Evidence or otherwise of Scale Aversion: Public Reactions to major disasters. Reference 0091699-TN03 Rev. 4. June 2009. ERM report for HSE.
5. WS Atkins Technical Note 1. Development of potential frameworks for the assessment of societal risk. Atkins 5077030 TN1 Issue 02 November 2008, for HSE.
6. What is wrong with FN-Criterion lines for judging tolerability of risk? A W Evans and N Q Verlander. Risk Analysis, 17(2), 157-168. (1997).
7. I. L. Hirst, Risk Assessment – a note on F-N curves, expected numbers of fatalities and weighted indicators of risk, J. Hazard. Mater. 57 (1998) 169-175.
8. HSE Research Report RR703 – Societal Risk: Initial briefing to the Societal Risk Technical Advisory Group. www.hse.gov.uk/research/rrhtm/rr703.htm
9. Risk criteria for land-use planning in the vicinity of major industrial hazards HSE Books ISBN 9780118854917