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# USING GIS TO EXPLORE THE TECHNICAL AND SOCIAL ASPECTS OF SITE SELECTION FOR RADIOACTIVE WASTE DISPOSAL FACILITIES

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## Abstract

This working paper reviews the current situation regarding radioactive waste disposal in the UK and questions the pursuance of a purely engineering approach to gaining public support. Past histories concerning the siting of nuclear industry facilities; power stations and latterly, waste repositories, are briefly discussed and used to demonstrate that more attention needs to be paid to the geographical and social science if current proposals for a rock laboratory, and ultimately an operational repository, at Longlands Farm near Sellafield are to succeed. The usefulness of Geographical Information Systems (GIS) and associated spatial information technologies are highlighted. Suggestions are made as to how these may be made available for public use via the Internet in adopting a more open approach to public information, consultation and participation.

## 1. Introduction: identifying the problem

The radioactive waste disposal problem has been with us now for nearly half a century. After the ban on sea disposal in 1983 attention turned towards geological disposal on land; and with it came the NIMBY (Not In My BackYard) syndrome. The scientific and engineering aspects of deep geological disposal are not disputed. Deep cavity disposal is generally accepted as the safest and most reliable means of disposal and has been the adopted model of most nuclear countries, with facilities being developed by USA at Yucca Mountain, Sweden at Forsmark, Germany at Gorleben, etc. In the UK, after several years pursuing the less expensive option of near surface disposal, NIREX have decided to pursue the deep cavity disposal route for both low and intermediate level waste arisings, partly in response to the need for heightened public acceptability.

How and why the UK's stocks of LLW and ILW need to be disposed of is not questioned here, neither is when and at what cost. These are all questions which have been adequately answered elsewhere. The question of greatest concern now is how the solutions proffered by NIREX are to be communicated effectively to the public and politicians to gain the maximum possible level of acceptance. For the current proposals for the Longlands Farm site to succeed, the solution needs to be, not only scientifically supportable, but acceptable to the greater majority of the general public. Since the development phase of the rock laboratory and repository is projected to last into the next century, public acceptance also needs to be long term, as it is likely to span at least two more terms of office of this or some future Government.

The political vulnerability of a radioactive waste repository makes its development a very risky business. The Longlands Farm developments are estimated to cost £1.9 billion; a figure that, as with all major engineering projects, may well double as work progresses. The development therefore represents a massive commercial investment and one which the industry cannot literally afford to be abandoned at the last minute due to political tergiversation. It is accepted, in most quarters at least, that the current design is based on sound science and engineering, but public acceptability is still low, making the development politically vulnerable and at severe risk of cancellation at any stage. And yet, the development must succeed. If Longlands Farm fails to gain long term public and political approval failure will almost certainly ensue at one of the planning stages and/or public inquiries down the line. This will represent a massive waste of money and result in the effective sterilisation of probably the best and most obvious site in the UK, together with the removal of remaining credibility from NIREX as the organisation in charge.

## 2. Historical legacies

If we are to fully understand the current situation regarding public acceptability, some past issues and legacies need to be examined. Firstly, it is perhaps true to say that current attitudes in today's nuclear industry still reflect those of the past. There is an inherent inertia to change, especially in relation to today's need for greater openness and public involvement.

Early decisions by the nuclear industry were born out of the need for secrecy. The Cold War was beginning and nuclear weapons development was a high priority. As a result public awareness was low and there was a general air of enthusiasm for the promise of nuclear power in the post war "jet-age". This is reflected in the approach towards power station siting adopted in the 1950's and 1960's. Engineering issues dominated the siting process. Factors such as access to cooling water, suitable geology for building foundations, proximity to the national grid and proximity to areas of demand took priority over social aspects. Public safety was ensured solely by good engineering design and remote siting. The opportunity for public input was negligible, whilst public inquiries were little more than vehicles for information, and were not intended to provide an arena for true public participation in the decision making process.

This approach to siting only works when public apathy is high, such as in the immediate post war years. In more recent years, accidents such as Three Mile Island and Chernobyl have ensured that this is no longer the case. The public are more informed (for better or worse) as to what is happening and they are concerned. This is amply demonstrated by the number of anti-nuclear groups in existence; BOND, SCRAM and CARE to name but a few. The public today are no longer contented to sit back and let politicians and scientists make all the important decisions regarding their environment. They are keen to be involved and the nuclear industry should recognise this fact.

## 3. Geographical issues

Geography is important, make not mistake about it. Location influences the number of people who feel threatened, endangered, at risk or worried about a particular development. This therefore has a political effect, because wherever public opinion goes, political opinion is sure to follow. Old style nuclear siting strategies will not work in the 1990's. They did not work in the 1980's as demonstrated by the failure of NIREX to secure various repository sites at Billingham, Bradwell, Elstow, Fulbeck and Killingholme. And yet, whereas nuclear power is optional, nuclear waste is not. It exists, nearly 50 years of nuclear energy, weapons development and scientific/medical use of radionuclides has seen to that, and therefore it needs to be safely disposed of. This fact is unquestionable and there is a very strong public and national interest ensuring that disposal is via the safest possible means.

Unfortunately, this does not mean that the oft cited "National Interest" argument holds water. It may well do at a national level, and even this still needs to be adequately explored, but it certainly does not hold at a local level, especially one affected by a proposal for a new repository. The "National Interest" argument no longer means what it used to; the public do not believe in it. There are alternative sites around the country and more openness is needed in public and political debate.

A radioactive waste repository is forever. True, dangerous radioactivity will decay to harmless levels in several thousand years time, but in the eyes of the public, that amounts to forever. Folger and Morris (1995) are correct in saying that it is important that any repository must be based on unimpeachable science and engineering. It is also important that their social science is also unimpeachable if they are to gain and maintain long term public acceptability. The science cannot be rushed; and this is true for both engineering and social science, nor can public sensitivities be trampled on. Public inquiries with limited terms of reference, such as Thorp and Sizewell B, are not a good model to be adopted for radioactive waste disposal.

The Sizewell B inquiry was not allowed to discuss the site selection issue, but this should not be the case with Longlands Farm. People and politicians are going to want to know why this particular site was chosen over all the other hundreds, or even thousands, of possible sites in the UK. Greater openness about the problem is required about why Longlands Farm has been chosen, about the possibility of high level waste storage, about the commercial operation of the repository, about the risks and about the social and economic costs of not having a deep cavity repository such as the relative advantages/disadvantages associated with indefinite surface storage.

## 4. Geographical Information Systems

The 1980's saw a revolution in the way geographical and cartographic sciences were carried out. This came about with the development of practical Geographical Information Systems (GIS) software, vastly improved supplies of digital map data and sophisticated spatial analysis and decision support systems. GIS are essentially advanced computer tools for the input, storage, manipulation, transformation, analysis and visualisation of spatial information. In the right hands and with appropriate data a GIS becomes a very powerful tool for spatial decision making and support. Surely, GIS is the perfect tool for aiding NIREX in their search for and development of the UK's next radioactive waste repository? There is very little evidence, however, that NIREX or their appointed consultants have used GIS in identifying the Longlands Farm site. This is surprising since virtually every other commercial organisation in the UK and indeed the world, who are involved in making spatial decisions or processing geographical data have embraced GIS as a major component of their set decision making procedures. This is even more remarkable since GIS received a fillip from the

DoE as early as 1986 in its report on Handling Geographic Information (Chorley, 1987). In addition, major government backed research initiatives, such as the Regional Research Laboratories (RRLs) funded by the ESRC in the UK and the National Centre for Geographic Information and Analysis (NCGIA) funded by the NSF in the USA, have made many advances in the technical and applications fields of GIS. GIS as a technology and science, can no longer be regarded as being in its infancy. GIS has, in all senses, matured and cannot be ignored on the grounds of it being a new and unproven technology.

If the views expressed in this paper are incorrect and NIREX have made extensive use of GIS, then the results have yet to be seen and need to be made public. Without full openness in the presentation and discussion of site search results, there will always be a nagging doubt in the minds of the public that the site selection procedures adopted and used by NIREX remain the same as those of early nuclear siting decisions; driven by purely engineering and economic requirements. If it is true that NIREX and their consultant researchers have not used GIS in their site search, then their manual site search must be viewed as poor geographical science and may therefore have missed many feasible alternatives. To re-phrase the words of Folger and Morris (1995) again, site selection too needs to be based on unimpeachable geographical and social science.

Looking at the typical site selection procedure it can be seen that GIS should have an important role to play in virtually all stages of the site selection process, from the initial area screening exercise and identifying potential sites through to the environmental assessment of short-listed sites and decision support in public inquiries (Carver, 1991). The potential of GIS for siting nuclear facilities was brought firmly to the attention of the nuclear industry in the mid 1980's (Openshaw, 1986; Openshaw and Fernie, 1986) and subsequently by Openshaw, Carver and Fernie (1989) in the book *Britain's Nuclear Waste: safety and siting*. Increasingly these tools are not just useful for nuclear industry experts and academics, but may seen as providing a useful framework for allowing other interested parties (the public, pressure groups, local government, etc.) to explore the issues, industry siting decisions and their own ideas. Systems are currently under development which use GIS and associated techniques to allow non-specialists to explore spatial decision making problems, generate spatial ideas and resolve conflicts where they occur (Carver, 1991; Heywood and Carver, 1994).

## 5. Spatial Decision Support Systems

By its very nature GIS is an elitist technology. GIS software and hardware is generally expensive. As a solution to any problem it is technocratic (i.e. GIS are generally only usable by technicians with several years experience), whilst access to relevant data is often tightly controlled. As such, GIS has been criticised on the grounds that it is the preserve of industry, government and academics and therefore represents a repressive technology. This need no longer be the case. It is suggested here, that GIS and associated decision support systems could easily be adapted to run on the Internet, thereby providing widespread access to the data and the technology.

GIS provides an exploratory framework for applied physical and social science, analysis of data, application of expert knowledge and visualisation of geographical phenomena. It is therefore not difficult to imagine how such systems could be used by the nuclear industry to:

1. accurately inform the public about the radioactive waste problem;
2. explain repository engineering and siting procedures;
3. allow the public to explore the physical and social science involved and make informed personal decisions;
4. gather accurate and extensive information about public opinion and formulate a consensus; and
5. deal more sensitively and effectively with public concerns when addressing the acceptability problem.

Spatial Decision Support Systems (SDSS) technology would form a key component of such public Internet-based systems. SDSS incorporate easy-to-use graphical user interfaces, data appropriate to the problem, spatial analysis functionality and are adaptable to allow the user to explore particular avenues or ideas, whilst incorporating a GIS to perform all the database management and spatial operations concerning visualisation and manipulation of map data.

The spatial analysis component of the SDSS has been shown to be best provided by multicriteria evaluation (MCE) techniques (Carver, 1991). These are complex and advanced algorithms, originally developed in the planning, decision analysis and operations research fields for decision making and conflict resolution (Zeleny, 1976; Keeney and Raiffa, 1976; Voogd, 1983), which have been adapted for use in GIS (Janssen and Rietveld, 1990; Carver, 1991; Eastman, et al., 1993). GIS on its own provides the user with only limited tools for conflict resolution where locational problems involve multiple criteria and multiple, often conflicting objectives. The example of radioactive waste disposal illustrates this point perfectly when considering the four main siting factors of geology, population, accessibility and conservation issues. Considering population and accessibility, feasible sites should be located away from centres of population and yet be easily accessible via existing road and rail networks. The road and rail infrastructure has been built to serve populated areas and as such much of the UK's transport networks are in highly populated areas. In a further example, feasible sites should be located outside of conservation areas and yet away from centres of population. In this case the conflict arises from conservation areas, by their nature and origins, covering much of the UK's sparsely populated areas.

Using GIS alone it is difficult to solve these types of problems and more advanced spatial analytical techniques are required. MCE algorithms work by allowing users to specify preference weights for each criteria considered in the decision making problem. MCE algorithms then perform the complex trade-offs involved in making decisions between alternatives with conflicting criteria and objectives. By integrating GIS and MCE techniques within a SDSS framework the user is provided with an ideal tool for conflict resolution and hence the identification of optimal or near optimal locations. It is worth noting here that, unlike in the engineering sciences, there is no one "correct" solution to geographical and social problems such as this. Different people have different ideas and desires, and so will inevitably stress different criteria and objectives in any spatial exploration of the siting problem. Their resulting map, should be regarded not as a definitive answer, but merely as a spatial representation of their ideas (Heywood and Carver, 1994). By combining the "idea maps" of several people a consensus view can be obtained and physically and socially robust sites identified.

## 6. Towards a Cyberdemocracy

Accurate public information and active public consultation and participation are the principal routes to the ultimate success of any of NIREX's proposals for a radioactive waste repository. Without these key elements, any proposals and subsequent developments are at great risk of cancellation as a result of public and political pressure. Significant gains in public confidence can be attained through greater openness and through improving public knowledge, understanding and awareness of the issues and problems. This can only serve to support siting decisions and maintain essential political support. At the same time, NIREX and the rest of the nuclear industry can hope to gain a greater insight into the consensus of wider public opinion.

It is suggested that by using the Internet, national access to the necessary information and technology can be achieved. An independent, well designed and engineered, easy-to-use SDSS accessed via the Internet is perhaps the only way to ensure mass exposure into the 21st Century. The Internet is the ideal media for mass, interactive, two-way communication and exploration of ideas and facts. It is open and politically independent. It is fun and maintains attention through the current fascination for the "electronic-age" of computers, virtual reality and multi-media. A key point is that the information flow can be both ways; the public learn more about the issues and what is at stake at the same time as generating their own ideas and solutions. At the same time, the system can be programmed to log user responses for later analysis to provide the industry with valuable insight into public opinions.

A pilot radioactive waste information and exploration system on the Internet may contain a number of components. These are as follows:

1. an interactive radioactive waste information system that uses multimedia to describe the problem in all its aspects;
2. an effects scenario system that allows the user to interactively investigate the impacts of various political, economic, geographical and social scenarios on the radioactive waste problem. This would allow users to explore such questions as "What if nuclear power was abandoned tomorrow?" and "What if terrorists damaged the HLW storage tanks at Sellafield?". Simulations could be used to demonstrate the consequences on people, land and the economy;
3. a radioactive waste repository site search decision making and support system that utilises GIS and MCE to allow the user to design their own site search based on real data and their own criteria and preference weights. This would again be interactive allowing the user to observe the effects of different criteria weighting schemes and decisions. This part of the system could operate as game or simulation that places the user in the position of overall decision maker who has to simultaneously balance all the major aspects of the problem such as public safety, acceptability, political indecision, commercial interests, environment, etc.

The aim would not be to demonstrate the qualities of any one solution. It is definitely not about explaining why site A is the best and only choice. Instead, it should be aimed at ensuring full public awareness and the ability to learn through interactive exploration of ideas. At least via this route the public will discover just how hard the problem really is and perhaps begin to sympathise with NIREX.

Although the Internet is accessible from anywhere with a telephone line or satellite link, it is perhaps only ever done so at present on a regular basis from institutional sites. However, by 2000 it is predicted that every home will have some form of connection to the global Internet allowing the general public access to whatever systems are in place. In the meantime, it is envisaged that Internet access points in universities, public libraries, town halls, etc. will adequately serve the interested publics needs. NIREX should be looking towards this medium as a means of improving public awareness and acceptability.

## 7. Conclusions

The main conclusion from this paper is that we cannot afford another failure in the search for a repository location for the UK's growing stocks of LLW and ILW. If the unthinkable happened and Longlands Farm was refused planning permission, the UK nuclear industry would be deprived of its best site for a repository, NIREX would loose its remaining credibility as a waste management organisation and vast sums of money and effort would have been wasted. In addition, if indeed Longlands Farm is the best site, its effective sterilisation through having planning permission denied, makes it very difficult to foresee how NIREX could either over turn the decision or find a more acceptable site.

As a consequence, it is of the utmost urgency that NIREX succeed. No stone can be left unturned, and it is obvious from the preliminary discussion in this paper that the geographical and social aspects of the siting and development procedures are still being largely ignored in favour of attempting to ensure public acceptance through traditional science and engineering. There is a need for a greater focus on geographical and social science if public and political acceptability and support is to be found and maintained throughout the life cycle stages of the proposed repository. One possible route in achieving this wider support is through greater openness and truly independent and interactive public consultation and participation exercises such as may be engineered via decision support, idea exploration and information systems installed on the Internet.

Be more open and trust people. There is nothing to hide... is there?

## Bibliography


Carver, S.J., (1991), *Integrating multi-criteria evaluation with Geographical Information Systems*. In International Journal of Geographical Information Systems. 5(3), 321-339.

Chorley, R., (1987), *Handling Geographic Information* Report of the Committee of Enquiry. DoE, HMSO, London.

Eastman, J.R., Kyem, P.K.A., Toledano, J. & Weigen, J., (1993), *GIS and Decision Making: explorations in Geographic Information Systems technology*. UNITAR, Geneva.

Heywood, D.I. & Carver, S.J., (1994), *Decision support or idea generation: the role of GIS in policy formulation*. In Proceedings Symposium für Angewante Geographische Informationsverarbeitung (AGIT'94). (Salzburg, Austria), July 1994, pp. 259-266.

Janssen, R. & Rietveld, P., (1990), *Multicriteria analysis with GIS: an application to agricultural landuse in The Netherlands*. In Geographical Information Systems for Urban and Regional Planning, edited by H.J.Scholten and J.C.H.Stillwell, Kluwer, Dordrecht.

Keeney, R.L. & Raiffa, H., (1976), *Decisions with Multiple Objectives: preferences and value trade-offs.* Wiley, New York.

Openshaw, S., (1986), *Nuclear Power: siting and safety*. Routledge, London.

Openshaw, S. & Fernie, J., (1986), *Computer techniques for identifying and evaluating potential radioactive waste disposal sites*. In Radioactive Waste. First Report of the Environment Committee, 3, 645-647, HMSO, London.

Openshaw, S., Carver, S.J. & Fernie, J., (1989), *Britain's Nuclear Waste: safety and siting.* Belhaven Press, London.

Voogd, H., (1983), *Multicriteria Evaluation for Urban and Regional Planning.* Pion, London.

Zeleny, M., (editor) (1976), *Multiple Criteria Decision-making*. Springer, Berlin.