# NON-TECHNICAL FACTORS INFLUENCING THE DECISION MAKING PROCESSES IN ENVIRONMENTAL REMEDIATION PROJECTS

W. Eberhard Falck
Waste Technology Section
International Atomic Energy Agency
Vienna
Austria

## ABSTRACT

The context of decision-making in environmental remediation projects will shape both its overall objectives within the framework of competing societal goals, as well as generate constraints on how it is performed. Environmental remediation projects inevitably take place against a backdrop of overall social goals and values. These goals can include, for example, full employment, preservation of the cultural, economic and archaeological resources, traditional patterns of land use, spiritual values, quality of life factors, biological diversity, environmental and socio-economic self-sustainability, protection of public health. Different countries will have different priorities, linked to the overall set of societal goals and the availability of resources, including funding, man-power and skills. These issues are embedded within both a national and local socio-cultural context, and will shape the way in which the remediation process is structured in any one country.

Hence, the overall effectiveness of a remediation project is determined by its overall efficiency within the given legal, institutional, and governance framework, under the prevailing socio-economic boundary conditions, and balancing technology performance and environmental targets with the reduction of implementation risks and fixed or limited budgetary resources.

## INTRODUCTION

The overall objective of remediation in an intervention situation is to minimise negative environmental and health impacts, including exposure to radiation [1]. These objectives can be met by a variety of technical and management measures, and any combination thereof.

Environmental decision-making will always take place against a backdrop of overall social goals and values. These goals can include, for example, full employment, preservation of the cultural, economic and archaeological resources, traditional patterns of land use, spiritual values, quality of life factors, biological diversity, self-sustainability (both in the environmental sense [2] and in a socio-economic sense), and protection of public health. There is a strong link between the overall set of societal goals and the availability of resources, including funding, man-power and skills. Maintaining or improving employment rates is particularly relevant for IAEA Member States with economies under pressure.

The IAEA is addressing these issues in a forthcoming technical document entitled: "Non-Technical Factors Impacting on the Decision Making Processes in Environmental Restoration - Influences on the Decision Making Process, such as Cost, Planned Land Use, and Public Perception".

It must be understood that resources spent on remediation activities are typically not available for use in achieving other goals of the society. Their availability, therefore, may be controlled by priority setting within the society:

> "*Society must distinguish between significant and trivial risks. … When money and resources are wasted on trivial problems, society's wealth and hence health is harmed*" (Bruce Ames, University of California, Berkley as quoted in [3]).

The balancing of the various goals of social policy is often handled in a political context, which specifies the level of resources available for remediation. Many remediation cases involve the spending of public money, particularly when the government has assumed responsibility for 'orphan' environmental contaminations. In such cases it is probably fair to expect that the overall benefit from its expenditure is maximised and the potential for other dividends is increased. There will be, however, pre-determined constraints, such as overriding principles for health protection or the maximum amount of resources available.

Hence, the decision makers in environmental remediation need to be aware of a wide range of influences and programmatic risks and benefits related to the implementation process in general and to the deployment of certain strategies or technologies in particular, which are illustrated in Figure 1.

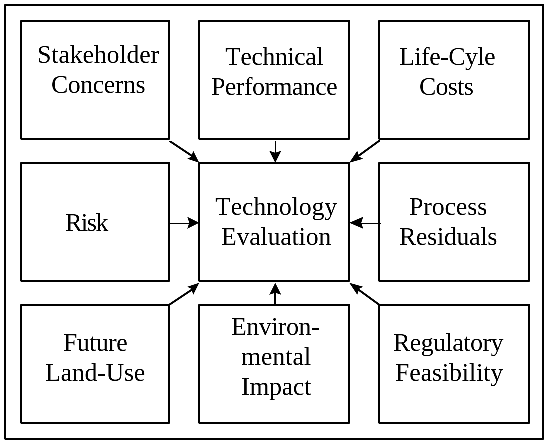


Fig. 1. Technology evaluation framework (from [4])

A number of specific factors and constraints can be identified that will impact more or less directly the decision making processes. Many of them have to be included explicitly and deliberately into the balancing process in order to make the latter most efficient. They include inter alia:

- Remediation objectives.
- Societal goals and added value derived from remediation, including
  - socio-economic self-sustainability;
  - employment situation and skill base;
  - envisaged land-use.
- Assessment of benefits from remediation projects, including
  - public perception/acceptance and public participation;
  - ownership and social identity issues;
  - culture and communication issues.
- Project implementation related risks, including
  - regulatory aspects, such as clean-up standards and competing legislation;
  - costs, funding, and availability of resources;
  - local infrastructure;
  - risks related to specific remediation technologies and strategies;
  - environmental impact and residual wastes.

In the following, those factors from the above list that have the largest potential for generating added value and optimisation of overall benefit from an environmental remediation project, or that entail significant implementation risks, will be discussed in more detail.

## THE OBJECTIVES OF REMEDIATION

In any case, the objectives of a remediation project must be defined *a priori* in order to serve as a benchmark against which programme planning and implementation results can be judged.

The overall objective of remediation in an 'intervention' situation (as opposed to licensed 'practices') is to minimise negative environmental and health impacts, including exposure to radiation [1]. These objectives can be met by a variety of technical and management measures, and any combination thereof. A full 'technical' remediation will result in an unrestricted release of the site or territory. Prohibiting access, strictly speaking, does not constitute a remediation, but it may be expedient to do so in the case of contamination with short-lived nuclides.

Apart from the 'justification' as defined by radiological criteria (ref. ICRP), the need for remediation and its end-point with respect to permissible residual contamination levels are often driven by the demand to bring land back into use. Depending on the envisaged land use permissible residual contaminations may be different. Land to be sealed and earmarked for industrial use may be left with a higher residual contamination than land for residential, recreational or agricultural uses.

In many instances the objective is to restore the original functionality of a site, while in cases of past practices and obsolete industrial activities new land uses may (need to) be envisaged. Depending on the level of socio-economic pressure, different restoration strategies and technologies may be chosen. Where a high demand for land puts a prime price on it, more expensive and/or faster processes might be chosen. The choice of restoration technique and strategy may also put restrictions on possible future land-use. For instance, certain land-use types may interfere with containment or *in situ* fixation techniques.

## SOCIAL GOALS AND ADDED VALUE

### Socio-Economic Self-Sustainability

Sustainability, as an overarching social value, is becoming an increasingly significant issue in environmental and economic decision-making. Sustainable development was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [2], although many critics have argued that sustainable development is an unachievable goal. Sustainable development therefore requires reconciliation between improving the conditions of life in an equitable way, now and in the future, and in the long-term conservation of the natural environment, which supplies the resources on which development is founded. Sustainability, however, should not be restricted to the aspects of using natural resources, but should encompass the socio-economic foundations of the community concerned as well. As remediation projects often draw resources from outside the area actually affected, for instance tax money generated elsewhere, initially they are inherently not self-sustained. The lack of self-sustainability in contamination affected areas typically goes beyond the actual dealing with the contamination itself, as the overall socio-economic situation may have been seriously impaired. Therefore, the aim should be to develop remediation projects that either lead to self-sustaining communities, or communities that can return some other benefit to the society at large that supports the remediation project.

Achieving self-sustainability depends, not the least, on the people concerned. Hence, when environmental remediation strategies are being developed, decisions should be based on an understanding of affected peoples' values [5], interests and priorities. These priorities may vary considerably as a function of the socio-economic circumstances. Thus priorities may be set quite differently in developed, emerging and developing countries.

The structure of the local economy may be significant in framing the objectives of the remediation activities. Remediation in an industrialised region may focus, for example, on issues such as employment and economic re-use of lands; in a region with a primarily rural 'traditional' economy, emphasis on avoiding disturbances to indigenous cultural conditions may be paramount. A prolonged contamination situation and ensuing remediation measures may have a serious impact on the socio-economic structure of the communities concerned. Such impact may ensue from restrictions on land-use or marketing its products, or from perception by the outside world, which e.g. shies away from buying the products. Compensations paid to the affected people can be a major item of the overall project costs. While some side-effects of the project may desirable or even intended, such as creating employment, at the same time, some kind of dependency on the project ('cargo culture') may develop.

While it is understood that the socio-economic context would be very much site and country specific, it may be helpful for regulators and operators alike to develop a clear understanding of the various factors and their possible interactions.

### Socio-Economic Background

Depending on the size of the problem, remediation decisions can have wide-ranging economic implications. Those implications may occur over short or long time-scales. Rationalising the impact of economic considerations on the decision making process is not a straightforward task [6]. Constraining decisions are often taken on political grounds and are not necessarily related to scientific or technical aspects of the environmental remediation problem. Therefore, the economic benefits, or detriments for that matter, of decisions on remediation projects should be evaluated *a priori*.

Economic impacts of contamination events may manifest themselves in a variety of direct and indirect forms, including loss of property value, loss of markets for agricultural produce, job losses, relocation costs, costs of extended commuting to farther workplaces, or higher cost of food-stuffs. Unlike the siting of nuclear installations, including waste management facilities, where often the negative perception of things nuclear prevails [7], owing to the inherent benefits, there should be an inherent positive perception of the remediation activities. The remediation measures may bring with them an influx of money. The average education of the residents often increases as a result of improved access to it owing to the financial means available. Overall, the standard of living increases - at least with respect to a situation without remediation - and sometimes above pre-contamination levels.

Social groups typically differ in their perception. For example, certain groups of the public may be reluctant to support a given proposal affecting their settlements owing to an inability to move elsewhere - often reflecting a lack of inward investment, or regional decline, thus lowering its respective appeal. This is not to say that the individuals actually wish to leave - just that if they should wish to do so, they are unlikely to find a buyer for their property, or receive a relatively low price which curtails their ability to purchase elsewhere. There is, therefore, a perception of inhibited mobility, which may not be felt by other groups, who retain more flexibility/mobility. Typical examples include the rural communities in developing countries, but urban middle and upper classes in developed countries living in declining regions have found themselves in a similar situation.

The choice of remediation technologies should be tailored to the socio-economic needs of a region and the respective resources available. Thus the overall economic benefit for a region might be improved by choosing a perhaps less sophisticated technique, but involving more local human and other resources. Drawing out a project over a longer time scale, thus keeping local staff employed for a longer period of time, might be more economical at the bottom line than earlier completion followed by paying unemployment benefits; and it may add a social dividend. Working out such trade-offs requires the collaboration of all parties involved, the contractor, the operator, licensing authorities and the funding bodies. Installation of a quantitative decision aiding system can make the complex process of decision finding more transparent to all stakeholders and parties.

## Employment

Employment is an important societal factor to consider within any decision making process. Employment rates effectively provide a measure of the direct and indirect jobs created through remediation process implementation. Often, for past practices employment has been in decline owing to (large-scale) facilities being closed down. Employment can be effected in a number of ways, namely:

- directly during the physical implementation process and any required aftercare by creating jobs on these projects;
- indirectly in other economic areas within the local community, for example due to increase in business volume of shops, hotels and other service industries;
- by re-deployment of specialists, e.g. from the nuclear complexes in the USA and the former Soviet Union;
- owing to the general socio-economic revitalisation of areas previously in decline.

Improvement of the employment situation through a remediation project, therefore, provides a considerable social dividend and added value to the project.

## Skill Base and Education

Depending on the size and nature of the problem, the design of a remediation programme may be determined by the skill base and level of education available in the community or region, as well as impact on these. Local unavailability of skilled personnel may preclude implementation of an otherwise viable remediation option. The problem can be overcome by either drafting in staff with the required skills, or by training and education, if project resources and time scales permit this. Re-training and re-deployment of scientists and engineers from the workforce of the previous operation on a site is a major element of the conversion programmes from nuclear weapons production to civilian activities in the USA and the successor countries of the former USSR.

The effects on the socio-economic situation of the communities may be quite varied, again depending on the scale of these measures with the respect to the size of the community. A sizeable influx of outside workers with higher levels of education and/or higher levels of disposable income may give rise to social tensions, but at the same time boost the economic situation of the community. Training and education of locals is likely to improve their 'market value', but can induce demographic changes later on, e.g. by outward migration following the completion of the remediation project. Assessing such effects in detail is probably beyond the means of the average remediation project, but decision makers on the (higher) political level may well be guided by such deliberations and aim for the added value to be gained.

**Future Land Use - Objectives and Restrictions**

Local land-use and landcover in the region will also affect the remediation decision. Hence, decisions on the remediation of a contaminated urban site may be very different from those taken in a wilderness area. In the first case, the local needs for industrial or commercial lands may shape the final endstate and require a different remediation process.

One of the overarching objectives is that the remediation should not only improve the radiological situation, but that it also should not result in undue detriments to other properties of the site. The baseline case for future land use in accident scenarios would be return to its previous use, while for past practices it would be the unrestricted release [1]. In practice, the possible land use depends on the degree of restrictions placed on it due to any residual contamination remaining. Restricted use (industrial or commercial) or unrestricted use (residential or agricultural) as remediation end-points influence the kind of technology to be implemented and level to which remediation has to take place [8].

The degree of restrictions to be applied may vary between different areas forming part of a larger contaminated site. Certain parts of a 'site', i.e. the location of an industrial or other operation, may not have received any contamination at all, and therefore could be turned to other uses without restriction. Chosen end-points for remediation and hence the amount and form of residual contamination can put restrictions on certain forms of land use.

Information on pre-existing plans can be obtained from land management plans, land use decisions, zoning regulations, building regulations, or any other relevant spatial planning instruments that are available. If the future land use is unknown or undecided, as a basis for comparison, a common assumption can be made for all remediation options. Land use, however, can also be a variable in itself during the decision making process, allowing for optimisation within certain limits set e.g. by the criteria justifying remediation [1].

Land use after environmental remediation in many Member States is a public participation and community issue. The issue is often part of a broader transition in the local economy and, as such, subject to a variety of expectations and goals with the society affected. The contaminated site may have been part of the operation of a major local employer who has ceased to exist or has changed the market sector, with ensuing changes in employment levels and structures, and hence the overall socio-economic situation.

In the interest of the public, a "most beneficial use" of surplus land in government ownership should be found, which reflects a balance among various goals, including maximum return to the taxpayer, wise land stewardship, adherence to community values, economic development, environmental protection, cultural and natural resource preservation, and aesthetic value [9]. For some sites, the most beneficial use will be readily evident. For example, if a site is already industrial and can be re-used as an industrial area to create jobs, the re-use determination is likely to be relatively simple. For other sites, where multiple uses are feasible and natural and/or cultural resources are present, determining the most beneficial use may be more difficult. The most beneficial use will depend upon the site's particular traits, strengths, and weaknesses, as well as the goals that the site, affected governments and communities, and other interested parties would like to fulfil through re-use. Community support is particularly critical in cases where institutional controls are needed to ensure a specific, restricted use. A site may have multiple re-use alternatives with each option satisfying one or more particular values.

## WHO BENEFITS?

### The Public and the Stakeholders

Previously, concerned communities were generally considered to be restricted to those local to or directly affected by a contamination, or who were benefiting from the implementation of a remediation project. Deliberation and decision analysis therefore was typically restricted to those parties with a recognised claim and vested interests. Next to those immediately concerned, either being the affected or being the originators, a variety of individuals or groups and the public at large may benefit from remediation projects. Increasingly, all those concerned voice their interest in the outcome of remediation project and their interest in participating in the relevant decision making processes.

The concepts of 'public participation' and 'stakeholder involvement' have mainly emerged in North America and Northern Europe, where, in some countries, direct participation of citizens in decision-making processes has a long history. Nevertheless, the following deliberations concerning affected groups are equally valid in a different cultural context, even though 'active' participation may have no tradition there and may not be sought (yet).

The definition and delineation of the 'public' and the 'stakeholder' is neither straightforward nor unequivocally accepted. Indeed, any one individual can be both member of the public and stakeholder, depending on whether the private, political, or professional aspects of the life are concerned. Typically, the 'public' comprises 'stakeholders' such as affected citizens and civic organisations, environmental groups, labour organisations, schools and universities, representatives of business interests (e.g. chambers of commerce), representatives of government (local, regional, state etc.), and the scientific and technical expert community (academia, professional organisations, government departments). However, not each member of these groups or not all groups are necessarily directly affected by the contamination in question and the related remedial activities. The question of whether all 'concerned' or only those 'affected' should be considered stakeholders in the decision making process remains unresolved to date - not the least because a clear definition of the groups is difficult.

Stakeholders are likely those individuals or organisations that have an interest in the results of a remediation project or are affected by that project. Although identification of stakeholders is difficult, consideration of the following questions may provide some guidance as to their identity:

- Who has the information and expertise that might be helpful?
- Who has been involved or wanted to be involved in similar risk situations before?
- Who may be affected, with or without their knowledge, by the remediation planning?
- Who may be mobilized to act or angered if they are not included?

The stakeholders within a remediation programme are identified in Figure 2 as potential actors, or affected parties. It should be noted that the figure is for information only and is far from comprehensive. In the different societal systems of the different Member States, stakeholders may appear under different names and guises, may be one and the same person or organisation, and are not necessarily active.

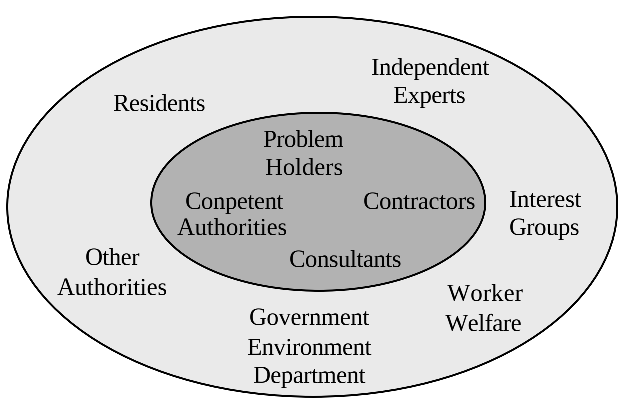


Fig. 2. Stakeholders, after [10]

Various groups of the public will be affected by both the contamination and the remediation process, in various ways. Table I summarises the interests and potential benefits for the stakeholders in an environmental remediation project. There will be also a considerable difference between actual effects and risks ensuing and those perceived. Individual or group decision makers dealing with radioactive contamination issues naturally base their decisions on the problem as they perceive it. It is important to recognise that 'perceived' risks are as tangible as 'real' risks as far as the decision making process is concerned. In planning for remediation objectives, including future land use, and before taking any step towards remediation, it is important to take the community's perceptions into consideration. Local attitudes, perceptions and values have formed over long years, they are active agents in organising a system of resource usage in practice and they reflect the basis from which a future land use and other benefits could emerge.

The involvement of NGOs (Non-governmental Organisations) - despite their qualitatively mixed appearance- has had a positive effect in many Member States. Acting as a voice for less influential societal groups, they have been playing an interfacing role between the communities, on the one hand, and the government on the other, allowing to frame the concerns. NGOs are not limited to environmental groups; the paralleled increase of industries' (lobbying) associations has also led to significant changes in the number and scope of interest parties potentially involved in decision making. However, it may be stated that most of the NGOs have their own perceptions and agenda, which may often be at variance from those actually affected, sometimes because of different socio-cultural background of their key leaders and workers. In the process, NGOs may not only impose their own perspectives, but tend to expand their own space and establish their indispensability as mediators [11].

Table I. The Function of interested parties in the remediation project, after [12].

| ACTORS | INTERESTS AND EXPECTED BENEFITS |
|---|---|
| Problem holder | cost effectiveness<br>functionality of environmental media<br>efficient decision-making |
| Authorities | multifunctionality of soil<br>minimisation of remaining environmental load<br>consistent policy<br>efficient decision-making<br>maintain/improve tax revenue through viable economy |
| Consultants | looking after the interests of the client (problem holder or competent authority)<br>efficient decision-making |
| Contractor | looking after the interests of the client<br>efficient decision-making<br>shareholder benefit |
| Public | risk reduction<br>minimal limitations of use<br>minimal nuisance<br>efficient decision-making<br>maintain/improve socio-economic situation |

The result are sometimes considerable differences in reasoning/logic between the 'public' and decision makers and between official/scientific estimates of benefits and risks ensuing and those perceived by the communities, leading to misunderstandings on the goals and objectives of a project. Priorities might also change with time and as remediation progresses. Those immediately affected might be concerned at the beginning with health risks, but later on in the process, economic criteria typically become more dominant. These problems have been, for instance, addressed by a recent OECD-workshop [13], but no simple solution to the problem is available. The objective should be to reach, by conflict management, a 'win-win' situation.

Providing for public participation is likely to require a non-negligible amount of financial resources, which is an important reason - apart from differing traditions in governance - why it seems to frequently implemented in more affluent countries. Means for measuring success and positive contribution of participation, therefore, are justified requirements in a project management context. Measuring success is complicated frequently by the fact that public participation does not necessarily lead to tangible results and a 'control case' without participation for comparison does not exist. Rather, participation typically results in a reduction of programmatic risks and in savings, i.e. in averted overruns of schedule and budget. The public concerned may apply different measures of success, according to their agenda.

### Ownership and Social Identity

Even though the customary level of community participation in decision-making varies significantly from country to country, local communities still play an important role in providing the context for decision making. A community is formed on more than the natural ties of kinship; implicit in the term are: the sense of territory, a considerable degree of interpersonal acquaintance and contact, and some special bases of coherence that separate it from neighbouring groups. Traditionally, communities have been based on ascriptive identities developed over long periods of time and patterns of loyalty. In many countries, and not only in the Western World, 'new communities' have emerged in recent years as strong players in the collective bargaining process of environmental interventions. These new communities are 'communities of place and interest', a means of delivering a decentralized welfare state and regional economies, and have emerged in the pursuit of individual interests. In other words, they are often autonomous associations that exist independently of the State. They include all forms of collectivities, associations, non-governmental agencies etc.

### Culture and Communication

Efficient communication between the various stakeholders is seen as the key to a successful remediation project. The culture of communication varies considerably from society to society and the notion of desirable methods of communication upheld by Western communication scientists and sociologist is not easily applicable in a different cultural context and in all Member States. Efficient communication between decision makers and stakeholders - whether be it one-way or a dialogue - has proven to be difficult enough in a homogeneous cultural context. Communication can be much more difficult across cultural boundaries, as is frequently necessary in Member States comprising various ethnic groups, an international corporation context, or were foreign experts are involved. Contrary to Western views, but also gaining ground there within certain groups of the public, Eastern and Native American ways of thinking often reject materialism and the importance of economic values, view nature as cyclical, life as a struggle for balance within nature, and value science less than does Western culture. This has obvious implications for risk perception and communication. Cultures that are less individualistic are likely to take issue with decision making strategies based on scientific rationale, which actually may appear irrational in cultures where nature is seen as most powerful. Claims that the risk of some project are minimal, or that contamination can be effectively contained or cleaned up, may be seen as full of hubris [14]. A view that is increasingly shared by many in the Western world, following a change in paradigms with respect to valuing scientific rationale in the last few decades.

## PROJECT IMPLEMENTATION RELATED RISKS

### Regulatory, and institutional aspects

Side effects of planned remediation measures may run afoul with legislation in related fields. For instance, changes in land-use may have impacts on drainage pattern, on groundwater recharge quality, may lead to eutrophication of surface water bodies, on the ecology of protected landscapes, and so on. A predictive assessment may be needed to ascertain that no such impacts will occur [15].

### Local socio-economic conditions

Failure to consider local conditions can derail a remediation process in a variety of ways. For example, a remediation plan may not be accepted by the local community, either through tacit and private non-compliance or open resistance by e.g. the formation of citizen groups, depending on local traditions of governance. Particularly when institutional measures are part of the overall remediation strategy, solutions may fail when local behaviours are not considered adequately. Decisions may be judged inappropriate when they interfere with local practices and customs.

### Infrastructure

The quality and availability of local infrastructure can affect and, in turn, may be affected by a remediation programme. Relevant variables include:

- the physical setting of the site;
- local facilities, e.g. transport (road, rail networks), accomodation, etc.;
- regional facilities, e.g. transport (road, rail networks), waste disposal facilities;
- general state of development.

The lack of infrastructure, e.g. the lack of roads/rail to bring certain equipment, housing for staff, suitable waste disposable facilities nearby, etc. can have a significant influence on the choice of remediation option. The added value from planned improvement of infrastructure may be an important factor in the decision making process. Due to the numerous disparate factors, which describe an area or community infrastructure, it is not possible to be prescriptive with respect to methods to be used for the analysis of potential benefits for and impacts on the infrastructure.

### Environmental risks and benefits of remediation projects

The implementation of a remediation project may result in a variety of environmental impacts in addition to those resulting from the contamination itself. Possible impacts may concern natural resources, such as surface waters, groundwater, air, geological or biological resources. Impacts on biological receptors can be assessed in terms of mortality or diversity. Natural resource damages can be assessed *a posteriori* with a view to mitigating existing damage or *a priori* with a view to prevent new damage.

Adverse impacts to ecological receptors that are located on-site or off-site may occur due to the deployment of a given remediation technology. Deployment of plant and any other works can cause significant disturbance to the site ecosystem and its surroundings. For instance, certain technologies, such as removal of topsoil or soil washing, effect the removal of surface contamination, albeit at the cost of destroying the soil ecosystem. Thus, the value of an ecosystem might need to be balanced against the likelihood and magnitude of radiological impacts.

An area larger than the actual contaminated site may be required for installations, intermediate storage of wastes and so on. Removal, transport and disposal of residual wastes may result in environmental impacts and risks at locations other than that of the original contamination. There is, for example, little benefit in removing a contaminant that is well fixed on a low volume of soil, only to produce a high volume of an aqueous waste with the contaminant in a more soluble or mobile form. In addition the remediation techniques chosen should not generate large quantities of secondary waste and should not pose risks of exposure to the public or operators that exceed the risks of quiescent contamination [16].

On the other hand, remediation projects may be designed to deliberately increase environmental benefits, for instance by improving biological diversity through creating certain types of habitats.

The decision making process must include such externalities of detrimental and beneficial nature. The potential for environmental risk may be an important factor in decision making because some remediation technologies are more likely than others to produce adverse impacts on ecological receptors, including habitat disruption, or generate natural resource damage [4].

The basis for assessing environmental risks and benefits can be obtained from a wide range ecological field and modelling studies, the use of contingent valuation, and other techniques to measure use value, existence value, intrinsic value and the ensuing costs of environmental damage [16]. Consideration should be given to the use and application of established environmental impact assessment (EIA) methods.

### Co-Contamination Issues

Co-contamination issues offer a good example of where a sound understanding and balancing of technical and non-technical factors is required. In many practice related contamination situations remediation is complicated by the co-occurrence of contaminants of radiological and toxicological or eco-toxicological relevance. This is frequently the case for mining and milling operations, were heavy metals including arsenic are incidental to the ore, or actually may be the major constituent. In other cases hazardous and low-level radioactive wastes may have been co-disposed [17] in a situation now requiring remediation. Complex practices, as for instance were/are found at large research centres, have led to multiple contaminations.

Different clean-up efforts can lead to conflicting clean-up goals at a particular site or to an unusual partitioning of a site into different clean-up units. The foreseen remediation technology has to take into account the possibly different geochemical behaviour of the contaminants. In other cases, the radiologically relevant component may be of lesser importance than the chemo-toxicological ones, and remediation criteria and technologies may need to be tailored according to the latter.

The different types of contaminants may also give rise to different types of waste streams and related conditioning and disposal requirements. Disposal facilities for hazardous wastes typically are not licensed to accept radioactive wastes and vice versa. The necessary separation of wastes will add to the operational costs and the cost of treatment and disposal.

**Project Costs, Funding and Financing**

The term 'cost' in the context of this section is meant to cover direct expenditure and not a numerical value coming out of the monetarisation of some non-tangible item, such as detriment to the environment etc. It is clear that all relevant cost items for all options under investigation must be included adequately in the decision making system. These include, inter alia, management costs, labour, procurement or renting of equipment, licensing fees for technologies, monitoring costs, and costs of final waste treatment and disposal. The latter can indeed become a major cost factor.

The issue of costs is also linked to the assessment of risks associated with the implementation a given remediation technique. More innovative techniques need higher provisions for contingency.

Costs consist of the total expenditure required to design, implement, and demobilise a remediation technology for the project. These costs can be divided into capital costs, management costs, and operation and maintenance costs. Capital costs include direct and indirect capital costs. Direct capital costs include equipment, labour, and materials to deploy the technology. Indirect capital costs include such items as design, construction management, and treatability studies. Management costs include regulatory compliance management, infrastructure and materials support for the project's operation, and assurance of an adequate workforce. Operation and maintenance costs include expenses for the start-up and operation, including monitoring activities, of the restoration alternative.

Because budgetary resources may be fixed or limited, delineating the costs can be an important input for the decision making process. A common cost basis permits evaluation of the costs of remediation alternatives.

The availability of funds can be, indeed, one factor overriding most of the other considerations. Many Members States today have adopted the 'polluter pays principle', meaning that the originator of a contamination is responsible for adequate remediation measures. However, in many cases the originator has ceased to exist or it is difficult, even impossible, to attribute a contamination, e.g. owing to multiple contamination events, thus resulting in 'orphan' contaminations. Owing to the nature of such radio logically relevant contaminations, the responsibility for making safe, clean-up and monitoring often rests with, or in the wider public interest, is assumed by the Government. The Government has to fund such activities through (regular) tax revenue. Limited tax income in any one year may hamper and delay remediation. Similar constraints apply to private enterprises, where remediation funds typically need to come out of the annual (gross) profits or from (non-taxable) reserves if these are permitted under the prevailing legislation. To overcome such potential problems in the private domain and for new practices, or the further extension of licenses for existing practices, insurance cover for environmental liabilities are increasingly required by the licensing authorities in many developed Member States. Depending on the type and size of operation, these may take the form of classical risk-type policies, obtainable on the insurance market, or the form of bonds [18]. Environmental liabilities and their financial coverage are also becoming an integral element of corporate business plans and company accounting systems [19], thus minimising the risk of generating new 'orphan' contaminations.

In some instances alternative funding can be sought, such as through the increase in market value of property following clean-up and re-development. Speculations on the property value may indeed influence the performance of a restoration programme as well as its end-point, for property value is closely linked to foreseen land-use. This kind of funding mechanism is more applicable to (former) practices, rather than to accidents, where after clean-up, typically previous activities resume.

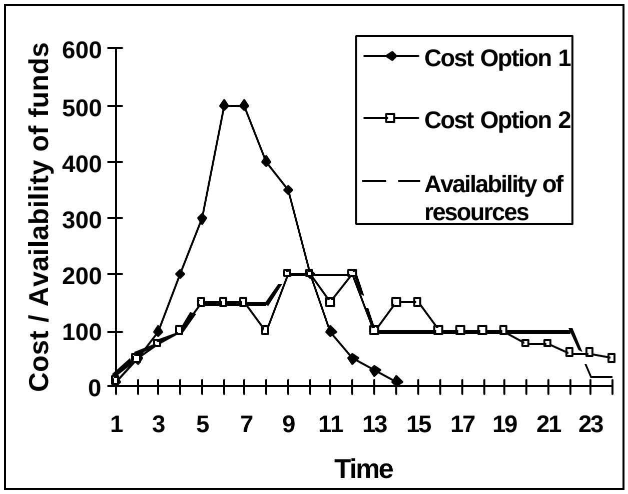


Fig. 3. Viable (Option 2) and not viable (Option 1) cost vs. time functions

Resources available for restoration measures are usually limited both in total amount and with respect to the time over which they can be spent. Allocation to the various sub-tasks and supporting activities will be an important aspect of the decision making process. Cost control not only addresses the allocation of resources to individual sub-task, but also controls the flow of resources over time. The amount of funds available at any one time might well limit the choice of restoration option. Two possible extremes are i) an option involving a high investment over a short period of time as opposed to ii) another option involving moderate expenditure of a longer period (Figure 3), both options incurring the same total cost. The second option may be more in line with the general mode for tax money availability, but additional costs from spreading out the task must be taken into account. These typically include interest on loans, rental fees, higher depreciation for equipment, and maintenance costs for the necessary infrastructure. This indicates that a full economic cost assessment and accounting is an essential element of the decision making process.

While the discussion above concerned the ultimate source of funding a remediation project, various models for financing the remediation activities exist. The method of financing is determined by the nature of the problem owner and the source of funding. Typically the problem owner or his intermediates, be it government or private, would contract out at least individual technical measures, if not the project management. Contracts would be honoured upon the achievement of certain agreed programme milestones, such as achieving a specified level of residual contamination or processing given amounts of wastes. There are also cases were the government handed over the whole problem to a contractor/management consultant to be delivered with the agreed final solution. In any case the financial and programmatic risks largely remained with the government in the case of public sector projects.

Tighter budgets, both in the public and private sector, and higher accountability of resources spent in the public sector have led to increased (financial) risk awareness and a move away from pure service contracting to (remediation) results oriented contracting [20]. The intention is to devolve programmatic, and hence, financial risks upon the contractor, with the aim to complete a project within budget and schedule, and to specification. Following the success in competitive bidding for a project, the economic incentive for a contractor resides in the margin to be obtained if the project can be completed within or below budget and schedule. In order to be economically attractive, the obtainable profits must be commensurate to the (financial) risk the contractor is exposing himself. A prerequisite, therefore, is a clear description of the project, its objectives, and identification of all risks associated. Parcelling a project into logical, smaller and easy to oversee work packages, however without compromising the overall efficiency, makes contracting and bidding easier.

Financing for the project execution may come from government or private sources, or a combination of both. The relative proportion will depend on how well the project and its associated risks can be defined in order that these risk remain commensurate with the market incentives for the contractor. In the case of public money financing, it may take, for instance, the form of down-payments to the contractor. In the case of private sector financing, the contractor may seek funding on a corporate or on a project basis.

Finally, the fiscal framework in the Member States, and in particular its flexibility or non-flexibility, can have a decisive influence on the methods of financing and the possible allocation and deployment of funds. Issues of relevance include allowable reserves, fiscal vs. project-oriented accounting, continuity etc.

## SUMMARY AND CONCLUSIONS

The local factors - social, cultural, and economic goals and values - will form a critical backdrop to the process of defining the remediation objective and the way towards it and are more or less independent of the traditions of governance in a given country. The choice of remediation technologies will need to be tailored to the socio-economic needs of a region and the respective resources available - a notions that is even more important in countries with economies under pressure at present. Thus, the overall socio-economic benefit in a region might be improved by choosing a perhaps less sophisticated technique, but involving the local man-power and other resources. Drawing out a project over a longer time scale, thus keeping local staff employed for a longer period of time, might be more beneficial at the bottom line than earlier completion followed by paying unemployment benefits; and it may add a social dividend.

The intended use of a site following remediation is likely to be a factor significant for the overall benefit from the remedial operation.

Working out such trade-offs requires the collaboration of all parties involved, the owner of the contamination, licensing authorities, the funding bodies, the contractor, the operator, and indeed the affected people themselves.

## ACKNOWLEDGMENTS

During the work on the above mentioned technical document, the author profited from intensive discussions with P.M Booth (Research & Technology, BNFL plc., UK), K. Compton (IIASA, Laxenburg, Austria), J.J.C. Edwards (Research & Technology, BNFL plc., UK), K. Lahiri-Dutt (University of Burdwan, India), and J.L. Regens (Entergy Spatial Analysis Research Laboratory, Tulane University Medical Center, USA), and their contributions to the project are gratefully acknowledged.

## REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Rehabilitation of Contaminated Areas from Past Activities and Accidents, IAEA Safety Standard Series XXX, Vienna (in prep.).

[2] WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, "Our Common Future" (also known as "The Brundtland Report"), Oxford University Press (1987).

[3] GUIKEMA, S., BOLLINGER, M., "The Role of Risk in DOE Environmental Cleanup Decision-Making: The Regulatory Requirements", Waste Management 2000, 27 Feb.-02 Mar., Tucson, Ar., http://www.wmsym.org/wm2000/pdf/57/57-2.pdf (2000).

[4] REGENS, J.L., HODGES, D.G., WILKEY, P.L., ZIMMERMAN, E., ARMSTRONG, A.Q., KELLEY, L., HALL, T.A., HUGHES, E.A., "An Integrated Framework for Evaluating Subsurface Contamination Remediation Technologies", Environmental Geosciences (1999) 82-89.

[5] ROYAL COMMISSSION ON ENVIRONMENTAL POLLUTION, "Setting Environmental Standards", 21st Report, Cm 4053, London (1998).

[6] SALT, C.A., HANSEN, H.S., KIRCHNER, G., LETTNER, H., REKOLAINEN, S., DESMET, G., "Integrating Environmental and Socio-Economic Impacts into Countermeasure Decision Making", IUR Topical Meeting, 1-5 June 1998, Mol, Belgium (1998).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, "Review of the Factors Affecting the Selection and Implementation of Waste Management Technologies", IAEA TECDOC-1096, Vienna (1999).

[8] BOARDMAN, C., HOLMES, R., ROBBINS, R., FOX, R., MINCHER, B., "Remediation of Soil at Nuclear Sites", Waste Management 2000, 27 Feb.-02 Mar., Tucson, Ar., http://www.wmsym.org/wm2000/pdf/38/38-5.pdf (2000).

[9] LandTREK, "Land Reuse Plans", http://www.landtrek.org/LandTrek/DOEroadmap/Planning/Typical_Land_Reuse_Plan/typical_land_reuse_plan.html (tested 2000-05-12).

[10] KOLKMANN, X.I., "Besluitsvorming rond saneringsalternativen - een analyse van het beslisproces", TAUW report No. R0076686.1/XIK, Netherlands (1997).

[11] JODHA, N.S., "Waste Lands Management in India: Myths, Motives and Mechanisms", Economic and Political Weekly, XXXV(6) (2000) 466-473.

[12] BEINAT, E., VAN DRUNEN, M.A, JANSSEN, R., NIJBOER, M.H., KOOLENBRANDER, J.G.M., OKX, J.P., SCHUTTE, A.R., "The REC Decision Support System for Comparing Soil Remediation Options - A methodology Based on Risk Reduction, Environmental Merit and Costs", CUR/NOBIS, (September 1997).

[13] NUCLEAR ENERGY AGENCY - ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, "The Societal Aspects of Decision Making in Complex Radiological Situation", Report OECD-NEA, Paris (1998).

[14] EDELSON, M.C., SVATOS, M., "Why Don't They Understand?", Waste Management 2000, 27 Feb.-02 Mar., Tucson, Ar., http://www.wmsym.org/wm2000/ pdf/45/45-2.pdf (2000).

[15] DESMET, G., GUTIEREZ, J., VASQUEZ, C., SALT, C.A., VANDENHOVE, H., VOIGT, G., ZEEVAERT, T., "Techniques and Management Strategies for Environmental Restoration", Mid-Term Report of the EURATOM-CIEMAT Association Contract, CIEMAT, Madrid (1998) 215 p.

[16] HOLLAND, A., O'CONNOR, M., O'NEILL, J., "Costing Environmental Damage: A Critical Survey of Current Theory and Practice, and Recommendations for Policy Implementations", European Parliament/ STOA Report PE165 946/2, Luxembourg (1996) 77 p.

[17] US DOE OFFICE OF ENVIRONMENTAL MANAGEMENT, "The State of Development of Waste Forms for Mixed Wastes", National Academy Press, Washington (1999) 129 p.

[18] DA ROSA, C., "Financial Assurance", Mining Environmental Management, 7(2), (1999) 10-13.

[19] BELFIELD, D., "Environmental Accounting", Mining Environmental Management, 7(2), (1999) 7-8.

[20] HOWES, W.S., BOYD, G.G., SINK, C.H., LYNN, D.A., "Coupling Environmental Contracting Using Risk Allocation with U.S. Department of Energy Remediation Marketplace", Waste Management 2000, 27 Feb.-02 Mar., Tucson, Ar., http://www.wmsym.org/wm2000/pdf/57/57-3.pdf (2000).