AN ECONOMIC ASSESSMENT OF THE RECLAMATION AND RESTORATION OF LAND

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CONTENTS

Abstract

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The pollution of land by mining, industrial and other activities is an international environmental problem. Common features of derelict land are extremes of topography and the disruption of drainage systems. The natural colonisation of such land by plants can be slow, and so reclamation schemes are commonly undertaken to regrade, revegetate, stabilise, and landscape derelict sites. Reclamation is carried out to eliminate pollution, improve views and create productive after-uses for treated land. The objectives of this research were to 1) determine the economic costs and benefits of land reclamation and 2) to identify the extent to which well designed reclamation schemes can minimise the net costs or maximise the economic benefits of reclamation.

A questionnaire survey was employed at one of the biggest reclamation schemes ever undertaken in Britain. The social benefits of land reclamation, as measured by contingent valuation, were shown to be substantially less than its costs.

An investigation into the impact of coal mine dereliction on house prices indicated that such effects may be substantial. Surveys of the visitor use of land reclaimed for public open space revealed that the use of sites was generally for short periods of time, passive in nature and dominated by males rather than females.

Cost-benefit analysis (CBA) was applied to forty reclamation schemes in England and Wales. The economic assessments demonstrated the importance of the type of dereliction tackled and the after-use chosen in determining overall scheme costs. They also showed the extent to which good design can obviate unnecessary reclamation works and subsequent landscape maintenance costs. A common finding was that the cost of acquiring derelict sites was greater than their post-reclamation land values, suggesting that excessive prices are being paid to obtain such land.

CBA was also used in economic appraisals of the restoration of land, in which soils are removed sequentially in anticipation of their reinstatement following mineral extraction. It was found that where pits or quarries are landfilled, the associated economic benefits can greatly outweigh the costs of restoration.

Reclaimed coal mine sites often suffer from the gradual regression of surface vegetation. A field experiment was undertaken to evaluate how such sites should best be maintained. On land reclaimed for pasture, the highest annual yields were provided by the surface application of sewage sludge rather than the injection of liquid digested sludge or the use of high levels of mineral fertiliser.

An examination of the cost-effectiveness of the Derelict Land Grant system at the national level indicated that in England and Scotland the mean cost per hectare of reclamation has recently increased markedly in real terms. This appears to be due to the current official emphasis on reclamation for hard development rather than amenity or agricultural after-uses, as well as a growing proportion of industrial dereliction requiring treatment, which tends to be expensive to reclaim.

Whilst economic considerations are only one of a range of factors which need to be taken into account in land reclamation, they should not be ignored. The routine use of CBA in the economic evaluation of land reclamation projects and a greater emphasis on principles of ecological landscape design and management would help to ensure that scarce financial resources are not squandered.

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CHAPTER 1 INTRODUCTION

1.1 Definitions

Britain has a serious problem of waste land, much of which results from its industrial past. Waste land is any land which because of neglect or degradation is not being used to its full potential. It can be conveniently subdivided into three subjective categories (EAU, 1986):-

(1) Derelict land

In the United Kingdom, derelict land is defined administratively as '<u>land so damaged by industrial or other development that it is incapable of beneficial use without treatment</u>'. For government grant purposes such land includes buildings which have become so dilapidated or decayed that they are structurally unsound and therefore incapable of beneficial use. This is not a statutory definition, but one which the Department of the Environment (DoE) has agreed with the Treasury.

Land which qualifies as derelict under the above definition is eligible for Derelict Land Grant (DLG) from central government. Certain types of land such as sand dunes and land already covered by restoration conditions are not eligible for DLG (DoE, 1984). The precise nature of those items of work for which DLG may be approved has been described in detail elsewhere (EAU, 1986). This does not generally encompass funding for long term landscape maintenance costs, though it may include some additional resources for the initial costs of establishing vegetation, often arbitarily calculated at 10% of the reclamation works cost. Competitive tendering for reclamation contracts is used to attempt to ensure value for money.

(2) Neglected land

For grant purposes neglected land is officially defined as '<u>land which is capable of some beneficial use but which is at present uncared for, untidy and in a condition detrimental to the environment</u>'.

(3) Operational land

Operational land consists of areas within an ongoing industrial development. These may be in active use or may be lying idle, possibly with an adverse effect upon the environment. As a result, either before or after the cessation of industrial activities, parts of a site may comprise waste land, although other parts may have been relatively unaffected by the operations.

The treatment of neglected land usually involves only relatively minor works such as the removal of fly tipped rubbish and wastes, grassing and tree planting. The fencing of a site that has been tidied up is often desirable so as to safeguard it, but the current grant system does not always extend to this.

Since the improvement of neglected land is relatively straightforward, it is also quite cheap. Consequently, this research will concentrate on the much thornier problem of the reclamation of derelict land. When mining or other activities finish, operational land may become officially recognised as derelict.

A distinction will be made here between the <u>reclamation</u> and <u>restoration</u> of land, that may not agree in its entirety with other usages (see for example Bradshaw and Chadwick, 1980; Bradshaw, 1984), but which gives more precision for the purposes of this investigation. From an operational point of view, the reclamation of land will be taken to imply the treatment of derelict land, from which the original soils have almost invariably been lost, hindering attempts at revegetation. Reclamation may involve the rehabilitation of ecosystems or their replacement, often with simpler ones (Bradshaw, 1984). The restoration of land, will by contrast be defined in operational terms as the process of reinstatement which follows the temporary disturbance of land in which soils are not lost, but stripped off and stored for later re-use. According to these definitions, land which is due to be restored is neither derelict nor neglected, but is a temporarily disturbed form of operational land awaiting the reinstatement of soils.

1.2 The scale of the problem

A detailed survey has suggested that around 1974 there were approximately 200,000 hectares (ha) of waste land in England, 60,000 ha in Wales and 80,000 in Scotland, giving a total of some 340,000 ha in Great Britain as a whole (Dennington and Chadwick, 1982). Of this, some 78, 76 and 84% of the total was accounted for by neglected rather than derelict land in the respective countries.

In addition, informal surveys of urban wasteland as a whole were carried out in 1977 and 1988 by the Civic Trust. Reliable estimates are not available but it has been suggested that there may be as much as 100,000 ha of urban wasteland in Britain requiring treatment (Civic Trust, 1977; Civic Trust, 1988).

It has recently been estimated that there are some 120,000 hectares of operational land in England (EAU, 1986). However, only a fraction of this may actually comprise waste land.

In England, the area of officially derelict land has been recorded by the DoE in nearly every year since 1966. Published data is available in the form of the results of the derelict land surveys undertaken in 1974 and 1982 (Department of the Environment, 1975; Department of the Environment, 1984). These are compiled from returns provided by local authority planning departments. In addition, unpublished provisional results of the 1988 survey are also available (Department of the Environment, 1989). These results need to be interpreted with caution, however, because they are based on partial returns (333 out of 366 or 91% of local authorities). Where an authority has not yet provided a return, information from the 1982 survey has been used in compiling the provisional results.

A problem that is difficult to allow for is the extent to which recording methods have changed over time, perhaps leading to an unrepresentative increase in the total area of derelict land. A comparison of the results from 1982 and 1988 is likely to be the most accurate, however, because by the time of these more recent surveys planners will have had more experience of land classification, and they are only six years apart.

Overall totals and a breakdown of dereliction in England by type are given in Tables 1.1 and 1.2. Only part of the total area of derelict land is deemed to justify reclamation, because the DoE argues that some sites are situated in remote locations where they have relatively little impact, and others may be too costly to reclaim.

Table 1.1 Derelict land remaining and percentage change 1974-1988, by type of dereliction, England [Source: DoE (1989)]

	Derelict land remaining (hectares)				
Type of dereliction	1974	1982	1988	% change 1974-82	% change 1982-88
Spoil heaps	13,118	13,340	12,015	+2	-10
Excavations and pits	8,717	8,578	6,168	-2	-28
Military	3,777	3,016	2,624	-20	-13
Railway	9,107	8,210	6,650	-10	-19
Other forms of dereliction	8,554	12,539	13,981	+47	+12
Total	43,273	45,683	41,456	+6	-9

Table 1.2 The area of derelict land justifying reclamation and percentage change 1974-1988, by type of dereliction, England [Source: DoE (1989)]

	Derelict land justifying reclamation (hectares)				
Type of dereliction	1974	1982	1988	% change 1974-82	% change 1982-88
Spoil heaps	9,084	8,300	7,536	-9	-9
Excavations and pits	6,596	6,402	4,390	-3	-31
Military	3,145	2,452	2,072	-22	-15
Railway	6,412	6,015	5,129	-6	-15
Other forms of dereliction	7,831	11,109	12,883	+42	+16
Total	33,068	34,278	32,010	+4	-7

Tables 1.1 and 1.2 show that despite central government's policy of providing grants for land reclamation, the total area of derelict land and land justifying reclamation has not declined substantially over the period 1974-1982. This indicates that the hard core of the derelict land problem remains to be tackled.

The problem is that new dereliction is appearing just as fast as land is being reclaimed. This is particularly clear for the 'other forms of dereliction' category (Table 1.3).

Table 1.3 Mean annual rates of actual and net reclamation of derelict land 1982-1988, allowing for the creation of new dereliction, based on the area of derelict land justifying reclamation, by type of dereliction, England [Source: DoE (1989)]

	Mean annual rate (hectares)+					
Type of dereliction	Reclamation		New dereliction		Net rate of reclamation	
Spoil heaps	514	(23%)	387	(21%)	127	(33%)
Excavations and pits	311	(14%)	-24*	(-1%)	335	(88%)
Military	235	(11%)	172	(9%)	63	(17%)
Railway	323	(15%)	175	(10%)	148	(39%)
Other forms of dereliction	810	(37%)	1,106	(61%)	-296	(-77%)
Total	2,193		1,816		380	

* See text for possible explanations of this figure.
+ Figures are given the nearest hectare with consequent rounding errors.

There are a number of possible explanations for the apparently anomalous negative figure for the creation of new dereliction in the excavation and pits category in Table 1.3. This may be indicative of discrepancies in local authority returns. However, it is likely that much of this type of dereliction is accounted for by sand and gravel pits and quarries (Chapter 7). These may have been naturally reclaimed, for example where former quarries have become filled with water, and this may have gone unrecorded in the later survey. Alternatively, some such sites may have had restoration conditions imposed on them, so that by the time of the 1988 survey these sites are now no longer officially classified as derelict land, but as land covered by enforceable restoration conditions.

Table 1.3 also shows that the 'other forms of dereliction' category is the only one for which the creation of fresh dereliction is outstripping its reclamation. Much of this type of dereliction is made up of general industrial dereliction, which is discussed further in Chapter 6.

This table also shows that the mean annual rate of net reclamation in England between 1982 and 1988 was 380 ha $year^{-1}$. This is put into perspective by the fact that it represents only 1.2% of the total stock of land currently deemed to justify reclamation and only 0.9% of the total stock of derelict land in England. Despite this, in 1988 the total area of derelict land only covered some 0.3% of the total area of England.

The regional distribution of derelict land has implications for planning policies. This is shown in Fig. 1.1 for the total area (estimated as 41,456 ha) of derelict land in England for each of the DoE's standard administrative regions for the period 1982-1988. Since 1982, it is only in the Yorkshire and Humberside and West Midlands regions that the scale of the problem is growing. This is probably chiefly the result of a growth in industrial dereliction.

1.3 Why reclaim land ?

There are two sets of reasons for reclaiming land; environmental, and socioeconomic. These may be hard to separate.

The environmental effects of derelict land include its aesthetic effects, air pollution in the form of dust and sulphurous emissions from the spontaneous combustion of spoil heaps, and water pollution. The erosion of materials and release of toxic metals or

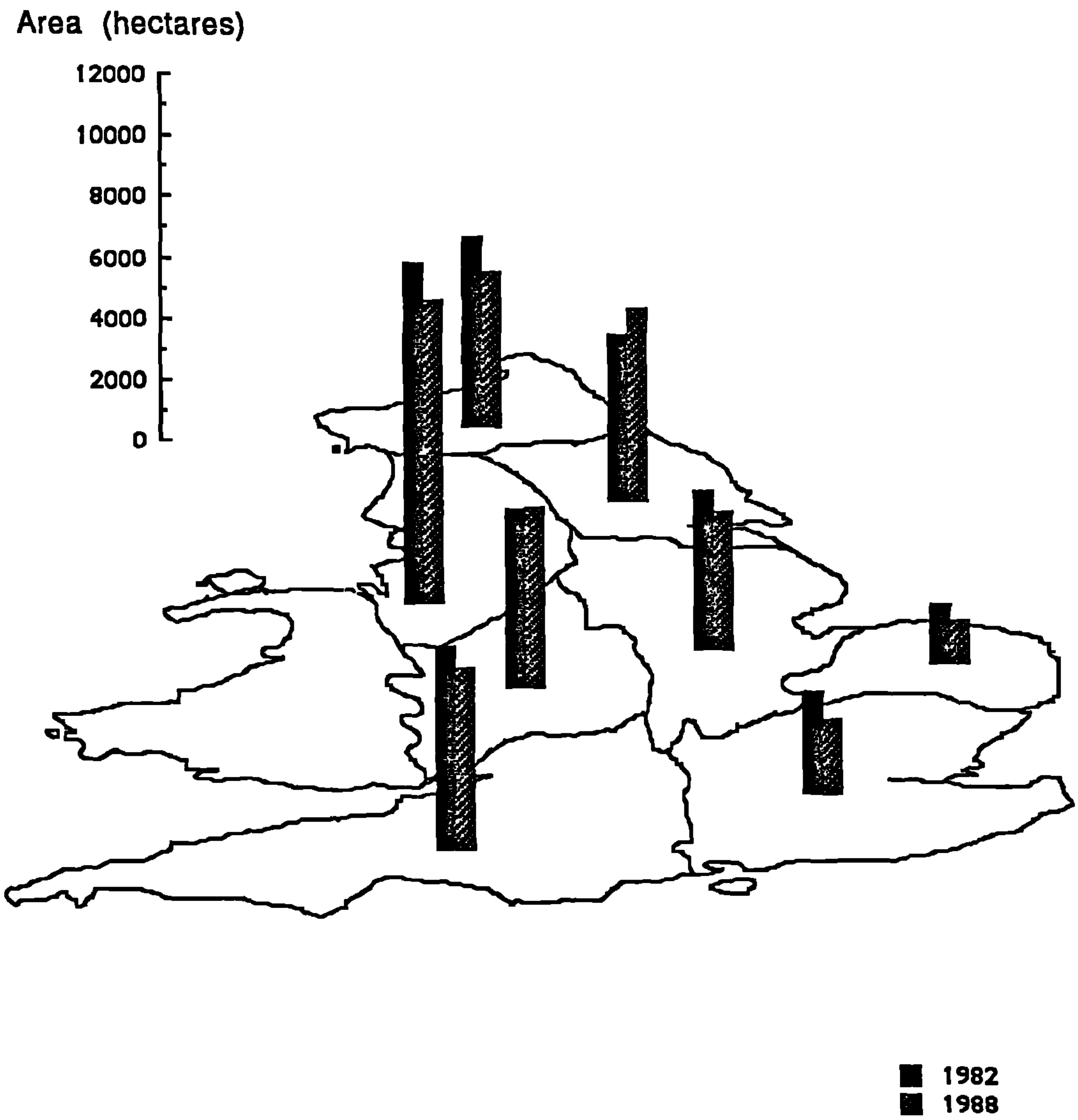

Fig. 1.1 The distribution of derelict land in England by standard region in 1982 and 1988.

other chemicals into the environment are other common problems. Derelict structures and subsidence flashes can endanger human life, and landslides can threaten whole communities, as in the case of the Aberfan disaster of 1966 (Barr, 1969).

The socioeconomic argument for land reclamation is that dereliction creates a poor living and working environment. This may contribute to problems of litter, vandalism, low psychological morale and an absence of civic pride, and encourage outmigration (with possible congestion costs elsewhere) and unplanned developments. In certain cases, falling land values, inadequate housing and unemployment can lead to the downward spiral of entire regions, as has occurred in the coal mining areas of Appalachia in the United States (Bradshaw and Chadwick, 1980).

The two commonest arguments put forward in favour of land reclamation on socioeconomic grounds have been that dereliction deters the establishment of new business activity by presenting a discouraging image to potential developers, and that reclamation can save high grade agricultural land, by reducing the pressure for development on greenfield sites. Strictly speaking these are socioeconomic considerations rather than purely economic arguments. This is because the attraction of developers from one area to another will not necessarily lead to any net increase in overall economic activity, and because economic theory predicts that land will tend to go to its maximum value in use. This therefore condones the development of agricultural land. Nonetheless, these socioeconomic considerations may be of considerable significance.

As will be shown, purely economic benefits may also accrue from reclamation. These may be measurable, for example, where people have positive economic demand for reclamation (Chapter 3), in the form of increased house prices (Chapter 4), or where land values rise as a result of reclamation (Chapters 5 and 6).

When DLG was first introduced in the late 1960's, this was largely for socioeconomic reasons, and formed a part of central government's regional policy. With the demise of New Town policy, the scaling down of regional policy and periods of prolonged economic recession, emphasis has now switched to the use of land reclamation in the environmental and economic regeneration of the inner cities. This is described in detail in Chapter 9.

1.4 The planning system

Government policy has a key role to play if the problem of waste land is to be tackled. Policies must seek both to prevent the formation of further waste land as well as to deal with that which is already in existence.

As regards derelict land, the main remedial legislation is the Derelict Land Act 1982 (EAU, 1986). This is an extension and development of the Local Government Act of 1966 which introduced DLG. In England, under section 1 of the Derelict Land Act 1982, central government grants are available both to local authorities and groundwork trusts and to the non-local authority sector (private companies, nationalised industries and so on) for the reclamation of derelict land. In addition, Section 89 of the National Parks and Access to the Countryside Act 1949, as substituted by section 3 of the Derelict Land Act 1982, provides local authorities with powers, but no statutory duty, to enable waste land to be brought back into use. The 1949 Act also enables local authorities to acquire land for such purposes either by agreement or by compulsory purchase.

Not all reclamation of derelict land in Britain is funded via DLG. Certain types of reclamation work are financed using Urban Programme Grant, and schemes may be carried out by Urban Development Corporations.

For neglected land, the main type of grant aid which is available comprises small clearance schemes. These were introduced in the Derelict Land Act 1982. The cost of such schemes must not exceed £10,000. Typical operations include site clearance, the removal of rubble and fly tipped rubbish and landscape enhancement works.

Most neglected land is found in urban areas and comprises numerous small sites (Dennington and Chadwick, 1982). These sites can only be dealt with by local authorities on land which they own or, by agreement, on privately owned land (EAU, 1986). To receive grant aid local authorities must satisfy the DoE that it is not appropriate for the authority to use its powers under section 65 of the Town and Country Planning Act 1971 to require private landowners to tidy up unsightly land themselves, with the imposition of fines if no action is taken.

In practice, this power has rarely been used, because of the legal difficulties involved, at least until the 1986 Housing Act, and because local authorities often own considerable areas of neglected land themselves. In recent years, the DoE has increased the pressure on local authorities to sell under-utilised land (Anon., 1986). Government policy is to dispose of land to developers where there is no early prospect of councils bringing it back into use for their own purposes. Land Registers, introduced in 1980 in the Local Government, Planning and Land Act, are being used as a basis for identifying idle land which should be sold. These registers record vacant or underused sites in public ownership of an acre (0.4 ha) or more in extent (EAU, 1986).

Government grants are not available for the treatment of operational land. However, the cessation of mining activities may mean that land becomes recognised as derelict or neglected, and therefore eligible for grants.

The main preventative legislation, intended to reduce the future creation of wasteland, is the Town and Country Planning Act 1971. In the case of mineral workings this has been amended by the Town and Country Planning (Minerals) Act of 1981 which established mineral planning authorities (MPA's), which have powers to control the environmental impacts of mining activities. MPAs may enforce the restoration of sites where mineral working has ceased, ensure that planning permission is obtained before new developments can proceed, and impose tidying-up and restoration requirements on extractive industries. Where restoration conditions are a planning requirement, MPAs can impose aftercare conditions, usually extending over five years, requiring land to be restored to agriculture, forestry or amenity (Town and Country Planning (Minerals) Act, 1981).

1.5 An international problem

Waste and derelict land is an international problem. For instance, there are large scale coal mine developments in Botswana, China, Colombia, Poland, West Germany, the USA, USSR, Tanzania and Zimbabwe (Bradshaw and Chadwick, 1980; BICRAM, 1987). There is also metal mining in many countries of the world; for example for aluminium, copper, gold, lead, iron ore, and molybdenum in the United States, aluminium, gold, iron ore, lead, manganese, tin and zinc in Australia, copper, gold, iron ore, lead and nickel in Canada and gold, iron ore and manganese in Brazil. The massive scale of some of these developments produces substantial environmental impacts.

The extent of environmental planning and development control measures in different countries varies widely. In the United States, the Surface Mining Control and Reclamation Act of 1977 imposed minimum reclamation performance standards, which includes a minimum five year period of aftercare, which is extended to 10 years in areas where annual precipitation is less than 66 cm (Bradshaw and Chadwick, 1980). A levy per ton of all coal produced is used to finance the reclamation of the legacy of historic dereliction. In the USA, some $100,000,000 has been spent in 36 states and tribal lands in clearing up such land in the abandoned mine land (AML) reclamation program in the last ten years, and it is estimated that every $1 million creates about 40 jobs in areas such as construction, labour, equipment and materials procurement, and other services (St. Aubin and Massie, 1987).

In the USSR, minerals extraction is generally governed by a 'hectare for hectare' philosophy in which new mines are only permitted if the reclamation of an equivalent area of mined land is guaranteed. The reclamation of coal mine developments in the Ruhr region of West Germany has attained a high level of technical sophistication, in which sites are progressively restored (Chapter 7), and houses built on afforested spoil banks (Bradshaw and Chadwick, 1980).

On the other hand, in many Third World countries, planning controls and restoration conditions may be non-existent (BICRAM, 1987). The technical problems of restoration faced in these countries are exacerbated by their poverty.

1.6 Economic aspects of land reclamation

Although a considerable literature amount of work has been undertaken in relation to developing scientifically based ecological principles to achieve the revegetation of derelict land (Schaller and Sutton, 1978; Bradshaw and Chadwick, 1980), far less attention has been paid to the economic aspects of land reclamation. In Britain, such an assessment has become long overdue because of recent changes in official policy towards the land reclamation (Chapter 9), and concern at the expense, poor design, high maintenance costs and visual and biological monotony of many reclamation schemes that has been voiced in recent years (DoE/MAFF, 1980; Baines, 1986; Groundwork Trust, 1986; RSNC, 1988).

As a result of such criticisms the DoE has recently commissioned consultants to evaluate the success of the Derelict Land Grant scheme (Department of the Environment, 1987). This relied upon financial rather than economic analyses (Chapter 2). The consultants shied away from a purely economic, cost-benefit analysis of land reclamation, believing it to be too difficult.

Where large sums of money are involved, there is clearly a need for such an overall appraisal of current reclamation designs and policies. As Bradshaw (1984) has suggested, the choice of methods of reclamation and their consequent after-uses could make a difference of thousands of millions of pounds in Great Britain alone.

Most of the work in the emerging subdiscipline of environmental economics has been undertaken in the United States. The most up to date American study which specifically addressed the <u>benefits</u> of land reclamation, was that of Randall *et al.* (1978). These workers reported the results of a cost-benefit analysis of land reclamation in a 4,100 square kilometre study region in central Appalachia in the eastern United States. The approach they used was to measure five discrete types of economic benefit directly resulting from land reclamation at the regional level. These were (1) water pollution, as it affects domestic, commercial and industrial users of water; (2) degradation of life-support systems for fish, wildlife and recreation resources; (3) increased frequency and intensity of flooding; (4) damage to land, structures, and buildings; and (5) aesthetic damages. The benefits accruing from reclamation were measured and valued using multiple regression techniques, direct valuation, surveys, published information and contingent valuation (Chapter 2). Randall and his colleagues found that for this region as a whole, the social benefits of reclamation exceeded its private costs. As has been shown above, this study was undertaken in an region where the impacts of coal mining in the past have been very severe.

Despite the seminal work of Randall *et al.*, research into the economics of land restoration is largely still in its infancy. This in part reflects the difficulties of integrating large arrays of economic data and information drawn from the natural sciences (Randall *et al.*, 1978).. However, the pollution of land is an international problem that will not go away of its own accord.

1.7 Research objectives

The objectives of this research have therefore been twofold; (1) to measure the economic costs and benefits of land reclamation; and (2) to identify which designs of reclamation schemes, technical approaches and after-uses are the most economic. Methods of achieving the former are reviewed in Chapter 2.

The application of the contingent valuation method to the measurement of the economic benefits of reclamation is described in Chapter 3. This chapter is based on Michael, N. and Pearce, D. (1989) Cost-Benefit Analysis and Land Reclamation: A Case Study. London Environmental Economics Centre Discussion Paper 89-02.

In Chapter 4, two other approaches to assessing the benefits of reclamation are discussed. The extent to which derelict land can suppress house prices was estimated in a survey of professional valuers. Since the level of visitor use of land which has been reclaimed to public open space is a useful indicator of the user benefits it provides, this was surveyed for a number of sites in North West England.

Chapters 5, 6 and 7 are concerned with the cost-benefit analysis of individual reclamation schemes. The costs and benefits of reclaiming deep-mined colliery spoil are appraised in Chapter 5, whilst Chapter 6 deals with industrial dereliction, metalliferous mining and urban clearance wastes. The costs and benefits of restoring disturbed land are analysed in Chapter 7.

Since reclaimed land commonly suffers from the regression of surface vegetation, a field experiment was carried out on reclaimed colliery spoil to investigate how this might best be tackled. This is described in Chapter 8.

The costs of land reclamation at the national and regional scales are considered in Chapter 9. This chapter is based on Michael, N. and Bradshaw, A. D. (1989) A hard future for derelict land. Landscape Design, 177, 37-40.

Overall conclusions are drawn in Chapter 10.

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CHAPTER 2 METHODS OF ECONOMIC ASSESSMENT

2.1 The range of methods

This research is concerned with examining the economic efficiency of land reclamation projects. There are a number of possible approaches to aid decision-making in public sector project appraisal. These include decision analysis, multi-criteria analysis, risk-benefit analysis, environmental impact assessment, cost-effectiveness analysis and cost-benefit analysis (Pearce and Markandya, 1989). Of these, only cost-effectiveness analysis and cost-benefit analysis (CBA) are methods of economic evaluation, and CBA has the advantage over all the other techniques that it is the only one which provides a framework which explicitly sets out to compare like with like, using money as the single measuring rod of benefits and costs (Pearce and Markandya, 1986). It also has the advantage that it requires relatively few value judgements on the part of the analyst (Pearce, 1983) and was therefore adopted in this study.

2.2 Cost-benefit analysis

CBA is based on the commonsense notion that in deciding whether or not to go ahead with a project, a comparison should be made between the costs and benefits associated with it. The basic idea underlying CBA is that if the economic benefits of a project to society exceed its costs, there is a net gain to society and the project should be undertaken. This is put into practice in CBA by first identifying all the relevant costs and benefits. Although it may be easy to list these costs and benefits, some of them may be very difficult to measure in practice. In <u>economic</u> evaluation, costs and benefits are valued at their real resource values. This corresponds to their opportunity cost, the maximum value which a resource could earn in an alternative use. Market prices may not reflect real resource values, for instance where they incorporate subsidies or taxes, which are purely financial instruments. Whereas market prices are used in purely financial analyses, in economic cost-benefit analyses they may require adjustment to reflect opportunity costs. This is known as shadow pricing.

Once the costs and benefits of a project have been itemised and assigned to the years in which they will occur, it is necessary to adjust them to take account of the fact that costs and benefits which accrue in different years have different values. This is because money which is tied up in a project could be earning interest instead and thus a 'cost of capital' is incurred in undertaking a project. This problem is overcome by the use of an interest or discount rate. Discounting has the effect of reducing the value of benefits and costs which accrue in the relatively distant future. By discounting the time stream of costs and benefits which occur over the duration of a project, it is possible to express them in terms of present values. The 'present' is usually taken to be the start of the project. Once all costs and benefits have been discounted to express them in present value terms, the net benefit or Net Present Value (NPV) of a project can be calculated. Thus, for a projcct with a life of n years, the NPV is given by:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

where B_t is the benefit which accrues at the mid-point of year t, C_t is the cost incurred at the mid-point of year t, and r is the discount rate. Since cost-benefit analysis is concerned with net gains to society as a whole, it uses what is known as a <u>social discount rate</u>.

The calculation of NPVs provides a decision rule in deciding whether to accept projects, and makes it possible to rank projects according to their economic desirability. If a project's NPV is positive, it is worthwhile, and the greater the NPV the more economically attractive it is. A project which has a negative NPV is not worthwhile. If, however, a project is not intended to make a profit, but to provide an objective at minimum cost, the economic aim is to minimise the negative NPV or Net Present Cost (NPC).

In situations where there are more projects than capital to finance them, projects should be selected in such a way as to maximise the total NPV within the budget constraint. Where a choice has to be made between mutually exclusive alternatives for a project, the proposal with the greatest NPV should be chosen.

An alternative decision criterion which can be used in assessing projects is the internal rate of return, also known as the interest rate of return or discounted cash flow return. This is defined as the discount rate which makes the NPV equal to zero:

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+r^*)^t} = 0$$

where r^* is the internal rate of return. The greater the value of the r^* the more attractive a project is. The internal rate of return can only be calculated iteratively, and there may be more than one value of r^* which satisfies the equation above, although usually only one of the multiple roots is real. The use of project NPVs is generally preferred to the internal rate of return in economic evaluation. The internal rate of return rule does not take into account project size and this means that, unlike the NPV measure, internal rates of return are not additive when dealing with multiple project selection. The internal rate of return decision rule is also unsuitable when selecting between alternative proposals for a project.

Although the NPV rule is the most generally useful decision criterion, if used naively when selecting between alternative independent projects given a capital constraint, it can give incorrect results. Under such conditions projects should be ranked by discounted benefit-cost ratios, so as to maximize total NPV. The formula for computing the benefit-cost ratio is:

$$\frac{B}{C} = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} \Big/ \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

This gives the discounted benefits per pound of discounted cost. If the benefit-cost ratio is greater than 1 then a project is worthwhile undertaking. However, the ratio rule should only be used in the above context as elsewhere it is liable to give erroneous results. A serious drawback of this rule is that it is sensitive to the definition of costs and benefits. Whilst with the NPV rule all costs can be treated as negative benefits and vice versa, the benefit-cost ratio is affected by this classification (Dasgupta and Pearce, 1978). This will cause problems when dealing with externalities such as pollution. For instance it is unclear whether a reduction in pollution should be counted as a social benefit or a reduction in cost (Sassone and Schaffer, 1978).

The question of what social discount rate (see above) to use in CBA has received considerable theoretical discussion and remains unresolved. The choice is between the social time preference rate (s), the social opportunity cost rate (r), or some combination of the two. The former represents the rate at which society is prepared to trade present for future consumption, whilst the latter is the marginal social rate of return from investment in the private sector. Use of the social opportunity cost rate prevents public sector projects being undertaken when funds are better invested in projects in the private sector.

In practice, the rate of r is much more observable than s, and the UK government recommends the use of a Required Rate of Return based on social opportunity cost arguments. The rates are currently 5% for purely financial projects where only revenues and costs are taken into account and 7% for projects evaluated using social CBA. The discount rate is higher in the latter case because the total benefits are expected to be greater. It is common practice to discount all time streams with some alternative discount rates in order to test the sensitivity of a study's findings to different discount rates employed, a practice known as sensitivity analysis.

The Required Rates of Return given above are expressed in real terms. There are two approaches to dealing with inflation in project appraisal. Firstly, all future costs and benefits can be valued at constant prices and discounted using a real rate, or they can be valued at current (inflated) prices and discounted using a money discount rate.

The distributional consequences of projects must be taken into account. The basis for efficiency comparisons in CBA is the Hicks-Kaldor potential Pareto improvement criterion that the gains to 'winners' are large enough to allow for potential compensation to 'losers' and still produce a net benefit for those who gain from a project. Nevertheless, a project with a positive NPV may have very negative consequences upon certain individuals or groups in society, and such distributional implications are often crucial from a decision-maker's point of view. Consequently, it is important to determine, as far as possible, how the costs and benefits of a proposed project are likely to be distributed across different social groups. Alternatively, weighting procedures can be directly incorporated into CBA to allow for distributional gains and losses (Pearce and Wise, 1972). In either case, it is apparent that CBA is never more than a guide to decision-making and that it does not obviate the need for political judgements.

There a number of ways in which risk and uncertainty can be incorporated into CBA. Risk implies that probabilities can be assigned to costs and benefits, whereas uncertainty means that the values that costs and benefits could take is known but the probability distribution is not. Approaches to dealing with risk and uncertainty include use of a fixed time horizon (cut-off period) over which costs and benefits are evaluated, adding a risk premium to the discount rate, and methods based on probability analysis, sensitivity analysis, risk analysis, game theory and scenario modelling. All these methods have their limitations and there appears to be no totally satisfactory way of dealing with either risk or uncertainty in CBA (Pearce, 1983). The most common approach to uncertainty is the use of sensitivity analysis in which the sensitivity of estimates to a range of assumptions is tested.

A cost-benefit analysis must also make allowance for intangible effects. These are benefits and costs which cannot be measured, such as the national prestige associated with the Concorde supersonic airliner project. All intangible effects need to be identified and listed, and it may also be possible to assign some form of physical measurement to them. Decision makers can also be informed of the magnitudes intangible effects would have to attain to substantially influence the findings based upon the measured effects, (Anderson and Settle, 1977). This is further discussed below.

2.3 Cost-effectiveness analysis

Cost-effectiveness analysis (CEA) is a variant of CBA which is used when monetary measures cannot be applied to benefits. Instead, benefits are measured in some physical units or merely stated as a policy objective. Since benefits are not monetised CEA cannot be used to determine the economic efficiency of a given policy objective, but if it has been decided to go ahead with a given objective, the use of CEA ensures that among a number of alternative projects, the one with the lowest ratio of cost to effectiveness is selected.

2.4 Methods of benefit measurement

Traditionally, many environmental goods such as quiet, visual amenity and unpolluted air and water have been regarded as intangibles. This would imply that they cannot readily be integrated into CBA, which attempts to express all costs and benefits in monetary terms. However, although environmental goods may not be priced, willingness to pay (economic demand) for them is likely to be positive. Thus within environmental economics, a number of methods of benefit measurement have been developed to provide monetary estimates of environmental benefits. These techniques and their potential usefulness in assessing the benefits of land reclamation must be understood.

There are three different ways of obtaining benefit measures in the absence of markets. Firstly, it is possible to observe surrogate markets which are influenced by an unmarketed environmental good. This approach underlies the hedonic property (house) price, hedonic wage and travel cost methods. Where surrogate markets cannot be found, it is possible to construct experimental (hypothetical) markets. This concept is central to the contingent valuation method. Since these two approaches both seek to directly elicit consumers' preferences they are known as techniques of direct valuation (Pearce and Markandya, 1989).

The third set of approaches comprise indirect valuation techniques based upon physical linkage models. These frequently use a negative attribute to estimate benefits. For example, a statistical dose-response relationship between variables such as pollution and mortality is first estimated. Economic valuation is then undertaken by applying a monetary value per unit of damage done. These different approaches to benefit measurement are set out in Table 2.1.

Table 2.1 Approaches to economic benefit measurement

Approach	**Methods**
(A) <u>Direct valuation</u>	
1) Observe surrogate markets	Hedonic property price Hedonic wage Travel cost method
2) Construct experimental markets	Contingent valuation method
(B) <u>Indirect valuation</u>	
3) Use indirect procedures	Physical linkage models such as dose-response relationships

2.4.1 Hedonic property prices

The basis of this approach is that house prices are influenced by variations in environmental attributes such as noise and air pollution. Thus the housing market is a surrogate market which is affected by the valuations placed on the benefits of unmarketed environmental goods or factors.

Since it is not possible to find houses that are identical in all respects except for the environmental factor such as noise levels being considered, multiple regression analysis is used on information drawn from the housing market to separate out the effect of environmental variables from the other variables which affect residential property values that are also included in the analysis. Once a relationship between property values and the environmental variable has been estimated, the costs of environmental damage or benefits of environmental improvement can be inferred (Freeman, 1979).

Owing to the indirectness of the approach it suffers from inaccuracy. It is likely that estimated benefits may be only within orders of magnitude of those determined independently using other approaches (Pearce and Markandya, 1989).

The hedonic property price approach has considerable informational requirements in terms of data on house prices or rents. In the case of land reclamation projects it can only be used where sites are surrounded by substantial areas of residential housing, because house price effects are likely to decline rapidly with increasing distance from a site. A survey approach based on property price impacts is presented in Chapter 4.

2.4.2 The value of life

In order to integrate the benefits of reductions in environmental pollution on human health into a cost-benefit analysis framework, it is necessary to estimate the value of a statistical life. This could be of relevance to the question of the costs and benefits of land reclamation where there are potential negative effects from derelict land. The appropriate measure is the *ex ante* willingness to pay (WTP) for a reduction, or willingness to accept (WTA) an increase in the risk of death. Economic theory holds that WTP and WTA measures should not differ significantly.

One of the main approaches to valuing life is wage risk studies, which are conducted on data from the labour market. Wage risk studies use multiple regression techniques to separate out that part of a worker's wage which is risk-determined. This method is similar to the property price technique described above and is consequently known as the 'hedonic wage' approach. Other approaches to estimating the value of life include those based on an examination of expenditure on safety measures such as car seat belts, and the contingent valuation method described below (Pearce and Markandya, 1989).

Estimates of the value of life based on these approaches vary quite widely (Violette and Chestnut, 1983). There are also problems in inferring the value of life in a pollution risk context because of the low probabilities of death involved, possible empirical disparities between WTP and WTA measures, and the involuntary rather than voluntary nature of such risk; wage risk studies being based on voluntary WTA increased levels of risk.

Nevertheless, use of a central estimate of the value of life such as £1 million, based largely on wage risk studies, may be of considerable use in the quantification of the health benefits of environmental policy. To the extent that derelict land can pose a threat to life, from the mass movement of wastes, as in the case of the Aberfan disaster, and dangers from mine shafts, asphyxiation from gases, unplanned water features and the collapse of unsafe structures, the incorporation of value of life measures into CBA may be instructive. The benefits due to reduced mortality must be weighed against the resource costs of all the projects which are undertaken. This would require an estimate of the loss of life in the absence of reclamation activity.

Unfortunately, such mortality data are not available for the United Kingdom which is unsurprising considering the difficulties that would be posed in collecting them. The only statistics that could be used are those relating to drownings in water-filled quarries, and this information is incomplete (D. Hirst, *Pers. comm.*, 1989).

2.4.3 The travel-cost method

The basis of the Clawson-Knetsch or travel cost method (TCM) is that the amount of money and time that people spend in travelling to and at a recreation site reflects their WTP for its benefits. The opportunity cost of travel time and time spent at a recreational site must be explicitly incorporated into an analysis if it is not to underestimate true WTP (Wilman, 1980). From the relationship between the cost per visit and the number of visits made, it is possible to derive a demand curve for a recreational experience (Clawson and Knetsch, 1966; Curry, 1980).

Travel cost models involve the specification of econometric equations which typically estimate the number of visits as a function of the travel cost, including time costs, income, and where environmental improvements are being assessed, the characteristics of a site. Application of these techniques requires a great deal of data which is time consuming to collect (Everett, 1979).

The method can only be used for recreational sites that have already been developed so that data can be collected from visitors. It is of little use in urban situations (Baxter, 1979) and where trips are undertaken for multiple purposes or are not site-specific.

It is clearly not feasible to apply this method to land reclamation schemes until after they have taken place. Use of the technique would be limited to estimating the benefits of schemes that have produced substantial recreational benefits capable of attracting visitors from appreciable distances, and it would be expensive and time consuming because of the approach's considerable data requirements.

2.4.4 Contingent valuation

The contingent valuation method (CVM) involves asking people about their WTP for an unmarketed benefit, or WTA a non-market cost. This may be accomplished using questionnaires or in laboratory experiments. Valuations are sought for environmental gains or losses, contingent upon a hypothetical market which is assumed to exist (Pearce and Markandya, 1989).

CVM seeks to ensure that the contingent market is as realistic as possible. In order to make sure that respondents have an understanding of, and familiarity with, the commodity being valued, photographs representing different levels of environmental quality are often used. Respondents should also be familiar with the hypothetical means of payment, such as an entrance fee, termed the payment vehicle.

It is usual for the researcher to suggest a starting point bid price for a commodity. Bids are then varied in constant increments or decrements, until maximum WTA or minimum WTA is elicited.

The careful design of CVM questionnaires is necessary to avoid biases, some of which are specific to the nature of the technique. <u>Strategic bias</u> is evident where respondents deliberately give untruthful bids. They may either exaggerate their reply in the hope of bringing a proposed change about or understate their real preference. The latter case is known as the 'free rider' problem (Samuelson, 1954), and results from the fact that environmental commodities tend to be public goods which are consumed collectively and non-excludable. Free riders are those who understate their preferences for public goods because they know that they will benefit from its supply to others. Strategic bias can be detected by testing whether the distribution of bids is normally distributed. In practice, strategic bias has not been found to be a problem (Schulze *et al.*, 1981).

<u>Design bias</u> encompasses starting point bias, vehicle bias and informational bias. The possible influence of the choice of

starting bid on the results of the bidding process can be tested by using different starting point bids and comparing the resultant mean bids statistically. Alternatively, the respondent can be allowed to make the initial bid (Schulze *et al.*, 1983).

Vehicle bias arises if different results are obtained with different payment vehicles (methods of payment). This form of bias can be tested for by using a number of different vehicles and seeing if mean bids vary significantly.

Information bias occurs if the information given to a respondent in a survey does not correspond very accurately with reality. One test for information bias is to withhold information from one group of respondents and to provide it to another.

Hypothetical bias exists if bids in contingent markets differ from those in real markets. This can be tested for by comparing the results of using actual as well as hypothetical payments in a CVM. This form of bias does seem to be a problem in CVM studies (Cummings *et al.*, 1986).

Operational bias occurs if contingent markets are inconsistent with actual market conditions. This has led to the suggestion that certain 'Reference Operating Conditions' must be met (Cummings *et al.*, 1986). This is, however, disputed by other workers (Randall and Kriesel, 1987).

CVM has the major advantage that it has extremely wide applicability. In many situations it will be the only method of benefit measurement that can be used. Those studies which have compared CVM with other approaches such as the hedonic property price technique and TCM indicate acceptable ranges of agreement (Pearce and Markandya, 1989).

Since both WTP and WTA can be elicited using CVM, this method has been used to compare them. Although economic theory holds that they should hardly differ, in CVM studies WTA tends to exceed WTP by factors of three or more. This remains an unresolved issue.

CVM can be used to measure intrinsic (non-user) benefits as well as user benefits, which together make up total economic (preservation) value. Intrinsic benefits include existence values which are values that individuals attach to environmental assets even though they do not themselves expect to make use of them or even exercise the option of doing so. User benefits consist of consumptive and non-consumptive benefits and WTP to preserve the option of enjoying an environmental asset, which is known as option value.

Where existence values have been reported for environmental resources that are unique, their magnitude has tended to overwhelm user values (Schulze *et al.*, 1983). This is unlikely in the more common situation where there are a number of substitutes for a resource, as in the case of sites reclaimed for public open space.

The extent to which CVM questionnaire designs can be closely controlled makes their use very appealing. The findings of a CVM survey of the benefits of land reclamation are presented in Chapter 3.

2.4.5 Indirect valuation procedures

Indirect valuation techniques tend to involve the estimation of a purely statistical dose-response relationship, as already discussed above, using multiple regression analysis. This is then followed by an economic valuation exercise (Pearce and Markandya, 1989). These approaches are typically used to value the impact of air pollution on health, vegetation and aquatic ecosystems, or in causing damage to buildings and other materials at the national level. Consequently, they often require very large data sets. Similar approaches may be useful, however, in assessing the benefits of land reclamation at the regional scale. For instance, Randall *et al.*'s (1978) seminal study of the benefits of land reclamation in Central Appalachia in the United States, used multiple regression techniques to relate water quality to a number of variables including the extent of surface mining activity in the immediate catchments of monitoring sites. From this and allied work they were able to estimate the magnitude of increased water treatment costs and losses in the value of water-based recreational activities attributable to the effects of surface coal mining at the regional scale.

2.5 Implicit valuation

Where it proves impossible to measure benefits using any of the approaches described above, implicit valuation can be used. Take, for example, a land reclamation scheme which costs £1,000,000 and has monetary benefits of £800,000 plus unknown social benefits which cannot be measured. The problem can be restated as whether the social benefits of reclamation are worth £200,000. If the decision is made to go ahead with the scheme, £200,000 is the implicit minimum valuation of the social benefits of reclaiming the land (Pearce and Markandya, 1989).

2.6 Conclusions

In the economic appraisal of land reclamation projects, it is likely to be harder to assess the benefits of reclamation than its costs. This is because many environmental goods are not marketed (priced). However, as has been shown, there are a number of approaches to the measurement of economic benefits that might be used in the cost-benefit analysis of reclamation schemes (Table 2.1).

Of these, the contingent valuation method is perhaps the most promising, because of its relative ease of application compared with other approaches and the fact that possible biases can be tested (Chapter 3). Although potentially useful, the hedonic property price approach suffers from considerable informational requirements and inaccuracy owing to its indirectness.

The incorporation of value of life considerations into land reclamation policy at the national scale would allow the benefits to human safety from treating derelict land to be assessed. However, the relevant data are presently unavailable and would require an enormous and probably unjustifiable amount of work to collect.

The travel cost method also necessitates extensive data gathering. Furthermore, its use would be confined to the small number of reclamation schemes which attract visitors from considerable distances.

The work of Randall *et al.* (1978) illustrates that indirect valuation procedures may be valuable in appraising the benefits of land reclamation. However, the amount of time needed to collect and process data means that these techniques are most useful at the regional or national scales.

Where it is not possible to measure the economic benefits of reclamation, it will be necessary to fall back on methods of implicit valuation or cost-effectiveness analysis. The latter method is used in an analysis of national reclamation policies described in Chapter 9.

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CHAPTER 3 THE MEASUREMENT OF BENEFITS: CONTINGENT VALUATION

3.1 Introduction

Monetary benefit measurement is increasingly being used in the United Kingdom to assist decision-making with respect to environmental improvement (Markandya and Pearce 1989; Turner, 1988). The contingent valuation method (CVM) is widely regarded as the most applicable technique because of its reliance on controllable interviews. As we have seen, other valuation techniques, such as hedonic pricing from the use of surrogate markets, require fairly extensive data gathering and may involve unrealistic assumptions about the efficient workings of markets (Pearce and Markandya, 1989). CVM, by contrast, relies on a direct questionnaire approach, asking individuals what they are willing to pay for environmental improvement. Biases within the approach can be tested. Evidence to date suggests that 'hypothetical bias' - biased responses due to the interviewee being placed in a hypothetical situation rather than one involving real monetary exchange - is a problem. The direction of the bias tends to be known, and it may be quantifiable through 'mixed' CVMs in which some respondents engage in actual money payments (Cummings *et al.*, 1986).

Although the contingent valuation technique is now a well established method of benefit measurement (Randall *et al.*, 1974; Brookshire *et al.*, 1976; Brookshire *et al.*, 1980; Rowe *et al.*, 1980; Thayer, 1981; Schulze *et al.*, 1983), it has been little applied in relation to a major form of environmental improvement, namely land reclamation schemes. These seek to alleviate the effects of environmental dereliction through operations such as the regrading of spoil heaps, cultivation, seeding and tree planting. The most detailed study of the costs and benefits of reclaiming surface coal mines was that of Randall *et al.* (1978). Randall and his co-workers found, that, for the Central Appalachian region as a whole, the social benefits of reclamation exceeded its private costs.

CVM is however quite laborious and involves considerable time spent in interview. Policy makers are concerned with individual reclamation schemes as well as with regional considerations. Therefore, this investigation was focused on a single case study site of a deep mine in North West England.

3.2 Background to the study

A contingent valuation survey was carried out at Higher Folds, located between the towns of Leigh and Tyldesley in Lancashire (National Grid Reference SD 685005). Prior to reclamation, which began in 1977, this 191 hectare site included a prominent plateau of colliery spoil heaps up to 25 metres high, some of which loomed over houses on the Higher Folds housing estate and collapsed into back gardens. The spoil heaps frequently caught fire, causing problems of nuisance from smoke and unpleasant sulphurous smells, and dust blew off the site in dry weather. The site also contained 14 mine shafts, dangerous subsidence flashes and lagoons, derelict buildings, disused railway lines, a station and sidings and a former sewage works. Owing to the high acidity of the colliery spoil, vegetation was slow to colonise the site (Plate 1).

The complete removal of the enormous spoil heaps could not be justified on economic grounds, and so they were regraded to form gentle slopes for 122 hectares of agriculture, 67 hectares of tree planting and 2 hectares of football pitches. Over 330,000 trees were planted in what was Britain's biggest land reclamation scheme

Plate 1. Higher Folds prior to reclamation, 1977.

Plate 2. Higher Folds after reclamation to agriculture and public open space.

at the time (Plate 2).

The reclamation works consisted of advance drainage provision, site clearance and demolition, earthmoving including the filling of drainage ponds and flashes, the stripping and re-spreading over 40 hectares of what topsoil was available on the site, and the extraction of subsoil to provide a layer of protective material to prevent acidity rising due to the weathering of iron sulphide in the spoil beneath. This was followed by the construction of 22 km of drainage ditches and 25 km of fences, the treatment of mineshafts, the importation of 23,000 tonnes of lime waste to neutralise spoil acidity and cultivation works to establish grass and clover. Finally, tree planting was undertaken and 6 km of footpaths and 9 km of bridleways laid down. The initial reclamation works lasted about two years, with further cultivation and landscaping taking place over the following five years.

The Higher Folds reclamation scheme was designed to produce aesthetic, environmental, health and safety benefits. It was a 'soft' after-use scheme, primarily undertaken to improve the environment rather than a 'hard' after-use scheme, designed to provide land for development.

3.3 Survey method

An iterative bidding technique was used to value the benefits of the Higher Folds reclamation scheme. The questionnaire that was used consisted of three different sets of questions. In the first set of questions, respondents were asked how long they had been living near to the site, whether they remembered the site prior to reclamation, about their level of use of the site before and after reclamation, and their household incomes. Respondents were asked to place their income within specified ranges, but this was the final question in the survey because of possible objections to it.

Secondly, respondents were questioned about their willingness to pay to use the site and for reclamation. At the beginning of the questionnaire, each interviewee was shown a map to clarify the location and extent of the site. They were then shown sets of photographs of the site before and after reclamation.

Three measurement procedures were used, and this part of the questionnaire was broadly based on the design of Brookshire *et al.* (1976). Firstly, respondents were asked if they would be willing to pay a £1 family entrance charge to visit the site. The amount was increased by 50 pence a day until a negative response was obtained and then decreased in steps of 10 pence at a time until a positive response was obtained.

Two alternative payment vehicles were employed to measure willingness to pay for reclamation, making it possible to test for vehicle bias. Respondents were first asked, supposing that the site was still unreclaimed, how large a single, once and for all payment in rent or rates they would be willing to make towards reclaiming and maintaining the site to its present state. It was stressed that no rebates would be available from the local council and that this form of payment would be the only way of financing reclamation at the site. The starting point bid was £10 and the bidding steps used were the same as those for the entrance charge question.

The final payment vehicle was willingness to pay for reclamation via electricity bills. The use of this alternative vehicle was justified by explaining that if the Coal Board did the reclamation work, it could increase the price of coal used to generate electricity, and therefore consumers' electricity bills.

Respondents were asked, supposing that the site was still unreclaimed, how large an increase in their quarterly electricity bill they would be willing to make as a single, one-off payment towards reclaiming and maintaining the site to its present condition. It was again emphasized that no rebates would be available for this payment from the local council and the starting point bid and steps used in the bidding process were the same as those for the rent or rates vehicle.

Finally, respondents were asked a number of other questions. They were asked to name and rank those benefits of reclamation that they were willing to pay for, to specify the advantages and disadvantages of reclamation to their households and whether they preferred the site in an unreclaimed or reclaimed condition. In addition, they were questioned as to what uses of the land and facilities they wanted to see on the site, to comment on the design of the reclamation scheme and whether they had any preferences about the way in which similar sites should be reclaimed in the future.

Interviews were conducted in May and June 1988 among a random sample of 100 residents living in the immediate vicinity of the reclamation scheme. The houses that were visited were all council houses, a small proportion of which were owned by housing associations.

3.4 Results and discussion

Household characteristics are summarised in Table 3.1. Standard errors are in parentheses. Residents in the immediate vicinity of the reclamation scheme are relatively immobile and have low annual incomes. Over three-quarters of them remember what the site was like prior to reclamation. 85% of respondents preferred the site after reclamation, but the fact that 8% preferred what was there before indicates some dissatisfaction with the policy of reclamation.

Table 3.1 Household characteristics

Yearly income (mean of 70 respondents)	£ 4,874.50 (516.41)
Mean number of years spent living near to the site of the reclamation scheme	22.73 (1.82)
Percentage of respondents who remembered what the unreclaimed site was like	77%
Percentage of respondents who preferred the site:-	
Unreclaimed	8%
Reclaimed	85%
No preference	7%

The results of the bidding games are presented in Table 3.2. The mean bids for the rent or rates and electricity bill vehicles are not significantly different even at the 10% significance level, indicating the presence of negligible vehicle bias, i.e. bias due to the choice of hypothetical payment mechanism.

Table 3.2 Mean bids of survey respondents (£s)

Method of payment	
Rent or rates	8.30[1] (2.31)
Electricity bills	9.06[1] (2.50)
Site use (per day)	0.16 (0.03)
Site use (yearly)	18.47 (6.16)

Standard errors are in parentheses.

[1] Not significantly different from each other at 10% level.

The contingent valuations in the range £8.3-9.0 can be used to estimate an aggregate bid for reclamation on a one-off basis. From estimates of the effect of reclaimed and unreclaimed land on house prices obtained from a survey of professional valuers working in local estate agencies, it was assumed that residents living within 250 metres of the site are likely to be affected by its state. In this survey, which is fully discussed in Chapter 4, valuers were asked to provide valuations for a house with a built-up area on one side and greenbelt farmland stretching away from it on the other. They were told that this greenbelt land may or may not, however, include an unreclaimed or a reclaimed colliery spoil site at different distances from the house being valued. Valuers were shown photographs of coal mine sites, including Higher Folds, before and after reclamation and asked to assess the extent to which houses, worth £20,000, £30,000 and £40,000 when the neighbouring land has never had a coal mine on it, would be affected by their proximity to reclaimed and unreclaimed deep-mined colliery spoil sites. In the case of the Higher Folds reclamation scheme, for a £20,000 house, which is the most appropriate in this area, 250 metres was the greatest distance at which a statistically significant difference between house prices associated with reclaimed and unreclaimed sites was obtained at the 5% level.

From 1981 population census returns at the enumeration district level the number of households within 250 metres of the site is estimated to be approximately 2,000. This gives an aggregate willingness to pay a once-and-for-all sum of some £17,000 - 18,000 in 1988 prices. This is very low in relation to the costs of reclaiming the site, as Table 3.3 indicates. Table 3.3 shows the results of cost-benefit analyses of the Higher Folds reclamation scheme. The relevant costs and benefits are also itemised separately, as are land acquisition costs, which are not real resource costs. All figures are in constant 1987/88 prices and have been discounted over a twenty year time period at both 5 and 7% rates to provide sensitivity analysis.

Table 3.3 Costs of reclamation and cost-benefit analyses of Higher Folds reclamation scheme, present values of willingness to pay figures and financial information (£s). Constant 1987/88 prices, 20 year time horizon.

1. Cost of reclamation including scheme design costs		
Discount rate		
r = 5%	-3,202,200	(-16,800 ha^{-1})
r = 7%	-2,843,000	(-14,900 ha^{-1})
2. Cost-benefit analyses of reclamation using CVM benefit measures		
(a) Net Present Value (Cost) using rent/rates		
r = 5%	-3,185,600	(-16,700 ha^{-1})
r = 7%	-2,826,400	(-14,800 ha^{-1})
(b) Net Present Value (Cost) using electricity bills		
r = 5%	-3,184,100	(-16,700 ha^{-1})
r = 7%	-2,824,900	(-14,800 ha^{-1})
(c) Net Present Value (Cost) using annual user charge		
r = 5%	-2,718,000	(-14,200 ha^{-1})
r = 7%	-2,423,600	(-12,700 ha^{-1})
3. Present value of aggregate one-off willingness to pay via rent/rates		
r = 5%	16,600	
r = 7%	16,600	
4. Present value of aggregate one-off willingness to pay via electricity bills		
r = 5%	18,100	
r = 7%	18,100	
5. Present value of aggregate willingness to pay via annual user charge bills		
r = 5%	484,200	
r = 7%	419,400	
6. Cost of land acquisition including associated administrative costs (financial analysis; not a real resource cost)		
r = 5%	-1,116,400	(-5,800 ha^{-1})
r = 7%	-1,056,400	(-5,500 ha^{-1})
7. The post-reclamation value of the reclaimed land (financial analysis)		
r = 5%	242,900	(1,300 ha^{-1})
r = 7%	190,100	(1,000 ha^{-1})

The remaining vehicle used in the CVM approach was a hypothetical user charge. Table 3.2 shows that this was £18.5 per annum, suggesting an aggregate bid across the 2,000 households of £37,000 per annum. Over a twenty year time horizon, at a 5% discount rate this suggests a present value of some £480,000, and at 7% a value of £420,000.

Such figures are markedly higher than those for the 'one off' valuations based on the rent/rates and electricity bill vehicles. Table 3.4 shows that the unreclaimed site was used by over half the residents who lived next to the site before as well as after it was reclaimed.

Table 3.4 Site usage by respondents who lived next to the site before and after reclamation (N=61)

Percentage of respondents who used the site before it was reclaimed	52%
Mean number of times a week they used the unreclaimed site	2.92[1] (0.42)
Percentage of respondents who use the site after reclamation	56%
Mean number of times a week they use the reclaimed site	2.34[1] (0.39)

Standard errors are in parentheses.

[1] Not significantly different from each other at 5% level.

The proportion of these residents visiting the site increased only slightly after reclamation whilst their level of use of the site declined, although this effect was not statistically significant. If there was positive willingness to pay for the use of the unreclaimed site, this should ideally be deducted from the willingness to pay for the reclaimed site to obtain a net measure of welfare improvement. Unfortunately it was not possible to test for the possibility of a positive valuation of the unreclaimed site. However, as Table 3.1 shows, the reclaimed site was preferred by the overwhelming majority of residents, suggesting a low valuation for the unreclaimed site. On this basis, therefore, net benefits from reclamation could be of the order of £400,000 - 500,000.

The marked difference in the results of the user charge vehicle compared with the other vehicles could be evidence of vehicle bias. Rents, rates and electricity bills have the image of being unavoidable, whereas a user charge is under the control of the respondent in that he or she can choose whether or not to incur it. It is also possible that the questions relating to the other vehicles did not adequately capture their intended 'one off' payment nature. Accordingly, we place greater faith in the user charge figure for benefits.

Despite this it remains the case that the benefit figure is significantly less than the reclamation costs by some £2.5 million. On cost-benefit criteria, the reclamation was not worthwhile.

Table 3.3 also shows the the post-reclamation value of the land based on estate valuers' assessments. These valuations may be interpreted as gross hedonic prices. However, Table 3.3 makes it clear that the valuations are actually significantly less than the cost of acquiring the land. Even allowing for some 10% of the acquisition costs being taken up in administrative costs, Table 3.3 suggests that land value <u>losses</u> of about £900,000 in present value terms were sustained, indicating either a <u>negative</u> environmental benefit if the values are constructed as hedonic prices, or, and this seems more likely, that the land was acquired at excessive prices.

No landscape maintenance works have been carried out on the tree-planted area of the Higher Folds reclamation scheme since the abolition of the Metropolitan County Councils in April 1986. However, maintenance will soon resume and is expected to cost some £2,200 per annum in 1988 prices once initial works to catch up for the hiatus in maintenance have been undertaken. Grazing licences from the area reclaimed to agriculture provide about £6,000 in income per annum in 1988 prices, and so the site is currently generating net income of about £3,800 a year.

It is clear that the estimates of aggregate willingness to pay are extremely low in comparison with the reclamation costs presented in Table 3.3. For all the payment vehicles, the percentage of zero bids received was high; comprising 45% for the rent/rates vehicle, 48% for electricity bills and 65% for site use. However, the percentages of respondents who stated that their reason for a zero bid was that they couldn't afford to pay anything were only 11%, 11% and 5% for the respective payment vehicles. Thus in general it was an objection to the principle of paying for reclamation rather than the low average incomes of respondents which was the major reason for the high frequency of zero bids that was encountered.

The benefits of reclamation that more than 1% of respondents were willing to pay for are itemised in Table 3.5. The aesthetic improvement resulting from reclamation was the most commonly mentioned benefit, followed by recreational opportunities and walks. Respondents were also willing to pay for benefits in site safety and health. These included the prevention of spoil heaps collapsing into back gardens, the elimination of sulphurous smoke from burning spoil heaps which caused stomach aches and other health problems, and dangers from subsidence flashes in which one child drowned.

Table 3.5 Those benefits of reclamation that more than 1% of respondents were willing to pay for

Improved views	37%
Recreational opportunities and walks	18%
Site is safer	12%
Site is cleaner	7%
Creation of countryside	6%
Site is tidier	5%
Increased wildlife value of site	4%
Improved access to site	3%
Site no longer smells	3%
The land has been put to a good use	3%
Site is healthier	2%
Area now has a better reputation / morale	2%
House prices increase as a result of reclamation	2%

3.5 Distributional considerations

A comparison of mean bids and yearly income for respondents who lived near the site prior to reclamation and those who did not is shown in Table 3.6. It was hypothesised that residents who had experienced living next to the unreclaimed site would have a lower willingness to pay for reclamation and mean incomes than those who moved to the area after reclamation, because they would be unable to afford to move from the area. This theory is generally supported by the results in Table 3.6; willingness to pay via rent or rates and a daily entrance charge and mean annual income were significantly lower for those respondents who lived next to the site prior to reclamation compared with those who did not. On average, the former group had lived next to the site for 34 years, whilst those who arrived after reclamation had lived there for a mean of 5 years. It is also likely that the newcomers were typically younger, more affluent and more mobile and may have been attracted to the area by the increased attractiveness of housing surrounding the site following reclamation.

Table 3.6 Comparison of mean bids and annual income for respondents who lived near the site before reclamation with those who did not (£s)

	Those there before reclamation (N = 61)	Those there after reclamation (N = 39)
Rent or rates	4.31[1] (0.99)	14.53[1] (5.62)
Electricity bills	5.54 (1.86)	14.56 (5.64)
Site use (per day)	0.11[2] (0.03)	0.23[2] (0.05)
Site use (yearly)	16.03 (9.30)	22.29 (6.23)
Yearly income	4,085[3] (593.77) (Mean of 41 responses)	5,991[3] (929.26) (Mean of 29 responses)

Standard errors are in parentheses.

[1,2,3] Means which are significantly different from each other at the 5% level.

Annual household incomes were obtained for 70 respondents. Overall, the mean percentage of income that respondents were willing to pay for reclamation was 0.4% for site use on an annual basis, and 0.2% via rent or rates and electricity bills. Willingness to pay via rent or rates and electricity bills were both positively correlated with mean annual income at the 5% significance level, whereas willingness to pay for site use on an annual basis was not. However, the data for both willingness to pay via rent or rates and electricity bills included an outlier, which when excluded from the data meant that the relationships were not statistically significant. Thus, as regards the distributional impacts of reclamation, there was no strong relationship between willingness to pay and annual incomes. Income elasticities of demand were positive but less than one, indicating that demand for reclamation was not pro-rich (Pearce *et al.*, 1979).

3.6 Conclusions

A summary of the benefit estimates produced by the bidding game interview technique is given in Table 3.7 in present value terms. In comparison with the costs of reclamation, the cost-benefit approach strongly suggests that the reclamation was not warranted on economic efficiency grounds. This conclusion is further supported by the land value approach which indicates an actual loss in terms of post-reclamation land values compared with the cost of acquisition.

Table 3.7 Costs and benefits of reclamation at Higher Folds using different vehicles for measuring benefits (£s)

	Present Value of benefits	
Benefit measure	5%	7%
(1) One-off rental/rate increase	16,600	16,600
(2) One-off electricity bill increase	18,100	18,100
(3) Annual user charge	480,000	420,000
Net Present Values (Costs) of reclamation		
Net Present Value case (1)	-3,185,600	-2,826,400
Net Present Value case (2)	-3,184,100	-2,824,900
Net Present Value case (3)	-2,718,000	-2,423,600

As regards evidence on the distribution of benefits, it was found that residents who moved to the immediate vicinity of the site following its reclamation generally had higher incomes and willingness to pay for reclamation than those who lived there prior to reclamation. Income elasticities of demand for reclamation were less than unity.

It is possible that other benefits of reclamation might justify the scheme. These include the increased attractiveness of the area to business and potential developers, enhanced civic pride and social benefits in an area of above average unemployment and below average incomes. However, these were not quantified and would be very difficult to assess.

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CHAPTER 4 OTHER APPROACHES TO MEASURING BENEFITS

4.1 General introduction

Whilst the costs of undertaking land reclamation projects are relatively easy to obtain, determining the benefits of these schemes is likely to be more difficult. This is because, as was discussed in Chapter 2, reclamation produces environmental benefits such as visual amenity and reduced air and water pollution which are not usually priced.

In addition to the contingent valuation method discussed in Chapter 3, two other methods of assessing benefits were essayed. The first was a survey designed to measure the extent to which proximity to derelict land affects house prices. The rationale behind this approach is hedonic property price theory (Chapter 2).

The second approach was to assess the level of visitor use of land reclaimed to public open space. Whilst not an economic technique, this does provide useful indications of the user benefits of reclaiming land.

4.2.1 The effect of reclamation on house prices: introduction

There is informal evidence to suggest that house prices are adversely affected by proximity to derelict land (Lindley, 1986). This assertion needs to be tested if the magnitude of benefits which are likely to accrue from land reclamation schemes are to be assessed.

Since a full hedonic analysis of the effect of derelict and reclaimed land on house prices was not practicable in the course of this research because of the considerable time and informational requirements involved, a survey of professional valuers working for estate agents was undertaken instead. This type of approach has been used previously, for example in the valuation of the social costs of noise made as part of the cost-benefit analysis of the proposed third London airport (Flowerdew, 1972; Pearce, 1976). The survey was also used to estimate the furthest distance at which residents would be willing to pay for reclamation in the contingent valuation case study described in Chapter 3.

4.2.2 Survey method

Interviews with three valuers in estate agencies in the centre of Wigan were therefore carried out in March 1988. In the survey valuers were asked to provide valuations for a three bedroom house located on the outskirts of Wigan with a built-up area on one side and greenbelt farmland stretching away from it on the other. They were told that this greenbelt land may or may not, however, include an unreclaimed or a reclaimed deep-mined colliery spoil site at different distances from the house being valued. Valuers were shown photographs of three different coal mine sites before and after reclamation to public open space or agriculture and asked to assess the extent to which houses, worth £20,000, £30,000 and £40,000 when the neighbouring land has never had a coal mine on it, would be affected by their proximity to reclaimed and unreclaimed deep-mined colliery spoil sites. The three sites chosen for the study; Careless Lane (Plates 3 and 4), Baxter Pit and Higher Folds, are all located in the Wigan area and are discussed further in chapter 5. The valuers were shown five photographs of each site both before and after reclamation. They were also asked to describe what factors any differences in valuation reflected.

Plate 3. Careless Lane before reclamation.

Plate 4. Careless Lane following reclamation.

The £20,000 house was assumed to be a terraced house whilst the £30,000 and £40,000 houses were semi detached. The distances of the coal mine site from the house that were used in the survey are shown in Tables 4.1-4.3.

Table 4.1 Effect of unreclaimed and reclaimed land on house prices at the Careless Lane site; mean values, 95% confidence limits and difference in means as a percentage of total house price for what are £20,000, £30,000 and £40,000 houses when adjoined by pure greenbelt land (£s)

Distance of site from house (metres)	**Status of the open land** Includes unreclaimed site	Includes reclaimed site	Difference in means
1 metre			
£20,000 house	16,500 (±3,512)	19,667 (±667)	3,167 (15.8 %)
£30,000 house	24,667 (±4,807)	29,333 (±1,333)	4,666 (15.5 %)
£40,000 house	32,667 (±7,860)	39,167 (±1,667)	6,500 (16.2 %)
50 metres			
£20,000 house	17,333 (±2,333)	19,667 (±667)	2,334 (11.7 %)
£30,000 house	26,500 (±1,732)	29,500 (±1,000)	3,000 (10 %)
£40,000 house	33,500 (±6,658)	39,333 (±1,333)	5,833 (14.6 %)
100 metres			
£20,000 house	18,167 (±1,202)	19,833 (±333)	1,666 (8.3 %)
£30,000 house	27,333 (±667)	29,667 (±667)	2,334 (7.8 %)
£40,000 house	34,667 (±4,807)	39,333 (±1,333)	4,666 (11.7 %)
250 metres			
£20,000 house	19,167 (±882)	19,833 (±333)	666 (3.3 %)
£30,000 house	28,500 (±1,528)	29,667 (±667)	1,167 (3.9 %)
£40,000 house	36,667 (±1,764)	39,500 (±1,000)	2,833 (7.1 %)
500 metres			
£20,000 house	19,500 (±577)	20,000 (-)	500 (2.5 %)
£30,000 house	28,833 (±1,202)	29,833 (±333)	1,000 (3.3 %)
£40,000 house	38,667 (±1,453)	39,667 (±667)	1,000 (2.5 %)
1 kilometre			
£20,000 house	19,833 (±333)	20,000 (-)	167 (0.8 %)
£30,000 house	29,333 (±667)	30,000 (-)	667 (2.2 %)
£40,000 house	39,167 (±882)	40,000 (-)	833 (2.1 %)
5 kilometres			
£20,000 house	20,000 (-)	20,000 (-)	0 (0 %)
£30,000 house	30,000 (-)	30,000 (-)	0 (0 %)
£40,000 house	40,000 (-)	40,000 (-)	0 (0 %)

Table 4.2 Effect of unreclaimed and reclaimed land on house prices at the Baxter Pit site; mean values, 95% confidence limits and difference in means as a percentage of total house price for what what are £20,000, £30,000 and £40,000 houses when adjoined by pure greenbelt land (£s)

Distance of site from house (metres)	Status of the open land Includes unreclaimed site	Includes reclaimed site	Difference in means
1 metre			
£20,000 house	17,000 (±4,163)	19,667 (±667)	2,667 (13.3 %)
£30,000 house	25,667 (±5,925)	29,667 (±667)	4,000 (13.3 %)
£40,000 house	32,000 (±12,220)	39,500 (±1,000)	7,500 (18.8 %)
50 metres			
£20,000 house	17,167 (±4,256)	19,833 (±333)	2,666 (13.3 %)
£30,000 house	26,667 (±4,410)	29,833 (±333)	3,166 (10.6 %)
£40,000 house	33,000 (±10,693)	39,667 (±667)	6,667 (16.7 %)
100 metres			
£20,000 house	17,833 (±2,963)	19,833 (±333)	1,666 (8.3 %)
£30,000 house	26,833 (±4,485)	29,833 (±333)	3,000 (10 %)
£40,000 house	34,000 (±9,165)	39,833 (±333)	5,833 (14.6 %)
250 metres			
£20,000 house	19,167 (±882)	19,833 (±333)	666 (3.3 %)
£30,000 house	27,833 (±2,963)	30,000 (-)	2,167 (7.2 %)
£40,000 house	35,000 (±8,083)	40,000 (-)	5,000 (12.5 %)
500 metres			
£20,000 house	19,500 (±577)	20,000 (-)	500 (2.5 %)
£30,000 house	28,667 (±1,764)	30,000 (-)	1,333 (4.4 %)
£40,000 house	36,333 (±6,360)	40,000 (-)	3,667 (9.2 %)
1 kilometre			
£20,000 house	19,833 (±333)	20,000 (-)	167 (0.8 %)
£30,000 house	30,000 (-)	30,000 (-)	0 (0 %)
£40,000 house	39,833 (±333)	40,000 (-)	167 (0.4 %)
5 kilometres			
£20,000 house	20,000 (-)	20,000 (-)	0 (0 %)
£30,000 house	30,000 (-)	30,000 (-)	0 (0 %)
£40,000 house	40,000 (-)	40,000 (-)	0 (0 %)

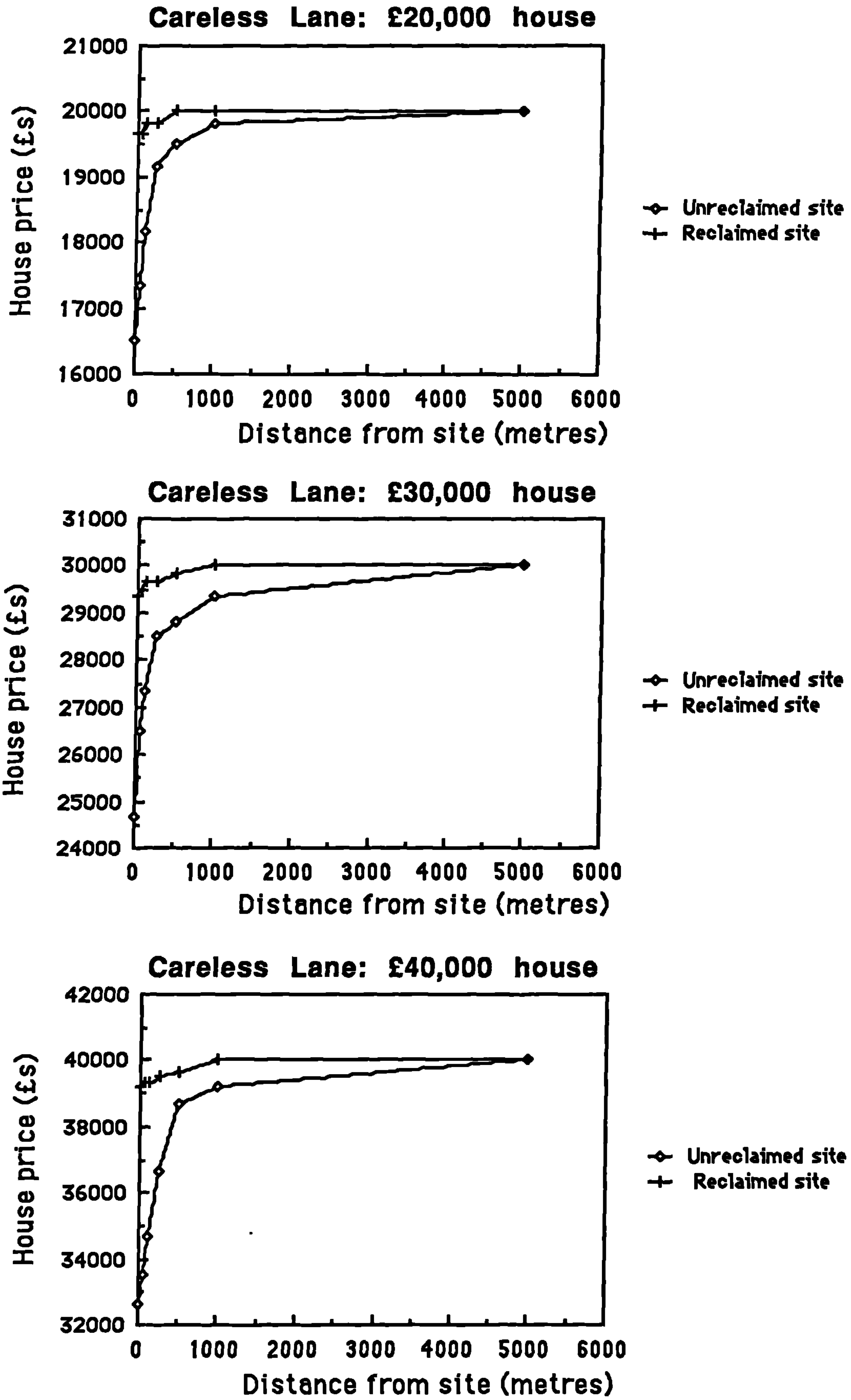


Fig. 4.1 Effect of reclamation on house prices: Careless Lane.

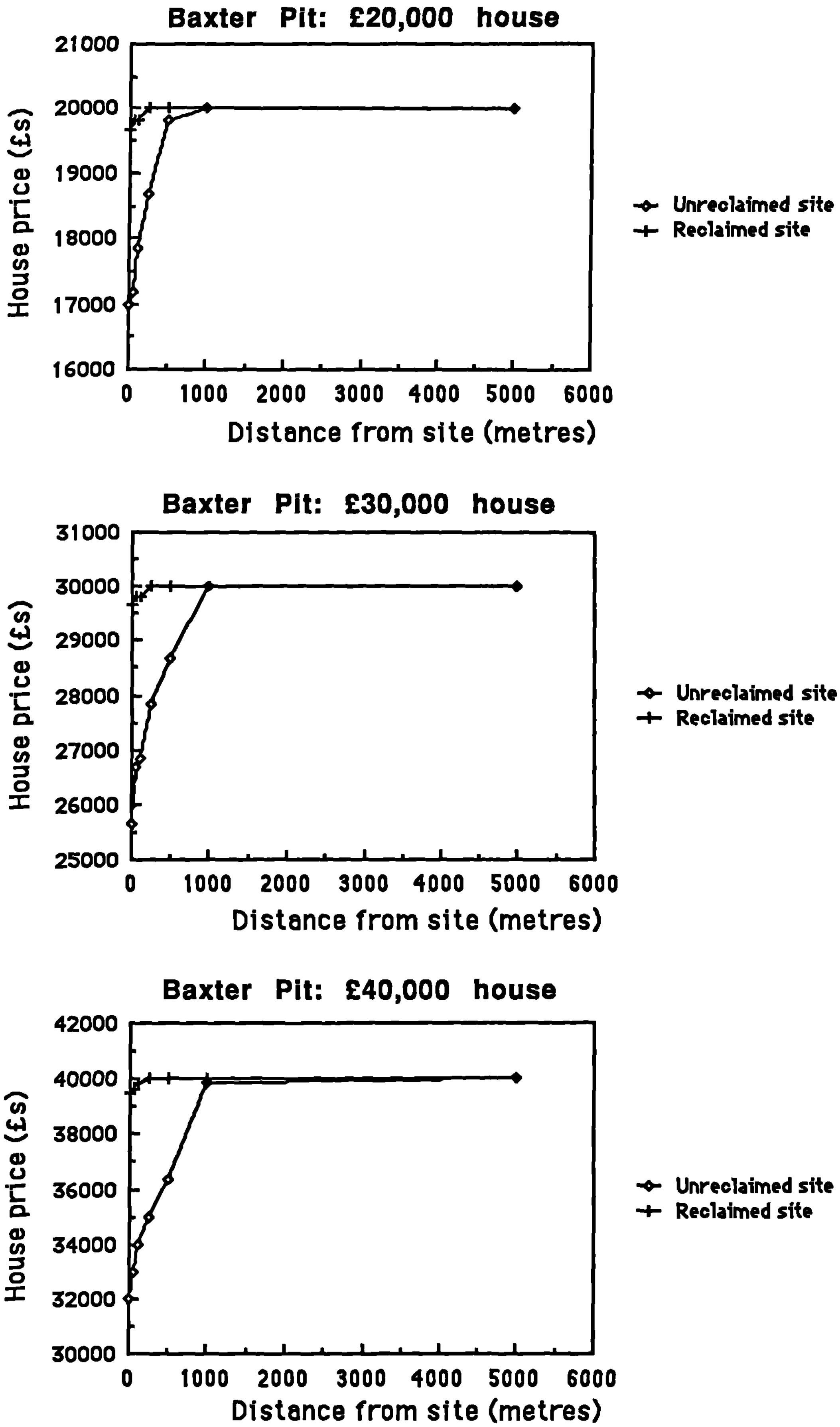
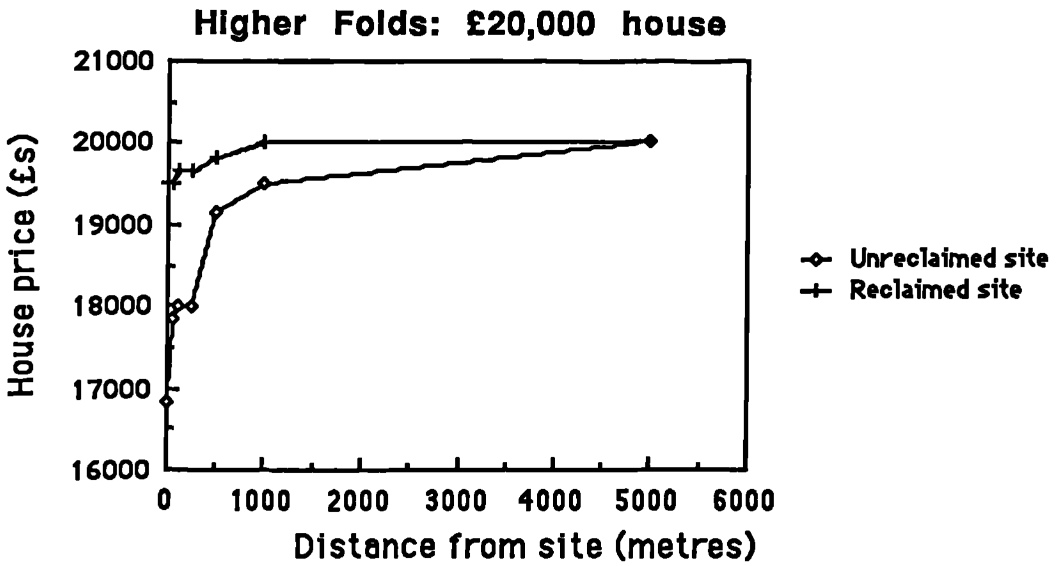
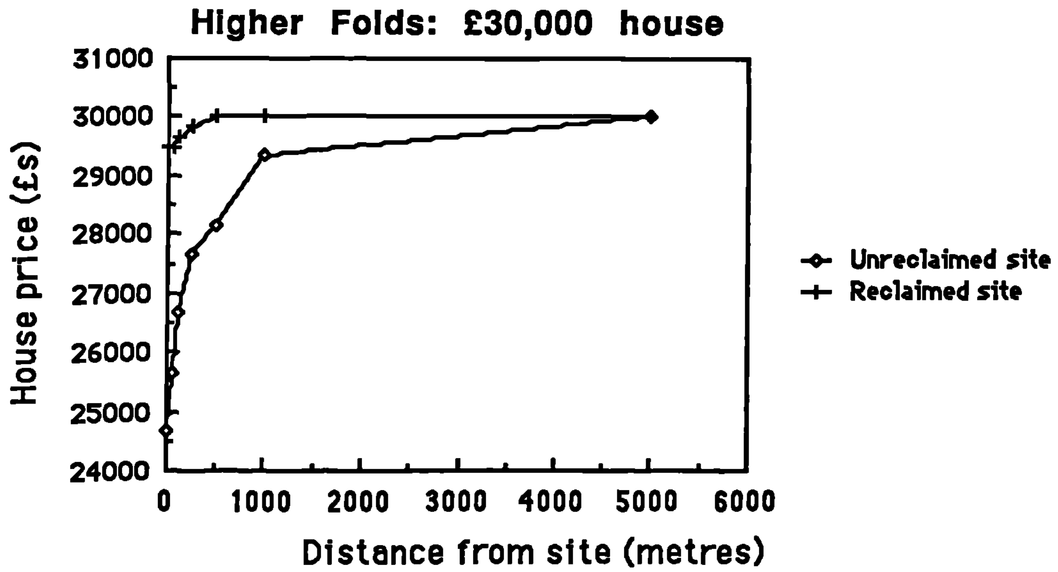


Fig. 4.2 Effect of reclamation on house prices: Baxter Pit.





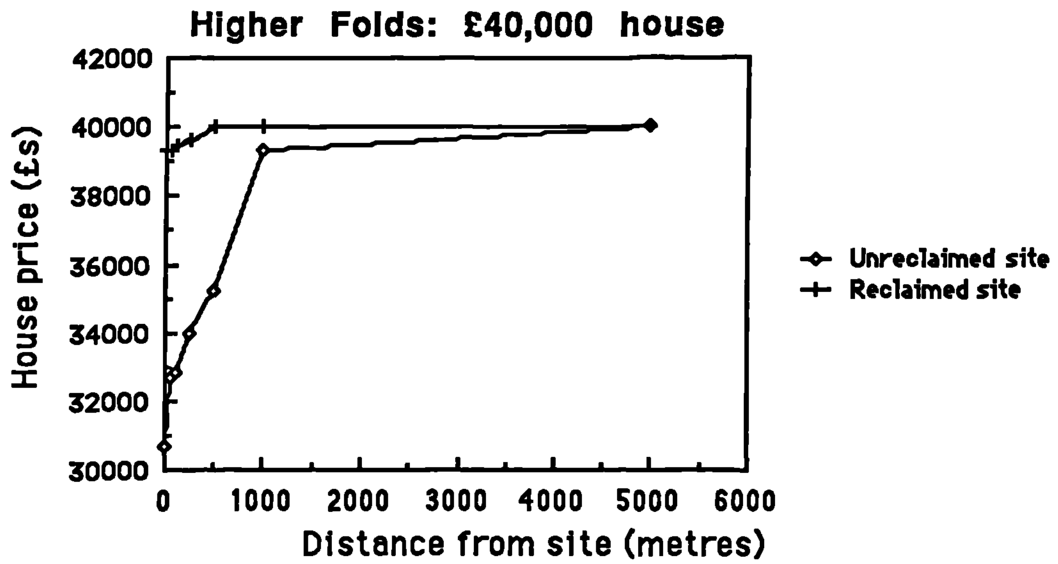


Fig. 4.3 Effect of reclamation on house prices: Higher Folds.

this. Firstly, a greater sample size (i.e. more than three valuers) is desirable for statistical purposes. Secondly, there was clearly disagreement amongst the valuers as to the extent of the effect of dereliction on house prices. For instance, whilst one of the valuers spent quite a lot of time working outside Wigan, another valuer suggested that people in Wigan have grown up with and are therefore used to mining activities and their legacy of mine shafts and subsidence, and so argued that dereliction had relatively little effect upon house prices, and indeed no effect at all at the Baxter Pit site. It therefore appears that valuers' assessments will be strongly affected by their level of experience of the impacts of former mining activities, which will in turn depend on their geographical location.

There were also difficulties in implementing the survey, the chief one being the tendency of the valuers to take into account the area where the house was to be situated in their assessments. This, and the condition of a property, are likely to be key determinants of house prices, but in this survey it had to be stressed that the intention was to separate out the influence of dereliction and reclamation from these other factors.

Despite the lack of statistical significance, the results are of considerable interest. On the whole the overall effects on house prices do not appear very great. There was a distinct trend however, that for the more expensive £40,000 property, dereliction had a greater proportional effect in depressing house prices than for the cheaper houses, an effect mentioned by two of the valuers. This is shown in Tables 4.1-4.3. The reason for this, according to the valuers, is that in the case of the cheaper property house buyers are more concerned with being able to afford the house than with the state of the neighbouring land.

The main responses given to the question about what factors differences in valuation reflected were improved views and security in terms of reduced subsidence and dangers to children, less pollution and dust, and the possible benefit of facilities such as footpaths and picnic areas provided as a result of reclamation. This supports the view that changes in property values reflect amenity losses or gains as well as other forms of environmental damage or improvement (Mäler and Wyzga, 1976).

4.2.4 Conclusions

In conclusion, then, the survey approach adopted did prove useful in suggesting that derelict land may have a considerable effect in depressing some house prices in its immediate vicinity, by as much as £8,700 (22%) for a £40,000 house in the case of Higher Folds (Table 4.3). This figure of £8,700 is a present value benefit because property prices capitalise the future stream of benefits associated with a property.

More surveying is necessary if the findings are to have greater statistical validity, and care clearly needs to be taken in interpreting results from different geographical areas which may have widely different levels of personal income (ability to pay) and experience of dereliction. In practice, although this survey approach is easy to use, there are difficulties in aggregating the values to the level of an individual reclamation scheme because this requires knowledge of the distribution of houses at different distances from a site and their property values. Clearly the former can be estimated from maps and the latter from information from the housing market, but then much of the advantage of the technique in terms of its ease of application is lost.

4.3.1 The visitor use of land reclaimed for public open space: introduction

In England, a great deal of derelict land has been reclaimed for public open space (EAU, 1986). According to provisional results taken from the 1988 derelict land survey, almost 32% of all land reclaimed between 1982 and 1988 was brought back into use in this form (Department of the Environment, 1989). Typically, prominent heaps of colliery spoil have been regraded and grassed over (Lindley, 1986), and in urban areas public open space has been created as a result of the demolition of slum housing (Dutton and Bradshaw, 1982).

Although a considerable number of studies have been directed at the use of informal recreation sites and urban parks in Britain (TRRU 1980a; TRRU 1980b; TRRU, 1981; TRRU 1983; Bradley and Millward, 1986), few if any have specifically addressed land reclaimed for public open space. Information about the types and levels of use of such reclaimed land is valuable because it has implications in both the design of land reclamation schemes and their subsequent management, if they are to be successful in meeting the public's needs.

4.3.2 Survey methods

Four colliery spoil sites reclaimed to public open space located near Wigan and Leigh in Greater Manchester and, for comparison, an unreclaimed site, were surveyed in the summer of 1987. Similarly, three reclaimed urban clearance (housing demolition) schemes and a nearby urban park situated close to the

University precinct in Liverpool were surveyed in the summer of 1988. The surveys were carried out during the school summer holidays on weekdays when the weather was dry. Each site was surveyed for five half-hourly periods at the following times; 10.30-11.00, 13.30-14.00, 15.00-15.30, 16.30-17.00 and 19.00-19.30 hours. The activities, sex, number of visitors who remained on site throughout the half-hourly survey periods and levels of site use were recorded.

In addition to the visitor surveys, 100 residents living in the vicinity of one of the sites surveyed, the Higher Folds reclamation scheme, were interviewed about their level of use of this large land reclamation scheme both before and after reclamation. Respondents were also questioned about what activities they used the site for, both prior to and after reclamation. This site was specifically reclaimed to a mixture of public open space and agriculture, with the creation of six kilometres of footpaths and the planting of 330,000 trees.

4.3.3 Results

The activities of a total of 303 users recorded on the four reclaimed colliery spoil sites are shown in Fig. 4.4. Crossing the site, dog walking, walking and watching football matches were the only activities enjoyed by more than 10% of visitors, and together comprised 66% of all visits. This illustrates the predominantly passive nature of recreation on these sites, a finding that has been made in other studies of visitor use of green space and reclaimed parkland (Bradley and Millward, 1986; Department of the Environment, 1987). By contrast, on the unreclaimed Cutacre Tip site, which is the largest unreclaimed colliery spoil heap in Europe, (National

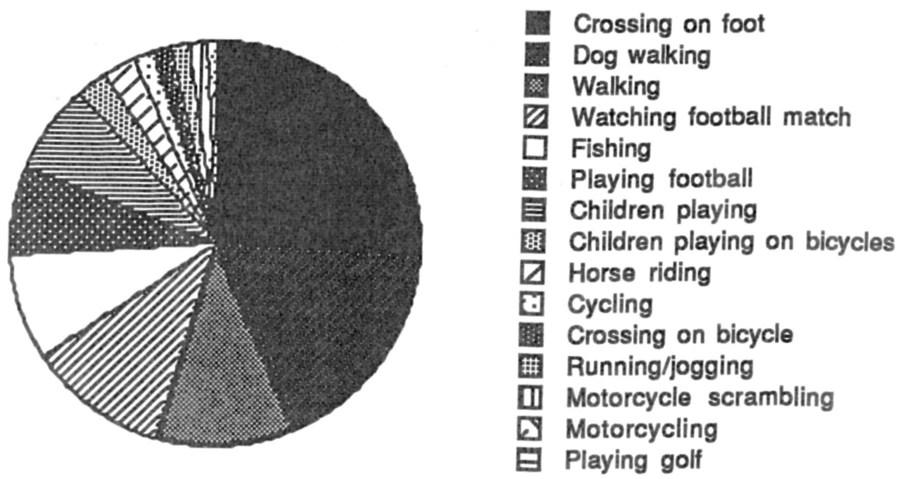


Fig. 4.4 Activities recorded on reclaimed colliery spoil survey sites.

Coal Board, 1983), walking, cycling and motorbike scrambling each accounted for two of the total of only six visits over the total two and a half hour survey period.

The activities of the total of 226 visitors using the three reclaimed urban clearance sites are illustrated in Fig. 4.5. Crossing accounts for 89% of the usage of these sites and dog walking some 7%. In comparison, in the case of Falkner Square, a formal urban park, 40% of the total of 48 visitors using the site over the two and a half hour survey period stopped in the park to either sit or lie down (Fig. 4.6). This indicates that visitors were spending more time in the park than on the reclaimed urban sites, which were chiefly used for short cuts.

For the colliery spoil schemes that were surveyed, the overall breakdown of users was 48% adult males, 14% adult females and 38% children. Adults were those who were judged to be twenty or more years old. On the unreclaimed Cutacre Tip only two adult males and four children were recorded over the two and a half hours.

The sex imbalance of visitors on the urban clearance survey sites was less pronounced, consisting of 47% adult males, 36% adult females and 17% children. For Falkner Square, the formal urban park, the figures were 52% adult males, 25% adult females and 23% children.

One explanation for this is that the colliery spoil schemes are larger and generally more remote than the urban clearance schemes (Tables 4.4 and 4.5). This is likely to discourage women from using the sites because of a lack of safety. The low level of use of these public open space sites by women may also reflect the fact that their recreational needs are rarely specifically catered for in the design process, for example in terms of sports provision (Bradley and Millward, 1986).

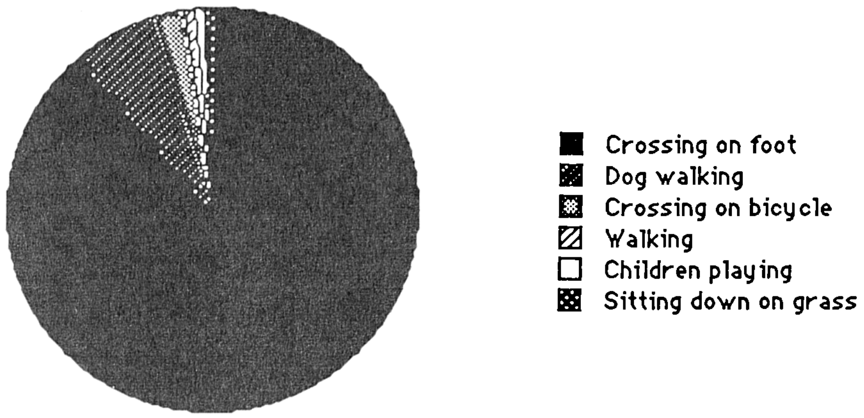


Fig. 4.5 Activities recorded on reclaimed urban clearance sites.

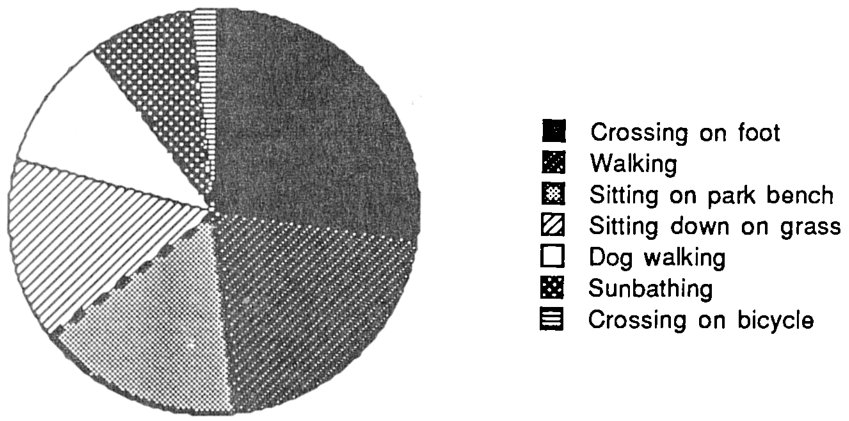


Fig. 4.6 Activities recorded at Falkner Square, a formal urban park.

Table 4.4 Level of use and percentage of visitors who remained on site throughout half-hourly survey periods for reclaimed colliery spoil survey sites and an unreclaimed site

Site:	**Baxter Pit (1)**	**Careless Lane (2)**	**Higher Folds (3)**	**Woodshaw Colliery (4)**	**Cutacre Tip (unreclaimed) (5)**
Mean number of visitors $hour^{-1}$	10	49	56	7	2
Area surveyed (hectares)	6.4	2.8	34.5	13.5	46
Percentage of visitors who remained on site throughout survey periods	21%	6%	46%	0%	0%

KEY:
(1) Formal public open space, suburbs of Wigan (NGR SD 553023).
(2) Formal public open space, near the centre of Wigan (NGR SD 599056).
(3) Agricultural land including public open space, outskirts of Leigh (NGR SD 685005).
(4) Informal public open space, suburbs of Wigan (NGR SD 612071).
(5) Unreclaimed spoil heap with some natural colonisation of vegetation, outskirts of Farnworth (NGR SD 704040).

Table 4.5 Level of use and percentage of visitors who remained on site throughout half-hourly survey periods for urban clearance scheme survey sites and an urban park

Site:	**Bamber Street**	**Crown Street**	**Melville Place**	**Falkner Square (urban park)**
National Grid Ref.	SJ 362902	SJ 361905	SJ 362898	SJ 361895
Mean number of visitors $hour^{-1}$	22	12	57	19
Area surveyed (hectares)	2.7	0.8	1.2	0.65
Percentage of visitors who remained on site throughout survey periods	0%	0%	0%	8%

The level and duration of use of the colliery spoil sites are set out in Table 4.4. For the reclaimed sites, visitor numbers were lowest at Woodshaw, the most inaccessible site, and highest at

Higher Folds, which comprised the biggest area of public open space and in which a playing field was provided as part of the reclamation scheme. Despite its small size, public open space at Careless Lane attracted a relatively high mean number of visitors per hour, a high proportion (46%) of whom used the site as a short cut. Although it was the largest site surveyed at 46 hectares, Cutacre Tip attracted few visitors, almost certainly because of its inaccessible location and derelict state.

The highest percentage of visitors who remained on site throughout the half-hourly survey periods was recorded at Higher Folds, largely because of the presence of the football pitch. At Baxter Pit the users remaining on site for half an hour were children playing and at Careless Lane mostly fishermen using the adjoining canal. Visitors did not remain on site throughout the survey periods at any of the remaining sites.

For the urban clearance schemes, Table 4.5 shows their level and duration of use. The Melville Place site had the highest usage, although 97% of this was accounted for by crossing the site for short cuts, which also comprised 80% of the usage of Bamber Street, 83% for Crown Street and 29% for Falkner Square, the traditional park. The short-lived nature of the use of these sites is brought out by the fact that no visitors remained on any of the urban clearance sites for half an hour at a time. By contrast, 8% of the users of Falkner Square remained in the park during the survey periods. Clearly, the urban clearance public open space sites are used chiefly for crossing and dog walking, and do not have features that are likely to attract visitors for long periods of time. However, the locations of the respective sites are also important; Falkner Square is surrounded by more housing and thus better placed than the other sites.

An important issue in the visitor use of land reclaimed for public open space is the extent to which reclamation leads to the increased use of a site compared with its use prior to reclamation. As it was not feasible to assess this using visitor surveys, in May and June 1988 a questionnaire was used to interview 100 residents of the Higher Folds reclamation scheme situated between Leigh and Tyldesley in Greater Manchester.

Levels of site use at Higher Folds are shown in Table 4.6. In order to make a direct comparison between site use before and after reclamation, only the 61 residents who lived in the immediate vicinity of the site before as well as after it was reclaimed are included in the following analyses. Table 4.6 indicates that the mean level of respondents' site use has declined following reclamation, but that this difference is not statistically significant. It is possible to conclude that there is no evidence that the level of use of Higher Folds has increased since the site was reclaimed.

Table 4.6 Site usage by respondents who lived next to the Higher Folds site before and after reclamation (N=61)

Percentage of respondents who used the site before it was reclaimed	52%
Mean number of times a week they used the unreclaimed site	2.92[1] (0.42)
Percentage of respondents who use the site after reclamation	56%
Mean number of times a week they use the reclaimed site	2.34[1] (0.39)

Standard errors are in parentheses.

[1] Not significantly different from each other at 5% level.

Table 4.7 shows the activities that these 61 residents undertook on the Higher Folds site before and after land reclamation. The decline in the popularity of the site for children's play following reclamation is particularly marked, falling from 25% of respondents to zero but largely seems to reflect the fact that questionnaire respondents have aged by some 13 years since reclamation took place. Fears were also expressed about the lack of safety for children's play on the reclaimed site with its blocks of tree planting preventing the supervision of children, which was much easier before the site was reclaimed, and the noise and danger from motorbike scrambling. The latter was the most commonly mentioned disadvantage of reclamation in the questionnaire survey (11% of responses). Furthermore, when asked what uses of the land and facilities they would like to see on the site, 43% of respondents stated a properly supervised children's play area. However, the apparent decrease in use of the site for children's play is not supported by the results of the visitor survey and this shows the value of observation studies as compared with questionnaire surveys which tend to be aimed exclusively at adult populations (Bradley and Millward, 1986). In the visitor survey, as regards activities undertaken on site, some 7% of all users were children directly engaged in play, besides some 3% scrambling on motorbikes and those playing or watching football, whilst about 24% of all recorded users were either children or adolescents (Table 4.8).

Table 4.7 Activities undertaken by respondents who lived next to the Higher Folds reclamation scheme before and after it was reclaimed (N=61)

	Before reclamation	After reclamation
Children playing	25%	0%
Crossing	13%	25%
Walking	10%	23%
Dog walking	3%	21%
Fishing	2%	0%
Motorcycling	2%	0%
Coal picking	2%	0%
Playing cricket	2%	0%
Playing football	0%	2%
Motorcycling	0%	2%
Children playing	0%	0%

Table 4.8 Activities recorded on colliery spoil survey sites, their relative popularity, (% of total users), and breakdown of visitors

Site:	Baxter Pit	Careless Lane	Higher Folds	Woodshaw Colliery	Cutacre Tip (un-reclaimed)
Activities:					
Crossing site on foot		44.3	16.4	5.9	
Dog walking	66.7	13.9	12.1	17.6	
Walking	12.5	6.6	15.7	5.9	33.3
Watching football			24.3		
Fishing		20.5			
Playing football			15.7		
Children playing	20.8	1.6	5.7	35.3	
Children playing on bicycles		4.9	1.4		
Horse riding		2.4	1.4	17.6	
Cycling		1.6	1.4	5.9	33.3
Running / jogging		0.8	0.7	11.8	
Crossing on bicycles		1.6	1.4		
Motorcycle scrambling			2.8		33.3
Motorcycling		1.6			
Playing golf			0.7		
N =	24	122	140	17	6
Total number of activities:	3	11	13	7	3
Breakdown of visitors:					
Adult male (%)	37.5	32.8	63.6	35.3	33.3
Adult female (%)	33.3	13.9	12.8		
Children (%)	29.2	53.3	23.6	64.7	66.7

4.3.4 Management implications

The activities and breakdown of users of the colliery spoil and urban clearance sites are given in Tables 4.8 and 4.9 on an individual site-by-site basis. Considerable care needs to be taken in relation to the small sample sizes involved (Table 4.10). However, these results do allow some tentative conclusions regarding possible management implications to be drawn.

Table 4.9 Activities recorded on urban clearance survey sites, their relative popularity, (% of total users), and breakdown of visitors

Site:	Bamber Street	Crown Street	Melville Place	Falkner Square (urban park)
Activities:				
Crossing site on foot	79.6	82.8	93	27.1
Dog walking	13	10.3	3.5	10.4
Crossing on bicycle			3.5	2.1
Walking	3.7			
Children playing	3.7			
Sitting down on grass		6.9		14.6
Sitting on bench				16.7
Sunbathing				8.3
N =	54	29	143	48
Total number of activities:	4	3	3	7
Breakdown of visitors:				
Adult male (%)	38.9	34.5	53.1	52.1
Adult female (%)	29.6	51.7	35	25
Children (%)	31.5	13.8	11.9	22.9

Table 4.10 Sampling errors on percentages in the form of 95% confidence limits, calculated for simple random samples (Source: TRRU, 1980a)

	Sample size					
	30	50	80	100	200	300
Percentages observed in sample		**Sampling errors, in percentages**				
50	±19.6	±14.9	±11.6	±10.3	±7.2	±5.8
40 or 60	*	±14.6	±11.4	±10.1	±6.9	±5.7
30 or 70	*	*	±10.7	±9.5	±6.6	±5.4
20 or 80	*	*	*	*	±5.8	±4.7
10 or 50	*	*	*	*	*	*

For instance, visitor use of the Baxter Pit site seems to be overwhelmingly passive in nature, and in such instances, management needs to concentrate on the provision of seats and footpaths. Account needs to be taken of the popularity of the canal bank at Careless Lane with anglers in the management of this site, for example in relation to the new tree planting which is planned. There is a conflict of use at Higher Folds because of noise and danger from motorbike scrambling. The solution to this would appear to be to allocate an area away from housing in the centre of the site specifically for this activity. Forty per cent of site usage at Higher Folds was associated with a playing field which will consequently require regular upkeep. At Woodshaw, a flight of sleeper steps up the steep Northern end of the site has become dangerous to climb, especially for the elderly, because rain has washed the ground away. This site suffers particularly from vandalism, and this is exacerbated by the low level of use it receives. The priorities here are to repair the steps and publicise the site's considerable attractions from the point of view of woodland walks and views.

The urban clearance schemes are predominantly used for crossing, especially to bus stops which adjoin all three reclaimed sites. Footpaths have not been provided at the Crown Street or Melville Place sites because they are usually unnecessary on hard-wearing brick rubble substrates. It is also advisable to wait until desire lines have formed before laying down paths. The Crown Street site (Plates 5 and 6) is close to a hospital and seating could be provided for users, although there are problems of vandalism, several seats, for example, having been destroyed in Falkner Square.

4.3.5 Conclusions

The visitor surveys have identified the main activities undertaken by users of a sample of colliery spoil and urban clearance schemes reclaimed to public open space. An imbalance in the use of these sites in favour of adult males was found in both cases, and the urban clearance schemes were generally visited only briefly or used for short cuts.

The usefulness of the survey results suffer from the fact that it was only possible to survey a small number of sites. Surveys were only undertaken during weekdays in the school summer holidays in dry weather and only covered certain times of the day so that visitors will have been missed. The proportion of elderly and adolescent visitors was not separately identified because of the difficulties in subjective classification of visitors, a problem which was already encountered in distinguishing between children (and adolescents) and adults. No disabled people were recorded using any of the survey sites.

Plate 5. Crown Street prior to reclamation.

Plate 6. Crown Street after reclamation to interim public open space.

Nevertheless, the surveys were able to estimate the relative if not the absolute use of sites. Clearly such surveys do have the potential to make it possible to identify where and on what to concentrate limited managerial resources. Finance for the maintenance of land tends to be in particularly short supply. This problem has been compounded in the case of some of the survey sites in Greater Manchester, where following abolition of the Metropolitan County Councils in April 1986, all landscape maintenance of the Baxter Pit, Careless Lane and Higher Folds sites ceased whilst the sites were transferred to the district council level. Maintenance is only now resuming.

In theory at least, such survey results could be used as an index of benefit in cost-benefit analyses of reclamation schemes. There are, however, difficulties in practice. The first problem is in deciding what the value of any visit is. This might be established by determining willingness to pay to use a site (Chapter 3). Secondly, visitor use of a site cannot be assessed until after it has been reclaimed making only ex post facto evaluations possible. Thirdly, use of the site prior to reclamation needs to be recorded and subtracted from that following reclamation to determine the net user benefits (costs) from reclamation. In a well designed scheme the activities and facilities enjoyed by site users on the unreclaimed site would be retained or re-introduced after reclamation. Fourthly, even assuming that sufficient sampling can be carried out for statistical purposes and to allow for variations in time of day, time of week, season and weather, there is the question of weighting different types of site use. Are people who briefly cross a site to be valued as highly as more active and persistent site users? The use of questionnaires might resolve this problem. Furthermore, there is considerable evidence that open spaces have significant benefits for non-users who nevertheless value the fact that they know a park is there and so need to be taken into account (Bradley and Millward, 1986). This means that existence values may require measurement (Chapter 2). Research has also established that peace and quiet are highly valued in parks, and this may conflict with maximising the number of users. Benefits may also be derived from the improved background environment that results from reclamation, and from an enhanced sense of security, as revealed by the house price study above.

The findings of the questionnaire survey indicate that visitor use of Britain's largest land reclamation scheme has not increased appreciably since reclamation. This may suggest that something is wrong with the design of these reclamation schemes. An alternative to landscapes imposed by the planning system is a consumer-orientated approach to the planning, design and maintenance of open spaces. The direct involvement of the local community, who will be the main users of a site after reclamation, in its design, could in theory lead to the creation of more imaginative green spaces which reflect the recreational needs of local people including the old, very young and disabled. More effort could obviously be made to find out what people actually <u>want</u> from public open space. If derelict sites comprising innocuous waste materials are more heavily used than reclaimed ones, for example as areas for children's play or wildlife study, then only minimal reclamation should be considered, such as the treatment of mine shafts and other dangers, and any necessary environmental works. Equally, if the only aim is to provide a green background environment, only basic facilities need to be provided for visitors. To some extent this is what was done at Higher Folds.

It is clear that the geographical location of sites is a major factor in determining their level of use (TRRU, 1980a). Thus it may seem that sites such as Woodshaw, which was surveyed and found to have relatively few visitors because of its remote location, should not have been reclaimed to public open space. It must be borne in mind, however, that such sites were not reclaimed primarily with the intention of creating public open space, but rather were reclaimed at minimum cost in order to improve the environment, and have often been assigned as public places by default, no other after-use being likely to materialise on them. This is brought out by a recent study of derelict land grant reclamation schemes which suggested that local authorities view the removal of eyesores as a more important objective (54% of schemes) than providing recreational opportunities (33% of schemes) out of a sample of 46 sites recently reclaimed for public open space (Department of the Environment, 1987).

Despite the inherent limitations of surveys, we can conclude that more attention should be paid to what visitor use is likely, and that questionnaires aimed at establishing the attitudes and desires of users and non-users would be extremely useful in the design and management of public open space, as well as having a major role to play in future research.

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CHAPTER 5 COST-BENEFIT ANALYSIS OF COLLIERY SPOIL RECLAMATION SCHEMES

5.1 The reclamation of deep-mined colliery spoil

The extraction of coal from deep mines requires extensive areas of land for spoil tipping, and has therefore been a major historic source of dereliction in Britain. Provisional results from the 1988 survey of derelict land indicate that there are currently about 7,500 hectares of colliery spoil related dereliction in England which justify reclamation. They also show that whilst about 400 hectares of this form of dereliction are being reclaimed each year, a similar amount of new colliery spoil dereliction is being created (Chapter 1). Despite the advent of methods of progressive restoration of such wastes described in Chapter 7, the need for full scale reclamation of colliery spoil wastes seems set to continue in the foreseeable future. This is because in the past restoration conditions have not been imposed at collieries, and although they may shortly become a statutory requirement, it is unlikely that these new powers will act retrospectively (National Audit Office, 1988).

The revegetation of colliery spoil mine wastes poses a number of difficulties. Colliery spoil is usually acidic. Its pH typically lies between 3 and 5, but may be as low as 1.5, and vary widely within a single site. The generation of acidity is a persistent problem, because once iron pyrites in colliery spoil becomes exposed to moisture and oxygen, its prolonged weathering continues to release sulphuric acid:

$$4FeS_2 + 15O_2 + 14H_2O \longrightarrow 4Fe(OH)_3 + 8H_2SO_4$$

The acidity of raw colliery spoil has several effects. It tends to inhibit root growth, decrease nutrient availability and cause soil structure to deteriorate. Acidity also tends to mobilise phytotoxic heavy metals, particularly Al^{3+} and Mn^{2+} (Chadwick *et al.*, 1969) and fix phosphorus, principally through its conversion to insoluble ferric and aluminium phosphates and adsorption on to amorphous ferric hydroxide (Doubleday, 1971). It is usually the case that spoils are extremely deficient in major plant nutrients, especially nitrogen and phosphorus (Gemmell, 1977; Bradshaw and Chadwick, 1980).

In addition, the lack of organic matter in colliery spoils means that they suffer from problems of soil structure. Such wastes are thus prone to compaction in the winter, with consequent waterlogging, gullying and erosion, and droughting with the 'burning off' of vegetation in the summer, due to high soil surface temperatures associated with their dark, even matt black colours.

Although it is possible to spread topsoil on reclaimed coal mine sites to facilitate vegetation establishment, in practice this approach is rarely used. This is because of the prohibitive expense involved. In the North West of England, the supply and spreading of topsoil cost approximately £10.50 m^{-3} in 1989. To cover a mine site of some 20 hectares to a depth of 25 cm would cost £525,000 (£26,250 ha^{-1}). Furthermore, the procurement of such vast quantities of topsoil is likely to prove impossible, and research has shown that topsoils supplied by many landscape contractors are of variable and often very poor quality (Bloomfield *et al.*, 1981). In an attempt to improve the unacceptably low quality of topsoil, a new British Standard specification is currently being developed.

The biological problems associated with the reclamation of deep-mined colliery spoil received intensive study in the late 1960's and the 1970's. Methods of directly revegetating wastes without the costly importation of topsoil were developed, and successfully implemented. Table 5.1 itemises the cultivation methods that were used at the Higher Folds reclamation scheme in Greater Manchester which was a typical colliery spoil scheme in which the wastes were directly seeded without the use of topsoil. The deep incorporation of very large quantities of lime is necessary to counteract the problem of persistent acidity generation from spoils. The post-reclamation application of lime to the surface of spoils to attempt to treat acidity is relatively ineffective, and adequate limestone must therefore be added during initial reclamation (Bloomfield *et al.*, 1982).

Gemmell (1977) has identified the main types of pollution which result from derelict deep mines. Water pollution takes the form of acidic runoff and seepage into watercourses, the release of suspended solids in runoff and the deposition of ferruginous compounds in stream channels. In addition, there may be air pollution from wind blown dust, the emission of sulphurous gases from the spontaneous combustion of spoil heaps and the threat of landslides, as in the Aberfan disaster of 1966.

Table 5.1 Cultivation treatments used in the Higher Folds reclamation scheme

1. Rip to 50 cm at 40 cm spacing.
2. Lime at equivalent of 100 tonnes $ha.^{-1}$
3. Tine to 15 cm to incorporate lime.
4. Spread phosphate fertiliser (triple superphosphate) at 900 Kg $ha.^{-1}$
5. Tine to 10 cm.
6. Harrow with a medium disc.
7. Chain harrow.
8. Spread compound NPK fertiliser at 625 Kg $ha.^{-1}$
9. Seed with grass mix including white clover (*Trifolium repens*).
10. Light roll.

A breakdown of the cost of works associated with the Higher Folds reclamation scheme is shown in Table 5.2. This indicates that the biological component of reclamation is relatively insignificant in financial terms compared with the cost of the reclamation contract.

Table 5.2 Breakdown of total project cost for Higher Folds reclamation scheme (see also Table 5.5)

Operation	Percentage
1. Land acquisition, including 10% administrative costs	15
2. Advanced drainage works	2.4
3. Site investigations	0.2
4. Main engineering contract	52
5. Mineshaft treatment	2.5
6. Additional compaction works	0.1
7. Cultivation	7.6
8. Gabions to arrest erosion	0.9
9. Additional demolition	0.1
10. Staff costs	9.4
11. Treatment to small diameter shafts	0.2
12. Removal of silt	0.2
13. Tree planting	6.3
14. Rhyl Fold (minor works)	0.3
15. South Lane (minor demolition/clearance)	0.9
16. Landscaping (Gin Pit Village)	2

5.2 The method of economic analysis

Cost-benefit analysis was applied retrospectively to twenty deep-mined colliery spoil reclamation schemes in England and Wales. The schemes have been classified according to their main intended after-use, as this is likely to be a major factor affecting their overall cost. This is shown in Table 5.3.

Table 5.3 Classification of deep-mined colliery spoil reclamation schemes by principal after-use

Table	Scheme	Principal after-use
5.4	Chisnall Hall, Coppull †	Agriculture
5.5	Higher Folds, Leigh †	Agriculture
5.6	Rowley Tip, Burnley †	Agriculture
5.7	Aberbargoed colliery, Bargoed	Commercial forestry
5.8	Careless Lane, Ince-in-Makerfield	Housing
5.9	Industrious Bee, Ince-in-Makerfield	Housing
5.10	Berryhill, Stoke-on-Trent † *	Industry
5.11	Chanters colliery, Atherton †	Industry
5.12	Hot Lane, Stoke-on-Trent †	Industry
5.13	Neath Abbey, Neath †	Industry
5.14	Baxter Pit, Winstanley †	Public open space
5.15	Bryn Road II, Ashton-in-Makerfield †	Public open space
5.16	Central Forest Park, Stoke-on-Trent †	Public open space
5.17	Chatterley Whitfield, Stoke-on-Trent †	Public open space
5.18	Ogilvie colliery, Deri †	Public open space
5.19	Pennington Flash, Leigh †	Public open space
5.20	Sidings Lane, Rainford †	Public open space
5.21	Sneyd Tip, Stoke-on-Trent †	Public open space
5.22	Welch Whittle II, Chorley †	Public open space
5.23	Woodshaw, Aspull	Public open space

† Funded wholly or partly with Derelict Land Grant.
* Industrial development has not in fact materialised on this site.

Schemes were selected as follows. The case studies that were chosen had to have a principal intended after-use. Schemes with complex combinations of after-uses or which were not purely colliery spoil reclamation schemes are not considered. A major criterion was the availability of financial information in the reclamation files of the local authorities, government departments and other agencies from whom the data were collected. As far as possible, within these constraints, schemes were selected at random, so that the projects analysed include some which were badly carried out or excessively expensive as well as innovative and cost-effective schemes. Since most of the derelict deep-mined colliery spoil in the North West of England was reclaimed in the 1960's and 1970's, many of the schemes date from this period. Some 80% of them were funded using Derelict Land Grant (Table 5.3).

Each scheme has been appraised using cost-benefit analysis (CBA) over a twenty year time horizon. The effects of inflation have been taken into account using an index based on the Retail Price Index, calculated by financial year. The costs and benefits of reclamation were assigned to financial years as this is how local authorities and the Department of the Environment maintain their financial records.

The individual CBAs are presented in Tables 5.4-5.23 in which all costs and benefits are expressed in constant 1987/88 prices. In addition to the overall CBA model, it is informative to have a breakdown of its various components and these are also given. The following definitions are used:

5.2.1 Definition of terms used

1. PROJECT COST

The project cost (PC) is the full CBA model. It includes the cost of land acquisition and an estimated 10% for associated administrative costs, all the costs of works to reclaim a site including scheme design costs and the post-reclamation value of the land. The difference between pre- and post-reclamation values is thus counted as a project benefit if it is positive and a cost if it is not, in the overall Net Present Cost (NPC) or Net Present Value (NPV) calculations.

2. RECLAMATION COST

The reclamation cost (RC) illustrates the effect of including only acquisition plus reclamation costs and associated administrative and design costs in the CBA model. This is thus a financial not a strictly economic analysis, but it is valuable from the point of view of the government, since it reflects the initial outlay upon a reclamation scheme. The RC is calculated as a Present Cost (PC).

3. WORKS COST

The works cost (WC) consists of the cost of reclamation works plus associated staff costs only. This is an economic (real resource) cost. Good design will minimise the WC, whereas poor design will inflate it. Only those demolition works associated with reclamation contracts have been included in the analyses. The WC is shown as a Present Cost (PC) in Tables 5.4-5.23.

4. COST OF LAND ACQUISITION

The cost of land acquisition only (CLA) is provided for purely financial information. It includes an estimated 10% administrative cost. The CLA is presented as a Present Cost (PC).

5. POST-RECLAMATION VALUE

The post-reclamation value (PRV) of the land is again included for financial information, and to enable comparison with the CLA.

It is the value of the land after reclamation but prior to development. The PRV represents a <u>Present Value</u> (<u>PV</u>).

The (hopefully) increased value of a piece of land following reclamation is a measure of the benefits associated with reclaiming that land (see Chapter 3). Since under free market conditions the price of a parcel of land reflects an implicit valuation of the discounted <u>net</u> benefits of its ownership, it would be incorrect to also include maintenance costs (or income) in the approach taken here. This would be to fall prey to the commonly encountered danger in CBA of <u>double counting</u>.

The estimated figure of 10% for the additional administrative costs of land acquisition was derived from interviews with local authority officers, including those who had undertaken such administrative costing exercises. Land acquisition costs, the costs of reclamation works and staff (scheme design) costs were obtained from files. In several cases (Tables 5.7, 5.17, 5.20 and 5.23) land acquisition costs were not available, sometimes because the land had been in local authority ownership for a number of years. These costs were therefore estimated with the assistance of estate (district) valuers as the value of the land prior to reclamation on the open market or by using inflation and area-adjusted costs from similar, neighbouring, schemes. For two schemes, (Tables 5.7 and 5.23) reclamation works costs were not available, but since these schemes involved only the direct tree planting of tips, it was possible to estimate these costs with the assistance of professional foresters. Where such estimates have proven necessary, this should be borne in mind.

For some of the schemes, post-reclamation land values, known administratively as 'after values', were available from the files because sites were immediately sold for development. Where this was not the case, PRVs were estimated with the assistance of estate (district) valuers as the value of the land on the open market after reclamation. Where estimates were necessary, the values have been assigned to the year following the completion of the engineering works were completed, when the one year contract maintenance included in many engineering contracts would be about to cease.

A difficulty arises with respect to the post-reclamation value of sites reclaimed to public open space. These schemes are assigned nil after values in the administration of the derelict land grant system, but this obviously has no economic meaning. Indeed, on opportunity cost grounds it can be argued that the implicit value of the land is its foregone commercial value if it were not zoned by the planning system as public open space.

However, the sites analysed are largely situated in locations where there is little demand for residential or industrial development. Many of the sites are too small to be developed or too big too be developed in their entirety. Several are steep or sloping and there are also problems of possible subsidence and settlement, requiring costly foundation preparation, arising from the formerly derelict state of these sites. Consequently, the approach that has been taken is to value these sites in terms of the value of the land on the open market on the assumption that development is unlikely to materialise on them in the foreseeable future. These schemes have therefore been assigned nominal or speculator's post-reclamation land values, as estimated by professional valuers.

The WC figures have not been shadow priced because of the lack of availability of information about the labour cost element of engineering contracts. Similarly CLA figures have not been shadow priced (except where valuers' estimates proved necessary), to investigate the financial aspects of the costs of land acquisition.

The figures presented in Tables 5.4-5.23 have been discounted at both the 5 and 7% real discount rates (Required Rates of Return) recommended by the government in project appraisal to provide sensitivity analysis (Chapter 2).

It has not been possible to take project risk explicitly into account in these analyses. This would obviously be extremely useful, however, from a decision-making point of view.

The intangible and unmeasured benefits of reclamation are discussed below. The distributional effects of land reclamation are discussed in detail in the case study presented in Chapter 3.

Net Present Values and Costs have been rounded to the nearest £100 for clarity. They are also given as unit costs (NPC or NPV hectare^{-1}) to facilitate cost comparisons between schemes.

Care needs to be taken in interpreting the benefit-cost ratio figures, for, as was shown in Chapter 2, these are sensitive to the classification of costs and benefits. The approach that has been taken throughout this research has been to classify the CLA as a project cost, and the PRV as a benefit.

5.3 Results and discussions

The results are presented in Tables 5.4-5.23. Each scheme is first discussed separately. Schemes are also discussed in relation to their after-use before overall conclusions are drawn. Landscape maintenance costs and income are shown, where appropriate, in Table

5.3.1 Agriculture as an after-use

Chisnall Hall, Coppull

Table 5.4 Chisnall Hall: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heaps, near Coppull, Chorley, Lancashire (NGR SD 547125).
After-uses: Agriculture (54 ha), tree planting (15 ha), a playing field and allotments (9.9 ha). Total 78.9 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-790,300	-10,000 ha^{-1}	0.09
r = 7%	-768,900	-9,700 ha^{-1}	0.08

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-866,700	-11,000 ha^{-1}
r = 7%	-838,400	-10,600 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-529,100	-6,700 ha^{-1}
r = 7%	-500,800	-6,300 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-337,600	-4,300 ha^{-1}
r = 7%	-337,600	-4,300 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	76,400	1,000 ha^{-1}
r = 7%	69,500	900 ha^{-1}

Table 5.4 indicates that a low CLA and WC are reflected in a very reasonable overall PC for this scheme. The WC was low because the 6 million m^3 of very acidic colliery wastes were directly seeded, 40,000 whips and transplants planted and phosphate-rich industrial waste used as a cheap phosphorus fertiliser. Unit costs were brought down by acquiring extra, non-derelict land from which

topsoil was stripped. Grass and woodland establishment has been excellent in this award-winning scheme (Plate 7).

Although the PRV is low, the site does generate income from agricultural licences (Table 5.24). Prior to reclamation, toxic leachate from the spoil heaps affected about 29 ha of adjoining farmland, a benefit of the project that has not been measured here. The scheme had the intangible benefit that its location and smouldering condition alongside the M6 motorway may have meant that prior to reclamation its derelict state had a negative influence on potential developers *entering Lancashire.*

Plate 7. Chisnall Hall after reclamation to agriculture and amenity woodland.

Plate 8. Chanters colliery: an exposed area of colliery spoil indicates unsatisfactory reclamation.

Higher Folds, Leigh

Table 5.5 Higher Folds: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heaps, between Leigh and Tyldesley, Greater Manchester (NGR SD 685005).
After-uses: Agriculture (122 ha), tree planting (67 ha), and playing fields (2 ha). Total 191 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-4,075,700	-21,300 ha^{-1}	0.06
r = 7%	-3,709,400	-19,400 ha^{-1}	0.05

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-4,318,600	-22,600 ha^{-1}
r = 7%	-3,899,400	-20,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-3,202,200	-16,800 ha^{-1}
r = 7%	-2,843,000	-14,900 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,116,400	-5,800 ha^{-1}
r = 7%	-1,056,500	-5,500 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	242,900	1,300 ha^{-1}
r = 7%	190,100	1,000 ha^{-1}

The WC was higher than that for the Chisnall Hall scheme because this scheme involved more earthmoving. The WC was kept down by directly seeding the wastes, planting transplants and using a lime waste by-product from a chemical waste tip as a cheap liming material.

Income from grazing and mowing licences more than covers the cost of maintaining the area of public open space (Table 5.24). The costs, benefits and distributional impacts of this scheme are discussed in detail in Chapter 3. One consequence of the scheme has been to increase the popularity of the nearby Higher Folds housing estate.

Rowley Tip, Burnley

Table 5.6 Rowley Tip: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, near Burnley, Lancashire (NGR SD 859332).
After-uses: Agriculture and tree planting. Total 20.7 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-677,000	-32,700 ha^{-1}	0.03
r = 7%	-655,000	-31,600 ha^{-1}	0.03

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-698,000	-33,700 ha^{-1}
r = 7%	-674,500	-32,600 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-676,200	-32,700 ha^{-1}
r = 7%	-652,700	-31,500 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-21,800	-1,100 ha^{-1}
r = 7%	-21,800	-1,100 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	21,000	1,000 ha^{-1}
r = 7%	19,500	900 ha^{-1}

The WC was relatively high at this directly-seeded site, partly because the spoil was very acidic. The grass cover is patchy, suggesting that insufficient lime was incorporated during reclamation.

Maintenance costs outweigh site income (Table 5.24). In part this reflects problems with the continued generation of acidity. Post-reclamation surface applications of lime have had little effect in increasing grass yields. The discharge of ferruginous compounds into the River Brun continues, despite reclamation.

Discussion

For all three schemes where agriculture is an after-use, the CLA exceeded the PRV. This suggests that the price paid for the derelict sites was too high. This may occur because land owners hold out for higher prices than those that should apply on the free market.

The PRVs of reclaimed agricultural land in North West England are also low. This reflects a lack of demand for the low quality farmland that reclamation produces.

Despite this, it is apparent from these examples that the costs of directly seeding colliery spoil to reclaim it to an agricultural after-use need not be excessively high on a unit cost basis. Although the reclaimed land is unlikely to have an Agricultural Land Classification above grade 5, it does provide income which may cover landscape maintenance costs associated with areas of public open space. To argue, as the D.o.E. and M.A.F.F. (1980) have, that reclamation to an agricultural after-use is uneconomic, is to miss the point. These sites were not reclaimed <u>primarily</u> to create an agricultural resource, but to improve the environment, on sites which had few prospects of development (Broughton, 1985). The fact that they are financially self-maintaining is valuable given the highly restricted availability of funding for landscape maintenance works within the Derelict Land Grant.

Clearly, current policies of agricultural set aside cast further doubt upon the already low incomes generated by these sites. Other revenue-generating approaches may be preferable, chief amongst them being forestry.

5.3.2 Commercial forestry as an after-use

Aberbargoed colliery, Bargoed

Table 5.7 Aberbargoed colliery: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, near Bargoed, South Wales (NGR ST 156994).
After-use: Commercial forestry. Total 21 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-11,100	-500 ha^{-1}	0.59
r = 7%	-13,200	-600 ha^{-1}	0.50

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-27,000	-1,300 ha^{-1}
r = 7%	-26,400	-1,300 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-15,800	-800 ha^{-1}
r = 7%	-15,200	-700 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-11,200	-500 ha^{-1}
r = 7%	-11,200	-500 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	15,900	800 ha^{-1}
r = 7%	13,200	600 ha^{-1}

The WC is extremely low for this scheme because the spoil heap itself, containing some 5 million m^3 of spoil was not regraded. Instead, the tip was left in situ and directly planted with trees, chiefly Japanese Larch, Lodgepole Pine and Corsican Pine. The site is now managed by the Forestry Commission. Anticipated Yield Classes are 6 for the Japanese Larch, 6-10 for the Corsican Pine and only 4 for the Lodgepole Pine. Cropping will take place after some

50-55 years. The nature of colliery spoil means that weed control is generally unnecessary on this site.

Discussion

It proved extremely difficult to find examples of reclamation to commercial, as opposed to amenity forestry on deep-mined colliery spoil. There are essentially two ways of carrying out such reclamation. Either unregraded tips can be directly planted, and this has the advantage of not incurring harmful compaction from earthmoving operations (Bradshaw and Chadwick, 1980). Alternatively, if land is regraded, deep ripping is necessary to relieve compaction. Planting can then take place according to Forestry Commission guidelines (Jobling and Stevens, 1980; Jobling, 1983). This approach is relatively new and examples of reclamation schemes using it are not yet available.

The direct planting of tips is an attractive low cost option, and the possibility of its commercial viability merits further investigation. However, such an approach should only be undertaken on tips which are not excessively acidic, which are stable, and located away from houses. Although tree planting will help to stabilise tips, any subsequent thinning and harvesting operations should be undertaken selectively, to prevent erosion and for aesthetic reasons.

5.3.3 Housing as an after-use

Careless Lane, Ince-in-Makerfield

Table 5.8 Careless Lane: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPV=Net Present Value, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heaps, Ince-in-Makerfield, near Wigan, Greater Manchester (NGR SD 599056).
After-uses: Housing (7.4 ha), playing fields (4.2 ha) and public open space (2.8 ha). Total 14.3 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPV (NPC)	NPV (NPC) ha^{-1}	Benefit-cost ratio
r = 5%	6,900	500 ha^{-1}	1.02
r = 7%	-9,100	-600 ha^{-1}	0.97

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-285,600	-20,000 ha^{-1}
r = 7%	-270,200	-18,900 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-155,400	-10,900 ha^{-1}
r = 7%	-141,400	-9,900 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-130,200	-9,100 ha^{-1}
r = 7%	-128,800	-9,000 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	292,500	20,500 ha^{-1}
r = 7%	261,200	18,300 ha^{-1}

At the 5% discount rate this scheme is self-financing. This results from the high PRV of the portion of the land sold for housing. The sale of land for residential development also permitted an area of public open space to be reclaimed at no overall cost, and the provision of playing fields.

The standard of landscape maintenance of the area reclaimed to public open space (Chapter 4) has been very poor. The standard trees that were planted have been neglected and suffered heavy losses from tie strangulation and rabbit guard constriction (Gilbertson and Bradshaw, 1985). This has necessitated replacement planting, which should never have been needed.

Industrious Bee, Ince-in-Makerfield

Table 5.9 Industrious Bee: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Crickets Lane, Pennington Green, Ince-in-Makerfield, near Wigan, Greater Manchester (NGR SD 603055).
After-use: Housing. Total 9.6 ha.

1. Project cost (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-22,400	-2,300 ha^{-1}	0.81
r = 7%	-28,000	-2,900 ha^{-1}	0.76

2. Reclamation cost (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-120,800	-12,600 ha^{-1}
r = 7%	-118,200	-12,300 ha^{-1}

3. Works cost (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-96,300	-10,000 ha^{-1}
r = 7%	-93,700	-9,800 ha^{-1}

4. Cost of land acquisition (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-24,500	-2,600 ha^{-1}
r = 7%	-24,500	-2,600 ha^{-1}

5. The post-reclamation value of the land (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	98,400	10,300 ha^{-1}
r = 7%	90,100	9,400 ha^{-1}

The overall PC for this scheme is very reasonable, because of the high PRV resulting from the sale of land for housing. However, some 23% of the reclamation engineering works comprised the purchase of topsoil, which seems a remarkably unnecessary expense considering that the land was immediately built upon.

Discussion

It is apparent from these examples that reclamation for housing is extremely cost-effective and may even be profitable. It has the further benefit of reducing pressure for development in the countryside, and thus should be undertaken wherever it is practicable to do so. The need to take into account load bearing characteristics and possible differential settlement and subsidence mean that housing will only be a feasible after-use on parts of most sites.

5.3.4 Industry as an after-use

Berryhill and Bush Pits, Stoke-on-Trent

Table 5.10 Berryhill: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap and marl hole, Fenton, Stoke-on-Trent, Staffordshire (NGR SJ 900460).
After-use: Industry. Total 17.7 ha.

1. Project cost (cost-benefit analysis)			
Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-433,100	-24,500 ha^{-1}	0.68
r = 7%	-469,300	-26,500 ha^{-1}	0.65
2. Reclamation cost (financial analysis)			
Discount rate	PC	PC ha^{-1}	
r = 5%	-1,372,700	-77,600 ha^{-1}	
r = 7%	-1,340,500	-75,700 ha^{-1}	
3. Works cost (economic analysis)			
Discount rate	PC	PC ha^{-1}	
r = 5%	-1,104,300	-62,400 ha^{-1}	
r = 7%	-1,076,700	-60,800 ha^{-1}	
4. Cost of land acquisition (financial analysis)			
Discount rate	PC	PC ha^{-1}	
r = 5%	-268,500	-15,200 ha^{-1}	
r = 7%	-263,800	-14,900 ha^{-1}	
5. The post-reclamation value of the land (financial analysis)			
Discount rate	PV	PV ha^{-1}	
r = 5%	939,600	53,100 ha^{-1}	
r = 7%	871,300	49,200 ha^{-1}	

The WC was relatively high for this scheme, but this is counteracted by a substantial PRV. The site included a marl hole, which was filled using the colliery wastes, thus solving two problems at once.

Chanters colliery, Atherton

Table 5.11 Chanters colliery: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, off Green Street, Shakerley, Atherton, Greater Manchester (NGR SD 685027).
After-uses: Industry (11.6 ha) but never taken up, public open space (9 ha), of which 3.3 ha is tree planting. Total 20.6 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-881,600	-42,800 ha^{-1}	0.02
r = 7%	-862,500	-41,900 ha^{-1}	0.01

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-897,000	-43,500 ha^{-1}
r = 7%	-875,500	-42,500 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-313,200	-15,200 ha^{-1}
r = 7%	-294,700	-14,300 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-583,800	-28,300 ha^{-1}
r = 7%	-580,800	-28,200 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	15,300	700 ha^{-1}
r = 7%	13,000	600 ha^{-1}

Although the WC for this scheme was relatively low, its high PC indicates that it cannot be regarded as a success. The intended industrial after-use failed to materialise, as a result of disagreement over the extent of unsatisfactory subsoil conditions.

Despite a further subsoil survey, additional works to remove pockets of slurry and the provision of roads and sewers, the site remains undeveloped today. As a result the PRV of the land is far less than the CLA.

At present the site is completely neglected, with no signs of any landscape maintenance. In places the standard of the reclamation work is very disappointing, with bare, exposed areas of colliery spoil (Plate 8). This may have been because the reclamation engineers cut corners and made the mistake of specifying insufficient limestone to counteract the generation of acidity from iron pyrites in the spoil.

Hot Lane, Stoke-on-Trent

Table 5.12 Hot Lane: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPV=Net Present Value, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Burslem, near Stoke-on-Trent, Staffordshire (NGR SJ 877497).
After-use: Industry. Total 10 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPV	NPV ha^{-1}	Benefit-cost ratio
r = 5%	298,500	29,900 ha^{-1}	1.53
r = 7%	256,900	25,700 ha^{-1}	1.46

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-563,500	-56,400 ha^{-1}
r = 7%	-557,700	-55,800 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-232,300	-23,200 ha^{-1}
r = 7%	-227,200	-22,700 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-331,200	-33,100 ha^{-1}
r = 7%	-330,500	-33,100 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	862,000	86,200 ha^{-1}
r = 7%	814,600	81,500 ha^{-1}

This scheme was a profitable investment. This is because of the high PRV which outweighed the RC.

Neath Abbey, Neath

Table 5.13 Neath Abbey: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, alongside the A65, Neath, South Wales (NGR SS 735972).
After-uses: Industry and retail. Total 14 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-496,600	-35,500 ha^{-1}	0.43
r = 7%	-475,900	-34,000 ha^{-1}	0.41

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-872,500	-62,300 ha^{-1}
r = 7%	-811,500	-58,000 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-803,600	-57,400 ha^{-1}
r = 7%	-745,200	-53,200 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-68,900	-4,900 ha^{-1}
r = 7%	-66,400	-4,700 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	375,900	26,800 ha^{-1}
r = 7%	335,600	24,000 ha^{-1}

The WC for this scheme was relatively high, probably due to the need to make the site suitable for industrial units. The CLA, however, was relatively low, and this is reflected in an acceptable overall PC.

Discussion

It might be expected that the WC associated with reclamation to an industrial after-use should be relatively high on a unit cost basis. This is because of the need for extra works to prepare a site for light industrial use, especially in terms of load bearing and settlement characteristics. However, the examples above do not always bring this out, perhaps because sites which are chosen for an industrial after-use tend to be ones which require relatively little earthmoving.

The reclamation of colliery spoil to an industrial after-use is not particularly common, because of the problems outlined above. Where a potential developer is assured, substantial PRVs may accrue, and reclamation may even be profitable. In such instances it is an economically attractive option. However, speculative reclamation for industry may represent an expensive waste of resources if industrial development does not materialise on the site, as in the case of Chanters colliery.

5.3.5 Public open space as an after-use

Baxter Pit, Winstanley

Table 5.14 Baxter Pit: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Winstanley, near Wigan, Greater Manchester (NGR SD 553023).
After-use: Public open space. Total 6.4 ha.

1. Project cost (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-129,400	-20,200 ha^{-1}	0.08
r = 7%	-121,000	-18,900 ha^{-1}	0.08

2. Reclamation cost (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-140,700	-22,000 ha^{-1}
r = 7%	-130,800	-20,400 ha^{-1}

3. Works cost (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-108,400	-16,900 ha^{-1}
r = 7%	-99,500	-15,500 ha^{-1}

4. Cost of land acquisition (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-32,200	-5,000 ha^{-1}
r = 7%	-31,400	-4,900 ha^{-1}

5. The post-reclamation value of the land (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	11,200	1,800 ha^{-1}
r = 7%	9,800	1,500 ha^{-1}

The WC for this scheme (Plate 9) was low because the southern end of the site had naturally recolonised over a number of years with a variety of tree species, including sycamore, oak, ash, alder, willow, silver birch and hazel. Some 35% of the 5,000 trees that were used died in the summer following planting, due to drought conditions. Since these were almost exclusively whips, however, replacement planting was not a major expense.

As in the case of other schemes formerly owned by the Greater Manchester Council, abolition of the Metropolitan County Councils in

Plate 9. Baxter Pit, reclaimed to public open space.

Plate 10. Woodshaw, a spoil heap treated by the direct planting of trees.

1986 has led to a cessation of landscape maintenance for several years. Despite the uncut grass, the site remains attractive with its extensive views and semi mature woodland. Quarry stone seats provided during reclamation have proven resistant to vandalism.

Bryn Road II, Ashton-in-Makerfield

Table 5.15 Bryn Road II: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heaps, now the Three Sisters Recreation Area, Ashton-in-Makerfield, Wigan, Greater Manchester (NGR SD 585015).
After-uses: Public open space (38.5 ha) and recreation (4 ha). Total 42.5 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,699,900	-40,000 ha^{-1}	0.04
r = 7%	-1,595,400	-37,500 ha^{-1}	0.04

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,773,600	-41,700 ha^{-1}
r = 7%	-1,654,100	-38,900 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-532,100	-12,500 ha^{-1}
r = 7%	-446,500	-10,500 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,241,500	-29,200 ha^{-1}
r = 7%	-1,207,600	-28,400 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	73,700	1,700 ha^{-1}
r = 7%	58,800	1,400 ha^{-1}

The fairly high PC of this scheme is largely accounted for by a substantial CLA. This CLA seems unacceptably high when the nature of this site prior to reclamation is taken into account. It was known locally as the 'Three Sisters' after three enormous spoil heaps towering up to 45 metres high, but it included eight spoil heaps in total, two of which were on fire, which were eroding, silting up and flooding adjoining watercourses and slumping onto neighbouring agricultural land. Sulphates leaching from one spoil heap attacked flagstones and kerbs in a nearby road. These project benefits have not been not costed here, although income earned from the commercial extraction of burnt red shale prior to reclamation is included in the cost-benefit analysis.

The size of the spoil heaps precluded their complete regrading. Instead 6 million tonnes of spoil were moved and reshaped to form an arena for noisy sports, and the remainder reclaimed for public open space, with the planting of over one million trees. Located near the M6 motorway, the site is now popular for a number of recreational uses; in 1984 over 29,000 people visited the visitor centre and/or spectated at the arena.

All available topsoil was recovered prior to the engineering works. Another well planned feature of the design was the creation of a lake which, whilst acting as a balancing reservoir in preventing excessive runoff from the site, is also used for recreational purposes. Table 5.24 shows that the income generated by recreational uses currently exceeds landscape maintenance costs.

Table 5.16 Central Forest Park: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heaps, Hanley, near Stoke-on-Trent, Staffordshire (NGR SJ 883486).
After-use: Public open space. Total 34.5 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,828,100	-53,000 ha^{-1}	0.02
r = 7%	-1,745,400	-50,600 ha^{-1}	0.02

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,871,200	-54,200 ha^{-1}
r = 7%	-1,778,400	-51,500 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,249,700	-36,200 ha^{-1}
r = 7%	-1,190,000	-34,500 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-621,400	-18,000 ha^{-1}
r = 7%	-588,400	-17,100 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	43,100	1,200 ha^{-1}
r = 7%	33,100	1,000 ha^{-1}

The WC and PC are surprisingly high at this site on a unit cost basis. This is despite the fact that it was designed as a low cost, low maintenance scheme making use of ecological techniques and won major awards at the time. Furthermore, Table 5.24 indicates that landscape maintenance costs are relatively high at this site, possibly because much more grass mowing is being carried out than was ever intended in the original design.

Prior to reclamation the site comprised three enormous spoil heaps, holes resulting from marl extraction, derelict buildings and mineral railway lines, and mine shafts, requiring considerable and therefore costly, engineering works to reclaim. The site was used for informal recreational activities, but its fly tipped and derelict state had a negative visual impact, given its prominent location in a built-up area close to Hanley city centre. The innovative design concept was to create a 'forest park' providing countryside wilderness in an urban location. The views of the general public were solicited prior to reclamation in an exhibition in Hanley.

Eight million tonnes of spoil were recontoured but the largest spoil heap was not regraded and the panoramic views and distinctive characteristics of the heaps were retained. They were planted with some 44,000 2+2 forestry transplants to create a semi natural landscape. Except for sports pitches which were topsoiled, the wastes were treated with sewage sludge or directly seeded. Low maintenance grass mixes were generally used, including *Festuca rubra*, *Agrostis capillaris* and *Deschampsia flexuosa*. The seed mix also included wild flowers such as yarrow, daisy, harebell, birdsfoot trefoil and white clover.

On-site and local materials were used to reduce costs. Paths were built using burnt red shale from the spoil heaps, whilst seats, bollards, litter bins and trip rails were made from old railway sleepers and abandoned timber. The paved surfaces of seating areas were constructed using unwanted materials in the process of being replaced in local streets.

Table 5.17 Chatterley Whitfield: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heaps, Burslem, near Stoke-on-Trent, Staffordshire (NGR SJ 883529).
After-use: Public open space. Total 130.4 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,883,700	-14,400 ha^{-1}	0.10
r = 7%	-1,827,800	-14,000 ha^{-1}	0.09

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-2,091,400	-16,000 ha^{-1}
r = 7%	-2,003,100	-15,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,376,500	-10,600 ha^{-1}
r = 7%	-1,288,300	-9,900 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-714,800	-5,500 ha^{-1}
r = 7%	-714,800	-5,500 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	207,700	1,600 ha^{-1}
r = 7%	175,300	1,300 ha^{-1}

This award-winning scheme was very cost-effective in unit cost terms. The WC was kept down by including non-derelict land in the total area.

The massive size of the spoil heaps, containing some 13.5 million tonnes of spoil, precluded full scale regrading operations. The site was directly seeded and the inaccessible mounds of spoil were hydroseeded. Tree planting was confined to the spoil heaps. The site now includes a popular mining museum.

Playing fields included as part of the scheme remain undrained because of financial restrictions. A farmer takes hay crops off the site, but is not charged for doing so.

Table 5.24 shows that maintenance costs for this site are quite low. The tops of the heaps are not maintained, and parts of the site are devoted to nature conservation and maintained by volunteers.

Ogilvie colliery, Deri

Table 5.18 Ogilvie colliery: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV-Present Value.

Site: Colliery spoil heap, Deri, South Wales (NGR SO 117033).
After-use: Public open space (country park). Total 81 ha.

1. Project cost (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-2,904,800	-35,900 ha^{-1}	0.06
r = 7%	-2,908,400	-35,900 ha^{-1}	0.06

2. Reclamation cost (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-3,095,400	-38,200 ha^{-1}
r = 7%	-3,095,400	-38,200 ha^{-1}

3. Works cost (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-3,037,900	-37,500 ha^{-1}
r = 7%	-3,037,900	-37,500 ha^{-1}

4. Cost of land acquisition (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-57,500	-700 ha^{-1}
r = 7%	-57,500	-700 ha^{-1}

5. The post-reclamation value of the land (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	190,600	2,400 ha^{-1}
r = 7%	187,100	2,300 ha^{-1}

The WC for this scheme was relatively high, but the CLA low. The site is now a country park and includes a lake which is used for fishing.

A softwood plantation of some 15 ha was included in this scheme, which may provide some commercial return. This consists entirely of Japanese Larch, which will be beaten up and screened with hardwoods for aesthetic reasons.

The area of larch planting was ploughed during site regrading operations. This was before the current Forestry Commission recommendations of deep ripping had been developed, and the silver birch, willow and alders planted on land that was ripped are doing much better than the larch which is expected to be only about Yield Class 4.

Pennington Flash, Leigh

Table 5.19 Pennington Flash: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Leigh, Greater Manchester (NGR SJ 643988).
After-use: Public open space (country park). Total 36.6 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-549,900	-15,000 ha^{-1}	0.07
r = 7%	-458,100	-12,500 ha^{-1}	0.06

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-589,400	-16,100 ha^{-1}
r = 7%	-486,800	-13,300 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-497,800	-13,600 ha^{-1}
r = 7%	-404,500	-11,100 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-91,600	-2,500 ha^{-1}
r = 7%	-82,200	-2,200 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	39,500	1,100 ha^{-1}
r = 7%	28,600	800 ha^{-1}

The reasonably low WC and CLA for this scheme are reflected in its PC. About 200 hectares of the country park are managed for recreation, of which only a fraction required reclamation. This includes picnic areas, a visitor centre, a car park, a golf course, and a 69 ha lake formed by mining subsidence used for sailing and angling. Scrapes and ponds have been especially created for wildlife and over 200 bird species have been recorded at the park which is becoming a nationally important ornithological site. Some 19 ha of the golf course, which was created during reclamation works, are suffering from mining subsidence and consequent flooding. The scheme has generally been a success; some 19,600 people used the visitor centre between May and September 1987.

Sidings Lane, Rainford

Table 5.20 Sidings Lane: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Rainford, Merseyside (NGR SD 463020).
After-use: Public open space. Total 11 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-28,400	-2,600 ha^{-1}	0.45
r = 7%	-28,500	-2,600 ha^{-1}	0.44

2. **Reclamation-cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-51,900	-4,700 ha^{-1}
r = 7%	-50,700	-4,600 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-45,900	-4,200 ha^{-1}
r = 7%	-44,600	-4,100 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-6,000	-600 ha^{-1}
r = 7%	-6,000	-600 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	23,500	2,100 ha^{-1}
r = 7%	22,200	2,000 ha^{-1}

The WC for this scheme was very low. This is because the site has gradually naturally colonised with mature birch woodland, with some sycamore, alder, oak, sallow and hawthorn. Consequently, only minimal reclamation works were necessary, consisting of the tidying up of woodland and creation of glades for recreational use, regrading, the importation of some topsoil and subsoil, the capping of mineshafts and tree planting. Since some 80% of the site is wooded, landscape maintenance costs are relatively low (Table 5.24).

Table 5.21 Sneyd Tip: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Burslem, near Stoke-on-Trent, Staffordshire (NGR SJ 882496).
After-use: Public open space. Total 15.1 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-256,000	-17,000 ha^{-1}	0.07
r = 7%	-246,600	-16,300 ha^{-1}	0.06

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-275,800	-18,300 ha^{-1}
r = 7%	-262,100	-17,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-205,300	-13,600 ha^{-1}
r = 7%	-195,400	-12,900 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-70,500	-4,700 ha^{-1}
r = 7%	-66,700	-4,400 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	19,800	1,300 ha^{-1}
r = 7%	15,500	1,000 ha^{-1}

The WC for this scheme was quite reasonable considering the difficult nature of the site. Public comment was sought at an exhibition as to the best way of treating this large and prominent mound of some 3 million m^3 of spoil which was on fire. There was general support for the retention of its basic form as a dramatic landform and so the heap was remodelled and not completely regraded during reclamation, which would have been prohibitively expensive.

Technical problems were encountered during reclamation due to the spontaneous combustion within the spoil. With spoil temperatures reaching over 520^{0}C, when excavating in hot areas, earthscrapers had to travel quickly to avoid excessive tyre wear, resulting in reduced loads. Steam and dust given off by burning materials made it difficult for the drivers to see. The problem of dust and the location of the mound in a built-up area meant that on windy days work had to be suspended.

Around 60% of the initial planting failed, due to continued burning within the tip. Reclamation also led to the flooding of houses due to more rapid runoff. Landscape maintenance costs are in the mid-range of those given in Table 5.24.

Welch Whittle II, Chorley

Table 5.22 Welch Whittle II: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Wrightington Bar, near Chorley, Lancashire (NGR SD 545135).
After-use: Amenity tree planting for eventual public open space. Total 18.1 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-268,000	-14,800 ha^{-1}	0.06
r = 7%	-245,300	-13,500 ha^{-1}	0.06

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-284,700	-15,700 ha^{-1}
r = 7%	-260,100	-14,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-251,200	-13,900 ha^{-1}
r = 7%	-230,900	-12,800 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-33,500	-1,900 ha^{-1}
r = 7%	-29,200	-1,600 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	16,700	900 ha^{-1}
r = 7%	14,900	800 ha^{-1}

The WC for this scheme was also reasonable. However, the costs above do not include an unsuccessful earlier scheme, Welch Whittle I, in which trees planted into inadequately limed, very acidic spoil failed to establish. As a result the area was completely remodelled and retreated using high rates of lime.

Public access to this site is difficult and not encouraged at present. The scheme was largely undertaken because of its prominent location next to the M6 motorway.

Woodshaw, Aspull

Table 5.23 Woodshaw: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Colliery spoil heap, Aspull, near Wigan, Greater Manchester (NGR SD 612071).
After-use: Public open space. Total 13.5 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-126,800	-9,400 ha^{-1}	0.19
r = 7%	-127,100	-9,400 ha^{-1}	0.18

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-155,600	-11,500 ha^{-1}
r = 7%	-154,300	-11,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-60,800	-4,500 ha^{-1}
r = 7%	-59,500	-4,400 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-94,800	-7,000 ha^{-1}
r = 7%	-94,800	-7,000 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	28,800	2,100 ha^{-1}
r = 7%	27,200	2,000 ha^{-1}

The WC for this scheme is so low because as at Aberbargoed, the spoil heap was not regraded but directly planted with 49,000 trees. Areas that caught fire were replanted. The site now has the appearance of a well wooded hill and some 35 years after the original planting, semi mature woodland has developed, from which some forestry returns will be possible (Plate 10).

The site has, however, considerable amenity and nature conservation value and further works to enhance this have been proposed, but not implemented. The site suffers from motorcycle scrambling and vandalism, which are exacerbated by the lack of resources for adequate wardening. A flight of sleeper steps at one end of the site have become dangerous due to erosion and require maintenance. Table 5.24 shows that maintenance expenditure on this site is currently very low, comprising only the renewal of gatelocks, repairs to fencing and limited beating up.

Table 5.24 Annual landscape maintenance costs and site income (£s) for deep-mined colliery spoil sites reclaimed to agriculture and public open space, where available (1987/88 prices).

Table	Scheme	Maintenance cost ha^{-1}	Income ha^{-1}
<u>Agricultural schemes</u>			
5.4	Chisnall Hall, Coppull	NA	42 (AAO)
5.5	Higher Folds, Leigh	32 (POSAO)	49 (AAO)
5.6	Rowley Tip, Burnley	227 (WS)	31 (WS)
<u>Public open space schemes</u>			
5.15	Bryn Road II, Ashton-in-Makerfield	350 (WS)	470 (RR,WS)
5.16	Central Forest Park, Stoke-on-Trent	247 (WS)	0 (WS)
5.17	Chatterley Whitfield, Stoke-on-Trent	146 (WS)	0 (WS)
5.20	Sidings Lane, Rainford	87 (WS)	0 (WS)
5.21	Sneyd Tip, Stoke-on-Trent	154 (WS)	0 (WS)
5.23	Woodshaw, Aspull	15 (WS)	0 (WS)

KEY:
NA = Not available, AAO = Agricultural area only, POSAO = Public open space area only, WS = Whole site, RR = Revenue from recreational use.

Discussion

It appears that the costs of reclamation to public open space and agriculture are broadly comparable. None of the agricultural or public open space schemes described above made extensive use of imported topsoil, which would have greatly increased costs.

Unlike agricultural schemes, reclamation for amenity has the disadvantage of creating a continued maintenance liability. The balance between such schemes will also be determined by planning considerations such as the existing level of provision of open space in the vicinity of the scheme.

The natural colonisation of tips, which occurred on parts of the Baxter Pit and Sidings Lane sites, costs virtually nothing, but it is slow. It is best suited to sites which are located in inaccessible places and do not contain dangerous features. Natural colonisation can be speeded up by techniques such as seeding suitable grass mixes by hand.

The direct planting of tips with trees, as at Woodshaw and Aberbargoed, is also attractive because of its cheapness and the possibility of it eventually producing income from sales of timber. However, with the current emphasis on reclamation to hard after-uses at the expense of soft schemes, there is a danger that such schemes may be undertaken in inappropriate situations, such as where spoils are highly acidic, for example if the pH is less than 3.

Where land continues to be reclaimed to public open space, good design is essential to ensure cost-effective reclamation and minimal maintenance. The financial liabilities associated with maintaining large areas of reclaimed open space have been recognised by local authorities and may even act as a deterrent to further reclamation (Groundwork Trust, 1986). In addition to its high maintenance costs, the unimaginative design, lack of income-generating ability and visual monotony of much reclamation for amenity has become a matter of growing concern in recent years. A more commercial approach to the management of sites which have considerable recreational attractions such as Pennington Flash, discussed above, might make them profitable, rather than a drain upon resources.

5.4 Overall conclusions

The analyses above suggest that reclamation for hard after-uses, despite incurring high WCs, can be very cost-effective, or even self-financing, because of the substantial PRVs that accrue. The net (Project Cost) of reclamation for soft after-uses may be higher, despite lower WCs.

Reclaimed public open space produces a maintenance liability (Table 5.24), whereas an agricultural after-use does not. This is important because maintenance costs are a crucial element in land reclamation. For example, excessive landscape maintenance costs allied to restrictions on the expenditure of local authorities in North West England have led to them refusing 100% grants to carry out reclamation work.

Commercial forestry is a promising alternative to agricultural and amenity after-uses. To date, however, it has been little tried on deep-mined colliery spoil.

In all, for some 12 out of the total of 20 schemes (60%), the CLA exceeded the PRV of the land. This was true for the majority of the soft after-use schemes, but not for the forestry or hard schemes, with the exception of Chanters colliery, where development did not materialise. This suggests that in most cases where land was to be reclaimed for agriculture or amenity, excessive prices were paid to acquire it.

The reason why this occurs is that once a reclamation agency expresses interest in a piece of land, land owners tend to try to extract the highest price they can for it. This is despite the severely degraded state of such land and the lack of other potential purchasers. This is a particular problem with organisations whose estate departments are under financial obligations to maximise the commercial value of their land holdings. Furthermore, local authorities tend to be loathe to use Compulsory Purchase Orders (CPOs), which are cumbersome, time consuming and expensive if outside counsel is required.

Where land is acquired from a publicly owned company at an excessive price this merely represents an intra-governmental transfer of resources, at no cost to the taxpayer, but where land is purchased from a private land owner at an inflated price, the taxpayer loses out. It cannot be acceptable to reward derelictors in this way, and it seems that a tightening of CPO legislation is necessary in the case of the acquisition of derelict land.

Clearly, factors other than after-use, which has been analysed here, will affect the relative cost of schemes. A site which contains numerous pit shafts, has highly acidic spoil, tips which are on fire or requires unusually large amounts of earthmoving is likely to be more expensive to reclaim than one that does not. Nevertheless, the examples above suggest that costs are broadly related to after-use.

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CHAPTER 6 COST-BENEFIT ANALYSIS OF OTHER FORMS OF DERELICTION

6.1 Introduction

General industrial dereliction, metalliferous spoil heaps and urban clearance wastes comprise major types of derelict land found in Britain. Reclamation schemes dealing with each of these three types of dereliction have been subjected to economic analysis, and they are discussed in turn.

6.2.1 The reclamation of general industrial dereliction

In Britain, the decline of traditional industries has led to the abandonment of former industrial sites and associated dereliction. Typical examples of such dereliction include former docks, steelworks, factories, power stations and gasworks (EAU, 1986).

Table 6.1 indicates that general industrial dereliction is now the most extensive type of derelict land in England. There are currently some 7,500 hectares (ha) of this form of dereliction in England which justify reclamation, comprising about 23% of the total stock of derelict land requiring treatment.

There is also indirect evidence that the area of this form of dereliction is growing in extent in England. Although industrial dereliction is only specifically identified in the latest (1988) derelict land survey, it is probably the major constituent of the administrative category of 'other forms of dereliction' which was recorded in the breakdowns of reclamation by type of dereliction in the earlier 1974 and 1982 surveys of derelict land. As Table 1.1 in Chapter 1 shows, the 'other' category has been growing steadily since 1974.

Table 6.1 Area of derelict land justifying reclamation (hectares) by type of dereliction, England, 1988 (Source: 1988 derelict land survey, provisional results)

Type of dereliction	**Area justifying reclamation (ha)**	**Percentage of total stock**
General industrial dereliction	7,466	23 %
Colliery spoil heaps	4,398	14 %
Metalliferous spoil heaps	1,211	4 %
Other spoil heaps	1,586	5 %
Spoil heaps (unknown)	341	1 %
Excavations and pits	4,390	14 %
Military dereliction	2,072	6 %
Derelict railway land	5,129	16 %
Mining subsidence and land affected by underground mining operations	928	3 %
Other forms of dereliction	4,489	14 %
Total stock justifying reclamation	32,010	100 %

The reclamation of industrial dereliction can pose difficult problems, especially where land is contaminated with toxic chemicals. Effective techniques have been developed to deal with contaminated land (ICRCL, 1983; ICRCL, 1984; ICRCL, 1985; Cairney, 1987), but they are likely to be expensive because of the need for site surveys and chemical analyses to assess the nature and extent of contamination. The main approaches to decontamination are to contain contamination on site using a barrier layer, treat degradable toxins on site, or remove contaminated material to a licensed waste disposal site.

Abandoned industrial sites may also include domestic refuse tips or areas of uncontrolled tipping. These require careful treatment to minimise potential problems of leachate generation, landfill gas production and differential settlement (Crawford and Smith, 1985).

Even where sites are not contaminated, unstable ground conditions and the presence of former foundations and basements can cause difficulties in the redevelopment of old industrial sites.

Ground instability can be overcome by the local removal of loose tipped wastes, their densification or compaction, or by building on piled foundations (EAU, 1986). Old foundations usually require excavation and removal or filling if new development is to occur.

6.2.2 The reclamation of metalliferous wastes

Non-ferrous metalliferous wastes are some of the hardest to revegetate. This is due to the toxicity of the high levels of heavy metals that are present in them. In Britain, Pb, Zn, and Cu are the most common toxic metals, but other metals such as Cd, As and Al may also be present in toxic concentrations. Metal ore wastes which contain appreciable amounts of pyrite are liable to secondary decomposition, in which ferric sulphate induces the dissolution of toxic metals from associated non-ferrous metal sulphides (Johnson and Bradshaw, 1979). This may be represented by the following equation, where M is the non-ferrous metal:

$$(M)S + 2Fe_2(SO_4)_3 + 2H_2O + 3O_2 \longrightarrow (M)SO_4 + 4FeSO_4 + H_2SO_4$$

Gemmell (1977) has described the main types of pollution which result from metalliferous mine spoils. Water pollution takes the form of contamination with toxic metals and the acidification of watercourses. Air pollution may arise from wind blown dust laden with heavy metals which may lead to high levels of heavy metal uptake in plants and grazing animals in the locality. These forms of pollution may pose health threats to man if toxic metals enter food chains.

Although the extraction and smelting of non-ferrous metal ores have largely ceased in Britain, a substantial legacy of dereliction remains. Table 6.1 shows that there are some 1,200 hectares of metalliferous spoil heaps justifying reclamation in England alone. There are over 300 former metal mines of at least one hectare in Wales, and in Britain, other metalliferous ore fields are located in the Pennines, the South West, West and North West of England, the Lake District and Southern Scotland. Many of these sites are situated in relatively remote, rural locations, but by their very nature they still pose a threat in the form of contamination of water supplies and the pollution of adjacent agricultural land. Those wastes which were deposited prior to 1900 tend to have higher concentrations of heavy metals than more recent tips, because of improvements in mining technology. The natural colonisation of such wastes by plants may be an extremely slow process (Johnson and Bradshaw, 1979).

Although the major factor to be overcome is metal toxicity, additional problems are often encountered in the form of nutrient deficiencies, acidity, salinity, a lack of organic matter and unfavourable physical conditions.

There are two different approaches to revegetating toxic mine tailings. The first is to physically isolate the wastes by covering them with a layer of inert material before establishing vegetation. The disadvantage of this approach is that it is very expensive, because some 45 cm of cover has to be imported if grasses are to be sown, and a two metre depth is required if trees are to establish successfully in the long term (Johnson and Bradshaw, 1979). In certain cases costs can be reduced by using locally available waste materials such as non-pyritic colliery spoil as a barrier layer (Johnson *et al.*, 1977).

The alternative approach is to directly revegetate wastes using plant ecotypes which have evolved heavy metal tolerance. Cultivars of *Festuca rubra* and *Agrostis capillaris* which are lead-zinc and copper tolerant are commercially available (Smith and Bradshaw, 1972). The reduced metal content of modern mine tailings brought about by improvements in mining technology, means that they can be directly revegetated using this technique provided that sufficient nutrients are added (Johnson *et al.*, 1976).

Although this technique is much cheaper than the physical barrier approach, it has disadvantages. Metal concentrations mean that grazing of the reclaimed land is either impossible or extremely restricted. Furthermore, erosion problems may re-occur if gaps develop in the vegetation cover. The possible after-uses of the land are also likely to be restricted, although this is also true of land reclaimed using the physical isolation approach.

6.2.3 The reclamation of urban clearance wastes

The most common form of derelict and neglected land found in cities arises from the demolition of substandard properties in urban clearance schemes. The resultant eyesores of rubble and fly tipped wastes blight adjoining areas and have an adverse effect upon the environment of inner cities. It was estimated in 1977 that there were some 100,000 hectares of urban wasteland in Britain (Civic Trust, 1977), and it seems unlikely that there has been more than a slight net decrease in this figure since then (Civic Trust, 1988).

The revegetation of urban clearance wastes presents several problems, including deficiencies of nitrogen and sometimes phosphorus, a lack of organic matter and the free-draining nature of 'soils' which usually consist of little more than brickwaste and subsoil. The surface of such sites is also often heavily compacted, hindering plant establishment (Bradshaw and Chadwick, 1980).

These problems can be overcome by traditional 'engineering approaches' which involve the importation of topsoil as a covering material and sowing a grass mix on top. However, the use of topsoil is very costly and gives variable results. Where clover is not included in the seed mix, grass swards are likely to become chlorotic, because of low quality topsoil and require the further expense of continued applications of maintenance fertiliser (Dutton and Bradshaw, 1982).

An ecological approach to revegetation is much cheaper. Instead of using topsoil, brickwaste substrates are directly seeded using conventional agricultural techniques. The ground surface is lightly chain harrowed, seeded, fertilised and stone picked, following techniques originally described by Bradshaw and Handley (1972). Nitrogen-fixing clover is included in the seed mix, shown in Table 6.2, to reduce the need for further fertiliser applications, since this has been shown to be a recurrent problem in land reclamation (Bloomfield *et al.*, 1982). This seed mix uses dwarf, wear-tolerant grass cultivars adapted to calcareous soils, and is broadcast at about 60-100 Kg ha^{-1} (Bradshaw, 1987).

Table 6.2 Seed mix for the direct improvement of urban brickwaste, used at Crown Street site, Liverpool (see also Table 6.25)

40%	*Festuca rubra* (Red fescue)
30%	*Lolium perenne* Manhatten Dwarf (Perennial ryegrass)
20%	*Agrostis stolonifera* (Creeping bent grass)
10%	*Trifolium repens* S.100 (White clover)

6.2.4 Costs of reclamation

These two approaches have very different costs. Since examples are readily available, this can be illustrated in the case of urban clearance wastes, but the costs of the two approaches would be very similar on a metalliferous spoil heap.

A cost breakdown for the second phase of the Everton Park reclamation scheme in Liverpool, which covered a separate area from the first phase, is shown in Table 6.3. This scheme used traditional site engineering approaches to revegetate the urban clearance wastes.

Table 6.3 Breakdown of phase II grant approval for works, Everton Park reclamation scheme, Liverpool, 1987/88 prices (see also Table 6.26)

Operation	Percentage	Cost hectare^{-1} (£s)
1. Site clearance and demolition	4.1	8,119
2. Earthworks and land drainage	17.4	34,827
3. Boundary treatment and retaining walls	16.9	33,924
4. Footpaths and hardstandings	16.8	33,646
5. Tree planting (cost of stock only)	14.9	29,920*
6. Grass seeding and establishment	0.7	1,490
7. Footpath lighting	5.1	10,296
8. Additional works	2.6	5,148
9. Statutory undertakers	2.0	3,960
10. Preliminaries	5.2	10,310
11. Contingencies	0.9	1,760
12. Play equipment, seating and bollards	2.5	5,034
13. Design and management fees	10.9	21,757
Total cost hectare^{-1}		200,190

* Tree stock cost £41,800 ha^{-1} at 1987/88 prices, but only 9 of the 12.5 hectares of this phase of the scheme were tree planted.

By contrast, a breakdown of the cost of works associated with the Crown Street reclamation scheme in Liverpool is shown in Table 6.4. This site was reclaimed using the ecological approach. A relatively high proportion of the total cost is accounted for by tree planting, but this works out as very much cheaper on an overall cost per hectare basis than the Everton Park scheme.

Table 6.4 Breakdown of works cost for Crown Street reclamation scheme, 1987/88 prices (see also Table 6.25)

Operation	Percentage	Cost hectare^{-1} (£s)
1. Site clearance	2.3	323
2. Soiling/cultivation of tree planted area	11.8	1,656
3. Harrowing	2.3	317
4. Spreading fertiliser	1.6	230
5. Stone picking	1.8	250
6. Grass seeding	5.9	829
7. Wild flower seeding	1.9	267
8. Harrowing and rolling after sowing	1.2	165
9. Supply of tree stock (whips)	28.5	4,000
10. Tree planting (whips)	24.8	3,477
11. First grass/wild flower meadow cut	0.6	86
12. Twelve month contract maintenance works	17.4	2,437
Total cost hectare^{-1}		14,036

6.3 The method of economic analysis

The method of analysis, definitions used and selection of schemes were identical to that described in Chapter 5 (Section 5.2). Cost-benefit analysis was applied retrospectively to nine industrial dereliction schemes, two metalliferous waste sites and nine urban clearance schemes in England and Wales. It proved difficult to obtain costs for the reclamation of metalliferous wastes and so there are only two such examples. The schemes have been classified according to their main intended after-use, as this is likely to be a significant factor in their overall cost. This is shown in Table 6.5.

Table 6.5 Classification of industrial, metalliferous and urban clearance reclamation schemes by principal after-use

Table(s)	Scheme	Principal after-use
	Industrial dereliction	
6.6	Salford Quays, Salford †	Residential, commercial and leisure development
6.7	International Garden Festival, Liverpool	Housing
6.8 & 6.9	Former Tate and Lyle refinery site, Liverpool †	Housing
6.10	Bromborough power station, Wirral †	Industry
6.11	GEC Gillmoss, Liverpool †	Industry
6.12	UML power station, Wirral †	Industry
6.13 & 6.14	Whitebirk Drive Business Park, Blackburn †	Industry
6.15	Jericho South Shore, Liverpool	Public open space
6.16	National Garden Festival, Stoke-on-Trent †	Public open space and permanent parkland
	Metalliferous wastes	
6.17	Parc Mine and Trecastell, Llanrwst †	Amenity
6.18	Minera, Minera †	Recreation
	Urban clearance wastes	
6.19	Aigburth/Ullet Roads, Liverpool	Housing*
6.20 & 6.21	Mother Redcap's, Wirral †	Housing
6.22	Kingsway Loop, Liverpool †	Industry
6.23	Bamber Street, Liverpool †	Public open space
6.24	Cooper Street, St. Helens	Public open space
6.25	Crown Street, Liverpool	Public open space
6.26	Everton Park, Liverpool †	Public open space
6.27	Melville Place, Liverpool	Public open space
6.28	444 New Chester Road, Wirral †	Public open space

† Funded wholly or partly with Derelict Land Grant.
* Residential development has not yet materialised on this site.

Some 70% of these reclamation schemes were funded via Derelict Land Grant (DLG). Most of the remainder would probably have qualified for it, but were financed by other means. However, the scheme at Cooper Street (Table 6.24) would not have qualified for DLG, as it involved the treatment of neglected rather than derelict land. The difficulty of obtaining DLG funding led to the use of cost-cutting approaches at sites such as Bamber Street, Crown Street and Melville Place, (Tables 6.23, 6.24 and 6.27), although the Bamber Street site was later enhanced using DLG.

For three schemes (Tables 6.12, 6.24 and 6.26), land acquisition costs were not available, and so they were estimated with the assistance of professional valuers or from similar, neigbouring schemes. This needs to be borne in mind. It should also be noted that the costs of the reclamation works at the Liverpool International Garden Festival and Jericho South Shore sites (Tables 6.7 and 6.15) are only the best estimates that could be obtained.

Schemes reclaimed to public open space have been assigned nominal after-values. The justification for this has been given in Chapter 5.

For two schemes (Tables 6.6 and 6.16) a full breakdown of the overall cost-benefit analyses has not been given. This is because of the confidential nature of some of the information on which the overall assessments are based.

Net Present Values and Costs have been rounded to the nearest £100 for clarity. They are also given as <u>unit</u> <u>costs</u> (NPC or NPV ha^{-1}) to facilitate cost comparisons between schemes.

6.4 Results and discussion

The results are presented in Tables 6.6-6.28 and the intangible and unmeasured benefits of reclamation are discussed below. Each scheme is first discussed separately. Schemes are also discussed in relation to their after-use before overall conclusions are drawn for each type of dereliction. Landscape maintenance costs and income are shown, where appropriate, in Table 6.29.

General industrial dereliction

6.4.1 Housing as an after-use

Salford Quays, Salford

Table 6.6 Salford Quays: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost.

Site: Former Salford Docks, Ordsall, Salford, Greater Manchester (NGR SJ 807972).
After-uses: Residential, commercial and leisure development. Total 60.8 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-21,625,900	-355,700 ha^{-1}	0.05
r = 7%	-20,287,700	-333,700 ha^{-1}	0.05

2. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-20,036,100	-329,500 ha^{-1}
r = 7%	-18,571,000	-305,400 ha^{-1}

A full breakdown of the project cost is not given for reasons of confidentiality.

This scheme is still in progress, although it is largely complete. Table 6.6 indicates that the WC is extremely high on a unit cost basis. This is due to the extent of works that have been necessary to reclaim the former Manchester Docks to a condition suitable for hard after-use development. Considerable infrastructural works were required, in the form of new roads, services and sewers. Three dock inlets have been isolated from the Manchester Ship canal by a series of dams to create enclosed areas of water.

Although the entire site is being developed for residential, commercial and leisure purposes, Table 6.6 reveals that the PRV is less than the CLA. Government policy has, however, been more concerned with triggering private investment in the scheme, employment creation and ensuring that proposed developments fit into its overall context than with extracting the maximum possible PRV from sales of the reclaimed land. In this the scheme has produced major benefits. Public sector investment in reclaiming the site has already triggered £90 million of private investment in commercial developments and this is expected to ultimately reach some £400 million. Reclamation is currently generating some 600 jobs, and 600 permanent jobs have also been created. Total employment from committed developments is expected to reach 3,000 by 1990, when reclamation works will be completed.

Table 6.7 Liverpool International Garden Festival: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former landfill site and dockland, Riverside, Liverpool, Merseyside (NGR SJ 365867).
After-uses: Initially Garden Festival. Subsequent development for housing (24.3 ha) and retention of theme gardens (Festival Park 18.2 ha). Total 42.5 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-15,902,500	-374,200 ha^{-1}	0.12
r = 7%	-15,942,600	-375,100 ha^{-1}	0.12

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-18,046,900	-424,600 ha^{-1}
r = 7%	-18,046,900	-424,600 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-14,609,400	-343,800 ha^{-1}
r = 7%	-14,609,400	-343,800 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-3,437,500	-80,900 ha^{-1}
r = 7%	-3,437,500	-80,900 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	2,144,400	50,500 ha^{-1}
r = 7%	2,104,300	49,500 ha^{-1}

The WC for this scheme is extremely high on a unit cost basis. This in part reflects the substantial difficulties that had to be overcome in reclaiming the site. Prior to reclamation, half the site consisted of a domestic and industrial landfill and the remainder disused dockland and oil storage tanks. The latter had been encased in concrete, and with contaminated soils, had to be removed from the site.

Substantial earthmoving operations were necessary to move tipped material to release land for subsequent development and create shelter for planting on a very exposed site (Clouston, 1984). The landfill portion of the site was reshaped to form a ridge and valley running alongside the River Mersey, an arena and a 40 metre high hill (Parker and Bradshaw, 1986) (Plate 11). Some of the earthmoving costs could have been avoided if waste disposal operations had been planned from the outset to produce the final landform. The landfilled area was capped with clay extracted from within the site, to a depth of one metre.

The danger of landfill gas production affecting the tree and shrub planting was successfully eliminated by installing a gas extraction system, which added to the cost of reclamation. A generation plant has been built to convert methane from the gas into electricity which is sold to the national grid.

All the planted areas received 50 cm of topsoil and grassed areas 15 cm. This is a very costly approach (Bradshaw *et al.*, 1973). The spreading of so much topsoil on areas zoned for development, despite the short term needs of the Garden Festival is particularly questionable. The latter could have been met by alternative methods.

The performance of the 250,000 trees which were planted was variable. Total mortality reached 50% in places, due to two very dry seasons and an almost complete lack of irrigation followed later by excessive weed competition. The choice of slow-growing species such as oak, beech and ash for the exposed hill was also a mistake (Parker and Bradshaw, 1986).

Table 6.7 indicates that despite sales of land for some 200 houses (Cass, 1988), the PRV is less than the CLA. Development cannot take place on the landfilled part of the site because of problems of subsidence and the danger of spontaneous combustion of

Plate 11. The Liverpool International Garden Festival site.

Plate 12. Reclamation in progress at the Tate and Lyle site, May 1987.

methane gas.

Table 6.29 shows that the costs of maintaining the area of public open space are very high. This results from the nature of the reclamation design, because its emphasis on creating an 'instant landscape' necessitated considerable overplanting. Furthermore, although some 3.37 million people visited the Garden Festival in 1984, since then the number of visitors to the theme park portion of the site has been declining each year. It is now doubtful whether the full costs of running the theme park, including site security, are being covered by income from ticket sales (Table 6.29). Difficulties have recently been encountered as a result of the clogging up of the gas extraction system with plastics from refuse and subsidence of the road running through the site, and the Festival Park will remain closed in 1989 whilst repairs are undertaken.

Table 6.8 Tate and Lyle: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former sugar refinery, off Vauxhall Road, Liverpool, Merseyside (NGR SJ 341916).
After-use: Housing. Total 5.6 ha.
ACTUAL COSTS OF RECLAMATION.

1. Project cost (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,800,100	-321,400 ha^{-1}	0.08
r = 7%	-1,785,400	-318,800 ha^{-1}	0.08

2. Reclamation cost (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,956,700	-349,400 ha^{-1}
r = 7%	-1,936,200	-345,800 ha^{-1}

3. Works cost (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,925,900	-343,900 ha^{-1}
r = 7%	-1,905,500	-340,300 ha^{-1}

4. Cost of land acquisition (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-30,800	-5,500 ha^{-1}
r = 7%	-30,700	-5,500 ha^{-1}

5. The post-reclamation value of the land (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	156,600	28,000 ha^{-1}
r = 7%	150,800	26,900 ha^{-1}

Table 6.8 indicates that the WC for this scheme was very high. After the former Tate and Lyle sugar refinery closed, it was demolished, leaving a rubble-strewn site covered with reinforced concrete foundations and basements, which it would have been prohibitively expensive to grub up. The site also contained a tar well which was contaminated with phenols. All contaminated material in the tar well was removed from the site during reclamation.

A subsoil survey showed that the rest of the site was partially but not heavily contaminated with metals. However, an expensive and probably excessively cautious approach was taken on the site as a whole. This was to seal the surface of the site with an impermeable barrier of 30 cm of clay, place a plastic membrane over the site and importing 125,000 m^3 of river sand from the River Mersey to raise the ground level by 3 metres (Plate 12). Use of river dredgings provided substantial cost savings over the alternative of imported stone hardcore. Costs were also reduced by using hardcore which was already on the site.

However, the reclamation of this site for housing was questionable on economic grounds, and was partly undertaken for political reasons. As Table 6.9 shows, reclamation to public open space would have been much cheaper, despite a lower PRV, although it would have created a landscape maintenance liability.

Table 6.9 Tate and Lyle: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former sugar refinery, off Vauxhall Road, Liverpool, Merseyside (NGR SJ 341916).

ESTIMATED COSTS AND BENEFITS OF RECLAMATION TO PUBLIC OPEN SPACE (5.6 ha).

1. Project cost (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,033,500	-184,500 ha^{-1}	0.01
r = 7%	-1,033,800	-184,600 ha^{-1}	0.01

2. Reclamation cost (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,046,000	-186,800 ha^{-1}
r = 7%	-1,045,900	-186,800 ha^{-1}

3. Works cost (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,015,200	-181,300 ha^{-1}
r = 7%	-1,015,200	-181,300 ha^{-1}

4. Cost of land acquisition (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-30,800	-5,500 ha^{-1}
r = 7%	-30,700	-5,500 ha^{-1}

5. The post-reclamation value of the land (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	12,600	2,200 ha^{-1}
r = 7%	12,100	2,200 ha^{-1}

Discussion

The above examples suggest that the costs of reclaiming industrial dereliction to housing are very high, because of the problems that have to be overcome in making sites suitable for redevelopment. For all three schemes both the WC and PC are over £300,000 ha^{-1}. Furthermore, for two of the schemes the CLA exceeded the PRV, despite reclamation to a hard after-use. The low PRVs of the schemes reflects their geographical location in North West England. By contrast, reclamation and infrastructural works carried out by the London Docklands Development Corporation in London has produced post-reclamation land values as high as £11 million ha^{-1}.

It is the idea that reclamation might cause similar transformations in confidence, demand and therefore land values which was perhaps behind the government's support for such schemes. Nevertheless, they remain very expensive.

6.4.2 Industry as an after-use

Bromborough power station, Wirral

Table 6.10 Bromborough power station: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former power station, Bromborough, the Wirral, Merseyside (NGR SJ 361824).
After-uses: Industrial (13 ha) and public open space (7.5 ha). Total 20.5 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-611,000	-29,800 ha^{-1}	0.29
r = 7%	-612,700	-29,900 ha^{-1}	0.27

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-860,500	-42,000 ha^{-1}
r = 7%	-835,500	-40,800 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-308,900	-15,100 ha^{-1}
r = 7%	-283,900	-13,800 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-551,600	-26,900 ha^{-1}
r = 7%	-551,600	-26,900 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	249,500	12,200 ha^{-1}
r = 7%	222,800	10,900 ha^{-1}

The WC of reclaiming this former power station to a greenfield site was low in unit cost terms. This is probably because the power station itself did not cover the full extent of the site, some of which was tree planted in the reclamation scheme and is designated as public open space. However, the overall PC was double the WC, because despite reclamation for an industrial after-use, the CLA exceeded the PRV to a remarkable extent.

GEC Gillmoss, Liverpool

Table 6.11 GEC Gilmoss: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former factory and office block, off East Lancashire Road, Kirkby, Liverpool, Merseyside (NGR SJ 398965).
After-use: Industry with retention of a playing field. Total 15 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,394,400	-93,000 ha^{-1}	0.15
r = 7%	-1,374,100	-91,600 ha^{-1}	0.14

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,632,400	-108,800 ha^{-1}
r = 7%	-1,599,100	-106,600 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-415,400	-27,700 ha^{-1}
r = 7%	-404,800	-27,000 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,217,100	-81,100 ha^{-1}
r = 7%	-1,194,300	-79,600 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	238,100	15,900 ha^{-1}
r = 7%	225,000	15,000 ha^{-1}

The PC of this scheme, which involved the reclamation of a former factory and office block to provide a greenfield site for industry which has been sold, was three times its WC. This is because the CLA was some five times the PRV.

Table 6.12 UML power station: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former power station, Bromborough, the Wirral, Merseyside (NGR SJ 354833).
After-use: Industry. Total 1.6 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-147,700	-92,300 ha^{-1}	0.26
r = 7%	-148,600	-92,900 ha^{-1}	0.25

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-198,800	-124,200 ha^{-1}
r = 7%	-198,800	-124,200 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-155,700	-97,300 ha^{-1}
r = 7%	-155,700	-97,300 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-43,100	-26,900 ha^{-1}
r = 7%	-43,100	-26,900 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	51,100	31,900 ha^{-1}
r = 7%	50,100	31,300 ha^{-1}

Although the WC is high at this scheme, the PRV does exceed the CLA, which was taken from the nearby Bromborough power station scheme. Nevertheless, the overall PC is some three times that for the Bromborough scheme. Now that the site has been reclaimed, the original owners of the site, a chemical company, will expand back onto it. This policy is questionable given that it was this company which originally degraded the site.

Table 6.13 Whitebirk Drive Business Park: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former gasworks, Blackburn, Lancashire (NGR SD 707292).
After-use: Industry. Total 24.6 ha.
ACTUAL COSTS OF RECLAMATION USING MICROBIAL TREATMENT.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,193,600	-48,500 ha^{-1}	0.26
r = 7%	-1,164,100	-47,300 ha^{-1}	0.25

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,604,900	-65,200 ha^{-1}
r = 7%	-1,545,600	-62,800 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,234,700	-50,200 ha^{-1}
r = 7%	-1,180,500	-48,000 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-370,200	-15,000 ha^{-1}
r = 7%	-365,100	-14,800 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	411,400	16,700 ha^{-1}
r = 7%	381,400	15,500 ha^{-1}

Table 6.13 shows that the WC was relatively high for this scheme, but this is counteracted by a substantial PRV. However, this PRV only just exceeded the CLA.

This former gasworks site contained about 28,500 m^3 of soil contaminated with coal tars, phenols, cyanides, arsenic, lead, mercury and spent oxides. In addition, fly tipped builders' wastes were spread over much of the site.

Two independent site surveys were undertaken to assess the nature and distribution of the contamination. The distance to nearby landfill sites meant that conventional treatment of the site, involving the excavation of contaminated material and carting it away, was expected to be extremely costly. Thus at this site microbial land decontamination was used for the first time in Britain.

The areas of the site which contained biodegradeable contaminants such as coal tars and phenolic compounds were excavated to a depth of 2-4 metres and spread in layers to form treatment beds. Each layer was sprayed with a mixture of micro-organisms, nutrients and other agents using modified agricultural equipment. The beds were watered and periodically rotovated to maintain optimal conditions and pollutant concentrations monitored at regular intervals. Once pre-determined target concentrations for an industrial after-use had been achieved, and subjected to independent validation, the treated soil was returned to ground and consolidated ready for site development.

A pollution control system was constructed during decontamination to prevent further leaching of pollutants into the adjoining River Blakewater. The 14,000 m^3 of non-biodegradeable material such as spent oxides and heavy metals were treated using conventional techniques by encapsulating them in a clay-lined landfill on the site under a proposed road embankment. In this way no material had to be imported or exported from the site, eliminating waste haulage costs.

Table 6.14 shows the likely cost of reclaiming the entire site using conventional techniques, estimated by putting this work out to tender. This is more expensive than the approach that was undertaken, because of the savings in waste haulage costs attributable to microbial decontamination. The overall savings attributable to the use of microbial treatment were about 5% of the WC (£2,700 ha^{-1} at the 7% discount rate). It is disappointing that the new technological approach did not turn out to provide greater economies.

Table 6.14 Whitebirk Drive Business Park: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former gasworks, Blackburn, Lancashire (NGR SD 707292).
After-use: Industry. Total 24.6 ha.
ESTIMATED COSTS AND BENEFITS OF RECLAMATION USING CONVENTIONAL TREATMENT (removal of wastes from site).

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,259,100	-51,200 ha^{-1}	0.25
r = 7%	-1,226,700	-49,900 ha^{-1}	0.24

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,670,400	-67,900 ha^{-1}
r = 7%	-1,608,100	-65,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,300,200	-52,900 ha^{-1}
r = 7%	-1,243,000	-50,500 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-370,200	-15,000 ha^{-1}
r = 7%	-365,100	-14,800 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	411,400	16,700 ha^{-1}
r = 7%	381,400	15,500 ha^{-1}

Discussion

The WC and overall PC for these schemes are all less than £100,000 ha^{-1}. Although this is lower than the housing after-use schemes discussed above, they are not directly comparable because of the different nature of the problems that had to be tackled. Nevertheless, on chemically contaminated sites the cost of reclamation to housing is likely to be higher than that to industry because on land reclaimed for housing more exacting post-reclamation target concentrations of contaminants would have to be achieved.

Microbial decontamination appears to offer a possible method of reducing the costs of dealing with contaminated sites. The technology is new and is still being refined, but is expected to be cost-effective on sites as small as 1.5 hectares.

Two findings give cause for concern. The first are CLAs which are as high as, or even exceed PRVs. This indicates that excessive prices were paid to acquire land. The second are cases where the industry that originally polluted and degraded a site is allowed to move back on to it afterwards. This does nothing to encourage responsible attitudes within industry towards the prevention of dereliction.

6.4.3 Public open space as an after-use

Jericho South Shore, Liverpool

Table 6.15 Jericho South Shore: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Former landfill site, Riverside, Liverpool, Merseyside (NGR SJ 370862).
After-use: Public open space. Total 30.4 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,600,500	52,600 ha^{-1}	0.04
r = 7%	-1,601,800	52,700 ha^{-1}	0.04

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,672,000	-55,000 ha^{-1}
r = 7%	-1,672,000	-55,000 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,672,000	-55,000 ha^{-1}
r = 7%	-1,672,000	-55,000 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-	- ha^{-1}
r = 7%	-	- ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	71,500	2,400 ha^{-1}
r = 7%	70,200	2,300 ha^{-1}

This site adjoins the Liverpool International Garden Festival (IGF) site, and was reclaimed at the same time. It was formerly part of the domestic and industrial landfill site which also covered about half of the IGF site.

However, as Table 6.15 shows, the WC was much lower for this scheme than for the IGF. There are several reasons for this. A thinner clay cap was used to cover the landfilled wastes than at the IGF. Whereas the network of boreholes installed in the landfill gas extraction system at the IGF were located close together to ensure the total removal of all gas from the underlying wastes, fewer boreholes were used at the South Shore site. In addition, little topsoil was available and less earthmoving was required at South Shore. Over half the area the clay cap was directly seeded with a legume based seed mix to create a wild area.

Despite the fact that these cost cutting measures had to be instituted, the standard of reclamation at South Shore is perfectly acceptable and with the benefit of hindsight the IGF site was probably reclaimed to too high a standard. The WC at South Shore is almost seven times lower than that for the IGF and this is a strong argument in favour of the approach that was taken.

Table 6.29 also shows that maintenance costs are some five times lower than those for the Garden Festival site. This is partly attributable to the creation of a low maintenance area seeded with a legume mix in addition to an area of short mown grass. The low maintenance area only needs to be mown once a year, whereas the grassland area is cut every two weeks or so. The over zealous use of soil acting residual herbicides has however, been reflected in a high mortality of the trees that were planted.

This site was acquired free of charge, which is probably a realistic market valuation given that prior to reclamation it consisted of a domestic and industrial landfill site. Its PRV is very low because the ongoing subsidence of the site as a result of the settlememt of refuse in the landfill mean that in the short term the site's prospects of development are minimal.

Table 6.16 Stoke-on-Trent National Garden Festival: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost.

Site: Former steelworks, Etruria, Staffordshire (NGR SJ 870480).
After-uses: Initially Garden Festival. Retention of public open space (40.9 ha) and subsequent development for leisure, non-retail warehousing, offices and light industry (32 ha).

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-6,768,100	-92,800 ha^{-1}	0.31
r = 7%	-6,678,500	-91,600 ha^{-1}	0.29

2. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-8,481,200	-116,300 ha^{-1}
r = 7%	-8,040,600	-110,300 ha^{-1}

A full breakdown of the project cost is not given for reasons of commercial confidentiality.

The high WC of this scheme reflects the nature of the dereliction that had to be tackled. Prior to reclamation the site included a former steelworks, abandoned railways, industrial wastes and domestic refuse.

The reclamation scheme was designed to provide the maximum area possible for subsequent development (Stoke-on-Trent City Council, 1988). Consequently, considerable earthmoving was necessary. Domestic refuse was used to construct a woodland ridge, which comprised the bulk of the structure planting. Much of the woodland ridge was topsoiled, at major expense.

The reclamation works involved moving more than 1,400,000 m^3 of material, the excavation of 150,000 m^3 of slurry, and the breaking out of 22,000 m^3 of reinforced concrete. Subsoil and peat were imported and over 200,000 whips and transplants planted at one metre intervals. Unlike the Liverpool Garden Festival, Stoke had the advantage that tree planting could be carried out over four seasons.

Despite the release of some 32 ha of land for commercial development, and the fact that the PRV exceeds the CLA (Table 6.16), the PC remains substantial. Nevertheless, the reclamation of the largest derelict site in the West Midlands and the staging of a Garden Festival also had intangible benefits in that the site enjoyed some 2.18 million visits in 1986, and this will have done much to enhance the image of Stoke-on-Trent.

Discussion

Both of the schemes above involved the need to reclaim areas of domestic refuse. The WC and PC at the Stoke Garden Festival were roughly double those at Jericho South Shore, because at Stoke considerable earthmoving was necessary to release land for development. The WC was some three times cheaper at Stoke than the Liverpool IGF, where the extent of waste disposal operations was much greater.

There are likely to be few alternatives to reclamation to public open space in the case of landfill sites because of their unsuitability for hard development (ICRCL, 1978; Department of the Environment, 1986). Agriculture is a possibility, but this requires that pipes are laid before a completed refuse tip is capped to ensure that landfill gas can be vented off (EAU, 1986). With imaginative planting they also have potential as wildlife areas (Steels and Haigh, 1988). The most cost-effective approach may be to install pipes to vent off gases, cap the sites and then undertake planting and seeding specifically designed to accelerate the process of natural colonisation (Roberts and Gregson, 1987).

6.4.4 Overall conclusions: general industrial dereliction

A major problem in assessing the costs and benefits of the reclamation of industrial dereliction is that the nature of this form of dereliction can vary widely, from disused dockland and domestic and industrial waste tips, to former factories, power stations, and gasworks. In addition, sites may or may not require decontamination. This means that naive cost comparisons are dangerous.

However, the above examples do indicate that the costs of tackling industrial dereliction can be extremely high. This means that unless substantial PRVs can be recovered from reclaimed sites, the overall PCs of the schemes will be very high. This problem is compounded by the fact that in 4/9 (44%) of the schemes above the CLA exceeded the PRV. This means that agencies carrying out reclamation are often having to pay too much to acquire land.

Since it seems that a growing proportion of reclamation activity is likely to be concerned with tackling industrial dereliction in England, given the limited total budget available for land reclamation, the high costs of undertaking some of these schemes could cause the overall amount of land restored each year to decline. This problem might be overcome by adopting lower cost treatments such as reclamation to public open space, although these may produce lower PRVs. Alternatively, attempts need to be made to ensure higher PRVs are achieved by the better design and management of reclamation schemes, and that the costs of acquiring derelict sites are more realistic.

6.4.5 Soft after-uses

Parc Mine and Trecastell, Llanrwst

Table 6.17 Parc Mine and Trecastell: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Sites: Metalliferous spoil heaps, near Llanrwst, North Wales (NGR SH 788606 and SH 797578).
After-uses: Parc Mine: grazing (6 ha). Trecastell: amenity (2.1 ha). Total 8.1 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-867,200	-107,100 ha^{-1}	0.01
r = 7%	-850,500	-105,000 ha^{-1}	0.01

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-874,800	-108,000 ha^{-1}
r = 7%	-857,000	-105,800 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-865,700	-106,900 ha^{-1}
r = 7%	-848,900	-104,800 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-9,100	-1,100 ha^{-1}
r = 7%	-8,100	-1,000 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	7,500	900 ha^{-1}
r = 7%	6,500	800 ha^{-1}

The expenditure on these two reclamation schemes cannot be separated as they were undertaken together. They are thus analysed together. The project engineer responsible for both schemes has however stated that their unit costs were comparable. Prior to reclamation, both consisted of spoil heaps of lead/zinc waste.

At Parc Mine the continued erosion of some 10,000 tonnes of metalliferous tailings, containing as much as 0.8% lead and 1% zinc into the River Conway, was a cause for concern in a major salmon river. The erosion of spoil heaps also destroyed some 5 hectares of adjacent agricultural land. The economic benefits of alleviating such pollution are difficult to estimate, however, and this has not been attempted here. A particular problem is that heavy metal pollution of watercourses is likely to be a long term problem, because the weathering of the sulphide ores of lead and zinc (galena and sphalerite) is a gradual process.

At Parc Mine the metalliferous wastes were treated by covering them with a 15 cm deep barrier layer of inert gravelly waste from a nearby abandoned quarry. Topsoil was not used, but a metal tolerant variety of *Festuca rubra* sown together with white clover (*Trifolium repens*) and high levels of lime and fertiliser applied (EAU, 1986). A stream running through the site was canalised, and treated during reclamation to reduce water pollution. The growth of grass on the site has been so good that sheep grazing is now carried out (Plate 13). This needs to be done on a 'flying flock' basis in which a given animal is grazed for only about 6 weeks a year on the site because of the elevated levels of metals present in foliage due to plant uptake from the rooting zone beneath.

The Trecastell site was reclaimed using a similar approach, although less gravelly material was available as cover. Prior to reclamation, lead/zinc wastes were polluting about 0.5 ha of adjoining agricultural land and eroding into a stream running alongside the site. Spoil was regraded during reclamation to prevent this. The high levels of metals in the wastes mean that grazing is not a feasible after-use.

Table 6.17 shows that the WC for these two schemes was high. This reflects the cost of the earthmoving, importation of cover and

Plate 13. Parc Mine after reclamation for amenity.

Plate 14. A tailings dam at the Minera site.

stream canalisation that was undertaken.

The PRVs of the sites are low because of the restrictions upon site after-uses. Since the CLA exceeds the PRV for the two schemes as a whole, this further contributes to an already high overall PC.

Minera, Minera

Table 6.18 Minera: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Metalliferous spoil heaps, near Wrexham, North Wales (NGR SJ 270512).
After-use: Recreation and tourism. Total 27.5 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-1,211,800	-44,100 ha^{-1}	0.04
r = 7%	-1,097,600	-39,900 ha^{-1}	0.04

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,260,100	-45,800 ha^{-1}
r = 7%	-1,139,900	-41,500 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-1,174,200	-42,700 ha^{-1}
r = 7%	-1,057,500	-38,500 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-85,900	-3,100 ha^{-1}
r = 7%	-82,500	-3,000 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	48,300	1,800 ha^{-1}
r = 7%	42,300	1,500 ha^{-1}

Prior to reclamation this site contained extensive metalliferous spoil heaps, tailings dams and mine shafts (Plate 14). Since the mines at Minera have been active since before Roman times, pollution of the surrounding area by wind blown dust and water has gradually occurred with elevated levels of a variety of heavy metals, besides lead and zinc, being found in soils of agricultural land in the surrounding area (Robinson, Jones Design Partnership Limited, 1979; Bradshaw and Chadwick, 1980). This has produced chlorotic grass swards in agricultural fields.

Following site surveys and field trials the site has been reclaimed using a barrier layer of burnt colliery spoil. Burnt colliery spoil is not pyritic, and in this case had the advantage of being locally available.

The costly importation of topsoil has been avoided. Revegetation is taking place directly into the burnt spoil, which has been isolated from the underlying metalliferous wastes using plastic sheeting or ball clay as a capillary break. Several different seed mixes, some of which incorporate metal tolerant grass cultivars as a precautionary measure, are being used in an ecological planting design, which includes pockets of tree planting.

The mine shafts on site are being treated in a number of different ways. This is because some are important for public water supply, cavers and bats. Areas of industrial archaeological interest will be retained in the scheme.

Parts of this reclamation scheme are still in progress and so the economic analysis is based upon expected cost figures. Considering the difficult nature of the wastes, the WC and PC for this scheme are fairly reasonable. This probably reflects economies of scale in reclamation, and the limited amount of earthmoving that was necessary at this site. The CLA again exceeds the PRV, although as at Parc Mine and Trecastell the former is relatively low.

Conclusions

Although it proved difficult to obtain costs for the reclamation of metalliferous mine waste sites, some conclusions can be drawn from the above. There is an overriding need to limit metal pollution, and this results in high WCs. Since these sites tend to be located in relatively remote rural locations, and contain potential hazards to man, they are unlikely to be reclaimed for hard development. Amenity is likely to be the main after-use, with the possibility of some grazing being carried out. The heavy metal contents of these sites mean that there is little prospect of them being able to produce economic returns for agriculture or forestry and indeed the long term survival of trees planted on these substrates cannot be assured. Consequently, the nature of these sites means that their PRVs are likely to be low.

6.4.6 Hard after-uses

Corner of Aigburth and Ullet Roads, Liverpool

Table 6.19 Corner of Aigburth and Ullet Roads: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, Liverpool 17, Merseyside (NGR SJ 366877).
After-use: Housing (doctor's surgery). Total 0.166 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-56,500	-340,400 ha^{-1}	0.12
r = 7%	-56,300	-339,300 ha^{-1}	0.09

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-64,000	-385,800 ha^{-1}
r = 7%	-61,600	-371,000 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-12,800	-77,200 ha^{-1}
r = 7%	-10,400	-62,400 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-51,200	-308,600 ha^{-1}
r = 7%	-51,200	-308,600 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	7,500	45,400 ha^{-1}
r = 7%	5,300	31,700 ha^{-1}

This was originally the site of a church which had to be demolished. Rubble left on the site was used to reshape it. Tree and shrub planting was carried out around the edge of the site and a wildflower meadow sown on the remainder in a naturalistic approach. A herringbone brick path laid through the centre of the site was made out of second hand bricks and salvaged anchors were used to give the site character.

This temporary landscape treatment was successful in attracting development to the site, although a shortage of funds for landscape maintenance was a problem. It now contains a doctor's surgery.

The fairly high WC probably reflects diseconomies of scale on what is a small corner site. Landscape contractors tend to assume that any site smaller than 10 hectares in size will suffer from diseconomies of scale in land reclamation work.

The very high PC of this scheme is largely accounted for by an extremely high CLA. The CLA, which was paid by a speculator purchasing the unreclaimed site, seems excessive given the low PRV which was subsequently obtained when the site was sold.

Table 6.20 Mother Redcap's: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, Egremont Promenade, Wallasey, the Wirral, Merseyside (NGR SJ 316928).
After-use: Housing but not yet materialised. Total 0.18 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-9,900	-55,100 ha^{-1}	0.74
r = 7%	-10,800	-60,200 ha^{-1}	0.71

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-37,800	-209,800 ha^{-1}
r = 7%	-37,600	-209,100 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-5,900	-32,700 ha^{-1}
r = 7%	-5,800	-32,100 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-31,900	-177,100 ha^{-1}
r = 7%	-31,900	-177,100 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	27,800	154,700 ha^{-1}
r = 7%	26,800	149,000 ha^{-1}

Before it was reclaimed this site contained the remains of former buildings including basements. These had to be excavated and filled in, walls repaired and ground levels raised to make the site suitable for housing development.

The WC at this site was very modest, despite its unnecessary topsoiling. The CLA was high on a unit cost basis, but is almost counteracted by a substantial PRV.

This PRV assumes, however, that the site will be developed for housing. Some three years after reclamation this has still not taken place, although planning permission for residential use has been obtained. The site is currently completely unmaintained, and has an overgrown, neglected appearance (Plate 15).

In Table 6.21 the cost-benefit analysis is made assuming that a housing after-use is not forthcoming. This suggests that if the site remains undeveloped, perhaps as a small area of public open space, the overall PC will have been very much higher. This is because of the far lower PRV which applies.

Table 6.21 Mother Redcap's: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, Egremont Promenade, Wallasey, the Wirral, Merseyside (NGR SJ 316928).

ESTIMATED COSTS AND BENEFITS IF SITE REMAINS UNDEVELOPED, FOR EXAMPLE AS PUBLIC OPEN SPACE (0.18 ha).

1. Project cost (cost-benefit analysis)			
Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-37,400	-207,500 ha^{-1}	0.01
r = 7%	-37,300	-207,000 ha^{-1}	0.01
2. Reclamation cost (financial analysis)			
Discount rate	PC	PC ha^{-1}	
r = 5%	-37,800	-209,800 ha^{-1}	
r = 7%	-37,600	-209,100 ha^{-1}	
3. Works cost (economic analysis)			
Discount rate	PC	PC ha^{-1}	
r = 5%	-5,900	-32,700 ha^{-1}	
r = 7%	-5,800	-32,100 ha^{-1}	
4. Cost of land acquisition (financial analysis)			
Discount rate	PC	PC ha^{-1}	
r = 5%	-31,900	-177,100 ha^{-1}	
r = 7%	-31,900	-177,100 ha^{-1}	
5. The post-reclamation value of the land (financial analysis)			
Discount rate	PV	PV ha^{-1}	
r = 5%	400	2,200 ha^{-1}	
r = 7%	400	2,200 ha^{-1}	

Plate 15. Despite reclamation, no after-use has yet materialised on the Mother Redcap's site.

Plate 16. Reclamation to an industrial after-use at Kingsway Loop.

Kingsway Loop, Liverpool

Table 6.22 Kingsway Loop: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, on land surrounded by the entrance to the Wallasey Tunnel, Liverpool, Merseyside (NGR SJ 349917).
After-use: Industry. Total 1.8 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-556,200	-309,000 ha^{-1}	0.24
r = 7%	-553,400	-307,500 ha^{-1}	0.23

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-731,500	-406,400 ha^{-1}
r = 7%	-722,300	-401,300 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-493,300	-274,100 ha^{-1}
r = 7%	-484,100	-269,000 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-238,200	-132,300 ha^{-1}
r = 7%	-238,200	-132,300 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	175,300	97,400 ha^{-1}
r = 7%	168,800	93,800 ha^{-1}

Prior to reclamation this site consisted of inner city land which had already been developed at least three times for residential, commercial and industrial purposes before being cleared when the Wallasey Tunnel was built (Plate 16). The fact that the site was littered with the remains of buildings, old basements, badly filled cellars, brick rubble and voids was a major disincentive to its redevelopment.

Table 6.22 shows that due to the difficult ground conditions the WC for this scheme was very high. These costs turned out to be greater than originally anticipated because despite site investigations and extensive examination of all available ordnance survey maps of the area a large number of additional basements were found which required treatment.

The CLA for this scheme was also high and exceeded the PRV, which was, nonetheless, substantial. This led to an overall PC as high as those reported for the reclamation of industrial dereliction to housing above.

Discussion

The WC of reclaiming urban clearance areas to residential or industrial after-uses clearly depends on the extent to which old foundations have to be grubbed up to produce suitable conditions for development. It may be cheaper simply to grass such sites over but if taken too extremes such a policy could produce vast tracts of open space in cities and promote further development of the countryside (EAU, 1986).

The cost of acquiring all three sites above was greater than £100,000 ha^{-1}. This is excessively high when the derelict nature of these sites and the fact that in each case their PRVs were <u>lower</u> than their CLAs are considered. There is clearly something wrong in the acquisition process. It cannot be the case that these schemes are producing negative environmental benefits (costs).

6.4.7 Public open space as an after-use

Bamber Street, Liverpool

Table 6.23 Bamber Street: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, Grove Street, Liverpool 7, Merseyside. (NGR SJ 362902).
After-use: Interim public open space. Total 2.7 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-247,700	-91,700 ha^{-1}	0.01
r = 7%	-217,000	-80,400 ha^{-1}	0.01

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-250,400	-92,700 ha^{-1}
r = 7%	-218,900	-81,100 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-96,800	-35,900 ha^{-1}
r = 7%	-69,200	-25,600 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-153,500	-56,900 ha^{-1}
r = 7%	-149,700	-55,500 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	2,600	1,000 ha^{-1}
r = 7%	1,800	700 ha^{-1}

The WC for this scheme was relatively low, but the CLA high, and this produced a substantial overall PC. The low PRV reflects the nature of the after-use, a lack of demand for residential or other development and the difficulty of building houses on urban clearance wastes because of the added costs of excavating former basements. In addition, the site is afflicted by planning blight because it is in the path of the proposed Low Hill distributor road.

This scheme was reclaimed using an ecological approach, in which the environmental constraints of the site are accepted and only modified as much as is necessary to ensure the growth of plants, which are chosen for their ability to cope with the site problems. The three examples of this approach analysed here are this scheme, the Crown Street site and the Melville Place site (see below), all near the University precinct in Liverpool and each comprising a mixture of urban properties prior to reclamation.

This scheme was directly seeded in 1971 without the use of topsoil, using conventional agricultural techniques, as described in Section 6.2.3, as an interim measure, and ten years later the site was enhanced with gravel paths, massed tree and shrub planting and heavy standard trees. In contradiction to the original design principles, topsoil was then spread on the site during these enhancement works. This is reflected in the WC.

This scheme is now very attractive and already has a mature appearance (Plate 17). Maintenance costs, shown in Table 6.29, have been estimated for this and the two other ecological schemes from landscape design plans, and tables produced by the Groundwork Trust (1984). These costs are very reasonable for all three schemes. This site now requires only grass mowing every two-four weeks and the spraying of paths.

Plate 17. The Bamber Street site, reclaimed for interim public open space.

Plate 18. Everton Park, reclaimed to permanent parkland.

Table 6.24 Cooper Street: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Neglected urban gap site, St. Helens, Merseyside (NGR SJ 509959).
After-use: Public open space. Total 0.25 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-3,600	-14,300 ha^{-1}	0.73
r = 7%	-3,700	-14,700 ha^{-1}	0.72

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-13,400	-53,500 ha^{-1}
r = 7%	-13,300	-53,200 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-3,700	-14,700 ha^{-1}
r = 7%	-3,600	-14,400 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-9,700	-38,800 ha^{-1}
r = 7%	-9,700	-38,800 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	9,800	39,200 ha^{-1}
r = 7%	9,600	38,500 ha^{-1}

Strictly speaking, this scheme was not eligible for Derelict Land Grant as it comprised the interim treatment of a neglected, fly tipped and badly worn urban gap site. The low WC reflects this.

Works involved ripping the site, seeding it with a grass mix, planting it with container grown stock, putting down bollards to prevent car parking, and constructing a gravel footpath, which was later tarmaced over. A seat was provided, brick edging laid and protective fencing erected, following the lines of former houses, to maintain the identity of the area.

Before reclamation took place, a thorough survey was made of what the site was used for and what local people wanted. This temporary landscape treatment has been very effective; grass has established well directly on the rubble and the failure rate of the tree and shrub planting has been less than 1%.

The low WC and estimated CLA for this scheme are reflected in its very modest PC. The CLA roughly equals the PRV.

This site has a relatively high estimated landscape maintenance cost (Table 6.29). This is however, attributable to the site's urban location; almost half of these costs are for litter collection, fence, seat and bollard repairs.

Table 6.25 Crown Street: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, corner of Crown Street and West Derby Street, Liverpool 7, Merseyside (NGR SJ 361905).
After-use: Interim public open space. Total 0.8 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-71,200	-89,000 ha^{-1}	0.01
r = 7%	-65,000	-81,300 ha^{-1}	0.01

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-72,000	-89,900 ha^{-1}
r = 7%	-65,600	-81,900 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-4,900	-6,100 ha^{-1}
r = 7%	-3,400	-4,300 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-67,100	-83,800 ha^{-1}
r = 7%	-62,100	-77,700 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	800	1,000 ha^{-1}
r = 7%	500	700 ha^{-1}

The WC for this scheme was very low and further reduced by a factor of about 2.7 by the effects of discounting. The CLA was, however, extremely high, producing a considerable overall PC. This high CLA reflects the fact that the site was acquired by Liverpool University to be held for either new building or car parking.

The central part of this site was directly seeded, and a good cover of clover established in six months on the site. Bare-rooted tree and shrub stock was pit-planted as whips in blocks laid out around the edge of the site, in the event of its future use for car parking or development. The species used included pioneers such as alder (*Alnus glutinosa*), which also has the advantage of fixing nitrogen, and more long-lived trees such as oak (*Quercus petraea*) which will eventually emerge through the canopy provided by the faster-growing pioneers. The technique is that well established at Warrington New Town (Scott *et al.*, 1986). Those trees (*Salix caprea*, *Malus domestica*) already growing on the site before it was reclaimed were retained in the scheme.

Paths were not provided, because the substrate is essentially hardcore, and thus hard-wearing. In such circumstances, even where paths are necessary it is advisable to wait until desire lines have formed to ensure that the path network conforms to what users want (Dutton and Bradshaw, 1982).

Table 6.26 Everton Park: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, (phases I and II), Everton, Liverpool 5, Merseyside (NGR SJ 356923).
After-use: Permanent public open space. Total 24.2 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-4,561,500	-188,500 ha^{-1}	0.01
r = 7%	-4,420,200	-182,700 ha^{-1}	0.01

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-4,610,700	-190,500 ha^{-1}
r = 7%	-4,465,800	-184,500 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-4,344,500	-179,500 ha^{-1}
r = 7%	-4,199,600	-173,500 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-266,200	-11,000 ha^{-1}
r = 7%	-266,200	-11,000 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	49,200	2,000 ha^{-1}
r = 7%	45,600	1,900 ha^{-1}

Everton Park is an ambitious scheme to create a traditional Victorian Park out of an extensive area of wasteland and housing demolition wastes. The approach taken was an 'engineering' one in which an effectively new environment was constructed (Plate 18).

At Everton Park, the problems posed in revegetating urban clearance wastes have been overcome by importing topsoil as cover and sowing a grass mix, without white clover, on top. In addition, because of fears that massed tree and shrub plantings could harbour attackers, only extra heavy standard and semi mature trees have been planted, at wide spacings, and shrubs avoided altogether. It does seem, however, that shrubs could have been planted at Everton Park well away from the footpaths.

A comparison of Everton Park with the Crown Street site, reclaimed using an ecological approach, indicates that the WC for Everton Park was thirty four times greater. However, this figure is misleading because the WC in the Crown Street scheme occurs late in the project's life and is thus heavily discounted. If, to enable a fairer comparison, the WCs are both assigned to the first year of each project onwards, the Crown Street scheme still works out as some twelve times cheaper.

Compared with Crown Street, Everton Park was more expensive for a number of reasons. Firstly, the entire site was topsoiled. Current costs for supplying and spreading topsoil in Liverpool are of the order of £10.50 m^{-3}. This means that applying topsoil to a depth of 25 cm costs over £26,000 ha^{-1}.

Secondly, the costs of tree planting were far higher at Everton Park. Estimated total planting costs (tree stock, materials and labour) were £65,600 ha^{-1} at Everton Park and £7,500 ha^{-1} at Crown Street (1987/88 prices). This means that tree planting costs were almost nine times higher at Everton. The planting at Everton Park was based on an average of 160 extra heavy standards and 200 semi mature trees per hectare, giving an approximate planting density, for the site as a whole, of 360 trees ha^{-1}. By contrast, at Crown Street planting was undertaken at staggered 0.75 metre centres, giving a total planting density, for the site as a whole, of about 7,500 plants ha^{-1}, some twenty times more than that used at Everton Park. The two schemes have a similar ratio of open space to tree covered area.

Finally, the Everton Park scheme involved the use of high cost hard features and park furniture. This is an integral part of creating a Victorian Park.

However, the absence of shrubberies, rose gardens and lakes at Everton Park means that many of the features of a true Victorian Park are missing. Without these details a very monotonous landscape is likely to result.

With the very high costs of reclamation at Everton Park, it might be hoped that these would be compensated for by modest landscape maintenance costs. As Table 6.29 shows, however, this is not the case. Maintenance costs are about <u>ten times</u> higher than those for the ecological schemes, which require less maintenance of plantings, and, because trees are planted in discrete blocks or groups rather than individually or in rows, the mowing of a smaller proportion of the total site area.

Furthermore, the large trees, laid out in rows to create an instant landscape effect are not faring well at Everton Park. Some lines of trees are dead and have had to be replaced, and many of the remainder are showing signs of stress. This may be due to poor stock, poor planting practices, or a lack of after-care. However it is likely to be the very exposed nature of the site in which heavy standards will be particularly stressed. The opportunity to base species selection on the lessons learnt from the similarly highly exposed Liverpool International Garden Festival site was missed.

Considering the fact that the estimated CLA for this scheme is low on a unit cost basis, the overall PC is very high. In fact this is undoubtedly an underestimate of the true costs involved, because prior to the Everton Park scheme some areas of land had already been treated on an interim basis by grassing them over-as in the ecological schemes, but without clover.

There is little doubt that a reclamation scheme was urgently needed in this part of Everton. However, it is suggested here that the form that reclamation took is questionable, and that current grant approval policies need to be re-examined.

Melville Place, Liverpool

Table 6.27 Melville Place: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, Grove Street, Liverpool 7, Merseyside. (NGR SJ 362898).
After-use: Interim public open space. Total 1.2 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-328,400	-273,700 ha^{-1}	0.01
r = 7%	-327,800	-273,200 ha^{-1}	0.004

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-330,100	-275,100 ha^{-1}
r = 7%	-329,200	-274,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-3,100	-2,600 ha^{-1}
r = 7%	-2,800	-2,300 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-327,000	-272,500 ha^{-1}
r = 7%	-326,500	-272,100 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	1,700	1,400 ha^{-1}
r = 7%	1,400	1,200 ha^{-1}

The WC for this scheme was remarkably low. However, as in the case of the Bamber Street and Crown Street sites, the CLA was remarkably high, and exceeded the PRV by a factor of about 200. The high CLA is accounted for by the fact that the site was acquired in a piecemeal fashion by Liverpool University for possible later development. Like the adjacent Bamber Street scheme, this site is afflicted by planning blight because it is in the path of the proposed Low Hill distributor road.

This site was directly seeded together with the Bamber Street site in 1971. Standard trees were then added in 1975 and 1980. The grass cover on the site has successfully withstood the quite heavy use it receives from people crossing the site (Chapter 4).

The costly importation of topsoil has been proved unnecessary by this site in particular. Although reclaimed using direct improvement of urban clearance wastes, earthworm activity is causing topsoil to develop naturally over the underlying brickwaste substrate at a rate of some 0.3-0.4 cm a year (Bradshaw, 1987).

444 New Chester Road, Wirral

Table 6.28 444 New Chester Road: cost-benefit analysis of reclamation and financial information (£s). Constant 1987/88 prices, 20 year time horizon. NPC=Net Present Cost, PC=Present Cost, PV=Present Value.

Site: Urban clearance scheme, Rock Ferry, the Wirral, Merseyside (NGR SJ 330867).
After-use: Public open space. Total 0.06 ha.

1. **Project cost** (cost-benefit analysis)

Discount rate	NPC	NPC ha^{-1}	Benefit-cost ratio
r = 5%	-9,300	-154,800 ha^{-1}	0.32
r = 7%	-9,200	-154,100 ha^{-1}	0.31

2. **Reclamation cost** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-13,600	-226,800 ha^{-1}
r = 7%	-13,400	-223,400 ha^{-1}

3. **Works cost** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-10,800	-179,600 ha^{-1}
r = 7%	-10,600	-176,300 ha^{-1}

4. **Cost of land acquisition** (financial analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-2,800	-47,200 ha^{-1}
r = 7%	-2,800	-47,200 ha^{-1}

5. **The post-reclamation value of the land** (financial analysis)

Discount rate	PV	PV ha^{-1}
r = 5%	4,300	72,000 ha^{-1}
r = 7%	4,200	69,300 ha^{-1}

This site originally comprised a derelict shop with residential accommodation above it. It also included derelict stables but these were demolished prior to reclamation under a dangerous structures notice.

The inclusion of some demolition in the works contract, diseconomies of scale and the design of the landscaping combined to produce a very high WC on a unit cost basis. Some 17% of the WC was also taken up by staff costs.

Topsoil was imported during reclamation, which was an unnecessary expense. Twenty five standard trees were also planted, which represents a density of over 400 trees ha^{-1} and so is costly in unit cost terms. At current contractors' rates, planting standard trees in such conditions is likely to cost about £40 per tree (1987/88 prices) giving an undiscounted tree planting cost of some £16,000 ha^{-1} for this scheme.

As a result of the high WC and CLA, the PC for this scheme is large. The PRV does, however, exceed the CLA.

Discussion

The examples of Everton Park and 444 New Chester Road suggest that there is little to commend the traditional engineering approach to the reclamation of urban clearance wastes. If, as is almost inevitable, other schemes reclaimed using this approach are equally expensive, this is a matter of real concern.

Where land continues to be reclaimed to public open space, good design is essential to ensure cost-effective reclamation and maintenance. As the Groundwork Trust has argued, the monotony of many urban amenity landscapes is largely attributable to the system of gang mowing large open spaces, which have excessive growth due to the use of topsoil, that financially constrained and unimaginative local authorities have felt compelled to adopt. Moreover, fearing that low cost schemes will lead to high maintenance liabilities, local authorities have gravitated towards high cost schemes such as Everton Park above, erroneously thinking that these have low maintenance costs. This policy has been encouraged by the Department of the Environment.

If the financial pressures associated with maintaining large areas of reclaimed open space continue to grow, then the incentive to reclaim urban clearance areas to productive, income-generating after-uses will become ever greater. A promising possibility is commercial forestry, ranging from short term coppicing to longer rotation cropping. This is currently being developed on Merseyside by Knowsley Borough Council, and evaluated by the Groundwork Trust, on vacant but high security industrial land on Merseyside. Similar schemes have recently been announced for other areas. Data sufficient for an economic appraisal of the technique are not yet available. This approach also has the advantage that it does not preclude future development of the land. Another income-generating possibility is the cropping of grass for silage or grass meal.

6.4.8 Overall conclusions: urban clearance areas

A clear finding that can be drawn from the above examples is that, as in the cases of the other forms of dereliction, too much is generally being paid to acquire urban clearance sites. This problem has also been highlighted by the Civic Trust (1988). With the exceptions of 444 New Chester Road, and that of Cooper Street, where they were roughly equal, for all the other schemes the CLA greatly exceeded the PRV. In the case of schemes where large numbers of individual properties have to be purchased, the fact that some small parcels of land, which are integral to a scheme, are not derelict can greatly increase the overall CLA. An allied problem is where a site has multiple landowners, some of whom delay a reclamation scheme by holding out for excessively high prices for what become 'ransom strips' of land. These problems are probably best overcome by enacting strong legislation which empowers councils, private sector and other organisations undertaking reclamation, to compulsorily purchase land at a realistic market price.

Whilst it is likely to be cheaper than hard development, which requires the excavation of old basements and their backfilling and compaction with clean hardcore, reclamation for amenity has the disadvantage of creating a continued maintenance liability. This can, however, be minimised by good design (Table 6.29). It seems remarkable that there can be tenfold differences in maintenance costs between sites which in terms of amenity and visual effects are equal (indeed the cheaper may even be better). The balance between hard and soft schemes will be affected by planning considerations such as the existing level of provision of open space in the locality, and the extent of the perceived need to discourage further development in the countryside. If a more sensible approach was taken to design and establishment it would be easier to achieve this balance on amenity and planning considerations alone without excessive attention being paid to financial criteria.

In many cases, reclamation of urban clearance wastes to open space is an interim measure. This has several advantages (EAU, 1986). It is likely to be relatively cheap, and so large areas can be treated with limited financial resources. Unlike industrial dereliction, chemical contamination is rarely a problem. The example of Cooper Street illustrates that where land is merely neglected, rather than derelict, the costs of improving it may be very low. The values of surrounding properties may also increase as a result, an effect that has been shown for colliery spoil dereliction (Chapter 4). Much of the vacant land in cities is neglected rather than derelict (Chapter 1). If such an approach is to be taken on a large scale, ways will have to be found of maximising returns and minimising the costs of maintaining such land.

Table 6.29 Annual landscape maintenance costs and site income (£s) for industrial dereliction and urban clearance sites reclaimed for public open space, where available (1987/88 prices).

Table	Scheme	Year	Maintenance cost ha^{-1}	Income ha^{-1}
Industrial dereliction				
6.7	International Garden Festival, Liverpool	1984	11,000 (PAO)	288,000 (PAO,RF)
		1985	10,000 (PAO)	37,000 (PAO,RF)
		1986	NA	19,000 (PAO,RF)
		1987	10,000 (PAO)	12,000 (PAO,RF)
		1988	8,000 (PAO)	NA
6.15	Jericho South Shore, Liverpool	1984	1,900 (WS)	0 (WS)
		1985	1,600 (WS)	0 (WS)
		1986	1,500 (WS)	0 (WS)
		1987	1,500 (WS)	0 (WS)
Urban clearance schemes				
6.23	Bamber Street, Liverpool		940 (WS)	0 (WS)
6.24	Cooper Street, Liverpool		2,840 (WS)	0 (WS)
6.25	Crown Street, Liverpool		920 (WS)	0 (WS)
6.26	Everton Park, Liverpool	1985/86	11,100 (WS)	0 (WS)
		1986/87	10,800 (WS)	0 (WS)
		1987/88	6,800 (WS)	0 (WS)
6.27	Melville Place, Liverpool		900 (WS)	0 (WS)

KEY:
NA = Not available, PAO = Parkland area only, WS = Whole site, RF = Revenue from entrance charges to visit garden festival or theme park.

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CHAPTER 7 THE PROGRESSIVE RESTORATION OF DISTURBED LAND

7.1 Introduction

In Britain, to obtain planning permission, new opencast coal mines (strip mines), deep mines and sand and gravel quarries have to comply with restoration conditions which have been imposed via legislation (Street, 1986). It may be possible to restore older, abandoned sites if soils have been stored nearby and not lost, but often this is not the case, and they may require reclamation (Chapter 1).

Progressive restoration is the process of land restoration whereby mining overburden, subsoil and topsoil are removed and reinstated sequentially, in a continuous operation. The land is thus disturbed, but not made derelict. Reinstatement proceeds as mining takes place.

Progressive restoration may take two forms (RMC, 1986). The first is stockpiling, in which soils and overburden are stripped and stored in mounds, which may also be used to screen a site and reduce the impact of dust and noise on the surrounding environment.

The alternative approach is direct reinstatement. In this, soils are stripped from the area of active mineral working and immediately transported to an area being reinstated. Thus, except at the very start of operations, no stockpiling takes place. This means that all other things being equal, direct reinstatement is likely to be cheaper than stockpiling, because it involves less earthmoving as there is no double handling of soils. Since it is also quicker, it also means that a mining company can achieve a faster rate of restoration of its sites with a given amount of heavy earthmoving equipment.

The techniques and machinery used in restoration have been described in detail elsewhere (McRae, 1983; RMC, 1986). Very little data has, however, been published on the economics of land restoration. There are two reasons for this. Firstly, the majority of such work is carried out by the private rather than the public sector, and, as a result, cost information is frequently collected only by financial year, rather than a site by site basis. Secondly, the release of such information could have political repercussions. If, for example, it was decided that the cost of land restoration was relatively low, planners might insist that large numbers of old, abandoned sites are restored, at great cost to the commercial profitability of mining companies.

The practical implication of this is that cost information is almost impossible to obtain from either British Coal or the sand and gravel mining industry. Despite persistent attempts, this was the experience of this study.

7.2 Sand and gravel extraction

In Britain, the mining of sand and gravel is an enormous industry. In England alone about 1,500 hectares (ha) of land are used each year to produce some 70 million tonnes of aggregates (EAU, 1986). Although crushed rock can be used as an alternative in the construction industry, it is much more expensive to extract (Bradshaw and Chadwick, 1980).

Most of Britain's sand and gravel is produced in south east England, where demand is concentrated, and deposits tend to underlie high grade agricultural land. Crushed rock, on the other hand, is generally mined from quarries located in northern Britain.

There are two types of pits encountered in sand and gravel mining. Where deposits are worked above the water table, they are referred to as dry pits, and where they lie below the water table they are known as wet pits.

Dry pits are most commonly restored to agriculture. A grass ley may be sown in the early years of restoration, but an immediate return to arable cropping is possible on <u>well</u> restored and <u>sensitively</u> <u>managed</u> sites. Where sites are restored to agriculture, it is common practice to landfill the void space created by the extraction of minerals with domestic or industrial wastes, an operation that generates considerable commercial returns (see below). High levels of agricultural restoration can be obtained, especially where measures are taken to vent off landfill gas (Spreull and Cullum, 1987).

Dry pits may also be restored to commercial forestry or amenity, and hard after-use development (Chapter 9) is also possible. Where sites are restored to forestry, it is normally recommended that ridges are formed some 30 metres wide by 1.5 metres high. Deep ripping is then carried out to a depth of some 0.5-0.75 metres prior to planting. Following ripping, drainage channels are excavated with a backacting excavator along the furrow bottoms, leading either to a specially constructed pond or drainage outlet (Binns *et al.*, 1983; Heslegrave, 1988 *pers. comm.*).

After mineral extraction has ceased, it is usual to allow wet pits to flood. This means that the 'restoration' of such quarries may occur of its own accord. However, if sites are to be deliberately restored to water sports (Oliver, 1985; EAU, 1986), or nature conservation (Bradshaw and Chadwick, 1980; RMC 1986; ENDS, 1987), then earthmoving and other costs may be incurred in providing the necessary facilities or wildlife habitats.

Although in this research, cost information could not be obtained from sand and gravel companies, it was, however, possible to analyse the costs of restoring two sand and gravel quarries published in joint reports of the Department of the Environment, Ministry of Agriculture, Fisheries and Food, and the Sand and Gravel Association (DoE/MAFF/SAGA, 1982a; DoE/MAFF/SAGA, 1982b).

These reports cover two agricultural land restoration experiments in southern England which were set up to develop methods of restoring land to high grade arable agriculture. The Bush Farm experiment involved four experimental areas which each received different soil handling treatments during progressive restoration. The first and second quarters were reinstated using direct movement, whilst the third and fourth quarters were reinstated from soil stockpiles. Restoration was carried out using backacting excavators and dump trucks on the first and third quarters, whilst the remaining experimental areas were stripped and reinstated using earthscrapers.

The Papercourt Farm site, on the other hand, was divided into two experimental halves and later restored using old materials stockpiled near to the site. It could not, therefore be progressively restored, a situation that is commonly encountered with old workings that have been abandoned. Both experiments were set up in 1974.

In the reports, costs are presented for each experimental area, under two sets of assumptions. The so-called 'conventional' cost refers to the estimated cost of carrying out that work sufficient to meet the standard of restoration required by legislation at the time. The 'actual' cost, by contrast, denotes the cost of those operations that were in fact undertaken on site, which was restored to a higher specification than strictly necessary. Since restoration conditions were tightened up under the Town and Country Planning (Minerals) Act of 1981, it is the <u>actual</u> costs of restoration that are analysed here.

7.3 The method of economic analysis

The costs of surveying, reinstating, filling and draining the restored sites were obtained from the relevant reports, and allocated, using the details given, to the relevant financial year. This was then entered in the same cost-benefit model as described in Chapter 5, in which all costs were adjusted to constant 1987/88 prices. The results are shown in Tables 7.1-7.3.

7.4 Results and discussion

In the case of Bush Farm (Tables 7.1 and 7.2), costs are given for each of the four experimental quarters. Since there was no variation in the soil handling and reinstatement procedures used at Papercourt Farm (Table 7.3), the costs for the two experimental halves have been combined.

These analyses are, however, incomplete. Data for the costs of land acquisition, and post-reclamation values of the land are not available. It also seems likely that the administrative costs presented in the report and used in the analyses are an underestimate of the total scheme design costs.

Table 7.1 Bush Farm: cost-benefit analysis of progressive restoration (£s). Constant 1987/88 prices, 20 year time horizon. Analysis based on 'actual' cost information (DoE/MAFF/SAGA, 1982a). PC=Present Cost, NPV=Net Present Value.

Site: Sand and gravel quarry, Upminster, Essex (Joint Agricultural Land Restoration Experiment). NGR TQ 567844.
After-use: Agriculture. Total experimental area: 7.35 ha.

FIRST EXPERIMENTAL QUARTER (1.65 ha) (DM+DL).
Method of reinstatement: Direct movement of soils (DM).
Soil handling treatment: Dumper and loader method (DL).

1. **Works cost excluding income from landfill** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-129,100	-78,300 ha^{-1}
r = 7%	-126,700	-76,800 ha^{-1}

2. **Works cost including income from landfill** (cost-benefit analysis)

Discount rate	NPV	NPV ha^{-1}	Benefit-cost ratio
r = 5%	410,400	248,800 ha^{-1}	4.18
r = 7%	402,800	244,100 ha^{-1}	4.18

SECOND EXPERIMENTAL QUARTER (1.81 ha) (DM+E).
Method of reinstatement: Direct movement of soils (DM).
Soil handling treatment: Earthscraper method (E).

1. **Works cost excluding income from landfill** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-130,800	-72,300 ha^{-1}
r = 7%	-128,000	-70,700 ha^{-1}

2. **Works cost including income from landfill** (cost-benefit analysis)

Discount rate	NPV	NPV ha^{-1}	Benefit-cost ratio
r = 5%	408,700	225,800 ha^{-1}	4.12
r = 7%	401,500	221,800 ha^{-1}	4.14

Table 7.2 Bush Farm: cost-benefit analysis of progressive restoration (£s). Constant 1987/88 prices, 20 year time horizon. Analysis based on 'actual' cost information (DoE/MAFF/SAGA, 1982a). PC=Present Cost, NPV=Net Present Value.

Site: Sand and gravel quarry, Upminster, Essex (Joint Agricultural Land Restoration Experiment). NGR TQ 567844.
After-use: Agriculture. Total experimental area: 7.35 ha.

THIRD EXPERIMENTAL QUARTER (1.95 ha) (SS+DL).
Method of reinstatement: From stockpiled soils (SS).
Soil handling treatment: Dumper and loader method (DL).

1. Works cost excluding income from landfill (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-107,000	-54,900 ha^{-1}
r = 7%	-96,400	-49,400 ha^{-1}

2. Works cost including income from landfill (cost-benefit analysis)

Discount rate	NPV	NPV ha^{-1}	Benefit-cost ratio
r = 5%	329,800	169,100 ha^{-1}	4.08
r = 7%	297,400	152,500 ha^{-1}	4.09

FOURTH EXPERIMENTAL QUARTER (1.94 ha) (SS+E).
Method of reinstatement: From stockpiled soils (SS).
Soil handling treatment: Earthscraper method (E).

1. Works cost excluding income from landfill (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-96,700	-49,800 ha^{-1}
r = 7%	-87,100	-44,900 ha^{-1}

2. Works cost including income from landfill (cost-benefit analysis)

Discount rate	NPV	NPV ha^{-1}	Benefit-cost ratio
r = 5%	340,100	175,300 ha^{-1}	4.52
r = 7%	306,800	158,100 ha^{-1}	4.52

Table 7.3 Papercourt Farm: cost-benefit analysis of non-progressive restoration (£s). Constant 1987/88 prices, 20 year time horizon. Analysis based on 'actual' cost information (DoE/MAFF/SAGA, 1982b). PC=Present Cost, NPV=Net Present Value.

Site: Sand and gravel quarry, Ripley, Surrey (Joint Agricultural Land Restoration Experiment). NGR TQ 035560.
After-use: Agriculture. Total experimental area: 2.71 ha.

BOTH EXPERIMENTAL HALVES (2.71 ha) (SS+DL).
Method of reinstatement: From stockpiled soils (SS).
Soil handling treatment: Dumper and loader method (DL).

1. **Works cost excluding income from landfill** (economic analysis)

Discount rate	PC	PC ha^{-1}
r = 5%	-217,500	-80,300 ha^{-1}
r = 7%	-203,500	-75,100 ha^{-1}

2. **Works cost including income from landfill** (cost-benefit analysis)

Discount rate	NPV	NPV ha^{-1}	Benefit-cost ratio
r = 5%	677,600	250,000 ha^{-1}	4.11
r = 7%	634,700	234,200 ha^{-1}	4.12

The income earned by selling landfill space via tipping charges is not given in the reports. The volumes of void spaces filled are however known, so that this can be estimated. A waste disposal charge of £4.50 a tonne is a reasonable estimate at 1988 prices, based on statistics collected by CIPFA (1985) and allowing for the price war that has recently developed in the waste disposal industry. It is also assumed that wastes have been compacted to a rate of one tonne m^{-3}.

Each analysis is given with and without the income generated from tipping charges. Tables 7.1-7.3 show that the inclusion of income from landfilling completely transforms the economics of reinstatement operations. Instead of costing some £40,000-£80,000 ha^{-1}, restoration becomes a highly profitable operation, generating Net Present Values of some £150,000-£250,000 ha^{-1} and discounted benefit-cost ratios of over 4 (Tables 7.1-7.3).

The Bush Farm experiment was designed to compare the costs and restorative effectiveness of four different soil handling treatments. However, it is difficult to make meaningful comparisons between the alternative treatments because as at Papercourt Farm, controls were not set up, and the treatments were not replicated.

In theory, the direct movement of soils is substantially cheaper than their stockpiling, and the earthscraper method of handling soils is somewhat cheaper than the slower dumper and loader approach which has the countervailing advantage that it causes less soil compaction. For these reasons the expected order of costs on a per hectare basis for the different experimental treatments at Bush Farm can be abbreviated as DM+E, DM+DL, SS+E and SS+DL, starting with the most economical (Table 7.4).

Table 7.4 Bush Farm: summary of soil reinstatement and handling treatments.

Experimental quarter	Method of reinstatment	Soil handling treatment	Abbreviation
1	Direct movement of soils	Dumper and loader method	DM+DL
2	Direct movement of soils	Earthscraper	DM+E
3	From soil stockpiles	Dumper and loader method	SS+DL
4	From soil stockpiles	Earthscraper	SS+E

In fact, this expected trend is not found in the data in Tables 7.1 and 7.2. Where income from landfilling is included the order is SS+DL, SS+E, DM+E and DM+DL, and where it is excluded it is SS+E, SS+DL, DM+E and DM+DL.

In addition to the limitations of the experimental design, these discrepancies are also attributable to the fact that the cost of reinstating the first (DM+DL treatment) and second (DM+E treatment) quarters was significantly increased by the method of filling used, cancelling out savings due to the direct movement rather than the stockpiling of soils. It was also found during the experiment that the additional cost of handling soil by the dumper and loader method was partly offset by the cost of ripping required when placing soils using earthscrapers. Furthermore, costs were raised on the third quarter (SS+DL treatment) because of a large standard charge incurred when the weather was too wet to permit soil moving operations (DoE/MAFF/SAGA, 1982a).

It seems likely that the costs reported for the Bush and Papercourt Farm experiments are overestimates of actual restoration costs (W.J. Spreull, 1987 *pers. comm.*). This is because of the small size of the experimental areas, which being smaller than 10 hectares are likely to attract diseconomies of scale in earthmoving. Furthermore, in practice commercial tipping would not be undertaken on such small landfill sites.

Prior to restoration, the land at both the Bush Farm and Papercourt Farm experimental sites comprised agricultural land, of grade 3 quality according to the Agricultural Land Classification (ALC) system employed by the Ministry of Agriculture, Fisheries and Food (MAFF). At Papercourt Farm the land was abandoned for much longer before it was restored, but at both sites it has been restored to agriculture. The ALC subgrade of the restored land at both sites is a matter of some dispute between MAFF and outside consultants, partly because the land classification system was not designed to accommodate phenomena such as localised yield suppression due to the effects of landfill gas escaping from the tipped wastes beneath the restored soil layer. The overall ALC grade of the land is not being questioned however, and in both cases it is grade 3, the same as prior to mineral extraction. In the case of Bush Farm it appears that crop yields are now similar to those from nearby unaffected land (ENDS, 1987). At Hatfield Quarry in Hertfordshire, a sand and gravel quarry progressively restored to agriculture, post restoration yields of winter wheat ranged between 8 and 8.4 tonnes ha^{-1} in 1984 whilst mean yields in surrounding unaffected farmland were about 7.25 tonnes ha^{-1} for the same crop (EAU, 1986). At Hatfield Quarry, however, perforated pipes were installed to vent off landfill gas, which were not used at Bush or Papercourt Farms.

The joint restoration experiments were also designed to assess the agricultural performance of the different soil handling treatments. At Bush Farm, however, comparisons suffer from inconsistencies in landfilling practices and the effects of landfill gas emissions. The experiment seems to suggest that there is little difference in the standard of land restored with the earthscraper or dumper and loader methods, and that the quarters reinstated from soil stockpiles perform better than those that were directly moved. The deficiencies in the experimental design mean, however, that these conclusions should not be taken too seriously (McRae, 1987 *pers. comm.*).

The costs incurred during the five year restoration after-care period for an agricultural after-use are likely to vary considerably from year to year depending upon the treatments and cropping systems used. For instance, at the Papercourt Farm site, average annual after-care costs under grass were £470 ha^{-1}, whilst a year under cereals cost £1,000 ha^{-1} at 1987/88 prices (DoE/MAFF/SAGA, 1982b).

Where sites are not restored to agriculture, forestry is a common after-use. Typical costs, at 1987/88 prices, for the restoration of a 10 hectare sand and gravel pit to forestry in Berkshire are given in Table 7.5. These costs have not been discounted.

Table 7.5 Typical costs for the restoration of sand and gravel pits to forestry in southern England and total landscape maintenance costs in the five year after-care period. Constant 1987/88 prices, (£s) (undiscounted).

Operation	**Restoration cost ha^{-1}**
Form ridges, drainage channels and rip using winged tines	2,750
Plants and tree planting costs	600
Total	3,350
Operation	**Maintenance cost ha^{-1}**
Beating up	90
Fertiliser	85
Control gorse	80
Minor weed control	50
Total	305
Total cost over 5 years	**3,655**

In comparison with the costs of reinstatement to agriculture, the costs of restoration to forestry given in Table 7.5 are low. In addition, estates are eligible for Forestry Commission planting grants at £615 ha^{-1} (1987/88 prices). On the other hand, it needs to be borne in mind that a forestry after-use forgoes the considerable profits that can be made from landfilling sites, and that it represents a long term investment in which real rates of economic return are usually low.

7.5 The restoration of deep and opencast coal mines

The legislation enacted under the Town and Country Planning (Minerals) Act of 1981 requires that new opencast and deep mines are progressively restored and not merely abandoned, which would create derelict land. The nature of the operations involved is very similar to that already described in relation to the extraction of sand and gravel discussed above. Both deep and opencast coal mines are most commonly restored to agriculture and forestry.

In the case of opencast coaling, the need to obtain planning permission and to minimise undesirable environmental impacts on the surrounding area has led to the achievement of very high technical standards of restoration, although the visual and biological diversity of the restored landscapes is often low. It has even been suggested that in some cases opencast restoration has increased the productivity of agricultural land (Bradshaw and Chadwick, 1980), although hard evidence to support this contention is difficult to find.

In order to mitigate the problems of noise from machinery and blasting, dust and visual intrusion, opencast coal mines are commonly screened by baffle mounds of stockpiled materials. Since coaling may take a number of years, the void spaces created by mining are not landfilled as this would extend the period of site operations. It is also likely to heighten local opposition to a planning application for a new mine development.

In a modern deep mine operation, the colliery spoil generated by the workings is not merely dumped, but progressively restored. In most respects the operations involved in reinstating such land will be identical to those in the progressive restoration of sand and gravel quarries or opencast coaling. Differences will relate to factors such as the volume of spoil generated requiring burial, the volumes of void space created, and the types of wastes tipped if a site is landfilled. The depth of soils and overburden requiring stripping and reinstatement and the distances they have to be moved via stockpiling or direct placement will also vary on a site by site basis. Costs will also vary where unfavourable weather conditions cause delays in earthmoving operations or diseconomies of scale affect small sites (for example those covering less than 10 hectares).

7.6 Method of analysis

In connection with this study, British Coal was asked to provide economic data on the costs and benefits of restoring deep and opencast mines. This was not, however, made available, because of the possible political sensitivity of such information in relation to the likelihood of obtaining planning permissions for new mine developments.

The approach taken in this study was therefore to estimate costs of land restoration and initial after-care establishment for the progressive restoration of deep mines. The costs derived are necessarily crude and, as explained above, will in reality be complicated by a number of different factors, but it is suggested that they still provide useful indications of the levels of costs involved.

The cost model is presented in Tables 7.6 and 7.7 and the results summarised in Table 7.8. Tables 7.6 and 7.7 comprise a list of the operations carried out in the progressive restoration of deep-mined colliery spoil with their estimated costs. These operations are those specified by British Coal in modern coal tip restoration (NCB, 1983). In the model costs are presented for hypothetical sites of 10 ha and 50 ha, based on the assumption of topsoil stripping to a depth of 20 cm and subsoil stripping to 1 metre. All costs are in constant 1987/88 prices and have not been discounted. Restoration costs were obtained from landscape and construction work contractors and local authority engineers. After-care costs were provided by the opencast executive and, for a 'typical' job, from the Forestry Commission.

7.7 Results and discussion

Costs for the direct movement of soils are slight underestimates because at the beginning of a mining project soil stockpiles are necessary, before the direct movement of stripped soils to areas being reinstated can take place. Table 7.8 shows that in the case of this model, on a cost ha^{-1} basis, direct movement works out as 0.6 of the cost of stockpiling soils, regardless of whether the after-use is forestry or agriculture.

Another interesting finding is that the initial costs of establishing agricultural and forestry after-uses are very similar. The total costs of restoration and establishment for the 10 and 50 ha sites are not exact multiples of each other as there are some minor economies of scale associated with the larger site.

Table 7.6 Estimated costs for the progressive restoration of deep-mined colliery spoil and opencast mines. Constant 1987/88 prices, £s (undiscounted).

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1. Topographic site survey and mapping of planned final contours (prior to mining operations). £5,000 for any site.

10 ha site:	50 ha site:
£5,000	£5,000

2. Site analysis (chemical analysis). £2,000 for any site.

10 ha site:	50 ha site:
£2,000	£2,000

3. Strip topsoil during dry weather and (a) store in mounds (including screening and baffle mounds round the perimeter of the site) or (b) directly move to area being restored. £1.20 m^{-3} (£0.5 m^{-3} stripping, £0.7 m^{-3} deposition on mounds or area being reinstated).

10 ha site:	50 ha site:
£24,000	£120,000

4. Strip subsoil during dry weather and (a) store in mounds (including screening and baffle mounds) or (b) directly move to area being restored. £1.50 m^{-3} (£0.5 m^{-3} stripping, £0.7 m^{-3} deposition on mounds or area being reinstated, £0.3 m^{-3} consolidation).

10 ha site:	50 ha site:
£150,000	£750,000

5. Cultivation and grass seeding of mounds, including the cost of seed. £0.15 m^{-3} for say 10% of each site.

10 ha site:	50 ha site:
£1,500	£7,500

6. Grading of colliery spoil to planned contours using earthscrapers and bulldozers to deposit and consolidate spoil. Assume that the amount of spoil moved equals the quantity of subsoil moved. £0.25 m^{-3}.

10 ha site:	50 ha site:
£25,000	£125,000

7. Application of limestone as a top dressing to spoil at 50 tonnes ha^{-1}. £1,000 ha^{-1}.

10 ha site:	50 ha site:
£10,000	£50,000

8. Deep ripping of limed surface to a depth of 40 cm, using bulldozers pulling winged tines. £500 ha^{-1} (Cat D3).

10 ha site:	50 ha site:
£5,000	£25,000

Table 7.6 (Continued)

9. Removal of large stones and other debris. £40 ha^{-1} (machinery).
10 ha site: £400
50 ha site: £2,000

10. Either (a) replacement of subsoil from storage mounds or (b) direct movement from area being stripped, using earthscrapers (excludes the need for operation 5; reinstatement costs are already included under 3 and 4).

(a) Replacement from storage mounds. £1.50 m^{-3} (as for operation 4).
10 ha site: £150,000
50 ha site: £750,000

11. Ripping of subsoil using either heavy duty agricultural rippers or earthscrapers with ripping attachments. £500 ha^{-1} (Cat D3).
10 ha site: £5,000
50 ha site: £25,000

12. Either (a) replacement of topsoil from storage mounds or (b) direct movement from area being stripped, using earthscrapers (excludes the need for operation 5; reinstatement costs are already included under 3 and 4).

(a) Replacement from storage mounds. £1.20 m^{-3} (as for operation 3).
10 ha site: £24,000
50 ha site: £120,000

13. Testing of topsoil for lime or nutrient deficiencies (chemical analysis). £500 any site.
10 ha site: £500
50 ha site: £500

14. Ripping of soil surface using heavy duty cultivators, disc and power harrows. £500 ha^{-1}.
10 ha site: £5,000
50 ha site: £25,000

15. Seeding using a broadcaster-type spreader or direct-drilling machine, including the cost of seed. £500 ha^{-1}.
10 ha site: £5,000
50 ha site: £25,000

16. Application of NPK compound fertiliser. £200 ha^{-1}.
10 ha site: £2,000
50 ha site: £10,000

17. Final light harrowing and rolling. £100 ha^{-1}.
10 ha site: £1,000
50 ha site: £5,000

Table 7.6 (Continued)

TOTAL COST OF RESTORATION OPERATIONS:
(A) Replacement from storage mounds

10 ha site		50 ha site	
Cost per hectare:	Total cost:	Cost per hectare:	Total cost:
£41,540	£415,400	**£40,940**	£2,047,000
(B) Direct movement			
£23,990	£239,900	**£23,390**	£1,169,500

Table 7.7 Establishment costs of forestry and agricultural after-uses. Constant 1987/88 prices, £s (undiscounted).

(A) Tree planting-commercial forestry (grass established in first year).

1. Ripping of site using a crawler tractor pulling a single, deep ripping, winged tine. £170 ha^{-1} (Cat D8 or equivalent). The ripping and shaping of the site also include all necessary drainage works.

10 ha site:	50 ha site:
£1,700	£8,500

2. Planting of trees, 2 metres apart, giving about 2,500 trees per ha. Labour £505 ha^{-1}, stock 1+1 transplants or Japanese paper pots at 2 metre spacing £310 ha^{-1}. Total £815 ha^{-1}.

10 ha site:	50 ha site:
£8,150	£40,750

3. Fertiliser. Labour £35 ha^{-1}, materials £390 ha^{-1} (50 Kg ha^{-1} triple superphosphate). Total £425 ha^{-1}.

10 ha site:	50 ha site:
£4,250	£21,250

4. Erection of rabbit-proof fencing. £1.50 per linear metre. Assume in each case that the site is comprised of two equal sized fields.

10 ha site:	50 ha site:
£1,889	£4,233

5. Forestry access track. Assume a 3 metre wide stone access track is constructed through the centre of the site. £15 per linear metre.

10 ha site:	50 ha site:
£4,740	£10,605

Note that longer term maintenance costs are not included here (weed control, the maintenance of fences, beating up, cleaning after 7-8 years). Cleaning might cost £210 per hectare, whilst little beating up should be required with good planting.

Total cost of establishing forestry:

10 ha site:	50 ha site:
£20,729	£85,338
Cost per hectare:	Cost per hectare:
£2,073	**£1,707**

Table 7.7 (Continued)

(B) Pasture (grass sown in first year) or arable agriculture (barley sown in first year).

1. Erection of post and wire fencing or hedge planting. Both cost £3.50 per linear metre. Assume in both cases that sites comprise two fields of equal sizes.

10 ha site:	50 ha site:
£4,428	£9,898

2. Land drainage. Assume a herringbone drainage pattern at 12 metre centres, with plastic pipes which are backfilled with gravel to the surface. The pipes have holes in them and are laid by machine in a trenchless method. £1240 ha^{-1}.

10 ha site:	50 ha site:
£12,400	£62,000

3. Initial fertiliser application. £500 ha^{-1}.

10 ha site:	50 ha site:
£5,000	£25,000

4. Farmer's access track. Assume a 3 metre wide stone access track is constructed through the centre of the site. £15 per linear metre. Note that a suitable track may already be available on site, or a farmer will often not require one.

10 ha site:	50 ha site:
£4,740	£10,605

Note that longer term maintenance costs are not included here (weed control, the maintenance of fences or hedges, further fertiliser applications).

Total cost of establishing pasture/arable agriculture:

10 ha site:	50 ha site:
£26,568	£107,503
Cost per hectare:	Cost per hectare:
£2,657	£2,150

Total cost of establishing pasture/arable agriculture without constructing a farmer's access track:

10 ha site:	50 ha site:
£21,828	£96,898
Cost per hectare:	Cost per hectare:
£2,183	£1,938

Table 7.8 Total costs of restoration and establishment to forestry and agriculture. Constant 1987/88 prices (undiscounted). Rounded to the nearest £100.

(A) Commercial forestry

Total cost of restoration and initial forestry establishment

	10 ha site		50 ha site	
	Cost per hectare:	Total cost:	Cost per hectare:	Total cost:
(A) Replacement from storage mounds	£43,600	£436,100	£42,600	£2,132,300
(B) Direct movement	£26,100	£260,600	£25,100	£1,254,800

(B) Agriculture (arable or pasture)

Total cost of restoration and establishment of agriculture

(1) WITHOUT THE CONSTRUCTION OF A FARMER'S ACCESS TRACK

	10 ha site		50 ha site	
	Cost per hectare:	Total cost:	Cost per hectare:	Total cost:
(A) Replacement from storage mounds	£43,700	£437,200	£42,900	£2,143,900
(B) Direct movement	£26,200	£261,700	£25,300	£1,266,400

(2) INCLUDING THE CONSTRUCTION OF A FARMER'S ACCESS TRACK

	10 ha site		50 ha site	
	Cost per hectare:	Total cost:	Cost per hectare:	Total cost:
(A) Replacement from storage mounds	£44,200	£442,000	£43,100	£2,154,500
(B) Direct movement	£26,600	£266,500	£25,500	£1,277,000

7.8 Conclusions

Considerable difficulties were encountered in obtaining costs for the progressive restoration of land and so overall conclusions should be treated with caution. The analyses above do however suggest that the costs of progressively restoring land are comparable, and possibly lower, than the subsequent reclamation of abandoned sites.

Progressive restoration has several advantages over reclamation. It imposes fewer external economic costs such as noise, visual and water pollution upon the environment, and does so for a shorter period of time. Progressive restoration also gives longer for recuperative processes and tree growth to take place and reduces the total area being worked. Furthermore, after-uses can be established whilst mining operations are still continuing. Since soils are reinstated and not lost, agricultural and forestry after-uses may be highly productive.

Where income can be earned from landfill tipping charges, this may be a highly profitable operation, greatly outweighing the cost of restoration. Whether planning permission is granted for the landfilling of sites is likely to depend on a number of non-economic factors such as the past track record of the operators and the strength of local objections.

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CHAPTER 8 RECLAMATION AFTER-CARE

8.1 Introduction

Colliery spoil which has been reclaimed for grazing without the use of topsoil tends to suffer from problems of soil structure, soil texture and deficiencies of both N and P (Bradshaw and Chadwick, 1980). The regression of established vegetation may occur as a result of its recompaction following reclamation (Rimmer and Colbourn, 1978), poor nutrient supply or the regeneration of acidity from spoil.

The application of sewage sludge provides a potential solution to such problems (Hall *et al.*, 1986a; Rimmer and Gildon, 1986). Soil injection of sludge is seemingly attractive because it minimises the likelihood of public complaints about odour and visual aspects, controls surface runoff and has benefits in terms of soil loosening (Hall *et al.*, 1986b). A field experiment was therefore set up to test the relative effectiveness of sludge injection, surface application of sewage sludge, ripping and fertiliser treatments in promoting grass yields on reclaimed but regressing colliery spoil.

8.2 Experimental details

8.2.1 Site

The field experiment was initiated in April 1987 on a grass/clover mix which had been directly established several years earlier on a south facing slope of reclaimed colliery waste which showed signs of vegetation regression. The experimental site was located between Higher Folds and Gin Pit, near Leigh in Greater Manchester (NGR SD 688008).

The dominant grass species in the sward were *Lolium perenne*, *Agrostis capillaris*, *Phleum pratense and Holcus lanatus*. The other major species present was *Trifolium repens*.

8.2.2 Design

The experiment consisted of a detailed nutritional trial superimposed on four major treatments arranged in randomised blocks and replicated three times. The major treatments were:-

C Control (no treatment)

R Ripping ("injection" without sludge)

IL Injection of sewage sludge at low rate (170 m^3 ha^{-1}, 5.5 tds ha^{-1})

IH Injection of sewage sludge at high rate (340 m^3 ha^{-1}, 11 tds ha^{-1})

On the control (C) and ripping (R) major treatments, i) a partial factorial of 3 rates of N and 3 rates of P fertiliser was established, and ii) surface sludge from the same source applied at the same rates as those used in the injection operations (SL and SH). On the low (IL) and high (IH) injection treatments, control plots and control plots with 75 Kg ha^{-1} K were set up to make many treatment comparisons. All treatments were replicated three times. Full details of the design are given in Table 8.1.

8.2.3 Management of the experiment

Liquid digested sewage sludge was injected in late April 1987 when ground conditions were sufficiently dry to support machinery.

"Paraplow" soil injection equipment with three in-line tines spaced at 0.58 m centres was used to inject sludge to a depth of about 22.5 cm (Plate 19). Injection of the major treatment plots was undertaken in a downhill direction only. The plots were then rolled; for the low injection rate this was immediately after injection and for the higher rate a few hours later.

Table 8.1 Details of experimental treatments (fertilizer application rates in kg ha^{-1}). Sewage sludge low application rate = 170m^3 ha^{-1}; high rate = 340m^3 ha^{-1}

		N	P	K	
Control major treatments (C)		N	P	K	
C 0 0 0	=	0	0	0	Fertiliser
C 0 75 0	=	0	75	0	Fertiliser
C 0 150 0	=	0	150	0	Fertiliser
C 150 0 75	=	150	0	75	Fertiliser
C 150 75 75	=	150	75	75	Fertiliser
C 150 150 75	=	150	150	75	Fertiliser
C 300 0 150	=	300	0	150	Fertiliser
C 300 75 150	=	300	75	150	Fertiliser
C 300 150 150	=	300	150	150	Fertiliser
CSL 75K =	Surface sludge at low rate plus 75 K fertiliser				
CSH 75K =	Surface sludge at high rate plus 75 K fertiliser				
Ripping major treatments (R)		N	P	K	
R 0 0 0	=	0	0	0	Fertiliser
R 0 75 0	=	0	75	0	Fertiliser
R 0 150 0	=	0	150	0	Fertiliser
R 150 0 75	=	150	0	75	Fertiliser
R 150 75 75	=	150	75	75	Fertiliser
R 150 150 75	=	150	150	75	Fertiliser
R 300 0 150	=	300	0	150	Fertiliser
R 300 75 150	=	300	75	150	Fertiliser
R 300 150 150	=	300	150	150	Fertiliser
RSL 75K =	Surface sludge at low rate plus 75 K fertiliser				
RSH 75K =	Surface sludge at high rate plus 75 K fertiliser				
Injection of sewage sludge at low rate major treatments (IL)					
ILC	=	0	0	0	Fertiliser
IL 75K	=	0	0	75	Fertiliser
Injection of sewage sludge at high rate major treatments (IH)					
IHC	=	0	0	0	Fertiliser
IH 75K	=	0	0	75	Fertiliser

Plate 19. Soil injection of sewage sludge at Higher Folds, April 1987.

Plate 20. Experimental plots, August 1987.

Liquid digested sludge was applied by bucket to the surface sludge plots shortly after soil injection operations were completed. The major treatments were arranged in blocks of 10 x 20 m. Individual plot size was 2.2 x 3.6 m, of which 1 x 2.4 m was harvested in 1987 and 0.97 x 3.6 m harvested in 1988, these being functions of tine spacing.

Fertiliser dressings were broadcast by hand. Fertiliser P as superphosphate and K as potassium sulphate were applied in early May 1987. Applications of fertiliser N as ammonium nitrate were split, being broadcast in early May, and after the first and second harvests in the first year. The experiment was harvested in mid June, early August, mid September and late October of 1987 using a rotary mower (Plate 20).

No sludge or fertiliser applications were made in 1988 to compare the residual yields from the different treatments. Plots were harvested in late June and early November using a reciprocating blade mower.

The fresh weights of harvested grass were determined in the field and sub samples taken. These were then oven dried for seven days at 70 ^{0}C and reweighed for dry matter determination. The percentage dry weights thus obtained were then used to calculate field dry weights.

In addition to the yield assessments, the percentage cover of white clover in the plots was estimated in mid July 1988 to see if there was a relationship between the treatments applied and the presence of clover. After calibration using a point quadrat, the percentage cover of clover was assessed visually for each plot as the mean of five readings using a 0.5 x 0.5 m quadrat.

8.3 Results

8.3.1 First harvest, first year

Owing to the unbalanced nature of the overall design, the experimental plots on the C and R major treatments were analysed separately, using the appropriate analysis of variance (ANOVA) model for a split-plot randomised block design. Table 8.2 shows that at the first harvest, there was no statistically significant difference between dry matter yields on the C and R main plots, and no significant interaction between main and sub plots. There were, however, statistically significant differences at the sub plot (individual treatment) level.

Table 8.2 Analysis of variance of yield (Kg ha^{-1}) for first harvest only, first year, C and R major treatments only.

Analysis of variance					
Source	SS	DF	MS	F	P
Blocks	8,485,949	2	4,242,974	16.9	0.0001
Main Plots	984,924	1	984,924	4.2	0.1771
Main Plot Error (A)	469,726	2	234,863		
Sub Plots	15,234,600	10	1,523,600	6.1	0.0001
Main x Sub	3,376,780	10	337,678	1.3	0.2435
Error (B)	9,550,319	38	251,324		
Total	38,102,298	63	604,798		

Since there was no significant difference between yields on the C and R main plots, the data was combined at the sub plot level, giving 6 replicates for each treatment, except where there were missing values. This is shown in Fig 8.1 together with Waller-Duncan's k-ratio T Test with k=100, which approximates to a 5% significance level. This test was used because it is less conservative than other multiple range tests (Chew, 1976; Smith, 1978; Chew, 1980; SAS, 1985).

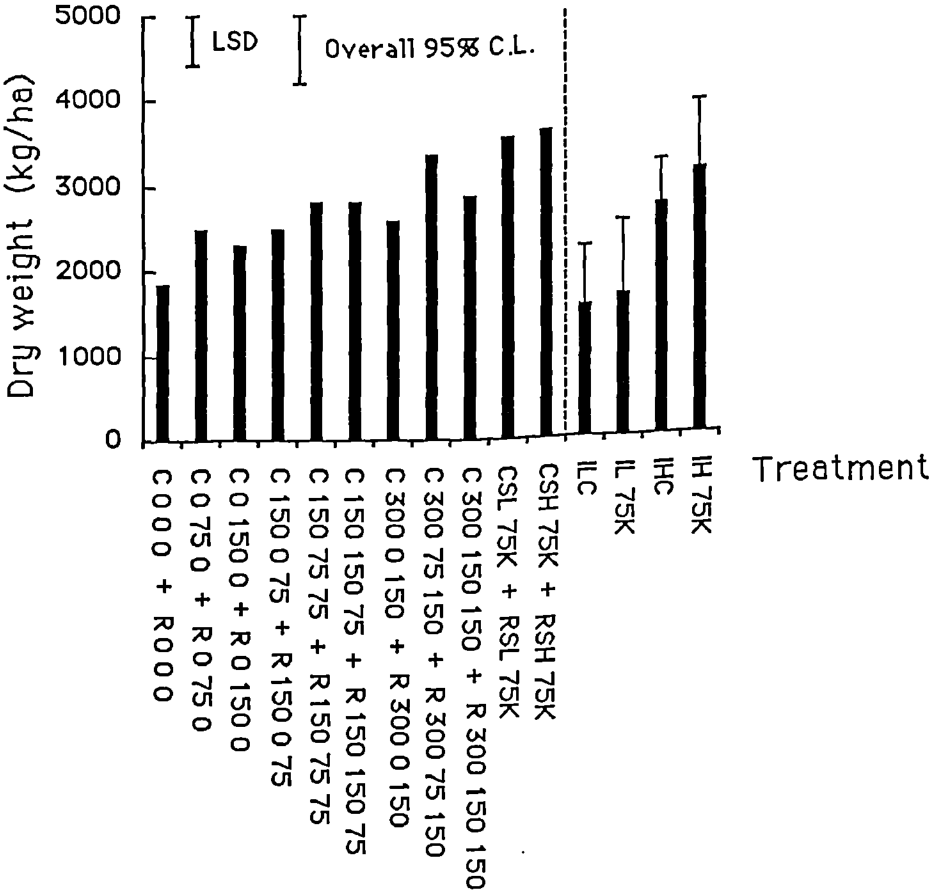

Fig. 8.1 Yield of a grass/clover mix on reclaimed but regressing colliery spoil, Higher Folds field experiment, 1987, at first harvest. Error bars are Waller-Duncan's k-ratio T test with k=100 approximating to $p < 0.05$ and an overall 95% confidence limit on the left hand side of the figure and 95% confidence limits on the right hand side of the figure. For details of treatments see Table 8.1.

The IL and IH major treatments are also shown in Fig. 8.1. The unbalanced nature of the experimental design means that these could not be included in an overall ANOVA model, and 95% confidence limits have been plotted for these treatments instead. These can be compared with the overall 95% confidence limit presented on the left hand side of Fig. 8.1.

As regards the C and R major treatments, the highest yield was recorded in the CSH 75K + RSH 75K treatment, followed by the CSL 75K + RSL 75K treatment and the C 300 75 150 + R 300 75 150 treatment (Fig 8.1). All three of these treatments gave yields of over 3,000 Kg ha^{-1}, almost doubling that produced in the lowest-yielding control (C 0 0 0 + R 0 0 0) treatment at the first harvest.

There is some evidence that yields in the C 0 0 0 + R 0 0 0, C 150 0 75 + R 150 0 75 and C 300 0 150 + R 300 0 150 treatments have been suppressed by a deficiency of P. Thus the C 0 75 0 + R 0 75 0 treatment was statistically significantly higher than the C 0 0 0 + R 0 0 0 treatment and the C 300 75 150 + R 300 75 150 treatment significantly outperformed the C 300 0 150 + R 300 0 150 treatment. However, the C 150 75 75 + R 150 75 75 treatment was not significantly greater than the C 150 0 75 + R 150 0 75 treatment (Fig 8.1).

ANOVA was also used to contrast the performance of the C 0 0 0, R 0 0 0, ILC and IHC treatments. There were no significant differences between these treatments. This suggests that the injection of sewage sludge was not an effective treatment at the first harvest, despite liquid digested sludge's quick acting properties (Hall *et al.*, 1986a).

It appears that surface applications of sludge were the most effective treatments in terms of yield at the first harvest.

It needs to be remembered, however, that only one third of fertiliser N had been applied at this stage.

8.3.2 Total yield in the first year

Table 8.3 shows that as regards total yield in the first year, although there was a significant interaction between main and sub plots, there was no statistically significant difference between dry matter yields on the C and R main plots. There were statistically significant differences at the sub plot level.

Table 8.3 Analysis of variance of yield (Kg ha^{-1}) for all harvests combined, first year, C and R major treatments only.

Analysis of variance					
Source	SS	DF	MS	F	P
Blocks	28,174,789	2	14,087,394	24.8	0.0001
Main Plots	26,873,914	1	26,873,914	6.8	0.1215
Main Plot Error (A)	7,945,980	2	3,972,990		
Sub Plots	121,245,527	10	12,124,553	21.3	0.0001
Main x Sub	15,546,668	10	1,554,667	2.7	0.0122
Error (B)	21,590,853	38	568,180		
Total	221,377,731	63	3,513,932		

Since there was no significant difference between yields on the C and R main plots, the data was combined at the sub plot level, giving 6 replicates for each treatment. This is shown in Fig 8.2 together with Waller-Duncan's k-ratio T Test with k=100, which approximates to a 5% significance level, and 95% confidence limits.

As regards the C and R major treatments, the highest yield was recorded in the C 300 75 150 + R 300 75 150 treatment, followed by the CSH 75K + RSH 75K treatment and the C 300 150 150 + R 300 150 150 treatment. All these treatments gave yields of over

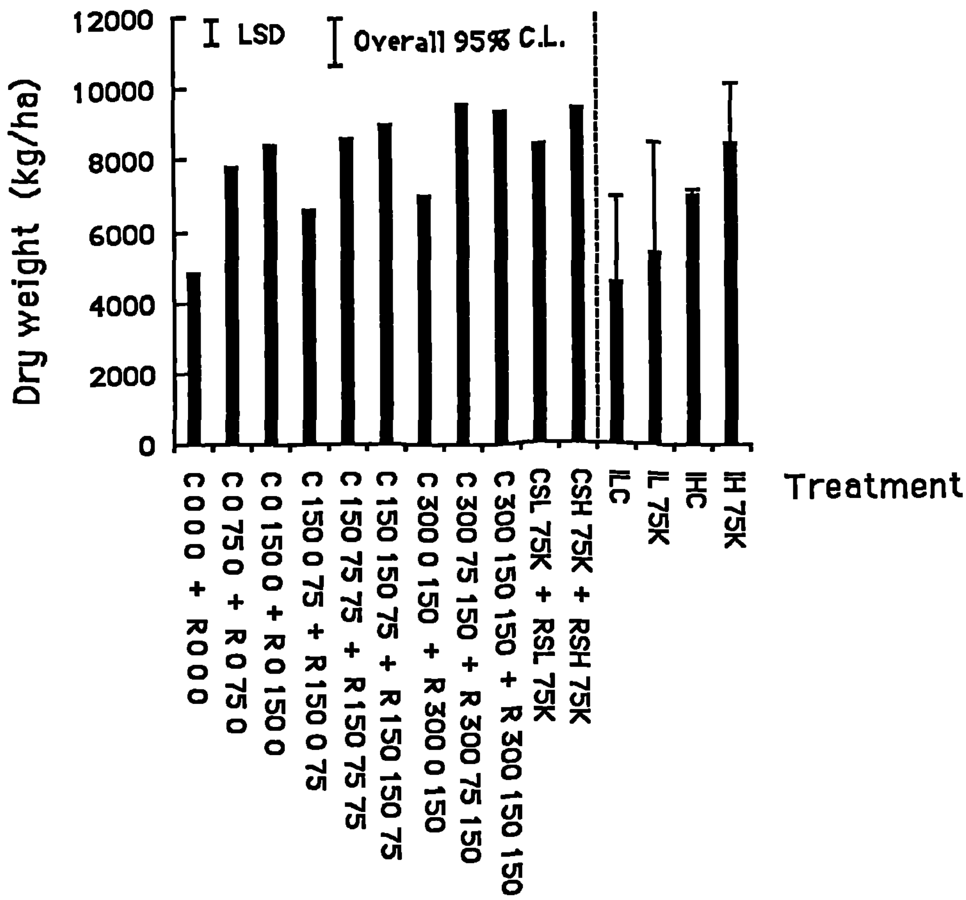

Fig. 8.2 Yield of a grass/clover mix on reclaimed but regressing colliery spoil, Higher Folds field experiment, 1987, all harvests combined. Error bars are Waller-Duncan's k-ratio T test with k=100 approximating to $p < 0.05$ and an overall 95% confidence limit on the left hand side of the figure and 95% confidence limits on the right hand side of the figure. For details of treatments see Table 8.1.

9,000 Kg ha^{-1}, approximately double that produced in the lowest-yielding control (C 0 0 0 + R 0 0 0) treatment. Yields of this magnitude compare favourably with grass yields from normal agricultural soils. For example, in an experiment carried out on S.23 perennial ryegrass at 21 sites throughout England and Wales over four harvest years on normal agricultural soils, applications of fertiliser N at 300 Kg ha^{-1} N produced a mean yield of 9,700 Kg ha^{-1} (Morrison *et al.*, 1980).

There is strong evidence that yields in the C 0 0 0 + R 0 0 0, C 150 0 75 + R 150 0 75 and C 300 0 150 + R 300 0 150 treatments, which were the lowest yielding on the C and R major treatments, have been suppressed by a deficiency of P. Thus the C 0 75 0 + R 0 75 0 treatment was statistically significantly higher than the C 0 0 0 + R 0 0 0 treatment, the C 150 75 75 + R 150 75 75 treatment significantly greater than the C 150 0 75 + R 150 0 75 treatment, and the C 300 75 150 + R 300 75 150 treatment significantly outperformed the C 300 0 150 + R 300 0 150 treatment (Fig 8.2).

ANOVA was used to contrast the performance of the C 0 0 0, R 0 0 0, ILC and IHC treatments. There was a significant treatment effect ($p < 0.05$) in the overall ANOVA model. In terms of comparisons made with Waller-Duncan's k-ratio T Test, with k=100, which approximates to a 5% significance level, the IHC treatment gave significantly higher yields than the ILC and C 0 0 0 treatments, but not the R 0 0 0 treatment. However, the IHC treatment produced a yield of only about 6,950 kg ha^{-1}, which was exceeded by all treatments on the C and R major treatments except C 0 0 0 + R 0 0 0 and C 150 0 75 + R 150 0 75. The ILC treatment yielded only about 4,500 kg ha^{-1}. Possible reasons for the ineffectiveness of the injection treatment are considered later.

A comparison of the ILC with the IL 75K treatment mean and the IHC with the IH 75K treatment suggests that for the IL and IH major treatments there was a K effect of some 900 and 1,400 Kg ha^{-1} respectively in terms of yield. This was not, however, statistically significant (Fig 8.2).

8.3.3 Residual yields in the second year

Table 8.4 shows that as regards the residual yields produced in the second year from the first year treatments, there were statistically significant differences between dry matter yields on the C and R main plots but no significant interaction between main and sub plots. There were also statistically significant differences at the sub plot level.

Table 8.4 Analysis of variance of yield (Kg ha^{-1}) for residual yield, second year, C and R major treatments only.

Analysis of variance					
Source	SS	DF	MS	F	P
Blocks	30,998,679	2	15,499,340	48.4	0.0001
Main Plots	11,319,733	1	11,319,733	58.0	0.0168
Main Plot Error (A)	390,194	2	195,097		
Sub Plots	35,260,016	10	352,600	11.0	0.0001
Main x Sub	3,120,871	10	312,087	1.0	0.4814
Error (B)	12,177,844	38	320,470		
Total	93,267,337	63	1,480,434		

Since there were significant differences between yields on the C and R main plots, individual treatment means are shown in Fig. 8.3, together with Tukey's Studentised range (honestly significant difference) test at the 5% significance level and 95% confidence limits. Waller-Duncan's k-ratio T Test was not computed because the F ratio was too small.

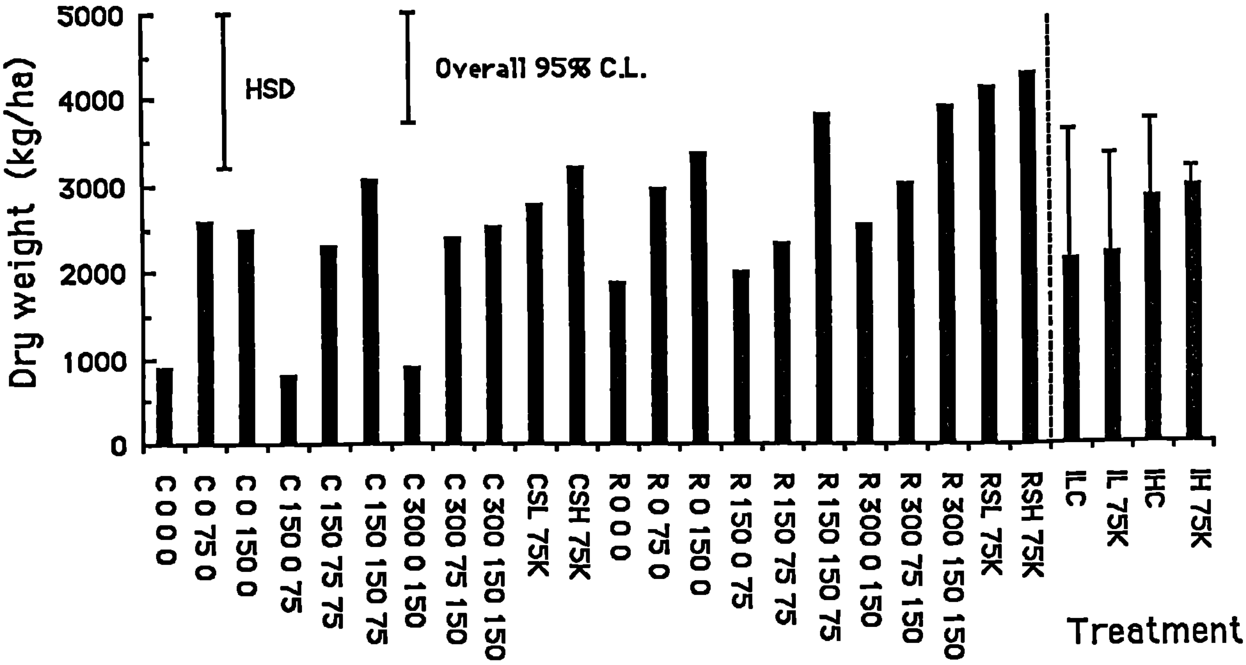

Fig. 8.3 Residual yield of grass/clover mix on reclaimed but regressing colliery spoil, Higher Folds field experiment, 1988, both harvests combined. Error bars are Tukey's H.S.D. test at $p < 0.05$ and an overall 95% confidence limit on the left hand side of the figure and 95% confidence limits on the right hand side of the figure. For details of treatments see Table 8.1.

As regards the C and R major treatments, the highest yield was recorded in the RSH 75K treatment, followed by the RSL 75K treatment and the R 300 150 150 treatment. Only the RSH 75K and RSL 75K treatments gave yields of over 4,000 Kg ha^{-1}, approximately five times that produced in the lowest-yielding C 150 0 75 treatment.

Although not statistically significant, there is again a suggestion that yields in the C 0 0 0, C 150 0 75, C 300 0 150, R 0 0 0, R 150 0 75 and R 300 0 150 treatments have been limited by a deficiency of P. This is not surprising considering that these plots did not receive any P for two years. Acid colliery spoil has the ability to immobilise P but, as a result of heavy liming during reclamation, the spoil at the experimental site was not acidic, with a mean pH of 7.5 (Hall and Kichenside, 1988). Experiments need to be set up at a number of field sites to investigate this further.

ANOVA was used to contrast the performance of the C 0 0 0, R 0 0 0, ILC and IHC treatments. There were no significant differences between these treatments. The IHC treatment produced a yield of about 2,800 kg ha^{-1}, whilst the ILC treatment yielded only about 2,100 kg ha^{-1}.

A comparison of the ILC with the IL 75K treatment and the IHC with the IH 75K treatment suggests that for the IL and IH major treatments there was a small K effect of some 60 and 130 Kg ha^{-1} respectively in terms of yield. This was not statistically significant (Fig. 8.3).

8.3.4 Percentage cover of clover in the second year

Table 8.5 shows that as regards the percentage cover of white clover in the second year, there was no statistically significant difference between cover on the C and R main plots, and no significant interaction between main and sub plots. There were, however, statistically significant differences at the sub plot level.

Table 8.5 Analysis of variance of percentage cover of clover, July 1988, C and R major treatments only.

Analysis of variance

Source	SS	DF	MS	F	P
Blocks	2,112	2	1,056	3.2	0.0517
Main Plots	2,249	1	2,249	4.4	0.1711
Main Plot Error (A)	1,024	2	512		
Sub Plots	9,078	10	908	2.8	0.0117
Main x Sub	1,834	10	183	0.6	0.8380
Error (B)	12,518	38	329		
Total	28,815	63	457		

Since there was no significant difference between the cover of clover on the C and R main plots, the data was combined at the sub plot level, giving 6 replicates for each treatment. This is shown in Fig 8.4 together with Waller-Duncan's k-ratio T Test with k=100, which approximates to a 5% significance level, and 95% confidence limits.

As regards the C and R major treatments, the highest level of clover cover was recorded on the C 0 150 0 + R 0 150 0 treatment, followed by the C 0 0 0 + R 0 0 0 treatment and the C 0 75 0 + R 0 75 0 treatment, all of which had mean cover of over 50%. These constitute the fertiliser treatments in which no N was applied. They were statistically significantly different from the three treatments with the lowest percentage cover of clover. These were the C 300 150 150 + R 300 150 150, C 300 75 150 + R 300 75 150 and C 300 0 150 + R 300 0 150 treatments, all of which had less than 25%

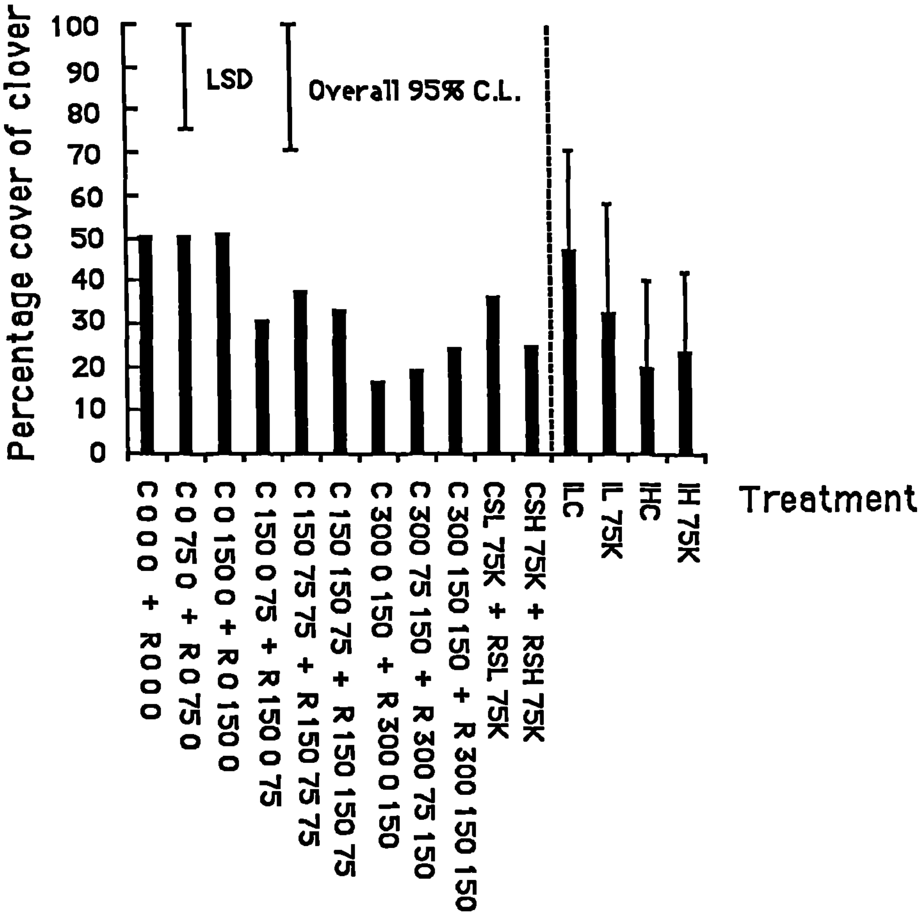

Fig. 8.4 Percentage cover of clover, Higher Folds field experiment, July 1988. Error bars are Waller-Duncan's k-ratio T test with k=100 approximating to $p < 0.05$ and an overall 95% confidence limit on the left hand side of the figure and 95% confidence limits on the right hand side of the figure. For details of treatments see Table 8.1.

clover cover. Since these are the fertiliser treatments in which N was applied at 300 Kg ha^{-1} it seems that the percentage cover of clover on the C and R major treatments is inversely related to the amount of N applied.

ANOVA was used to contrast the cover of clover on the C 0 0 0, R 0 0 0, ILC and IHC treatments. There was a significant treatment effect ($p < 0.05$) in the overall ANOVA model. In terms of comparisons made with Waller-Duncan's k-ratio T Test, with k=100, which approximates to a 5% significance level, the C 0 0 0, R 0 0 0 and ILC treatments all had significantly higher clover cover than the IHC treatment. This again suggests that clover cover decreases when the input of N increases, apparently because the addition of N stimulates grass growth at the expense of clover.

8.3.5 Nitrogen uptake

Estimated yield uptake of N has been calculated from the yield data, sludge analysis and application rates given in Table 8.6, and herbage analyses (Hall and Kichenside, 1988). Yield uptake of N for the first year is shown in Table 8.7. This assumes a 2% N content in vegetation, and that available N equals 100% inorganic N applied plus 15% organic N (Hall *et al.*, 1986a). Table 8.7 suggests that if the net uptake of N over and above that in the control treatment is considered, this was less than its expected availability from the sludge for seven of the eight sludge treatments, and especially low for the IL treatments. The figures for the net uptake of N as a percentage of expected available N suggest that whereas in the surface sludged plots a high proportion of N is being taken up by vegetation, in the injected treatments much of it is being wasted. This seems to be because injection supplies sludge at too great a depth to benefit plant rooting systems, an argument which is further developed below.

Table 8.6 Sludge analysis and application rates, from Hall and Kichenside (1988)

Analysis		Application rates IL	IH	
		170	340	$m^3\ ha^{-1}$
Dry solids (ds)	3.24 %	5.5	11	tds ha^{-1}
NH3	450 mgl^{-1}	76.5	153	Kg ha^{-1}
Organic N	3.18 %	174.9	349.8	Kg ha^{-1}
P	1.42 %	78.1	156.2	Kg ha^{-1}

Table 8.7 Estimated N uptake (Kg ha^{-1}) in sludged plots, including that over and above uptake in the control treatment in the first year

	Treatment Surface applied sludge				Injected sludge			
	CSL 75K	CSH 75K	RSL 75K	RSH 75K	ILC	IL 75K	IHC	IH 75K
Yield (Kg ha^{-1})	7396	8222	9670	10945	4484	5359	6951	8381
Increase in yield (Kg ha^{-1}) over control	3717	4543	5991	7266	805	1680	3272	4702
Available N applied (Kg ha^{-1})	103	205	103	205	103	103	205	205
Estimated N uptake (Kg ha^{-1})	148	164	193	219	90	107	139	168
Increase over estimated uptake in control (Kg ha^{-1})	82	98	127	153	24	41	73	101
Net uptake of N as % of available N	80%	48%	123%	75%	23%	40%	36%	49%

The amount of N supplied by sludge in the first year of the experiment was limited. The level of expected available N in the first year was only about 100 and 200 Kg ha^{-1} N for the low and high rates of sludge application respectively.

Estimated yield uptake of N for the second year is shown in Table 8.8. This again assumes a 2% N content in vegetation, and that available N equals 15% of the remaining organic N (Hall *et al.*, 1986a). Table 8.8 indicates that if the net uptake of N over and above that in the control treatment is considered, this exceeds its expected availability from the sludge for six of the eight sludge treatments. This suggests that the model assumed by Hall *et al.* underestimates the rate at which organic N is mineralised and that N availability was actually higher than postulated. In the Hall *et al.* model, only around 20 and 45 Kg ha^{-1} N is made available in the second year of the experiment from the low and high rates of sludge application respectively.

Table 8.8 Estimated N uptake (Kg ha^{-1}) in sludged plots, including that over and above uptake in the control treatment in the second year

	Treatment Surface applied sludge				Injected sludge			
	CSL 75K	CSH 75K	RSL 75K	RSH 75K	ILC	IL 75K	IHC	IH 75K
Yield (Kg ha^{-1})	2774	3228	4134	4294	2129	2192	2838	2964
Increase in yield (Kg ha^{-1}) over control	1874	2328	3234	3394	1229	1292	1938	2064
Available N applied (Kg ha^{-1})	22	45	22	45	22	22	45	45
Estimated N uptake (Kg ha^{-1})	55	65	83	86	43	44	57	59
Increase over estimated uptake in control (Kg ha^{-1})	39	48	66	70	26	28	41	43
Net uptake of N as % of available N	177%	107%	300%	155%	118%	127%	91%	73%

8.3.6 Rooting study

In order to investigate whether there were relationships between the treatments that were applied and the resultant rooting systems of the surface vegetation, soil samples were taken for a selection of the experimental treatments in early May 1989, in the third year of the field trial. Cores were extracted in the field with a soil corer and subdivided in the field into 0-6, 6-12 and 12-18 cm subsamples to enable the depth distribution of root length cm^{-3} of soil to be determined. These depths were chosen on the basis of a number of soil pits that were dug, which indicated that there were virtually no roots penetrating below 18 cm in the colliery spoil substrate.

Root length was estimated by a modified line intersect method (Tennant, 1975). The depth distribution of total root length for all treatments studied is shown in Fig. 8.5. These treatments are set out in Fig. 8.6. In the case of plots established on the R and IH major treatments, soil cores were taken from both the area of the injection slot and the gaps between them. There were three replicates per treatment, except where it was not possible to take a full set of samples.

Fig. 8.5 indicates that roots are overwhelmingly concentrated in the top 6 cm of the soil, a finding that has been reported previously, albeit for freshly reclaimed colliery spoil (Fitter and Bradshaw, 1974). This is despite the fact that reclamation was carried out at the experimental site around ten years ago. The differences in root length with depth shown in Fig. 8.5 are statistically significant at the $p < 0.001$ level using Tukey's Studentised range test on log transformed data.

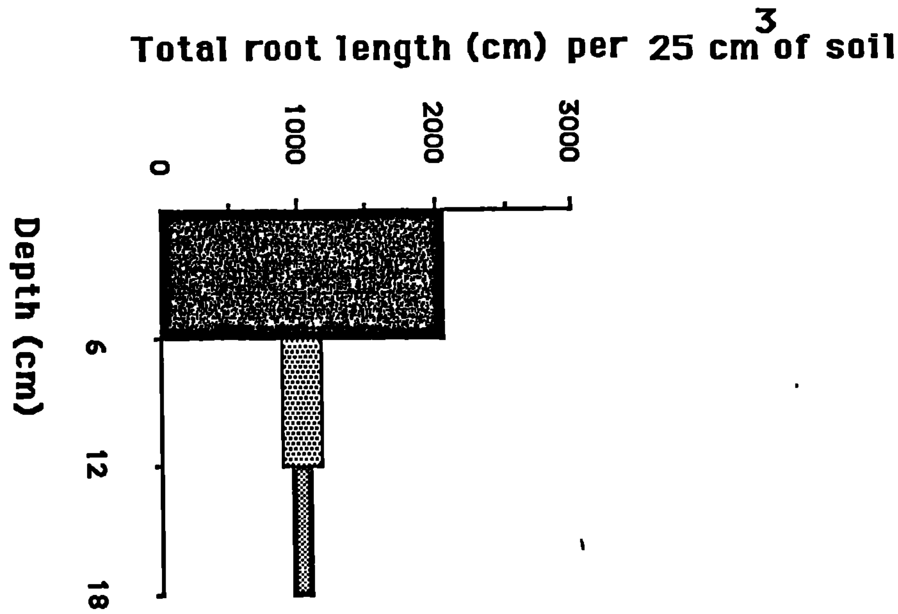

Fig. 8.5 The depth distribution of root length, for nine treatments combined, allowing for missing data, Higher Folds, 1989.

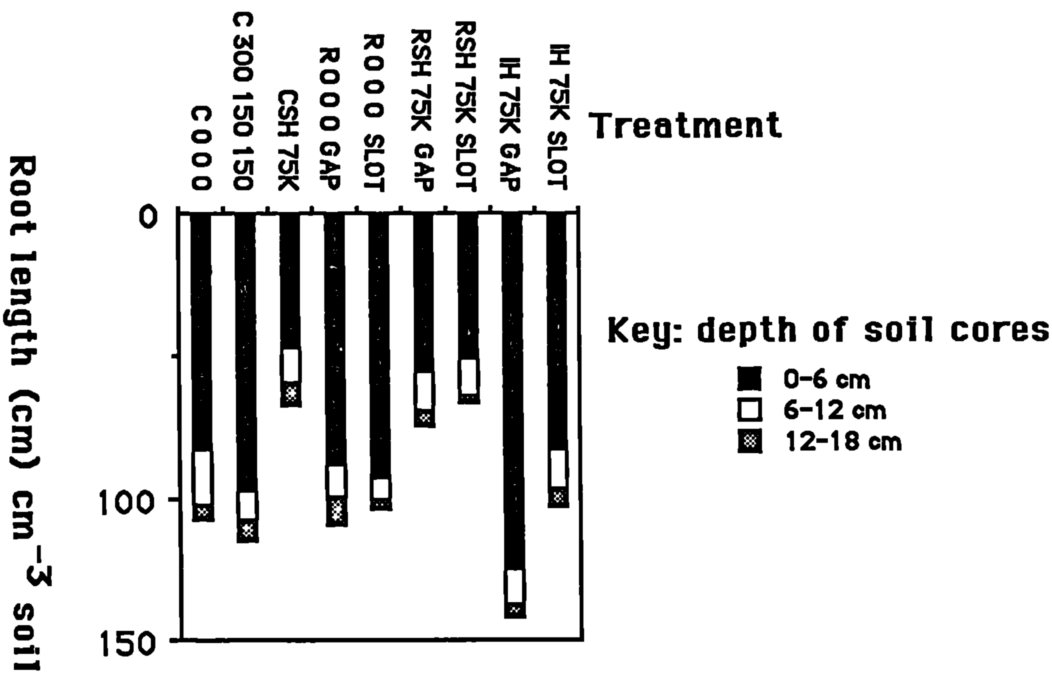

Fig. 8.6 The depth distribution of root length in selected treatments, Higher Folds field experiment, 1989.

The reason why rooting systems are largely confined to the surface layer of the soil appears to be soil compaction. In a survey of 12 reclaimed colliery spoil heaps in northern England, Rimmer (1982) showed that soil bulk density tended to increase markedly with depth from approximately 1.2 g cm^{-3} in the surface 0-5 cm layer to some 1.8 g cm^{-3} immediately below it. Rimmer (1979) has also identified 'threshold' soil bulk densities of 1.4-1.5 g cm^{-3}, above which root growth in colliery shale is reduced. At the experimental site, the soil bulk density on the control (C) major treatment was 1.6 g cm^{-3} which is above the threshold density. In the R and IH major treatments, however, soil bulk densities were reduced to 1.2 and 1.3 g cm^{-3} respectively (Hall and Kichenside, 1988).

ANOVA indicated that there were no significant differences between treatment means at any of the three discrete depths of soil (Tables 8.9-8.11, Fig. 8.6). The fact that the rooting study was not undertaken until the third year of the experiment may have contributed to this. For those plots established on the R or IH major treatments, there is a suggestion that root length cm^{-3} of soil is lower in the injection slot as opposed to the surrounding 'gap' areas. This may reflect the destruction of root systems that accompanies sludge injection. The differences in root length with depth illustrated in Fig. 8.6 are statistically significant at the $p = 0.0001$ level in an overall ANOVA model (Table 8.12).

Table 8.9 Analysis of variance of root length (cm) cm^{-3} of soil, 0-6 cm depth only, May 1989.

Analysis of variance (log transformation)

Source	SS	DF	MS	F	P
Treatments	0.3535	8	0.0442	1.1	0.4137
Blocks	0.1262	2	0.0631	1.6	0.2402
Error	0.5584	14	0.0399		
Total	1.0381	24	0.0433		

Table 8.10 Analysis of variance of root length (cm) cm^{-3} of soil, 6-12 cm depth only, May 1989.

Analysis of variance

Source	SS	DF	MS	F	P
Treatments	306	8	38	0.8	0.6030
Blocks	815	2	408	8.7	0.0036
Error	659	14	47		
Total	1,780	24	74		

Table 8.11 Analysis of variance of root length (cm) cm^{-3} of soil, 12-18 cm depth only, May 1989.

Analysis of variance

Source	SS	DF	MS	F	P
Treatments	100	8	12	1.3	0.3348
Blocks	100	2	50	5.2	0.0240
Error	116	14	8		
Total	316	24	13		

Table 8.12 Analysis of variance of root length (cm) cm^{-3} of soil, all depths combined, May 1989.

Analysis of variance (log transformation)

Source	SS	DF	MS	F	P
Treatments (T)	0.3267	8	0.0408	0.6	0.7986
Depth (D)	18.0371	2	9.0186	125.3	0.0001
T*D	1.1764	16	0.0735	1.0	0.4539
Blocks	1.5072	2	0.7536	10.5	0.0002
Error	3.1671	44	0.0720		
Total	24.2145	72	0.3363		

The marked concentration of root length in the surface layers of the colliery waste substrate is likely to have been a major factor in the poor performance of sludge injected plots compared with the surface sludge treatments. This is because injection was undertaken to a depth of some 22 cm, which is too deep to be of benefit to the rooting systems of plants. Surface application, on the other hand, releases sludge into the uppermost layers of the soil. It also has the advantages over injection that sludge is distributed evenly across a piece of land and that it does not cause localised sward dieback along an injection slot.

8.4 Economic considerations

From an economic point of view, the costs of applying different agricultural treatments must be weighed against their benefits in terms of promoting yield (output). Therefore an analysis is needed which evaluates the trade-offs between cost and yield.

An economic analysis of a selection of the treatments used in the field experiment is shown in Fig. 8.7. The treatments that were selected for inclusion were those that might realistically be undertaken in an actual farming context. The overall control (C 0 0 0) treatment was also included, to examine the effectiveness of not applying any nutrient inputs at all.

The economic model used assumes that a farmer initially owns a dairy farm of some 50 hectares. This is a typical size for a medium sized specialist dairy farm in England (Spedding, 1983). In the model the farmer then decides to expand onto an area of 50 hectares of reclaimed pasture. As a consequence, the fixed costs that the farmer incurs on the reclaimed land are marginal fixed costs.

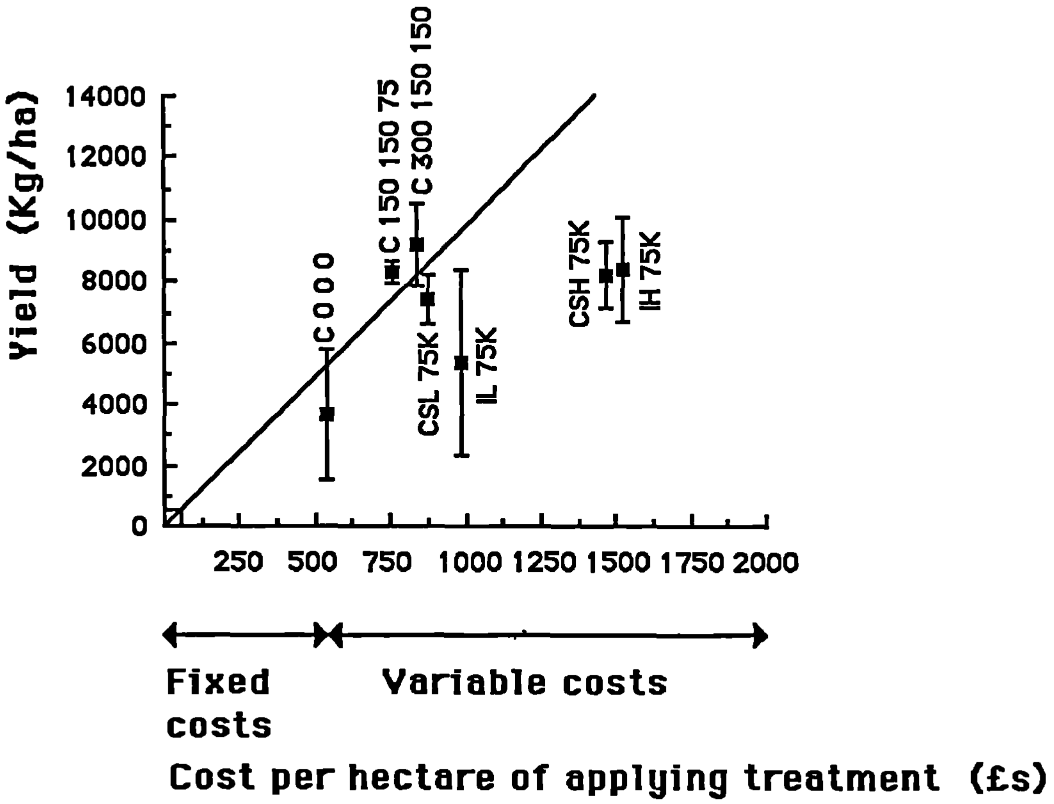

Fig. 8.7 Relationship between estimated costs of applying fertiliser, surface and injected sewage sludge and annual yield. Error bars are 95% confidence limits. For details of treatments see Table 8.1.

The annual marginal fixed costs of farming reclaimed grazing land were estimated using Nix and Hill (1988) and information supplied by the tenant farmer at the experimental site. They include the costs of paid and unpaid farm labour, power and machinery, renting reclaimed grazing land, general farm overheads and the cost of harvesting a grass crop. Power and machinery costs comprise the cost of depreciation, repairs, fuel and oil, unallocated contract charges and vehicle insurance. Vehicle tax was excluded from the analysis as it represents a financial transfer rather than a real resource cost. Tractor fuel is not taxed.

For the purposes of this analysis it was assumed that the land was being mown rather than grazed and grass made into silage. The cost of harvesting was therefore taken to be a typical contract charge for forage harvesting, carting and ensiling grass (Nix and Hill, 1988). Harvesting costs were treated as fixed rather than variable costs because the equipment used and time taken in harvesting the grass crops is likely to be essentially fixed across the different treatments shown in Fig. 8.7. There may be slight variations across treatments but these are likely to be very small in relation to the overall analysis.

All costs have been adjusted to 1989 prices. Fixed costs must be included in the analysis because they represent overheads i.e. costs which in the short run do not vary with output. Fixed costs were estimated on this basis to be of the order of £540 ha^{-1} $year^{-1}$, but this is clearly only a broad figure which will vary widely depending on many factors, particularly the intensity of farming (Nix and Hill, 1988).

The variable costs associated with applying the different treatments were estimated with the help of contractors' cost information, fertiliser wholesalers and Nix and Hill (1988). In the case of fertilisers, quotations were sought for nitram, triple superphosphate and muriate of potash because these represented the best buys. Fertiliser application costs include the costs of the materials themselves, delivery, and application by spinner. As in the field experiment, it is assumed that nitram is applied on three separate occasions. All costs are exclusive of VAT since this is a tax rather than a real resource cost.

It should be noted that the cost of fertilisers varies by some 10% depending on the time of year they are ordered (Nix and Hill, 1988). Fertiliser prices are also lower for bulk orders. In the economic model, contractors' costs were obtained for hypothetical fields of 10 hectares for each of the fertiliser and sludge treatments, to allow for such economies of scale.

Sewage sludge application costs were obtained from contractors specialising in this type of work and include the cost of transporting sludge 16 km (ten miles) to field, and its application to the soil surface or by injection. The work of Byrom (1984) suggests that on average the maximum distance that Water Authorities in England and Wales are willing to transport sludge free of charge is around 12.5 km (8 miles).

It is assumed that sludge is applied to the CSL 75K treatment using a road tanker running on, which is cheaper than using a tractor and spreader or irrigation reel, and to the CSH 75K treatment with an irrigation reel, because of the need to apply large volumes of sludge. The economic model assumes that sludge is applied to the IL 75K and IH 75K treatments using a tractor drawn injector.

It is assumed that sludge is provided free of charge. Where sludge is applied by injection, the cost of rolling the land afterwards has been included. All variable costs have been adjusted to 1989 prices. The costs obtained for the application of sewage sludge are based on contractors' charges and so are likely to be higher than typical farmers' costs.

Fig. 8.7 shows the relationship between yield and cost for seven different treatments over a single growing season. Yields have been taken from the first year results of the field experiment. The economic aim is to maximise the ratio of yield/cost and a 45° line has been added for clarity in Fig. 8.7. Some of the different treatments can be distinguished from each other on the basis of yield/cost ratios, taking into account the vertical error bars that have been plotted. Thus the C 150 150 75 treatment was significantly more cost effective than the CSL 75K, IL 75K, CSH 75K and IH 75K treatments, the C 300 150 150 treatment was more economic than the IL 75K, CSH 75K and IH 75K treatments, and the CSL 75K treatment was more cost effective than the CSH 75K and IH 75K treatments. This tends to suggest that it was the fertiliser treatments which were the most economic, although the cost effectiveness of the C 0 0 0 treatment is unclear because of the large error associated with the yield it produced.

Mean costs per unit of output have been plotted in Fig. 8.8. This suggests that the most cost effective treatments are the C 300 150 150 and C 150 150 75 fertiliser treatments. Unlike Fig. 8.7, however, Fig. 8.8 does not take the variability of yields into account.

Only tentative conclusions can be made on the basis of this economic analysis for two reasons. Firstly, fixed costs have only

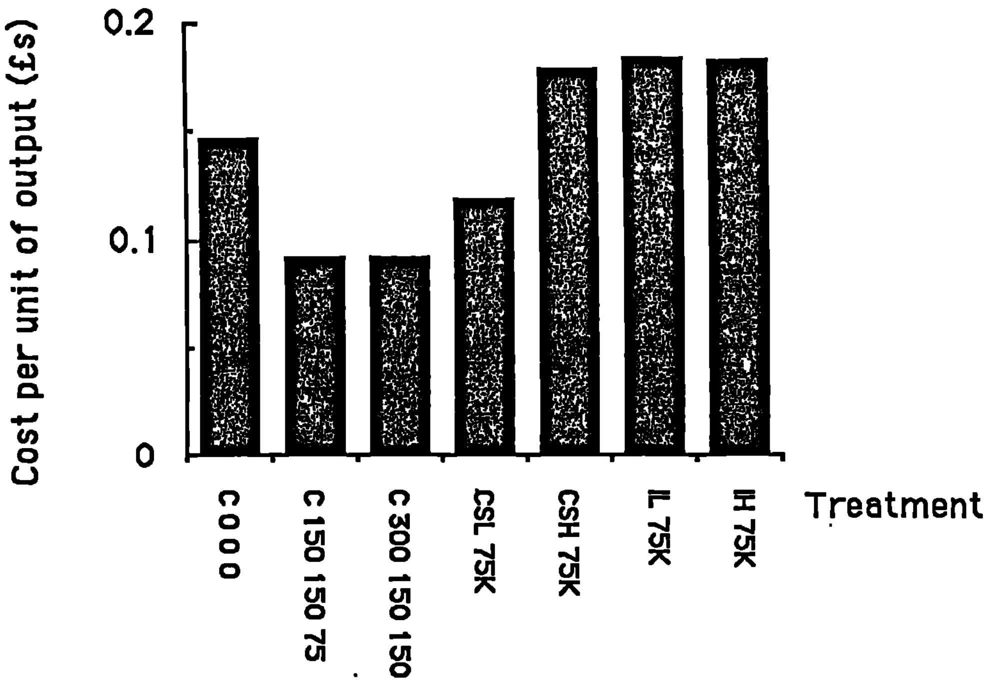

Fig. 8.8 Cost (£s) per Kg of agricultural output (yield) for selected treatments. For details of treatments see Table 8.1.

been estimated, and are likely to vary in different farming situations. Secondly, Fig. 8.7 does not include errors associated with the estimates of the costs of applying the different treatments because without undertaking a large scale survey these are difficult to establish. A more complete analysis would require less variability in the yield data, estimates of errors associated with variable costs and the modelling of a range of fixed cost scenarios.

8.5 Conclusions

In both the first and second years the most effective treatments in producing yield were the use of high levels of fertiliser nitrogen (300 Kg N ha^{-1}) with sufficient (75 or 150 Kg ha^{-1}) fertiliser P and the surface application of sewage sludge. The performance of the injected sludge (IL and IH) treatments was relatively disappointing. Since the sludge and application rates used in the experiment were identical for the surface treated and injected plots, it can be suggested that if the aim is yield maximisation, surface applications of sludge to reclaimed colliery spoil is preferable to soil injection. This is probably because injection only benefits a limited area around the injector tines in terms of nutrient supply owing to the shallow rooting of the sward, whereas surface applications of sludge benefit the entire sward and are well placed to be intercepted by the plants.

If economic considerations are foremost, it seems that fertiliser treatments may be the most cost effective in yield/cost terms. Conclusions cannot be drawn about the cost effectiveness of the C 0 0 0 treatment because of variability in yields, although in practice an overall control treatment could only be carried out for a year or two before a sward began to degenerate.

The economic analysis suffers from the limitation that by considering yield over only one year the possible long term benefits of sludge application in terms of buffering pH change, reducing soil strength (Rimmer and Gildon, 1986), supplying organic matter and providing a continued release of nutrients (Coker *et al.*, 1982; Metcalfe, 1983) over a number a years are ignored. On the other hand, when making repeated additions of sludge to land over a number of years, care must be taken to avoid the build up of heavy metals in soil above maximum permissible soil concentrations. In this trial, the heavy metal content of the sludge was low with all five metals of principal concern (Cu, Ni, Zn, Pb and Cd) being below the lower limit range specified in the European Community Directive on the use of sewage sludge in agriculture (CEC, 1986; Hall and Kichenside, 1988). Some of these factors would be difficult to include in analyses, but further economic modelling is clearly needed to resolve the question of the comparative cost effectiveness of treatments.

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CHAPTER 9 LAND RECLAMATION AT THE REGIONAL AND NATIONAL SCALES

9.1 Introduction

Almost all the reclamation of derelict land which has been discussed so far has been financed by derelict land grants (DLG). DLG can be applied wherever there is 'land so damaged by industrial or other development that it is incapable of beneficial use without treatment' (Department of the Environment, 1986a).

In England, DLG is administered by the Department of the Environment (DoE). Most land reclamation is carried out by local authorities. The levels of grant aid which are currently available to local authorities and the English Industrial Estates Corporation comprise 100% in Assisted Areas and Derelict Land Clearance Areas, 75% in National Parks and Areas of Outstanding Natural Beauty and 50% elsewhere. Grant is paid on the net loss incurred in undertaking reclamation work.

In the 1987/88 financial year, a total of £80.5 m was spent on DLG in England. Of this, 89% (£71.7 m) was allocated to the local authority sector, whilst the remaining 11% (£8.8 m) went to non-local authority schemes. The non-local authority sector includes the private sector, nationalised industries and statutory undertakers. The maximum rate of grant is 80% in Assisted Areas and Derelict Land Clearance Areas with 50% grants available elsewhere (Department of the Environment, 1986b).

Following the Aberfan disaster of 1966, derelict land grant was extended to cover the whole of England. In December 1975 grants to local authorities were increased to 100% in the Assisted Areas and Derelict Land Clearance Areas; immediately prior to this the maximum rate of grant was 75%. The 1980 Local Government Planning and Land

Act provided for the first time for grants to be paid to the non-local authority sector, which took effect in the middle of 1981/82.

In December 1981 a major change took place. The then Secretary of State for the Environment, Michael Heseltine, announced that DLG would play a much greater role in urban policy. Priority was to be given to reclamation schemes leading to so-called 'hard' industrial, commercial, residential, sporting or recreational development after-uses, especially those that were in inner city areas and were undertaken by local authorities in partnership with the private sector. This contrasts with the situation prior to 1981, when most land reclamation in England consisted of environmental or 'soft' after-use schemes, designed to treat eyesores such as colliery spoil heaps, which tend to be located away from inner city areas.

The Derelict Land Act 1982 consolidated the grant powers specified in earlier Acts of Parliament, and DoE circular 28/85 of December 1985 reaffirmed the policy of reclamation to hard after-uses and introduced rolling programmes for the treatment of extensive areas of dereliction (Department of the Environment, 1985). This circular also confirmed the abandonment of the previous category A and B system in which the highest priority was given to reclamation schemes linked to a private developer (category A schemes). This system was discontinued because of managerial difficulties brought about by the fact that supposedly committed developers often disappeared.

Nowadays, for a reclamation scheme to be approved a hard after-use and a potential developer are required. In response to government priorities, the amount of land reclaimed for hard development in England has risen from 6% in 1978/79 to approximately

25% in the period 1982-1988 (Department of the Environment, 1986c; Department of the Environment, 1989).

9.2 The method of analysis

It is therefore timely to assess whether the new policy of encouraging reclamation to hard after-uses, introduced at the end of 1981, has increased the cost-effectiveness, i.e. reduced the cost per hectare, of land reclamation. It is not possible to undertake a cost-benefit analysis of land reclamation at the macro scale in which a detailed assessment of all the actual benefits can be included because the data required for this are not available. It might be expected from what has been shown already, particularly in Chapter 6, that a greater concentration on hard after-uses would lead to an escalation in costs and, as a result, a reduction in cost-effectiveness.

The results of a cost-effectiveness analysis of either ten or twelve years of DLG expenditure in England,. Scotland and Wales are shown in Table 9.1. This contrasts the mean cost per hectare of reclamation over two periods, of either five or six years, before and after the change of emphasis to reclamation to hard after-uses. Such an approach is necessary because in many reclamation schemes there is considerable carry over of expenditure from one year to the next. Data have been collated from derelict land surveys and the relevant reclamation agencies (Department of the Environment, 1975; Department of the Environment, 1984).

All figures in Table 9.1 have been adjusted for the effects of inflation. They are expressed in constant 1987/88 prices and are based on the Retail Price Index calculated by financial year.

Table 9.1 Cost-effectiveness analysis of DLG expenditure, cost per hectare (£s), constant 1987/88 prices.

England (Source: Department of the Environment)

Local authority schemes	Six year mean 1976/77-1981/82	Six year mean 1982/83-1987/88	Change
England (total)	£27,000 ha^{-1}	£65,000 ha^{-1}	x 2.4
North West[+]	£29,000 ha^{-1}	£66,000 ha^{-1}	x 2.3
Northern[++]	£33,000 ha^{-1}	£60,000 ha^{-1}	x 1.8
West Midlands	£18,000 ha^{-1}	£62,000 ha^{-1}	x 3.4
East Midlands	£19,000 ha^{-1}	£74,000 ha^{-1}	x 3.9
Yorkshire and Humberside	£23,000 ha^{-1}	£65,000 ha^{-1}	x 2.8
Eastern[+++]	£99,000 ha^{-1}	£99,000 ha^{-1}	x 1
South West	£31,000 ha^{-1}	£30,000 ha^{-1}	x -0.97

+ Includes Merseyside.
++ Excludes the County of Cumbria from 1982/83 onwards, when it was added to the North West region.
+++ Includes Greater London, East Anglia and the South East.

Non-local authority schemes	Six year mean 1982/83-1987/88
England (total)	£75,000 ha^{-1}

Wales (Source: Welsh Development Agency)

Wales, total local and non-local authority schemes combined	Six year mean 1976/77-1981/82	Six year mean 1982/83-1987/88	Change
	£46,000 ha^{-1}	£53,000 ha^{-1}	x 1.2

Scotland (Source: Scottish Development Agency)

Scotland, total local and non-local authority schemes combined	Five year mean 1978/79-1982/83	Five year mean 1983/84-1987/88	Change
	£31,000 ha^{-1}	£63,000 ha^{-1}	x 2

The expenditure figures on which these analyses are based comprise the following. In the case of the local authority sector, they include the cost of land acquisition, reclamation works and associated staff costs. They do not include the benefit accruing from the (hopefully) increased market value of the land following reclamation, known as betterment. Betterment is usually recovered some years after the completion of reclamation works, and since it goes into a consolidated fund, is not reflected in the figures in

Table 9.1. It is, however, taken into account when issuing grants, as the total approved expenditure on a local authority scheme is offset against it and betterment is later 'clawed back' by the DoE. The market value of land after reclamation or 'after-value' is assessed by a district valuer, and, for administrative purposes, land reclaimed by local authorities for public open space is assigned nil after-value. It is not without significance that anyway a startling finding of the economic analyses in Chapters 5 and 6 is that land acquisition costs (CLA) have often been markedly higher than the value of land after reclamation (PRV).

The expenditure figures for the non-local authority sector do not include the same items. The non-local authority sector receives up to 80% of the <u>net cost</u> of eligible works only. This is the eligible works <u>less</u> betterment accruing from the increased value of land after reclamation. In other words, the expenditure figures in Table 9.1 for the non-local authority sector include reclamation works costs less betterment which is deducted before a reclamation scheme begins. Land acquisition and administrative expenses are not grant aided in private sector DLG schemes.

9.3 Reclamation costs in England

The cost-effectiveness of land reclamation in England before and after the policy change of 1981 is shown in Table 9.1. For local authority schemes in England as a whole, the mean cost of DLG schemes has more than doubled, increasing from £27,000 to £65,000 in real terms.

The table also shows this global figure broken down by the DoE's standard regions of England. The only exceptions to the trend of declining cost-effectiveness are the South West and Eastern regions where there has been little change in the cost per hectare of reclamation. This may be because relatively little land reclamation is carried out in either of these regions, as illustrated in Figs. 9.1 and 9.2.

The reason why the cost-effectiveness of local authority DLG schemes has declined markedly since 1981 appears to be the change of emphasis in reclamation to hard after-uses. Reclamation schemes in urban areas are likely to be much more expensive than soft after-use schemes which may only involve earthmoving, seeding and tree planting on relatively large areas of land which may reap the benefits of economies of scale. In urban areas problems of the re-excavation and filling of old basements, the diversion of services, the installation of new infrastructure and the possible chemical contamination of sites, may all have to be tackled.

Table 9.1 shows that the mean cost of non-local authority sector reclamation schemes is £75,000 per hectare in England, about one and a fifth times the mean cost of local authority sector schemes. This is despite the fact that in non-local authority schemes land acquisition and staff costs are not grant aided, and the figures in Table 9.1 include an allowance for betterment, which in the case of local authorities and English Estates they do not. Furthermore, the private sector can only receive at most 80% grant, whilst local authorities can receive up to 100% grant aid. The reason why private sector schemes are more expensive seems to be that they will almost inevitably be hard after-use schemes such as when a company expands on site onto formerly derelict land. The regional allocation of DLG expenditure and areas reclaimed by the non-local authority sector in England are shown in Figs. 9.3 and 9.4.

Fig. 9.1 Allocation of expenditure on local authority derelict land grant schemes to the standard regions of England, 1974/75-1987/88.

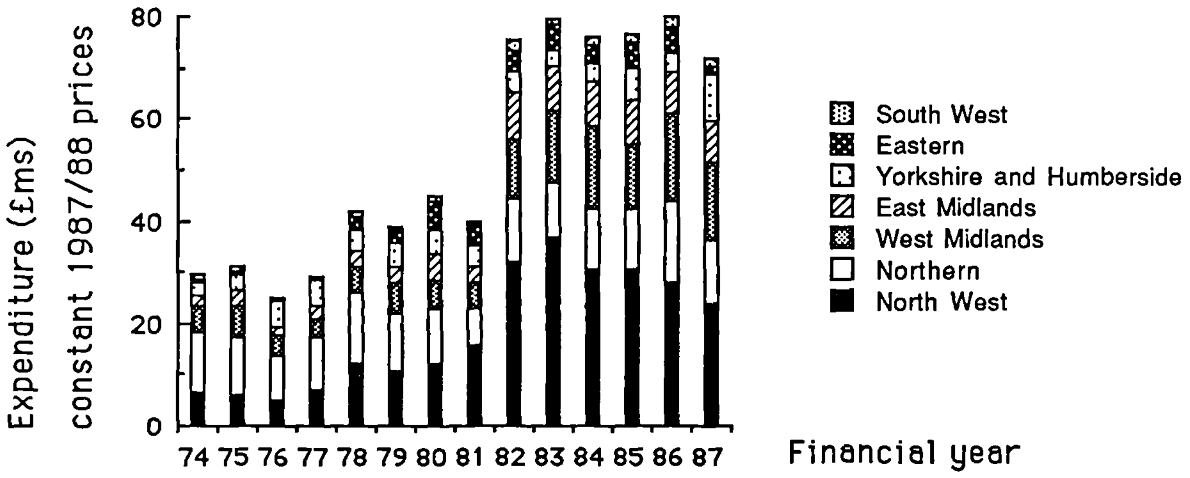
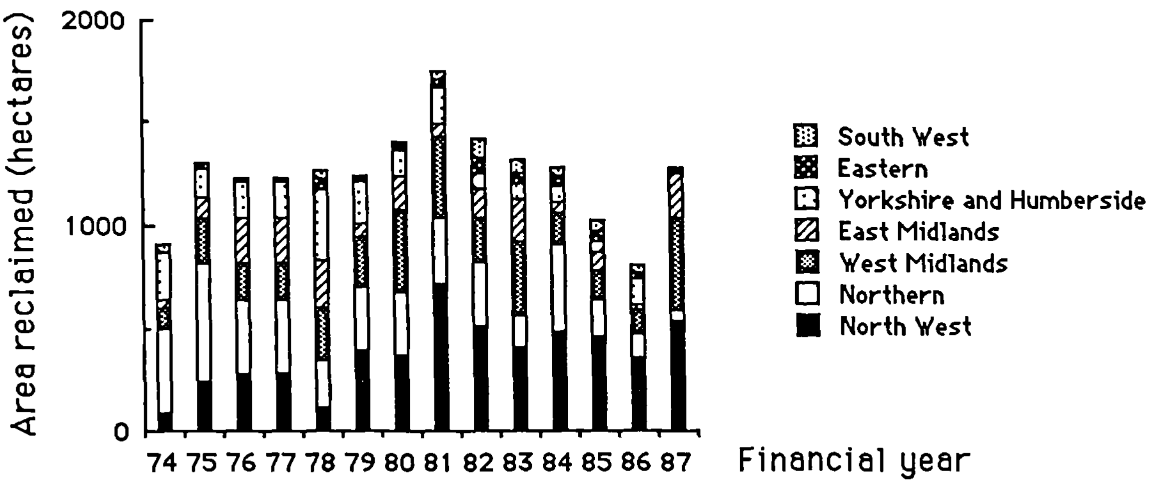


Fig. 9.2 Areas reclaimed by local authorities using derelict land grant, by standard region, 1974/75-1987/88, England (hectares).



Figs. 9.1 and 9.2 Regional allocation of expenditure and areas reclaimed by local authorities using derelict land grant, England, 1974/75-1987/88.

Fig. 9.3 Allocation of expenditure on non-local authority sector derelict land grant schemes to the standard regions of England, 1982/83-1987/88.

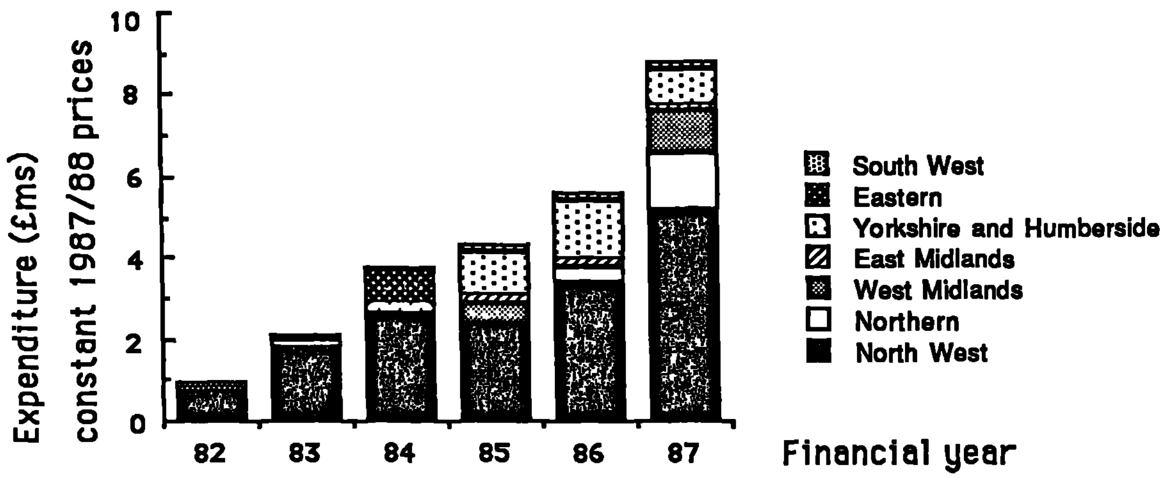
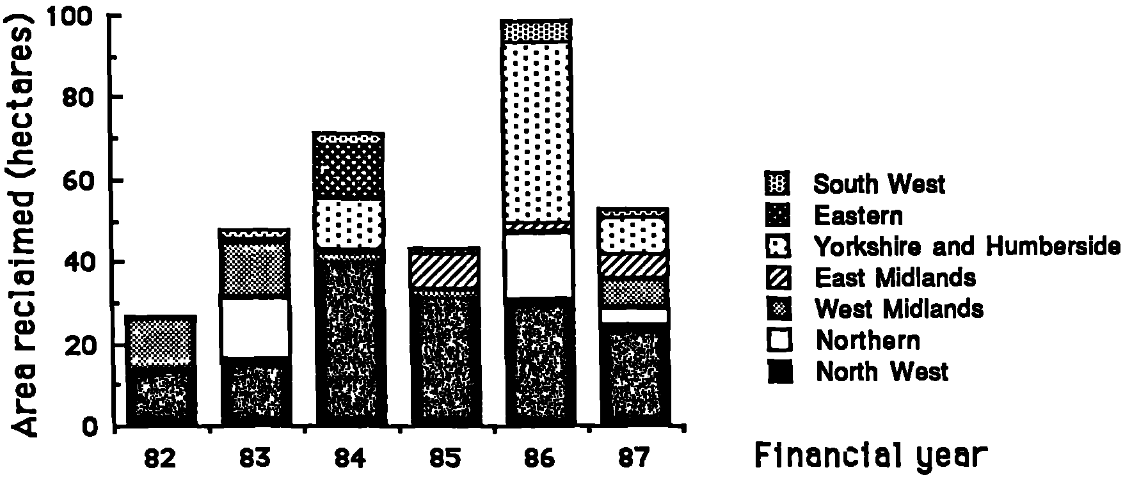


Fig. 9.4 Areas reclaimed by the non-local authority sector using derelict land grant, by standard region, 1982/83-1987/88, England (hectares).



Figs. 9.3 and 9.4 Regional allocation of expenditure and areas reclaimed by the non-local authority sector using derelict land grant, England, 1982/83-1987/88.

9.4 Reclamation costs in Wales

In Wales, DLG has been administered by the Welsh Development Agency (WDA) since 1976. Local authorities receive 100% grant aid whilst the non-local authority sector 80% grants. In 1987/88 some £14 m was spent on DLG in Wales as a whole, of which about £0.5 m was allocated to non-local authority schemes. In general, around 5% of the total expenditure on land reclamation in Wales goes to the non-local authority sector which was introduced in 1983/84.

Table 9.1 shows that the cost-effectiveness of land reclamation in Wales has declined only slightly between 1976/77 and 1987/88, despite the introduction of non-local authority sector schemes which are included in the figures. This is probably because, unlike England, in Wales around 70% of DLG expenditure has been allocated to hard after-use schemes since the 1970s.

9.5 Reclamation costs in Scotland

In Scotland, land reclamation is administered by the Scottish Development Agency (SDA). The SDA pays directly for works, acting as the employer and so technically does not issue DLG. The agency approves both local authority and private sector projects, and the rate of grant paid varies between 50-100% depending on the leverage ratio. In 1987/88 £23.4 m was spent on land reclamation in Scotland where no distinction is made between local authority and non-local authority schemes.

Although there has been a policy of reclamation to hard after-uses in Scotland since 1980, Table 9.1 shows that the cost-effectiveness of reclamation in Scotland has halved since the 1982/83 financial year. This may reflect an increasing emphasis on hard after-use schemes since 1980; about 70% of all expenditure in

Scotland is currently allocated to such schemes.

9.6 Conclusions

In the case of England, we can conclude that the cost-effectiveness of DLG expenditure has declined by more than a half since 1981. This appears to because of the new emphasis on reclamation on hard as opposed to soft after-uses. This also appears to have happened in Scotland, but not in Wales where there is a longer history of reclamation to hard after-uses.

It must be borne in mind, however, that these analyses only take into account area reclaimed as a measure of effectiveness. This is clearly only a crude indicator. Ideally we would be able to assess the economic benefits that accrue from these reclamation schemes, rather than use area reclaimed as a surrogate measure.

Indeed, compared with softer environmental schemes, which are largely undertaken for aesthetic reasons, hard after-use schemes are likely to generate more private investment and employment. Nowadays the leverage ratio of public to private investment is a major consideration in deciding whether a scheme will be approved for grant. Another factor which needs to be given attention is the extent to which reclamation can contribute to increased business confidence and attract developers to an area.

In the case of England, a limitation of the analysis is that levels of grant aid vary, between 50, 75 and 100% for the local authority sector, and between 50 and 80% for private sector schemes. For this and other reasons the figures in Table 9.1 cannot be taken as representing the true cost of reclamation to the economy. Furthermore, although the maximum rate of grant has remained at 100% for the local authority sector since December 1975, official statistics do not reveal if there have been changes in the proportional allocation of the different rates of grant since then.

Nevertheless, it seems safe to conclude that in England the cost-effectiveness of DLG expenditure in terms of area reclaimed has declined sharply since 1981. The figures in Table 9.1 have an obvious implication; that with the higher costs of reclamation to hard rather than soft after-uses, more than a doubling of exchequer resources will be necessary merely to maintain the level of previous reclamation effort in England. Moreover, despite the reclamation of nearly 17,000 hectares in England between 1974 and 1982, the area of existing dereliction grew by over 2,400 hectares in the same period (EAU, 1986). This means that the new emphasis on hard after-uses could lead to reclamation effort in England slipping even further behind the rate of creation of new derelict land.

Provisional results from the 1988 derelict land survey suggest that the rate of reclamation of derelict land is only just running ahead of growth in dereliction; the total stock of derelict land fell by only 9% between 1982 and 1988 (Chapter 1). Furthermore, as described in Chapter 1, there is evidence that an increasing proportion of land which is being abandoned comprises general industrial dereliction. The analyses in Chapter 6 illustrate that this can be extremely expensive to reclaim. It is therefore likely that in addition to the policy of favouring hard after-uses, the growing amount of industrial dereliction requiring treatment is also contributing to the increased costs shown in Table 9.1. Unfortunately, adequate information is not available to examine this possibility.

A recent report has stressed that the DoE's priority of reclamation to hard after-uses should not be applied inflexibly

(Department of the Environment, 1987). There is clearly a danger that the pendulum has swung too far away from purely environmental reclamation schemes which can be very effective in removing the serious problems that derelict land contributes to our society (EAU, 1986).

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CHAPTER 10 GENERAL CONCLUSIONS

10.1 Economic findings

Whilst the costs of land reclamation projects are relatively easy to obtain, greater difficulties are likely to be encountered in assessing their benefits. This research has shown that a number of different techniques can be used to estimate the economic benefits of reclamation schemes (Chapter 2). Of these, the contingent valuation method (Chapter 3) and post-reclamation land value approach (Chapters 5 and 6) appear to be the most promising. The CVM approach is versatile and can be applied relatively quickly, whilst the post-reclamation value approach needs only valuers' estimates, or the actual figures on disposal, of the market value of reclaimed land.

There are, however, good grounds for believing that both of these methods produce underestimates of the total benefits of land reclamation. This is because it is difficult to capture all the external benefits of reclamation, some of which may occur off site (Randall *et al.*, 1978). For instance, the reclamation of a piece of land may cause the value of surrounding, unaffected land to increase.

The use of a hedonic property price approach to assess the benefits of land reclamation suffers from methodological indirectness and considerable informational requirements. Whilst it is undoubtedly the case that dereliction has measurable effects upon house prices (Chapter 4), this approach is likely to be too time consuming to be instituted in the routine assessment of reclamation projects.

Studies of the visitor use of land reclaimed for amenity are valuable in so far as they provide indications of user benefits. The method is not, however, an economic one and there are therefore difficulties in combining it with cost-benefit analysis (Chapter 4).

Chapters 5, 6 and 7 suggest that cost-benefit analysis provides an effective framework with which to assess the costs and benefits of land reclamation to society as a whole. The use of a social discount rate (Chapter 2) and the listing of costs and benefits, with the avoidance of double counting, ensures that appraisals are rigorous. Non-economic factors are excluded from the analysis, and unmeasured or unmeasurable factors can be itemised to aid decision making.

10.2 Future policy

The present stock of derelict land reflects some of the social costs of the technological progress that was made by previous generations. If a similar burden is not to be passed on to future generations, the current rate of reclamation will have to be speeded up. Moreover, the increasing proportion of industrial dereliction that is being created, and is expensive to reclaim (Chapter 6), coupled with the new emphasis on hard after-use schemes, is likely to mean that financial resources will have to be increased merely to keep pace with the problem (Chapter 9). Industrial dereliction also tends to be located close to where people live and so has particularly strong impacts on the environment.

How can this increased rate of reclamation be achieved? As regards the prevention of new dereliction, mining industries can be made to restore their own workings. Restoration must be either progressive or bonded since otherwise there is the danger of industrial collapse with the creation of derelict land. Such restoration is now required of new sand and gravel, opencast and deep mined coal operations. It would also be desirable to institute these measures throughout other types of industry. At present this is rarely done, and the abandonment and dereliction of sites is commonplace, with central government having to finance reclamation via Derelict Land Grant (DLG).

The current backlog of derelict land also needs to be tackled. As far as mining industry is concerned, an increased rate of reclamation could be achieved by introducing a levy to finance the reclamation of derelict land, as practised in the United States. This approach has a precedent in Britain. In 1951 the Ironstone Restoration Fund was set up, based on a fixed levy from ironstone extractors, landowners and the government, for every ton of ironstone mined (Bradshaw and Chadwick, 1980). The scheme was very successful in treating this form of dereliction. Another way in which old mining dereliction may be treated is where it is incorporated in present operations such as the washing of colliery spoil heaps which with modern technology contain economically recoverable quantities of coal.

The backlog of dereliction caused by other types of industry cannot realistically be tackled this way because companies may have gone out of business. Such reclamation will therefore have to continue to be funded via DLG.

Mining and other industries impose external diseconomies (costs) on the environment. The resulting divergence between private and social costs implies economic inefficiency. This has led some economists to suggest that industries should reclaim land to an economically efficient degree <u>and</u> pay charges equivalent to the social costs of remaining environmental damage (Randall *et al.*, 1978). Whilst justifiable on economic grounds such measures would be complex and time consuming to administer.

10.3 Administrative implications

What sort of reclamation should be carried out? Chapters 5 and 6 suggest that reclamation schemes are only occasionally self-financing. Where they are not schemes must have low net costs. The analyses in Chapter 5 and 6 also show that schemes need to be well designed, in accordance with ecological principles, and be simple to manage and inexpensive to maintain. This might be achieved by undertaking either low or high cost schemes.

This work has indicated that economic cost-benefit analysis should be used in addition to the financial appraisals of reclamation schemes that already take place at the grant approval stage in central government. This could be used to compare the social costs and benefits of different policy options for individual schemes (Chapter 6) as well as in selecting amongst alternative projects where the total budget is constrained.

In this research it was found that obtaining data on the costs of reclamation schemes was often a laborious process. This is because of the inadequate records that have generally been kept in the past. Since computerised database systems are being introduced in central government (NAO, 1988), appraisal using cost-benefit analysis could easily be installed, to be carried out routinely. As regards the measurement of benefits, estimated post-reclamation land values are already obtained for non-public open space schemes in the grant approval system. If questionnaire surveys were automatically undertaken to find out what local people want from reclaimed public open space schemes (Chapter 4), it might be possible to integrate a contingent valuation questionnaire design within the overall survey format. The difficulties with this would be in overcoming the problems of strategic and hypothetical bias and the need to develop a consistent method to aggregate benefits.

A startling finding of this research has been that the costs of land acquisition (CLA) frequently exceed the post-reclamation value (PRV) of reclaimed sites. This strongly suggests that legislation must be introduced to prevent excessive prices being paid for land of little value. A summary of the results of the cost-benefit analyses of individual reclamation schemes is given in Table 10.1.

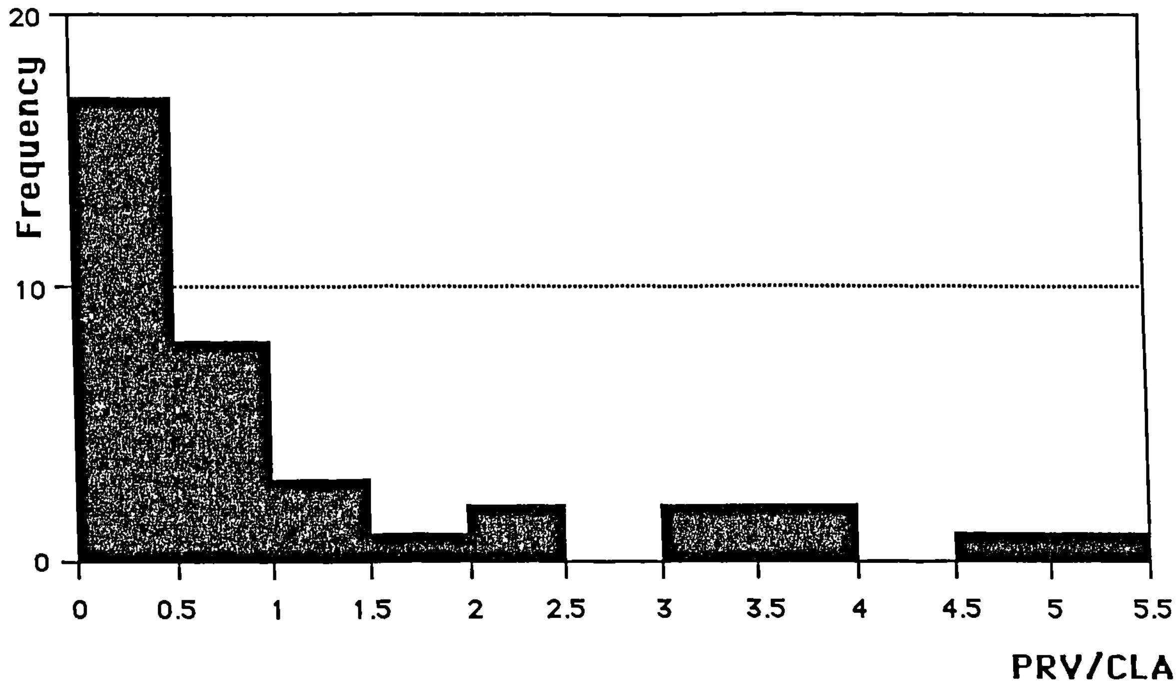
Table 10.1 The proportion of reclamation schemes examined using cost-benefit analysis for which the cost of land acquisition exceeded the post-reclamation value of the land

Type of dereliction	**Proportion**	
Deep-mined colliery spoil (Chapter 5)	12/20	(60%)
Industrial dereliction (Chapter 6)	4/9	(44%)
Metalliferous wastes (Chapter 6)	2/2*	(100%)
Urban clearance schemes (Chapter 6)	7/9	(78%)
Overall total	**25/40***	**(62%)**

*There was also one instance where the cost of land acquisition approximately equalled the post-reclamation value of the land.

In addition, a histogram of the ratios of PRV/CLA values is shown in Fig. 10.1 for 37 of the reclamation schemes analysed in Chapters 5 and 6. An astonishing 68% of these schemes had PRV/CLA ratios of <u>less than one</u>.

At the national and regional scales, the economic information that is needed to undertake a complete cost-effectiveness analysis of Derelict land Grant is simply not currently available (Chapter



KEY:
PRV = Post reclamation value of land
CLA = Cost of land acquisition

Fig. 10.1 Histogram of the ratios of PRV/CLAs for 37 reclamation schemes appraised at a 7% real discount rate.

9). It is to be hoped that computerised record keeping will facilitate such analyses in the near future. Ideally cost-benefit analysis of different policy objectives would be undertaken to determine their economic efficiency.

Quite apart from these considerations affecting the initial 'capital' costs of land reclamation, it is clear that the grant system pays too little attention to the key question of landscape maintenance costs (Chapter 8) and potential income from productive after-uses in land reclamation schemes. As a result of the restrictive grant system and capital expenditure controls upon local authorities, concepts of low maintenance 'naturalistic' landscapes, coppice and forestry plantations and wildlife areas are likely to be forced to the fore. In the North West of England, high levels of landscape maintenance costs led Knowsley and St. Helens Borough Councils to give up DLG work during the period 1985-87. They have only recommenced this work with the assistance of The Groundwork Trust in designing landscapes which are cheaper to maintain. Even where the Department of the Environment is willing to fund maintenance costs for five years following reclamation, good design is essential if long term landscape maintenance costs are to be affordable.

The very high costs of staging Garden Festivals, not only in terms of reclaiming derelict sites (Chapter 6), but with respect to Festival development costs, has meant that the current programme will be halted after 1992. A major problem with the first two Garden Festivals was that they left behind them sites with considerable overplanting and consequently very high landscape maintenance costs. Whilst not involving land reclamation, the third Garden Festival, at Glasgow, did have major advantages from the point of view of its subsequent maintenance. The much reduced landscape elements remaining on site after the Festival are likely to be well tended, because they are associated with private houses, and the remaining trees and shrubs from the site have been salvaged for use elsewhere. This does mean, however, that Glasgow did not really conform with the original Garden Festival concept at all.

A novel approach to the problems of financing the long term maintenance cost element of reclamation schemes is currently being essayed by the Groundwork Trust. This is to use only the interest earned by a sum of capital to fund reclamation. Whilst this has no particular economic advantages, from a financial point of view it does discourage the excessive 'front loading' of expenditure on a reclamation scheme by ensuring a more even distribution of funds through time.

At present, government policy discriminates against soft after-use schemes. There will, however, continue to be situations where such schemes merit a high priority on environmental or socioeconomic grounds. The current financial climate is thus likely to produce a bifurcation of reclamation schemes into high cost hard after-use schemes, with potentially large post reclamation land values and maintenance cover by new developments, and low cost amenity landscapes in areas where there are few or no prospects of immediate hard development and maintenance should be cut to a minimum.

It has already been recognised by the National Audit Office that there is currently too little monitoring of reclamation schemes to ensure that proposed after-uses are achieved (NAO, 1988). This current research can only provide further evidence of this (Chapters 5 and 6). Where reclaimed sites are forgotten about, they may soon become neglected, and even derelict again, necessitating the added cost of later treatment. Furthermore, money may have been wasted in the form of extra works needed to reclaim a site to an after-use that cannot in fact be realised and there may also be a failure to recoup post-reclamation land values.

10.4 Technical aspects

It is to be regretted that in many cases an adequate understanding of the biological principles and associated techniques underpinning land reclamation is lacking. This is in part a result of the lack of relevant technical expertise on the staff of both local and central government, in which expert ecological and other technical knowledge is often only available from outside. The result of this can be expensive mistakes (Chapters 5 and 6; NAO, 1988). The solution to this appears to be the improved transmission of information between researchers and practitioners. The field trial described in Chapter 8 illustrates that scientific experiments may be needed to resolve outstanding problems.

Another form of mistake has been where officially 'derelict' sites such as disused quarries, mines, and chemical waste heaps, which have naturally colonised with wildlife have been reclaimed for bland public open space, agricultural fields or waste disposal (Bradshaw, 1979; RSNC, 1988). This is not only a waste of money, but a missed opportunity.

For a number of reasons, the continued creation of new dereliction seems inevitable (EAU, 1986; NAO, 1988). Nevertheless, the scale of the problem can be greatly reduced by ensuring that methods of progressive restoration are undertaken wherever possible (Chapter 7). In Britain, the opencast coal and sand and gravel industries generally produce model operations in this respect. This has much to do with the need to produce convincing cases in favour of mineral extraction to obtain planning permission, and the enactment of the Town and Country (Minerals) Planning Act, 1981. On the other hand, however, the deep mine section of the coal industry's record in the field of land pollution is appalling, despite a few modern progressively restored 'showpiece' sites (NCB, 1983). This situation has arisen as a result of the lack of planning controls on the industry because it has existing permissions for which restoration conditions are not enforceable (Bradshaw, 1984).

10.5 Further research

There are clearly a number of areas where further research needs to be undertaken. As regards the cost-benefit analysis of land reclamation schemes, the shadow pricing of land acquisition costs will require attention if appraisals are to be purely economic in character. Rapid and reliable methods of estimating the benefits of reclamation must also be developed. For very large scale projects, it may be worthwhile incorporating the rather time consuming methods of risk analysis into project appraisal (Pearce, 1983).

Low cost approaches to reclamation and landscape maintenance will have to be further refined if present trends continue. A particular need is to develop productive uses of amenity landscapes such as biomass, coppice and urban forestry or grass cropping for silage or meal to reduce the financial burden of maintaining open spaces.

It is important not to lose sight of the fact that there are strong social, political and environmental arguments in favour of land reclamation, which may transcend purely economic ones. This is exemplified by the Aberfan disaster of 1966. The integration of 'value of life' criteria (Chapter 2) into environmental policy making at the national level, as is already routinely undertaken in the field of transport planning, might be valuable in helping to bridge this divide.

On the technical side it is likely that further developments will occur in land engineering. A high priority will be to harness these to improved methods of progressive restoration, especially for toxic materials such as metalliferous wastes. There are also likely to be advances in biotechnological land decontamination, which will reduce the need to remove toxins from a site, with both economic benefits and less waste requiring disposal by landfilling. The social costs and benefits of such developments will need to be compared with traditional approaches.

There are good grounds for believing that whilst the scientific and technological methods of land reclamation have, for the most part, now been developed and published, the message has not always got across to planners and practitioners. This is potentially a major problem in Third World countries, where it is imperative that the mistakes already made in the First and Second Worlds are not repeated. This will require the development of environmentally sensitive methods of ultra low cost land reclamation.

10.6 Overall conclusion

At present, following the very critical report of the National Audit Office (1988), the future of Derelict Land Grant is under a cloud. The Garden Festival concept is also under review. It is possible that the influence of Urban Development Corporations will expand still further, and the government is considering proposals that in the future local authorities should be managed more along the lines of private business.

The outcome of all this cannot be predicted. However, one thing is certain; that the basic aims of land reclamation will remain the same. These are to re-create functioning, self sustaining ecosystems and to achieve this at a low a cost as possible (Bradshaw, 1984). This requires economic and ecological know-how as well as other skills.

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