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LANDSCAPE YOUR SITE AND SAVE ENERGY

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SUMMARY

Describes research into how the visual attractions of well-landscaped site layouts can lead to functional benefits, when buildings and landscape elements are designed together to give a sheltered, heat-retaining microclimate, analogous to an urban heat island. Ways in which site layouts can best ensure solar access and wind shelter are outlined, and the possible effects on outdoor comfort and space-heating energy consumption are summarised. Variations across the UK are mentioned, along with environmental and market factors influencing prospects for microclimatic design.

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Can landscape graduate from its decorative role to improve outdoor comfort and help conserve energy? Eric Keeble reviews the possibilities.

LANDSCAPE YOUR SITE AND SAVE ENERGY

We all complain about the British weather, but perhaps we don't do enough when designing housing to make it more bearable? One possibility currently being researched is how the visual attractions of well-landscaped site layouts could lead to functional benefits too - if buildings and landscape elements were designed together to give a sheltered, heat-retaining microclimate. This is an approach which echoes the past but is highly relevant to today's needs for energy efficiency and multi-faceted lifestyles. It could give developers a new marketing edge, especially for sites regarded as exposed - such as on high ground, or near the coast, or simply next to stretches of open countryside.

The first function of any building is to protect its occupants from the elements, but the shelter afforded by the envelope is often only part of the story. Everyone appreciates that the climate of a town or suburb is different from that of a field: it is usually warmer and less windy, and surfaces are drier. So, in built-up areas, the climatic demands on a building - whether in relation to space-heating energy use, structural strength or frost resistance of materials - tend to be less than those on the same building in an exposed or isolated setting.

This observation underlies the idea of integrating the design of site layout, landscape and buildings to reduce climatic demands before they impact on the individual building. Such an approach can be termed *microclimatic* design, and involves two main strategies: letting in the sun, and keeping out the wind. This means site layout, building forms and landscaping need to fulfil two, sometimes conflicting criteria: avoiding excessive overshadowing of areas where the warmth of the sun can be put to good use, but providing tight enough groupings of buildings and landscape elements to ensure wind speeds near ground level are limited.

Attention to both solar access and wind control is important if creation of a small-scale "urban heat island" is intended. The subtle but effective warming of built environments under still-air conditions is easily dissipated when cool air from above is mixed in as wind speed increases. This is noticeable in dramatic form in the wind-chilled conditions often found around high buildings, even when relative calm prevails elsewhere at ground level. Solar gains to the interiors of buildings, present in most buildings but exploited deliberately in passive solar designs, are distinct from changes in microclimate, but provide a further reason for designing with solar access in mind.

Control of overshadowing can be fairly straightforward, and much can be achieved simply by visual inspection at the design stage. Some basic rules for housing, suggested in recent work for the Dept of Energy's Energy Technology Support Unit (ETSU), include:

Maximum use of roads running within +/-15° of E-W

Higher buildings towards the north of sites, for example two-storey houses to the north of bungalows

Terraces on E-W roads, detached houses on NE-SW or NW-SE roads

Plot shapes allowing wide, south-facing frontages

Coniferous tree planting to the north of houses, deciduous to the south.

Various architectural design aids such as sunpath diagrams and overlays can give more in the way of quantitative information on periods of overshadowing. Recently stand-alone computer software has been developed which can both save time and give better-integrated information, for example totalling the reduced amounts of solar radiation received at different times of the year in overshadowed situations (Fig. 1). In the near future it should be feasible to combine computer-held land-form data about a site and its surroundings with CAD-based models for proposed buildings and landscape development, and to examine overshadowing routinely along with other design variables and constraints.

Successful wind control is likely to be a more subtle art. The basic need on exposed sites is to try to ensure that the wind speed profile in the finished development is more like that of a town than of open country, with faster-moving air confined to rooftop level or above. Planting shelter belts at the edges of, or perhaps outside, the site is one possibility, but this may prove difficult to realise where high land values prevail, unless there is the possibility of environmental trade-offs. Failing this, suitable arrangement of buildings and associated planting, walls and fences on the windward edges of the site can act as barriers to the wind, offering shelter to the interior.

However, edge shelter is only one component of a wind control strategy, and needs to be complemented with more localised actions to maintain the "roughness" of the site, without provoking downdraughts or turbulence. For example:

Arrangement of buildings irregular on plan, but avoiding sudden changes in height

Space between buildings no more then 2.5 to 3 times their overall height, but avoiding small gaps likely to funnel the wind

Medium-pitched rather than low-pitched or flat roofs, and hips in preference to gable ends

Courtyards for maximum shelter, either fully enclosed or with openings away from dominant wind directions.

Less is available by way of design aids for wind control than for solar radiation, so the principles have to be applied largely by intuition. Modelling air-flow around buildings by computer is at a relatively early stage, and the use of physical models in wind tunnels is normally economical only for large-scale developments involving exceptional risks of adverse wind environments or loads. However, the protective effect of shelterbelts and windbreaks has been studied for many years in connection with agriculture and husbandry (Fig. 2). The sheltered area provided by barriers of particular heights and porosities, placed in different types of wind flow, can be calculated.

As it happens, many of the suggested wind-control features are consistent with modern practice that has come about for different reasons. Most road layouts in housing areas are complex and irregular for reasons of interest and road safety, the use of vernacular styles for buildings of all scales has broken with the rectilinear forms of the recent past, and the market-driven need to present schemes with high-quality outdoor visual environments is leading to better provision of both hard and soft landscaping. These factors suggest that, if the appeal and practical benefits of wind-sheltered, microclimatic design were taken on as marketable features, much could be achieved by fine-tuning present practices.

However, to implement solar and wind-protective features in site layouts changes would be needed in the sequence or priority of decisions at initial design stage. Road layout is often determined at the outset on quite different criteria, for example to minimise paved area and main service runs, while achieving access to maximum developable area. Roads and plot subdivisions determined on this basis alone could be a major constraint to microclimatic design. This is not to say that infrastructure costs or site densities would need to be markedly different: design studies for ETSU on passive solar site layouts (Fig. 3) suggest that, at densities up to 40 dwellings/hectare, the costs of conventional and passive designs are likely to be very similar.

This ETSU work offers some calculation-based conclusions about energy saving, but these are expressed mainly in terms of house designs containing substantial passive solar features. These tend to be particularly sensitive to overshadowing, so the performance of the site layouts was reported in terms of their *disadvantage* relative to a totally unobstructed setting. However, in many cases, lack of obstructions will coincide with exposure to wind and also to driving rain, so that the full energy argument is more intricate.

Can we predict the energy benefits that might be expected from a microclimatic approach? At the moment little data are available, as this aspect of energy efficiency has received sparse attention, rather surprisingly in view of our wet and windy climate. In the rather different climatic conditions of Sweden, it has been observed that energy consumption in houses in the centre of a town or village may be up to 20% less than on the exposed edge. This can be attributed to the various elements of the urban heat island, bringing mutual benefits to tightly packed dwellings, clustered together for warmth.

One study within the British Isles, undertaken in Eire and sponsored by the European Community R and D programme, showed space-heating energy savings of around 5% for wind shelter effects only. However, the height of windbreak used was only 2 metres, protecting single-storey buildings. The site for this experiment was chosen *because* it was typical and not extremely exposed to the wind. It was argued that, on the coast and on high ground, the case for wind shelter is self-evident. BRE, as part of its research programme for the DOE Property Services Agency (Landscape), is currently undertaking a complementary study, using a higher windbreak protecting two-storey housing.

Another practical application is the sheltered, microclimatic design adopted for the Milton Keynes Energy Park. With the opportunity of an integrated development, Milton Keynes Development Corporation was able to review the microclimatic characteristics of different parts of the 1 x 2 km site, and decide which part would be more suited to a design strategy based mainly on wind shelter, and which would benefit more from solar access. The investment in a microclimatic landscape infrastructure is accompanied by constraints on built form and and energy design targets for buildings of various types, and energy consumptions are being monitored.

Improved outdoor comfort for a greater part of the year may at present have more meaning for the customer than space-heating energy saving. The idea is consistent with increasing leisure-time and the pursuit of outdoor activities in general, and especially with the needs of the growing retired population. At the same time access to comfortable outdoor areas has a continuing appeal to those with young children at home, who make up a substantial proportion of the users of sheltered public open spaces such as parks. Also, studies suggest that the old and the very young are influenced more by the weather in their use of outdoor spaces than are other groups in the population.

Although the use of outdoor spaces is likely to increase progressively with increasing air temperature, the threshold of 12°C can be taken as the point at which people begin to regard it as pleasant. This seems especially significant in many parts of the UK because, with our relatively mild winters, the air temperature approximates to this value on many days during the cooler parts of the year. Often therefore conditions outdoors may be regarded as uncomfortable when exposed to the chill of the wind, but comfortable when sheltered. The penetration of sunshine into outdoor spaces has also been shown to have a marked effect on usage, over and above its influence on temperature sensation.

Wind-chill index is a measure that can directly describe the impact of air movement on temperature sensation, when expressed in terms of *wind-chill equivalent temperature* . For example, the still-air comfort threshold of 12°C is matched in cooling power by 14°C air at 4 m/sec, or 15.5°C air at 6 m/sec, and so on. Conversely, 12°C air at 4, 6 and 8 m/sec feels like still air at 9.5, 8 and 6.5°C respectively. This further illustrates the potential of wind-shelter to improve comfort. Note however that wind-chill equivalent temperatures are *not* valid indicators of relative heat losses from buildings under the combined effects of wind and low temperature.

Wind-chill index can also illustrate the directionality of wind and associated air temperatures at a site. In many locations a wind-chill rose will show substantial differences from a simple wind-direction rose (Fig. 4). For this purpose the unit plotted is true wind-chill, as a cooling rate in W/m², and not wind-chill equivalent temperature. Such roses can help in planning wind-protective and wind-control measures at a site, and will usually highlight the significance of shelter against the colder winds from the northerly points of the compass. This is likely to be a good strategy in many places, which will also complement solar access needs by not blocking winter sun on the site.

There are of course important climatic differences between different parts of the UK that condition the approach to microclimatic site design. Windiness increases towards the west and north, and on the western seaboard (and for some way inland) the persistence of the dominant westerlies may dictate wind protection against that direction. Special directional characteristics may apply on other coasts, and in certain areas where valleys funnel the wind. Solar radiation reduces less with increasing latitude than might at first be supposed, especially if the amounts received on south-facing walls and windows are considered. Because of the longer cool period, solar radiation can actually be more useful in the north, although there are difficulties in achieving good solar access with low sun angles.

Equally important are differences from site to site. The direction of any ground slope will significantly affect the building spacings needed for a given level of solar access. Less solar radiation may be available in existing built-up areas, especially where shaded by high buildings, large trees or other obstructions and, in some places, by hills. The wind exposure of coasts and upland sites, eg hill-tops and moors, is evident on all but the calmest days, and the crests of hills and ridges present particular problems due to the way wind flows over them, bringing faster-moving air close to ground level. In hilly country, drainage of cold air into valley bottoms on cold, still nights can produce marked increases in the severity and persistence of frost.

While the urban heat island effect due to buildings and hard landscaping is desirable in cool conditions, the need for comfort in summer also needs consideration. Soft landscaping has an important role, since the period of foliation of deciduous plants is naturally matched to the march of the seasons, and the rate of transpiration increases with increasing temperature. Provision of deciduous species within a site is likely to be compatible with both winter and summer needs, since in bare-branch condition these will allow through some 60 - 80% of the needed solar radiation in winter. Coniferous trees, while also contributing to summer comfort, are essential for effective wind shelter in winter, especially for major shelter planting against northerly winds.

So what is new? In the distant past, the siting and form of most settlements reflected the need for protection from winter winds, both to keep conditions within buildings tolerable and to provide sheltered outdoor spaces for essential craft work and small-scale industry. This was part of the vernacular tradition of building before the industrial revolution. The ability to distribute fuel easily reduced its scarcity and cost, and the development of effective heating systems led to a philosophy of building despite the climate, rather than in sympathy with it.

There are a range of reasons why the older approach, of planning built form and site layout in a climatically sensitive way, may be highly relevant to today's needs and circumstances (Fig. 5). People's expectations of quality in their home environment have already led to the provision of well-landscaped outdoor spaces becoming a marketable feature. Why not obtain some added value from this trend, and use the idea of landscape and buildings as the means to improve the appeal and usefulness of gardens and outdoor spaces generally, at times of the year when the weather is "in-between" - cool in the wind, but agreeable when sheltered?

Apart from direct customer appeal, other trends and influences suggest that the housebuilding industry could look closely into the possible advantages. The potential for microclimatic design is probably greatest on larger schemes, where the question of environmental impact often arises. Landscaping is recognised as being of benefit in such cases, but to produce a functional, sheltering landscape seems in sympathy with minimal intrusion on undeveloped land. Beyond this is the possibility of a collaborative approach to rural and urban land-use, where the trend towards "forest farms" on land released from agricultural production might be exploited to provide large-scale shelter planting adjacent to developable land.

Of course there are further factors. The energy benefits may have greatest appeal in tenanted properties. Housing Associations, building alongside or redeveloping council property on bleak, exposed sites may be attracted by the idea of providing an extra line of defence against the unforgiving weather, with benefits not only for energy but also for condensation risk and maintenance. Again, in hilly country, valley sites are often fully used and only exposed land is available. So microclimatic design is likely to have a range of applications, from achieving a more habitable and energy-efficient environment in lower-cost developments on marginal land, through to providing an added-value feature in up-market housing, especially in coastal settings.

During 1989 a BRE Digest will be issued elaborating the points in this article, and PSA will publish an entirely new Landscape Design Guide incorporating advice on microclimatic design. Advice is also available through BRE's Technical Consultancy.

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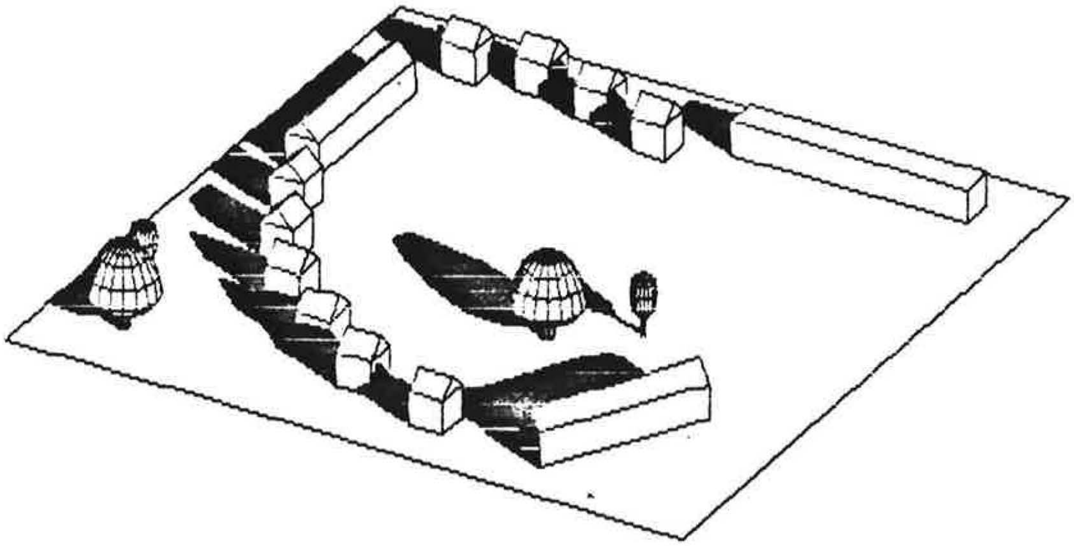
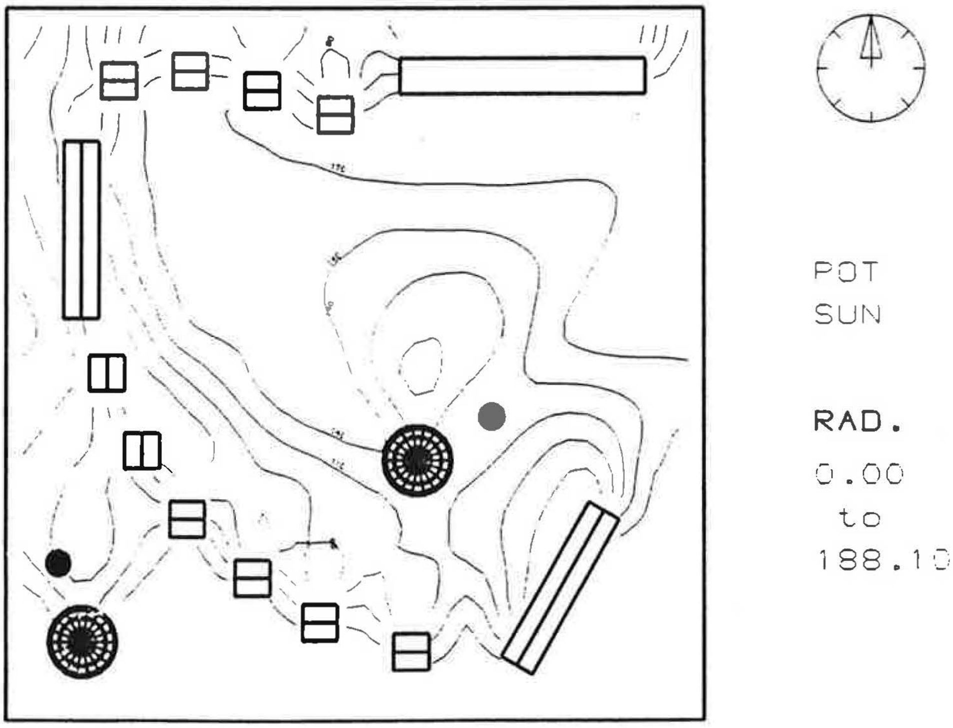
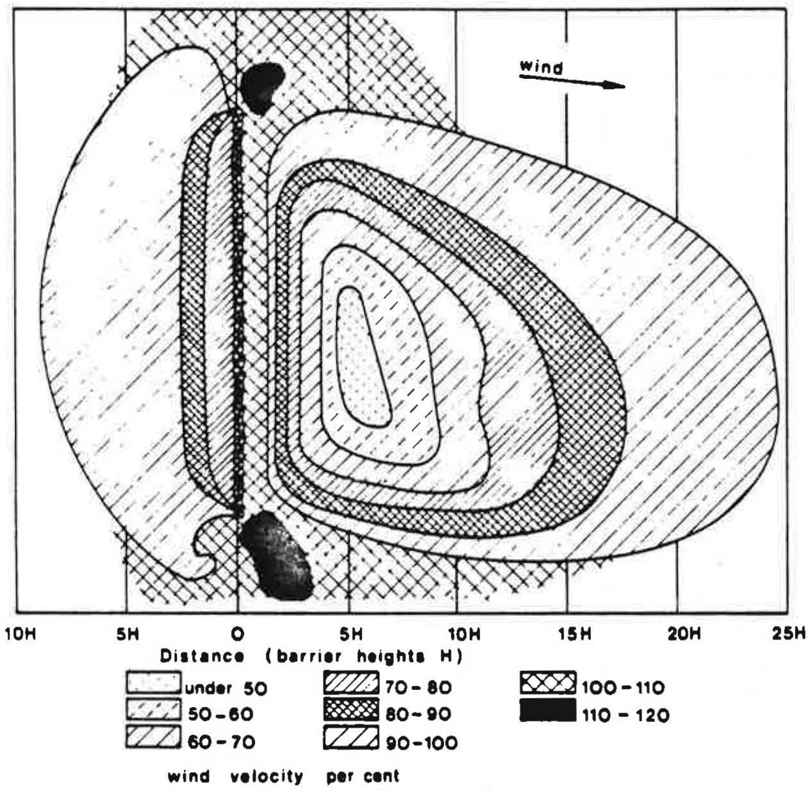


a) View of shadows cast at 08:00, September 21 for latitude 51°N



b) Plan showing isopleths of accumulated direct irradiation (potential sunshine) during December and January, in MJ/m² (maximum (unobstructed) value 188.1)

Figure 1: Computer-generated views of shadowed areas (BRE/CEC Ispra)



Zones of wind velocity near a shelterbelt of moderate permeability

Figure 2: Typical sheltered area behind shelterbelt (after Naegeli)

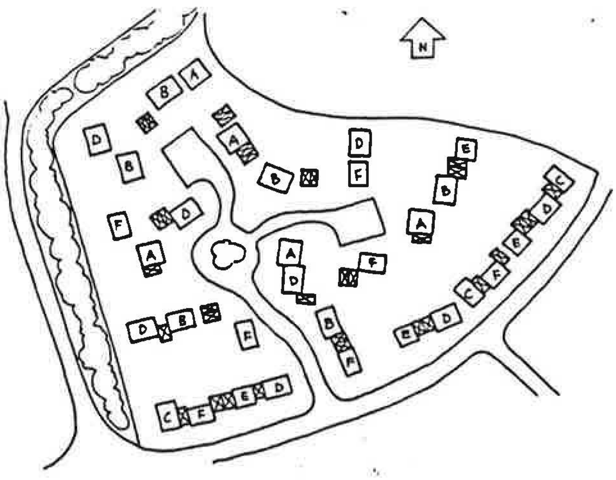


Figure 1: The original estate of detached houses

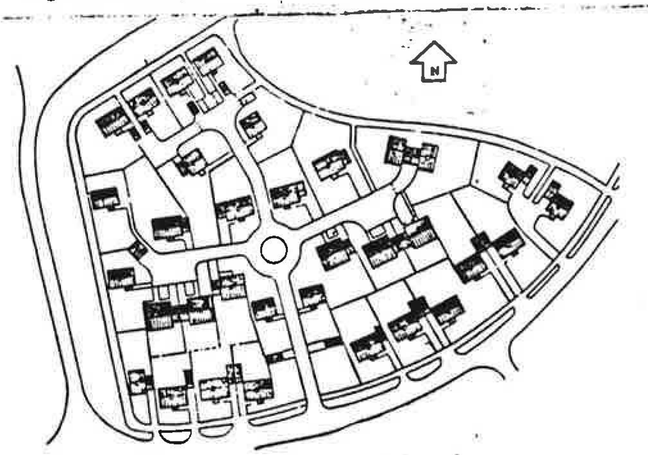


Figure 2: MCJ's improved layout

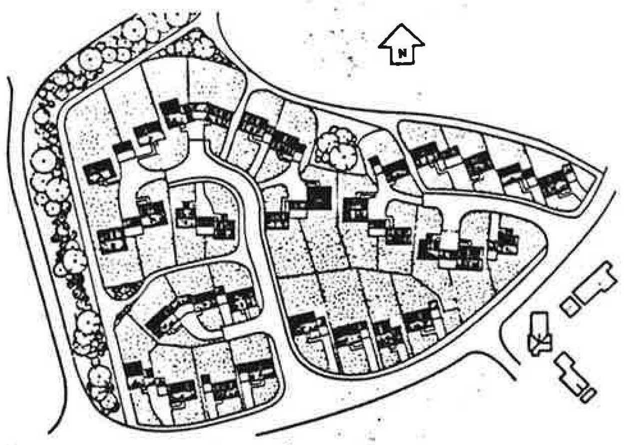


Figure 3: SEF's improved layout

Figure 3: Conventional and passive solar site layouts (ETSU)

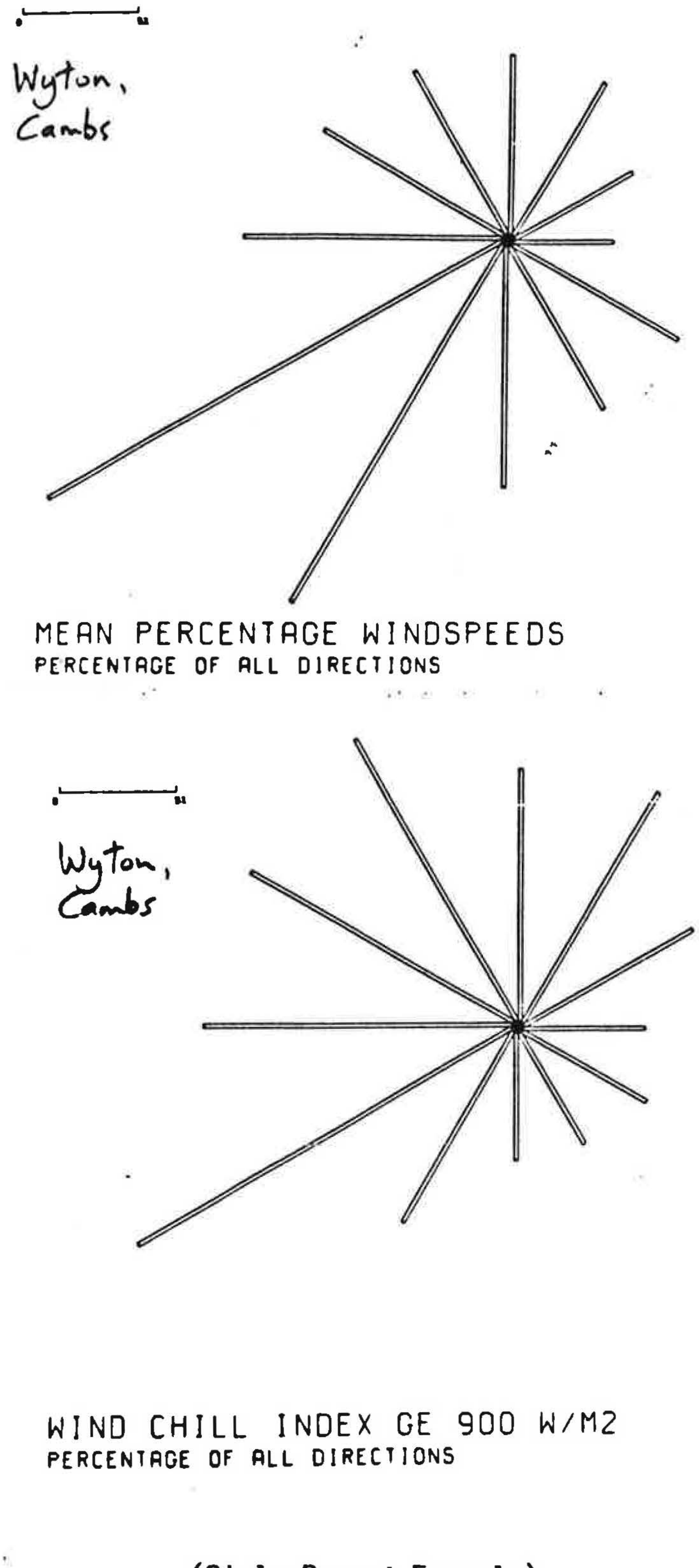


Figure 4: Wind rose and wind-chill rose (BRE/Met Office)

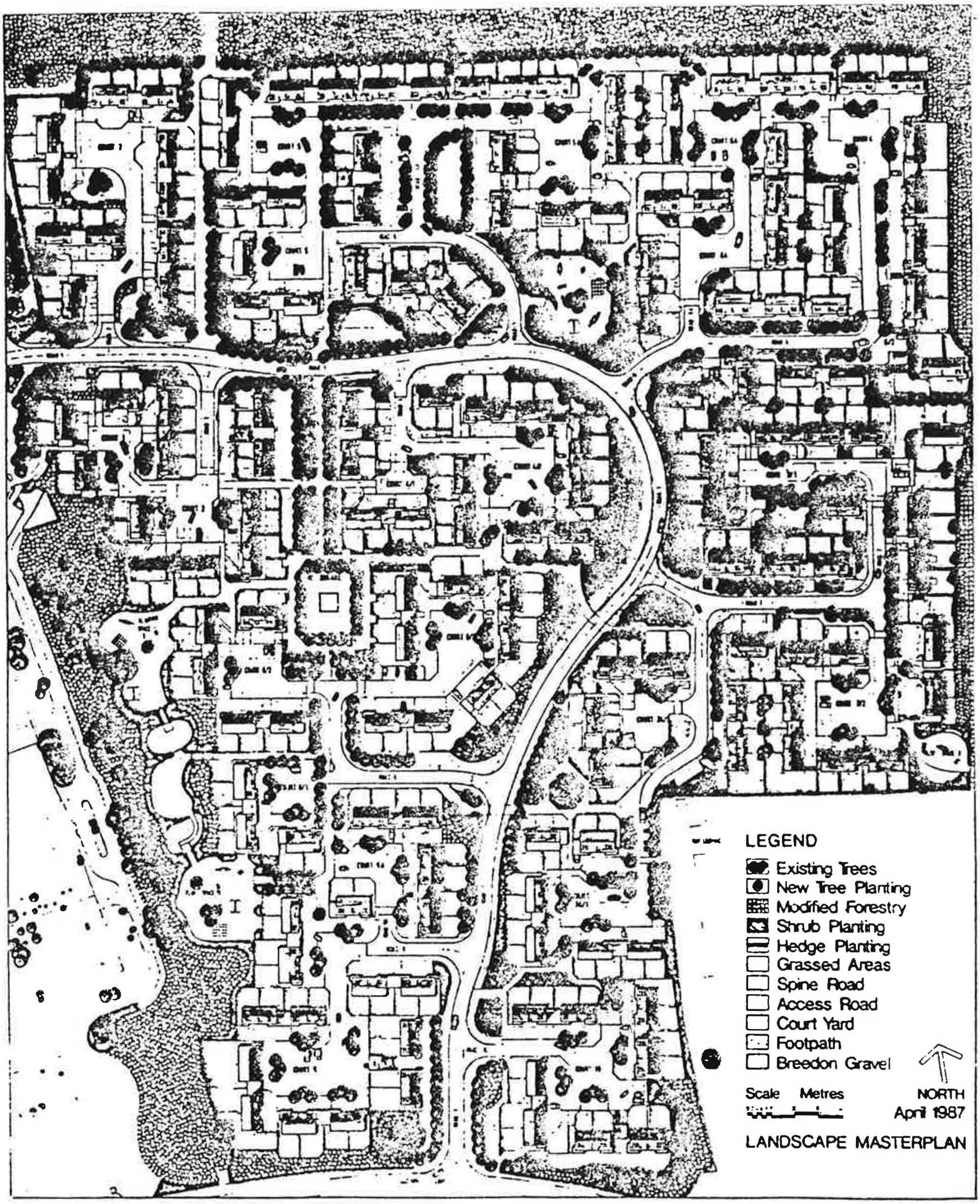


Figure 5: Landscaped scheme for 326 dwellings on exposed site (PSA)