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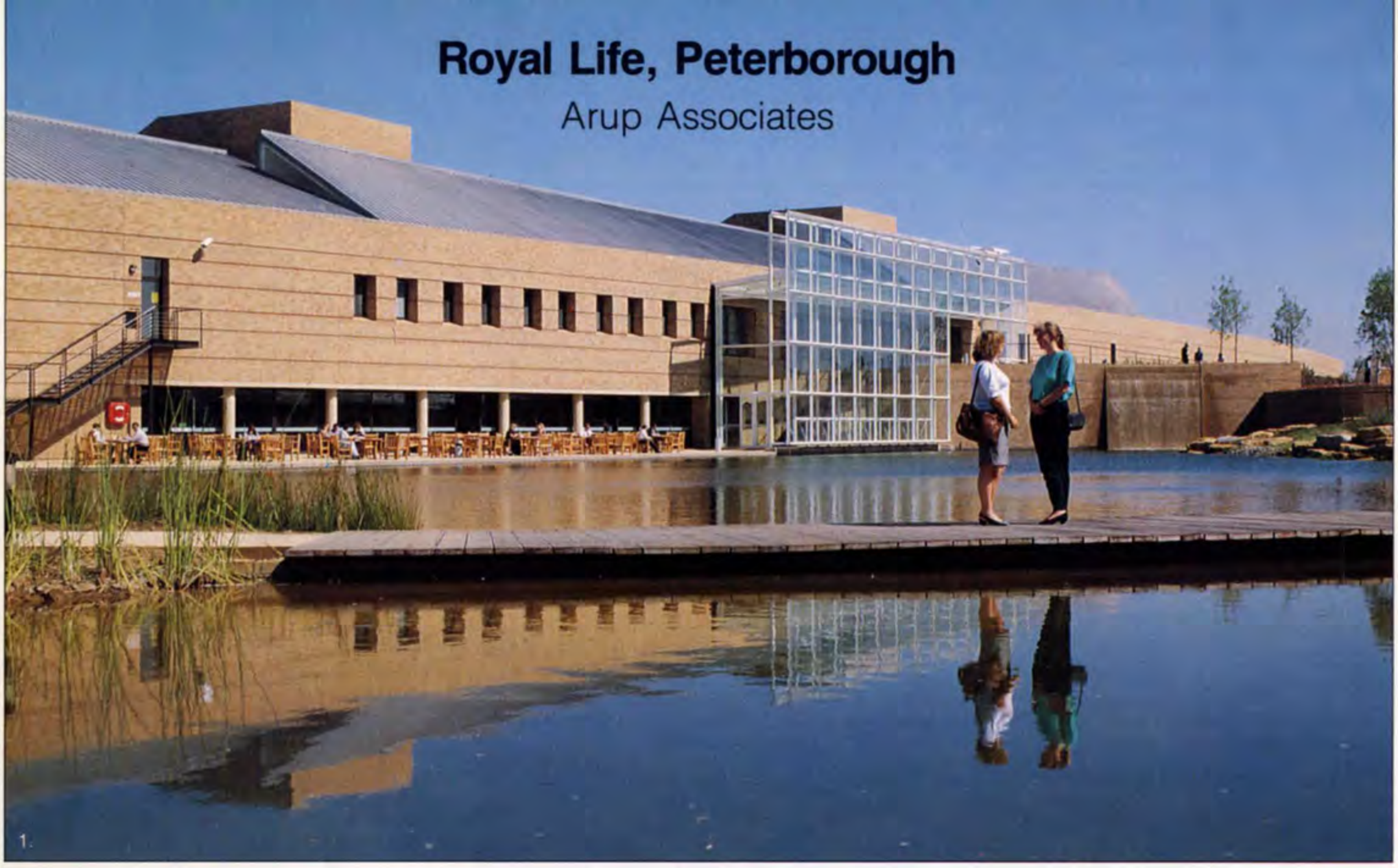
Front cover: Royal Life, Peterborough: detail of glass wall (Photo: Arup Associates)

Back cover: Stansted Airport Terminal, winner of the Building category in the 1991 British Construction Industry Awards (Photo: Richard Bryant)

Royal Life, Peterborough

Arup Associates



1.

Introduction
In August 1987 Arup Associates were appointed by Royal Life Holdings Ltd. to design a new office building on a site in the Peterborough Business Park at Lynch Wood, Cambridgeshire. The client, with an architectural consultant as part of his selection committee, invited four firms to present a design approach to the selected site which, together with an adjacent site on which they had an option, they were negotiating to buy from the Peterborough Development Corporation. Two firms were short listed and a final choice was made after site visits to completed buildings.

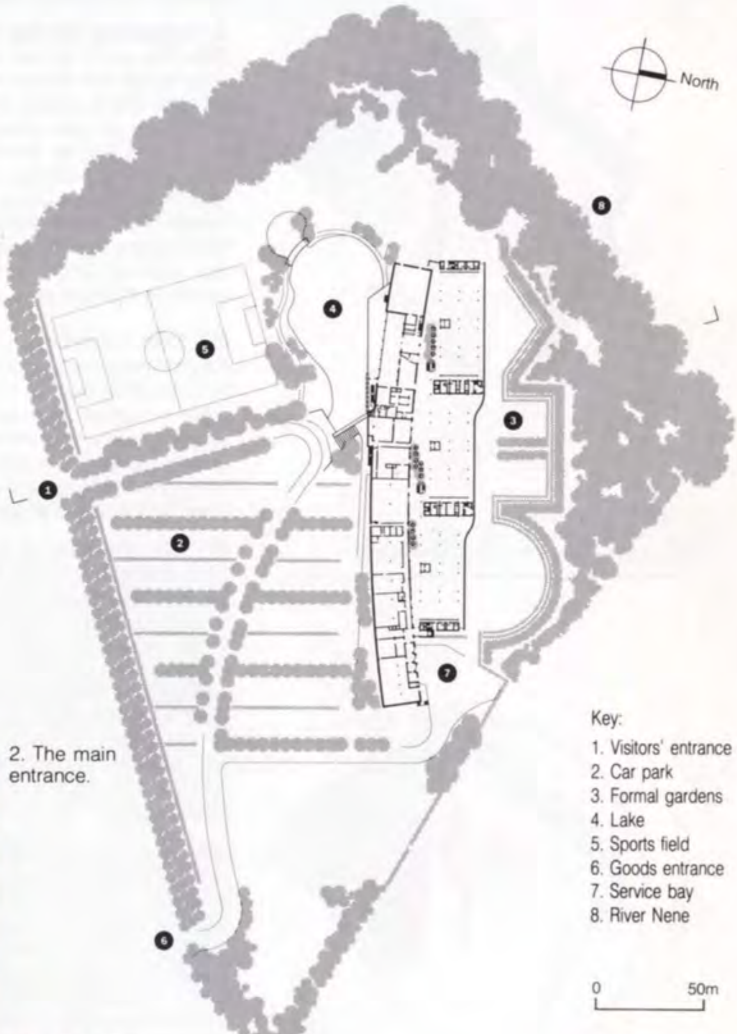
The site
The Peterborough Business Park is adjacent to the East of England Showground and close to the conservation village of Alwalton and the A1. The site covers 7.52ha of a gently sloping plateau above the River Nene. Encircled by natural woodlands and hedgerows, it is part of a rural landscape, albeit with other business park developments on adjacent sites.

The brief
The building will be occupied by the various divisions of Royal Insurance previously accommodated elsewhere around Peterborough. Commissioned at a time of perceived future growth, it will not immediately be occupied to its capacity of 1000 people.

In addition to 10 600m^2 of net office area, the building contains a 1200m^2 computer suite. A staff dining room has been provided, together with a coffee lounge and a licensed bar; a multi-purpose sports hall plus outdoor playing field complete the social provisions. Areas for printing of company literature have been provided but changing circumstances have left these currently unoccupied. There are 750 car parking spaces with room to increase this to 1000.

The client asked that the design team examine all aspects of energy conservation and that the occupants should be given as much personal control of their environment as was possible. The implications of non air-conditioned space with high use of PCs was to be considered.

2. The main entrance.



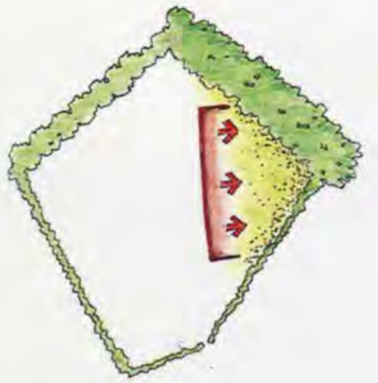
3a. Site plan

3b. Site section.

Design approach

The architectural form evolved by weaving together a response to the site, an analysis of the spatial and environmental functions of the brief, and the desire to create a relationship between the spaces people occupy and the landscape which they view from those spaces.

A

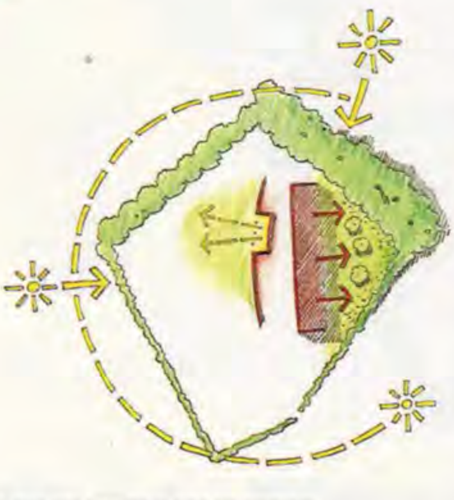


- all office areas have an outlook over landscape.
- maintains feel of a rural site.
- generates single aspect linear form.

B

- requirement for opening windows.
- form shelters office area from traffic noise.
- building orientated away from adjacent developments.

C



- office area orientated to avoid sun penetration.
- view of landscape from offices not blocked by shading devices.
- south-facing dining area gives change of environment during day.

A response to the site

(A) The intuitive response to the first site visit was to try to maintain the rural quality, and to create an environment which gave the occupants a close relationship with the landscape. This, combined with the client's wish that all offices should have a similar outlook, generated a linear building orientated towards the existing mature tree belt along the northern boundary of the site.

(B) The single aspect linear form gives the office areas protection from external influences on the site. Orientating the building away from the road affords any opening windows protection from traffic noise. However, overlooking from adjacent developments has not been totally avoided as the scale of the development to the east does intrude on the outlook from some of the office areas.

(C) Direct sunshine can be a major problem in modern offices. Office equipment generates high heat loads which have to be countered by some form of cooling; if office areas are also subject to high solar heat gain an additional load is placed on the cooling plant. Direct sunlight should also be minimized as it creates problems of glare and reflection on VDU screens. Rather than overcome these problems by resorting to the use of tinted glass or external shading devices and blinds, all of which would break the relationship between office areas and landscape, the building has been exactly orientated so that direct sunlight does not penetrate the office areas during the working day.

By contrast, in areas of the building such as the dining room, controlled direct sunshine is desirable, and therefore these have been located on the south-facing side of the building.

A response to the brief

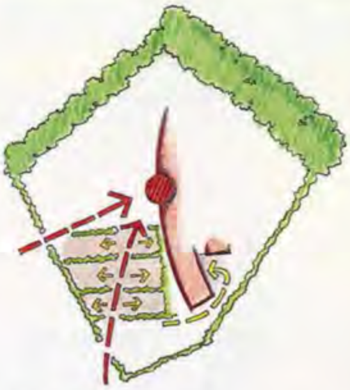
(D) The building has a single focal entrance used by all visitors and employees, which eases security and is socially more desirable. The location of the car park allows a natural progression from road to car park to building entrance. Landscaping has been used to control vistas to and from the building to ensure that the entrance is clearly visible on entering the site, that the building is not viewed across large areas of car parking, and that occupied areas do not overlook the car park.

(E) The requirement for out-of-hours access to the computer suite and the social facilities meant their location had to be closely related to the main entrance. The revolving glazed screens which separate the entrance from the main circulation area allow access to the out-of-hours functions to be maintained whilst denying access to the office areas.

(F) The schedule of functions in the client's brief divided very simply into office areas and facilities required to support the office functions. The spatial and environmental requirements of these areas also divided into two types of building — open flexible space for the offices and specific enclosed spaces requiring minimal outlook for the support facilities. The overall form of the building reflects this split, with the enclosed curved block containing the support facilities, contrasting with the open orthogonal office decks.

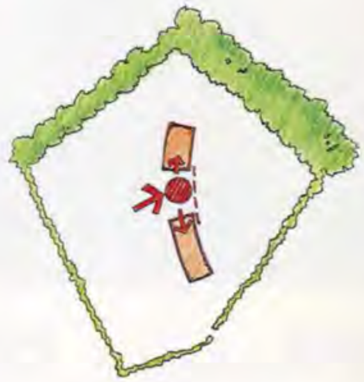
(G) In a building with a population of 1000 people a well-defined major circulation route is an important element in linking all parts. This internal 'street' is defined by the space between the curved wall of the support facilities and the edges of the open decks of office accommodation. The twisting geometry of the roof encloses the volume, adding to the visual excitement and variety of the spaces from one end to the other. The social significance of the street is, however, as important; by linking all parts of the building it gives an internal identity and provides a common space to be enjoyed by all. It allows users of the building to see themselves, and be seen, as a part of a larger open organization.

D



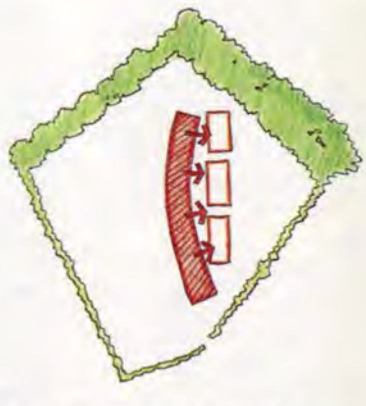
- building has a single focal entrance.
- car park located to give natural progression to entrance.
- service bay screened by form of building.
- no office areas overlook car park.

E



- out-of-hours access needed to computer suite and social facilities.
- access to be via main entrance.
- out-of-hours access to office areas to be prevented.

F



- office support functions contained in curved block.
- support functions require enclosure and minimal outlook.
- internal circulation connects support functions and office areas.

G

- internal 'street' provides clear circulation to all parts of building.
- office community requires common spaces to give sense of place.
- 'street' defined by space between curved wall and office decks.

(H) The internal street as the major circulation route is reflected in the service distribution system, with a service tunnel below the street containing all the pipe and cable service runs. This links the central plantroom and the local air-handling plantrooms on the roof of each core. The central plantrooms adjacent to the unloading bay house the central chillers, gas engines, central electrical equipment, sprinkler pumps and water storage tanks. The cores serving the office areas also contain the fire escape stairs and are located to suit escape distances.

A relationship to the landscape

The building and the landscape are designed to be a single architectural development of the site. Elements of the architecture are conceived as landscape and elements of the landscape are seen as architecture.

(I) The entrance to the building is formalized by the avenue of trees which define the main approach. They reinforce the focus on the entrance which is signalled by a glazed steel screen, an element which in itself provides a reference point to the glazed wall on the other side of the building. The volumes of the sports hall, the restaurant, the computer suite and the central plantrooms are placed behind the long, curved, two-storey, brickwork garden wall which forms a backdrop to the landscape enclosure of the car park.

(J) On the level below the main entrance, and connected to it by the waterfall and entrance screen, is the lake and its enclosing landscape. When viewed from inside, the relationship with the landscape is immediate, with only minimal visual separation between the dining room and its extension onto the lakeside terrace.

(K) Occupants of the building spend several hours at a time sitting at desks in generally open plan areas, so the element of visual relief provided by a view of the world outside is very important to the individual's feeling of wellbeing. A major emphasis within the design of the building was placed on the development of the relationship between their offices and the landscape beyond.

The logical generation of the plan gave the benefit of an unobstructed view from the offices towards the mature woodland belt along the northern site boundary. The intervening area is landscaped and planted with a ribbon of trees and hedges defining a series of room-like spaces, each of which is visually an extension of a space in which people work.

Critical to this concept was the design of the element placed between the internal and external spaces. It had to provide enclosure to the offices, but when viewed from inside had to place minimum visual obstruction to the flow of space. However, overall it had to be more a landscape element — a white trellis relating to the formality of the gardens — than the external wall of a building.

(L) The design of the building recognizes that it is not only a part of the landscape, but also an object within it. To reduce its visual scale the slight changes of level across the site were exploited to reduce the apparent height. From the main approach, the building appears as a long low wall with a roof floating above it, the scale of the office area being completely concealed.

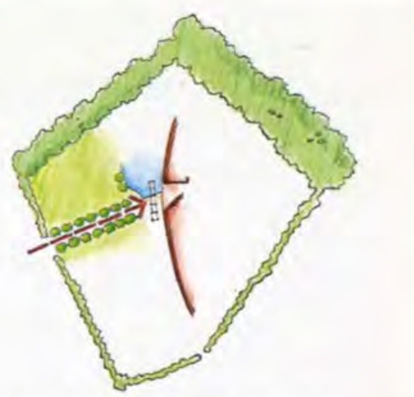
(M) The building section is crucial to the environmental design concept. The solid roof and curved block shade the open office areas, reducing solar heat gain and thus cooling loads, and excluding direct sunlight on workstations.

(N) The internal scale of the building, although dramatic due to the 'street', is essentially low-rise. The rise of the ground places the entrance at the centre of gravity, both vertically and horizontally, and people need only move up or down one level from the entrance.

H

- office areas subdivided by service cores.
- located to satisfy means of escape requirements.
- roof-top plantrooms connected to central plant by service tunnel.

I



- avenue of trees creates formal route to main entrance.
- glazed entrance screen provides focus and reference to glazed wall.
- waterfall and lake link entrance and landscape.

J

- dining area extends onto lakeside terrace.
- inside and outside become one space.
- view enclosed by landscape.

K

- internal spaces extend out into external spaces.
- external rooms defined by landscape.
- glazed wall becomes landscape element.

L

- building mass cut low into landscape.
- seen from south as a wall with a roof floating above.
- screened from north by existing tree belt.

M

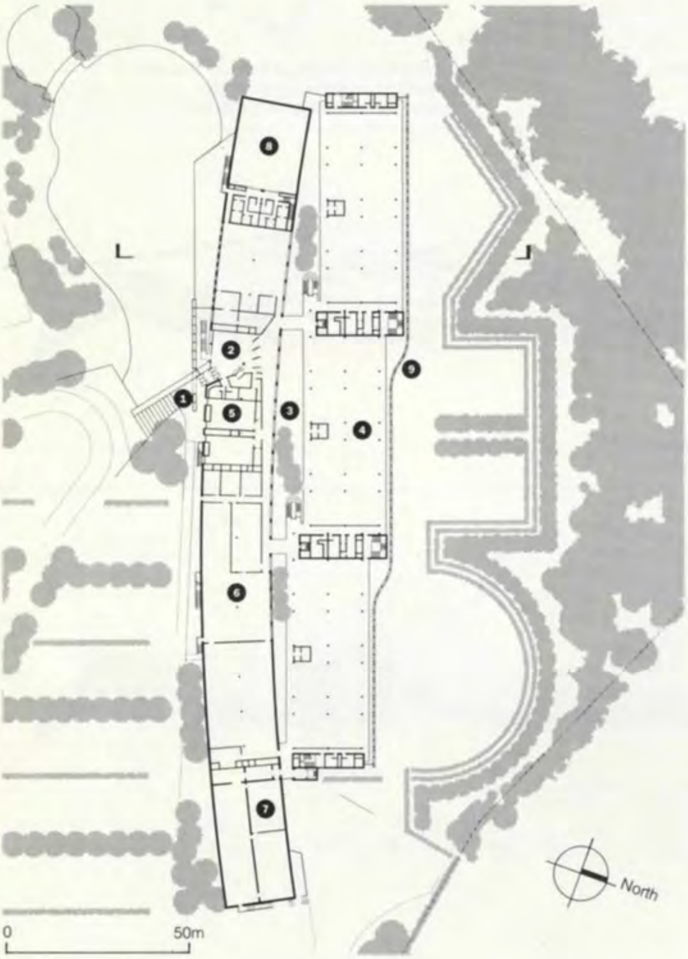
- solid street roof and curved block shade open office areas.
- reduces solar heat gain and cooling load.
- cuts out direct sunlight on workstations.

N

- building entrance located at centre of gravity.
- users only move one level from entrance.
- internally building feels low-rise.

4. The main entrance, and below, 5. The terrace and lake viewed from the dining room.

8. The dining terrace.



6. Left:
Level two plan

◀ Key:

1. Main entrance
2. Reception
3. Internal street
4. Office areas
5. Conference room
6. Computer suite
7. Central plantrooms
8. Sports hall
9. Glazed screen wall

7. Below: Section

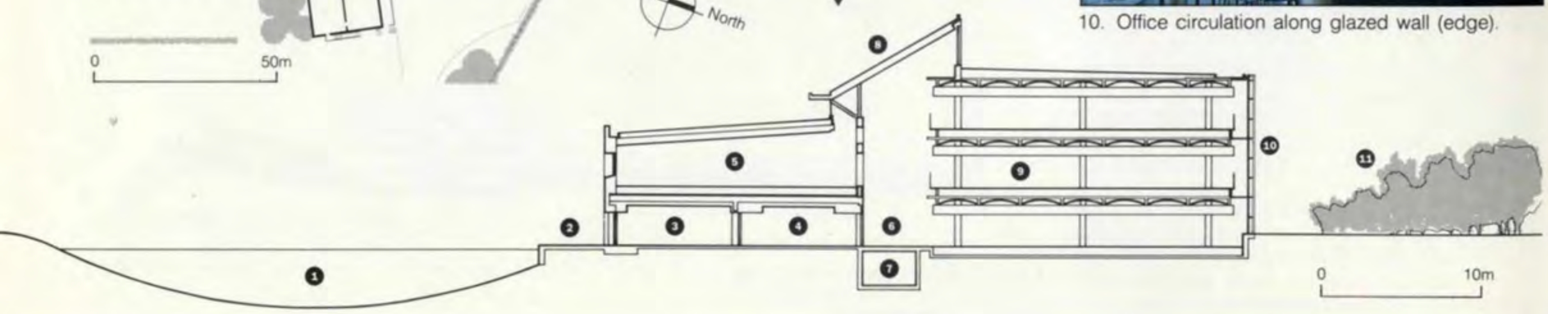
Key:

1. Lake
2. Dining terrace
3. Dining room
4. Coffee lounge
5. Support facilities
6. Internal street
7. Service tunnel
8. Street roof
9. Office areas
10. Glazed screen wall
11. Formal gardens

▼

9. Office circulation along street edge.

10. Office circulation along glazed wall (edge).



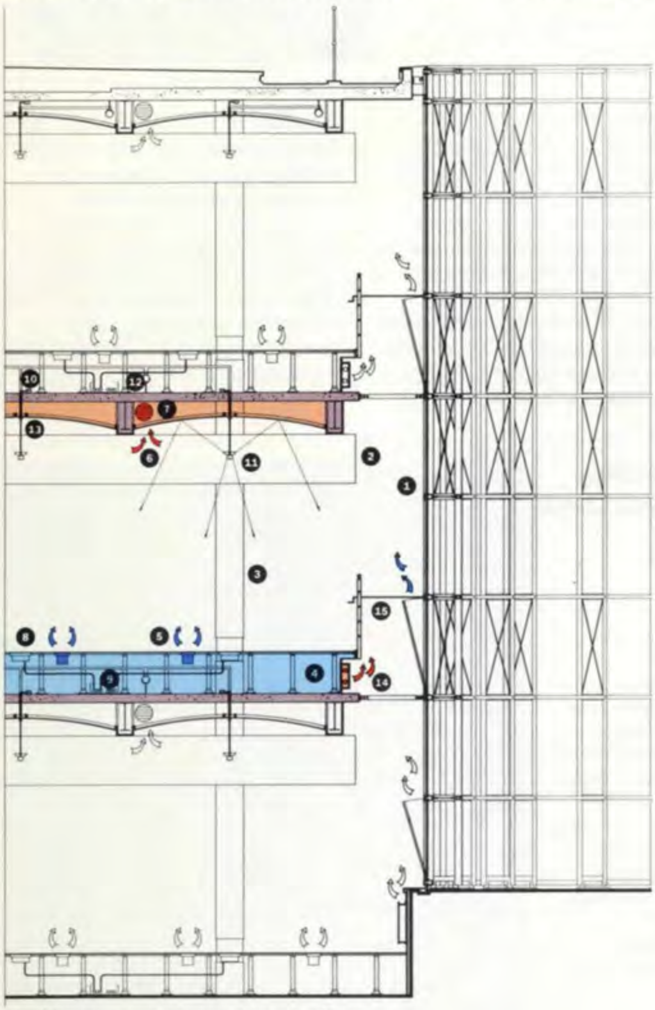
Office design: an integrated approach

The client's brief called for generally open-plan office accommodation with screened areas for managers and a limited number of closed offices, for senior personnel, which would also be used as meeting rooms.

The arrangement of the structure with major and minor bays provides the architectural and planning framework for the office layout. The minor bays, defined by the 18m longitudinal concrete beams at 4.5m centres, have conventional accessible ceilings which respond to a partition planning grid of 1.5m for cellular offices. The intermediate 9m × 18m major bays form the open plan spaces. In these the ceilings have been divided into a series of shallow vaults between the expressed secondary beams. The vaults are white pressed metal acoustic panels which also act as reflectors for the fluorescent up and downlighting fittings which are suspended below them.

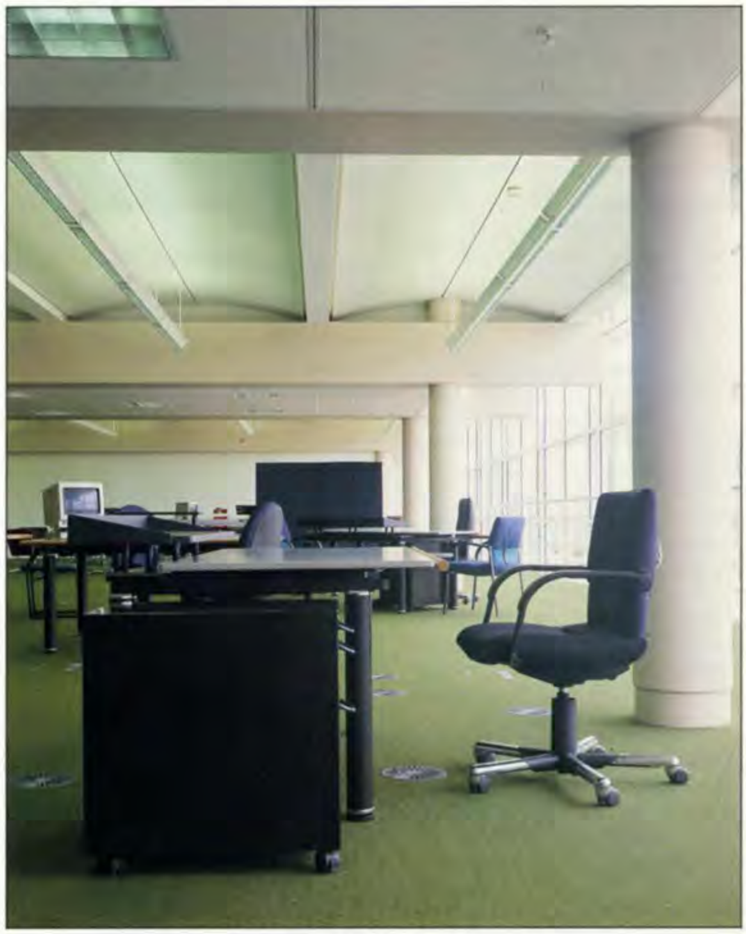
The office floors are raised 600mm off the concrete slabs to create a floor plenum from which the supply air emerges through swirl outlets which can be individually controlled by the occupants. The floor void also provides a horizontal distribution zone for sprinklers, power/data/telephone cabling, and the return air header ducts. This raised floor, together with the system of secondary beams above primary beams, has produced a solution which is virtually transparent to all horizontal service distributions.

The return air system exploits this to the maximum, with air from the major bays extracted at high level at the ends of the vaults above the primary and between the secondary beams. The return air ductwork is located above the minor bay ceilings running parallel to the primary and below the secondary beams. Extract from the minor bays is through the light fittings into the ceiling plenum.



11. Above: cross section through offices

Key: ▲
1. Glazed screen wall
2. Concrete beams
3. Concrete columns
4. Raised floor air plenum
5. Twist air outlet
6. Return air through ceiling
7. Return air duct in minor bay
8. Electrical floor outlet
9. Power/voice/data supply
10. Lighting power supply
11. Fluorescent up/down light
12. Sprinkler main
13. Sprinkler head
14. Perimeter heating
15. Manually opening window



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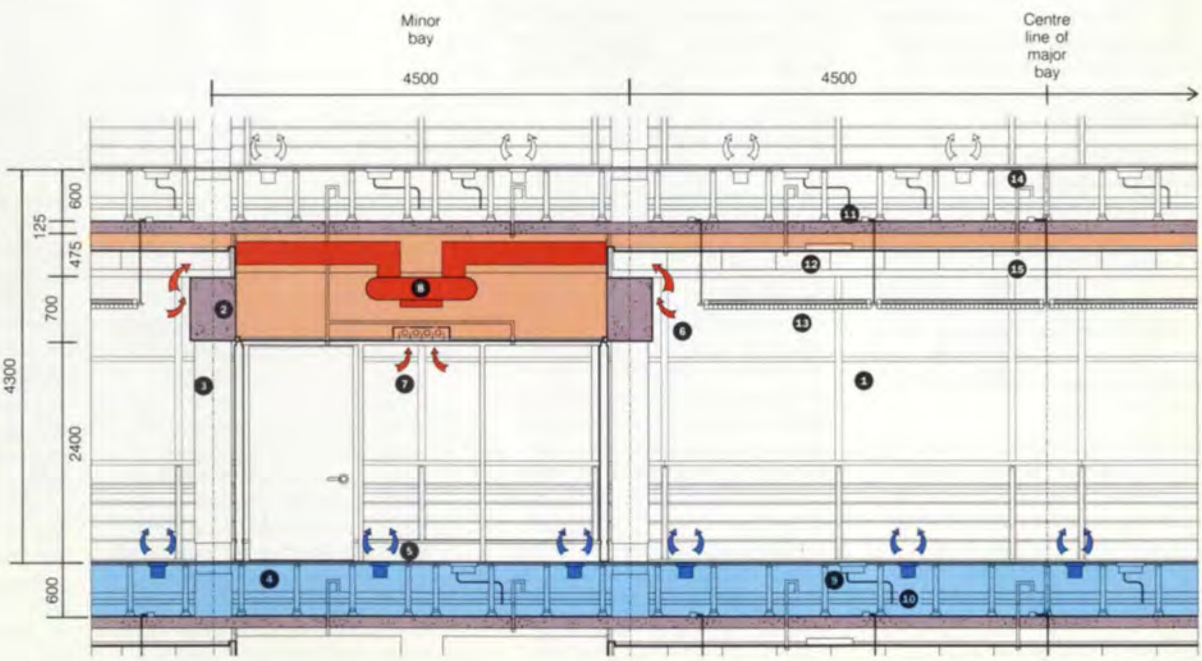
13. Office interior.



12. Right: Longitudinal section through offices

Key: ▶
1. Glazed screen wall
2. Concrete beams
3. Concrete columns
4. Raised floor air plenum
5. Twist air outlets
6. Return air into minor bay
7. Return air through light fittings
8. Return air duct
9. Electrical floor outlet
10. Power/voice/data supply
11. Lighting power supply
12. Lighting control gear
13. Fluorescent up/down light
14. Sprinkler range pipe
15. Sprinkler head

14. The minor bay concrete frame, September 1989.

15. The structured formwork, October 1989.

16. Exposed concrete and utility steelwork, October 1989.

17. The street roof structure, February 1990.

Structural design

The strategic structural decisions were influenced by the findings of the site investigation and the need for a fast construction programme.

Foundations

The site investigation revealed a sloping layer of Cornbrash rock underlaying the building's footprint, at a depth of 3m-6m below the ground slab.

Below this weak rock there was generally a mixture of sand and clay. The decision to adopt a light superstructure allowed the Cornbrash layer to be used as a founding bed without the need to perforate it. Because of the tight programme it was important to avoid the use of expensive and time-consuming traditional long piled foundations. Instead, the building has been sat on a series of short 2m and 900mm diameter mass concrete column-like piles bearing into the Cornbrash rock and loading it uniformly.

Superstructure and structured formwork

A pure in situ concrete, skeletal frame solution was adopted for the three-storey office blocks containing the office areas. Frames are spaced at 4.5m centres and coupled together to ensure stability. These pairs of frames, which create the minor bays, are placed with a void of 9m between them. This void, which becomes the major bay, is bridged using simple drop-in steel beams supporting a lightweight composite slab cast on a corrugated metal deck.

The decision to use pure main concrete frames in advance of the secondary beams and slabs was due to the programme demand to make an early start on site while the steel was still being fabricated. The use of concrete also satisfied the desire to create an expressed structure, hard to the touch, and which clearly defined and gave rhythm to the occupied spaces.

Speed of erection was achieved by developing with the sub-contractor single-piece steel formworks as used in the prefabrication industry. These were formed by bending long lengths of metal sheets with the corners as sharp as could reasonably be achieved. The formwork incorporated walkways on either side for construction access. Tubular side struts were provided at regular intervals, complete with screw mechanisms for extension and contraction, to facilitate levelling of the sides and demoulding. Side straps were located at 3m centres at the top of the forms to position the sleeves for the holding-down bolts.

The 'structuring of the formwork' was essential to the progress of the work, considering the chosen technique of building the frames before and separately from the slabs, the absence of extensive working platforms, and the absence on site throughout the contract of fixed cranes.

The curved block is a utility block. The two-storey structure is a standard steel building with composite floors, having all its components covered with dryline partitions. Off-site steelwork fabrication ran concurrently with the erection of the concrete frames. Once on site the steelwork erection was completed at the same time as the concrete frame and construction of the concrete slabs progressed in parallel.

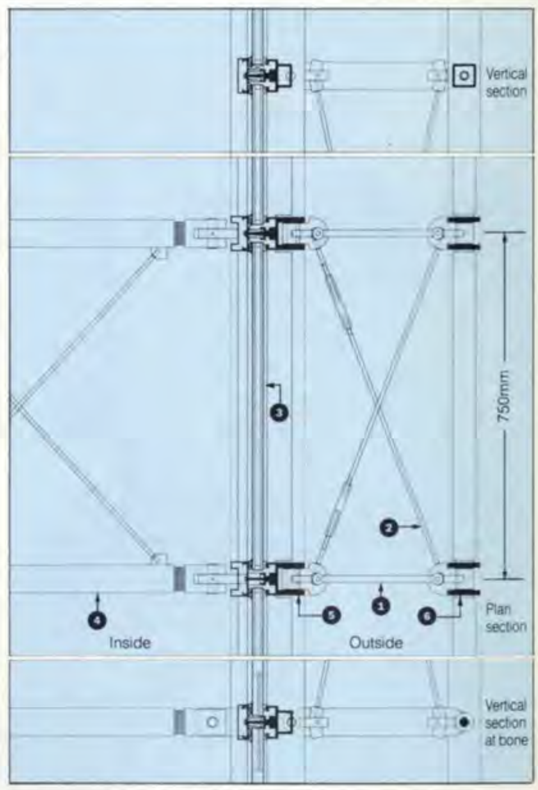
Street roof

The roof over the space created between the continuously curved, two-storey block of support facilities and the stepped orthogonal three-storey office blocks required an original solution. The complexity of the problem was due not only to the need to resolve the varying geometry, but also to the non-alignment of the expansion joints and the differential movements and deformations between the two differently constructed building strips.

The solution was a simple pinned steel portal with a sloping soffit to accommodate the different heights of the buildings. The span of the frame varies from about 3m at the ends of the street to about 11m at the centre. In its simplest form the frame's static behaviour was easy to understand and predict and its tolerance to movements was accommodated by the pinned connections. Excessive sway at its steepest positions was controlled by inserting a small push-pull solid square section at the bottom of the slope. Tubes as the support members, and two channels placed back to back and spaced by square boxes as the beams, constitute the structural members. The sprinkler pipes for the street are integrated between the two channels.

The frames are spaced at 4.5m centres and are arranged radially, following the geometry of the curved block. In order to resolve the difficulties created by the geometry, the pin joints on the members fixed to the office blocks were designed as freely rotating collars at the tops of the props. Once the frames had taken their correct position the collars were welded in place. The pinned portal frames, each set at a different pitch, provided the structure off which the roof was constructed. The sweeping twisting surface was created by spanning profiled steel sheets between the frames. Due to their negligible torsional stiffness they could easily take the out-of-plane differences from frame to frame. From this surface was constructed a 'traditional' roof with insulation, timber cross boarding, felt, and a finish of long strip, terne-coated stainless steel.

Glazing structures



Key:
1. Cast aluminium bone
2. Threaded stainless steel rods
3. Sealed double-glazed unit
4. Strut connection to slab edge
5. Aluminium structural glazing million
6. Aluminium structural mullion

18. Connection detail of glazed street wall.

The fully glazed screen wall on the north side.of the building is 180m long and 12m high. It flows continuously from one end to the other, sweeping around the steps in the building plan, detached from the building edge to emphasize its function as an element placed between the office areas and the landscape. Conceived as a constructed landscape element, it needed visual as well as structural depth: a minimal structural expression was not the intention. An external aluminium structure has been used, stabilized with stainless steel rods. To produce visually simple connections, all rods are threaded into the struts — single cast aluminium members in shape resembling bones — which connect the principal vertical aluminium members. The wind forces are conveyed to the edges of the floor slabs through a series of steel struts, while at the curved sections the loads are taken by single steel columns.

The main entrance to the building is enclosed by a glazed structure organized as a series of horizontal square sections welded to vertical 'T'-sections, the whole system forming a ladder which performs as a vierendeel beam for loads. Aluminium walkways are placed between the two glazed facades and overall stability is achieved by the introduction of stainless steel diagonal rods.

Mechanical design

The three main office areas are serviced from air-handling plants at roof level above the cores. These supply the air into floor plenums, from which it emerges through the swirl outlets in the raised floor. Each floor plate between cores is 45m × 18m, with the floor plenum divided into two by a cavity barrier. Supply air is ducted down within the cores and each plant, therefore, serves the space either side of the core as far as the cavity barrier.

Perimeter heating is provided at the north-facing glazed wall. At ground level this is easily accommodated at the bottom of the glazed wall, which rises free of the intermediate floor slabs. At the upper levels the heater casings are fixed to the edges of the floor plates, some 500mm from the outside wall. This arrangement has given good protection from downdraughts and largely offsets the fabric heat loss.

Return air is extracted through the ceiling spaces in the minor bays, which are designed as the zones for cellular offices. The air plants are supplied with low temperature hot water and chilled water and contain run-around coils in addition to fully modulating dampers to maximize 'free' energy use. The theme of maximizing 'free' energy, or minimizing purchased energy, is reflected in the organization of the central plant. The chillers producing chilled water for the air-handling plants and computer room coolers have two-speed compressors to maximize part-load performance. They receive their cooling water from the River Nene where the water temperature is lower than from cooling towers. The water is used directly in precooling coils in the computer room coolers so that the chillers are called for only when the river water is too warm to provide sufficient cooling.

A critical area of the building is the computer suite together with its gas-fuelled co-generation sets. The office content of the building is designed without mechanical cooling, but three chillers are provided with the duty of each being 66% of the computer suite load, with surplus capacity used to cool the offices. On failure of any one of the chillers, cooling is directed only to the computer suite. The generators are driven by gas engines which are used in winter to heat the building. A large thermal storage vessel is part of the system and immersion heaters in the vessel are used to optimize the efficiency of the engines as exporting power is not allowed by Eastern Electricity.

If the engines have to be run on loss of mains power at a time when the heat cannot be used in the building, the heat is rejected through dump radiators. Should the river water system fail, the chillers are cooled by their own discrete air blast coolers.

Electrical design

Distribution

Radial distribution feeds are taken from the low voltage switchroom to the various main load centres located throughout the building. Electrical distribution is by a busbar system installed in the underground service tunnel. An encapsulated busbar system was selected as the insurers required sprinklers in the service tunnel and special precautions had to be taken to prevent water ingress to the busbars.

Co-generators

Three gas-fuelled co-generation sets are installed in the plantrooms, each rated at 276kW and capable of running either independently or in parallel with other sets and/or the supply from the two 2MVA 1000/433V transformers.

Under normal conditions, sets are run in parallel with the Eastern Electricity supply to meet the building's heat demand, the electricity generated serving to reduce the units consumed from the mains. Peak demand lopping is provided by automatically running sufficient generators to limit the maximum power demand from the Eastern Electricity supply to a preset level.

Under mains failure conditions, all the available co-generation sets run in parallel to supply automatically selected loads across the site. Load shedding and sequential restart control has been provided to match the connected loads to the supply capacity available.

The glazed screen wall

The sets are sized such that if one is unavailable because of maintenance or failure, the remaining two can supply power to essential loads such as the fire detection and protection system, security services, emergency lighting and computer suite lighting and air-conditioning.

The heat produced by the co-generation sets is normally used to heat the building. Under mains failure conditions, excess heat not required in the building is rejected via dump radiators.

Uninterruptible power supply (UPS) system

A rotary UPS system is installed to provide a continuous clean supply to the computer suite electronic data processing equipment via a dedicated data processing switchboard. The system consists of two *Holec* 500KVA induction coupling type diesel-engine driven sets, each capable of supplying half the load, which are installed in a dedicated room adjacent to the plantroom. Under normal conditions the data processing switchboard is fed from the Eastern Electricity supply. Electrical noise and transients are filtered out by the UPS system to give a clean supply.

Each UPS set has an induction coupling which is powered from the mains supply and kept constantly spinning. The diesel engines are normally disconnected and stationary. If the mains supply fails or deviates outside set tolerances for voltage and frequency, the UPS disconnects itself. The induction coupling stores sufficient energy to maintain power to the load while the diesel engine starts and is brought up to speed. Unlike battery-based static UPS sets, the induction coupling type diesel UPS can supply power during a mains break of indefinite length, because diesel fuel can normally be resupplied before the storage tank is emptied. A bulk tank of 14 days' capacity is installed; each UPS set also has a local eight-hour day tank.

Under mains failure conditions, the UPS system runs completely independently of the co-generation equipment which supplies the computer suite chilled water, air-conditioning and lighting loads.

Office power and communications

Power distribution rising mains are provided in the cores of the main office areas, supplying general power and lighting requirements at each level through distribution boards. Motorized isolators on lighting and power distribution boards in risers allow the load shedding and restart system to reconnect loads sequentially after a supply interruption.

Voice and data wiring are routed along the appropriate underfloor cable tray to patch panels within the Office Communications Room (OCR) centrally situated in each office floor. The voice and data wiring are then taken to the computer suite and network services room via dedicated risers and the service tunnel.

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Computer suite power distribution

Power distribution units, energized via the UPS system, contain operational/maintenance control devices and circuit protection for 415/240V 50hz radial feeds to hardware items. Protection is provided by plug-in moulded case circuit breakers and contactors for emergency switching. The PDUs have lockable fronts to prevent unauthorized tampering.

Office lighting installation

A row of fluorescent luminaires suspended below the apex of the vaults at 3m centres achieves 450 lux illuminance, giving a high proportion of upward light as well as glare-controlled downward light. The upward light illuminates each of the suspended vaults to within brightness criteria generally accepted for terminal screens. The downward light boosts the illuminance, increases contrast rendering with the introduction of some shadow features, and reduces the blandness of a total uplighting installation. Minor bay offices with suspended ceilings are illuminated with glare-free recessed fluorescent fixtures, which provide similar levels of lighting to the open office areas.

Fire protection

The building is protected with sprinklers to meet 29th Edition FOC Rules OH III. In addition there is an external hydrant system. A waiver was obtained from the Department of the Environment to relax the Building Regulations' requirement for means of escape away from the voids at the edges of the office floors. It was agreed that, given the 'open' nature of the planning and the location of the stairs, the 'spirit of the Regulations' was met as there was always an adequate alternative means of escape.

Conclusion

Work began on site in March 1989 with Bovis as the management contractor. The building cost £33.4M; it was handed over in March 1991 and, after a fitting-out period, was occupied in July 1991.

The planning of the building and its location on the site developed from a logical analysis of the site, the brief, and a concept of how the building should relate to the landscape of which it is a part. Its anatomy developed from an analysis of the mechanical and electrical servicing requirements of its functions and an understanding of how these services could be integrated with the structure. However, for the building to be judged a success it must be seen as a place with its own special atmosphere that will excite those who work within it, a place to which they can relate and of which they can be proud. This cannot be achieved just by a logical analysis of the brief and the technical requirements of the functions. The design must recognize that the building will contain up to 1000 people who will spend their working hours there. The design must show a sensitivity that will make the scale of the building less overwhelming and intimidating. The design must respond to the needs of the individual as well as the smooth workings of the organization. Time will tell.

Credits

Client:
Royal Life Holdings Ltd.

Designers:
Arup Associates Architects + Engineers + Quantity Surveyors

Management contractor
Bovis Construction Ltd.

Photos:
Arup Associates except where indicated

Development and archaeology

Richard Hughes Hakop Mirzabaigian

Background

Redeveloping buildings in historic towns almost inevitably means that their new basements and foundations destroy the surviving archaeological resource. Pre-20th century buildings typically had shallow basements or none at all, and simple foundations that in many ways protected the substantial deeper fill deposits, accumulated over 2000 years or more. Buildings now generally have deep basements and sophisticated foundations that remove all the fill and hence all preserved valuable materials.

For the last two decades, or more, the engineering removal of the fill has been coped with by the growth of 'rescue archaeology'. Here the developer, engineer or contractor has permitted a team of 'diggers' site access for a short time before or even during site construction works. This works best where the fill over the whole site is to be removed for a basement and the archaeologists can have sole occupancy for their excavation. Archaeological intervention is not so successful where piling from ground level occurs. Here the operation does not allow for detailed observation and in situ recording of remains.

The archaeological site attendance has been, typically, a few days to a few months, depending on the predicted value of the resource. It has become standard practice for the developer to pay for the archaeological intervention, since it can be argued that he will be responsible for the resource destruction in the first place! In historic cities such as London or York, we in Arups are familiar with our developers paying from several thousand pounds to over a million for substantial excavations.

From an archaeological point of view 'Rescue' excavation is now felt not to be the best method to gain a thorough knowledge of the past. Many sites are simply not in locations where excavation helps us to form new concepts, for example, of how our forebears commercialized an inner city suburb.

Other sites are considered so archaeologically valuable that the resource should be protected or preserved until there are better excavation techniques or new models of the past that need verifying. Engineering the protection of archaeological resources on a development site is now in vogue. To this end DoE through its agents English Heritage has issued a guidance note (*PPG16*) to local authorities that clearly aims at initiating the new strategy and making archaeological preservation and excavation a material consideration in a planning application.

From a developer's point of view an expensive archaeological excavation, or preserving 'fill' by good foundation engineering (or by not having a basement at all!) can make a development scheme economically unviable. Perhaps the developer's greatest fear is still that the site construction operation can be held up by the chance discovery of valuable remains.

This possibility has for many years been successfully dealt with in Arups by regarding archaeological activities as part of the development process; something to be planned for at the earliest opportunity. To this end we carry out our own archaeological desk studies.

PPG16 effectively goes one step further by recommending local authorities to insist upon each site being archaeologically evaluated before Planning Consent is granted. The evaluation is to consist of a desk study, followed by geophysical prospecting, and trial pits at the site. In Arups we have often followed such an approach but with such works forming part of the geotechnical investigations.

The York study

York is one of the five designated 'Historic Cities', with legal archaeological requirements granted under the Ancient Monuments and Archaeological Areas Act of 1979.

To investigate further the integration of archaeological and engineering activities, York City Council and English Heritage appointed Arups' Manchester office to examine the problems faced in the centre of York. Here the archaeological resource is of international significance, where many excavations can last up to two years and cost several million pounds. This has inevitably put off developers from undertaking new works in York. The Manchester project has tried to resolve many of these excavation, preservation, and development issues. The overall objective of the commission was to update knowledge of the city's archaeological resources, and to provide a framework to ensure that development of sites was secured in a way to conserve the most outstanding archaeological resources.

This aim was achieved in a series of studies addressing these objectives:

(1) To update knowledge of the archaeological resource in the Area of Archaeological Importance.

(2) To provide a detailed resource assessment of 35 sites identified by York City Council for probable redevelopment.

(3) To review the responses to archaeology which have been undertaken in York and other cities.

(4) To advise on costs of investigating and recording comparable archaeological deposits identified as Category 2 sites as defined by York City Council.

(5) To advise on the feasibility and costs of undertaking further investigation of sites where insufficient data are available.

(6) To review experience with novel engineering foundation options which minimize the archaeological impact.

(7) To advise on technical-economic-planning information that can be best applied in the development process.

The study was directed by Ove Arup and Partners with significant input on archaeology provided by staff of the Department of Archaeology in the University of York, under the direction of Professor M.O.H. Carver. Bernard Thorpe & Partners provided guidance on the influence of archaeology on developers and the development process. Assessment of the proposed 35 development sites was undertaken in-house following the now nearly standard geotechnical desk study methodology.

The project document is particularly strong in zoning the extent and quality of the archaeological resource and showing how it is possible to reduce uncertainties for the developer, yet maximizing preservation and excavation strategies by careful foundation procedures.

One concept discussed with the client was of a good piling operation which only destroyed, say, 5% of the site. Was this an acceptable limit since 95% would by definition be preserved? In theory, the answer was yes, as long as the site was thoroughly researched and investigated beforehand. We were not able to suggest any new foundation techniques that would reduce the archaeological resource damage to significantly less than 5%.

Conclusion

Due to the recession and consequent slowdown in building development there has not been much opportunity for practical testing of the York project's methodology.

We now eagerly await new projects so we can use our skills, and natural advantages resulting from the commission, to demonstrate a new and improved level of engineering/archaeological integration.

Credits
Clients:
York City Council/English Heritage
Archaeological consultants:
Ove Arup & Partners, Manchester

The outline of a complete Roman stone building, perhaps a warehouse, discovered in excavation by York Archaeological Trust at Wellington Row, York

Courtesy York Archaeological Trust

A120 environmental design

Phil Hall Tadgh Ó'Mathúna

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Introduction

With the planned expansion of Stansted Airport, Essex County Council recognized that the existing single-carriageway A120 linking the airport eastwards to Braintree, which was already at capacity at peak times, would be unable to accommodate additional traffic. The County Council, therefore, proposed a new 25km dual carriageway from Stansted Airport, passing north of Takeley, and south of the villages of Great Dunmow and Rayne connecting with the Braintree southern by-pass (Fig. 2). The route is proposed to be all-purpose limited access, becoming a trunk road upon completion.

Ove Arup & Partners were appointed by the County Council as consultants for the design, environmental assessment and construction of the scheme. The client had developed a preliminary layout, selected from a number of options at route consultation stage. Arups were responsible for further development of the layout and preparation of an Environmental Statement to accompany the planning application.

During the route selection exercise Essex County Council undertook an attitude survey of local people. By far the greatest environmental concerns identified by the public were the effects of noise and pollution on residential property, followed by landscape concerns, safety, and loss of agricultural land. The effects on leisure and recreation pursuits were considered to be of little significance. Ecological interests were not viewed as a major issue at this stage.

These and other issues were addressed in detail by Arups' multi-disciplinary environmental assessment team, comprising the Highways Group based in Coventry, providing project management and highway design skills, members of Arup Environmental, Arup Acoustics, The Landscape Partnership and the Essex County Archaeologist.

Environmental assessment

The full requirements of the EC Directive on Environmental Assessment were observed in the production of the Environmental Statement. This involved an examination of existing conditions, a description of the effects of the scheme and a structured assessment of their significance and interaction. Recommendations on mitigating measures to minimize adverse environmental effects were incorporated in the scheme design.

The Statement also included a summary of the consequences of the development and an Action List recommending further survey and remedial measures.

The assessment highlighted a number of areas of concern of which the most significant were: landscape quality, the management of a large herd of fallow deer, and the presence of ancient woodland designated as a Site of Special Scientific Interest.

Landscape quality

The Council agreed that the landscape proposals for the scheme should be developed to a much greater level of detail than would normally be required for the planning application stage. This allowed the scheme to be presented to the public as an exhibition during the currency of the application which greatly improved its public acceptability.

The route is set in an area of rolling agricultural countryside, mainly classified as a Special Landscape Area by the County Council, although it is not regionally significant. Nevertheless, the planning policy framework requires that there is a presumption against development in the SLA unless its location, siting, design, materials and landscaping accord with the character of the area.

The physical and visual effects of the road proposals were therefore assessed by the landscape architects and measures to minimize intrusion proposed.

The intrusive features of the scheme included the road surface, earthworks, structures, lay-bys, lighting, traffic, deer fencing, grade-separated junction and road signs. In the more featureless landscapes, proposed grade-separated junctions would be highly visible and significant landform regrading was proposed to minimize the effect. Major off-site planting was recommended, and longer-distance views at present uninterrupted will be maintained by false mounding. There will also be opportunities for creative nature conservation and landscape enhancement in and around the balancing ponds associated with the scheme.

Close liaison between design engineers, environmental scientists and landscape architects, and the sympathetic attitude of the client, have resulted in the above measures being adopted as essential components of the scheme. This will be reflected in the serving of appropriate Compulsory Purchase Orders.

Fallow deer

It was clear at an early stage that there was a substantial number of deer in the vicinity of the existing A120 and that their movements would be hindered by the proposed alignment.

A large herd of some 500 fallow deer was recorded in Hatfield Forest and the neighbouring woods. Discussions with police, landowners and the British Deer Society revealed that deer frequently crossed the existing A120 and that measures had been taken to protect Stansted Airport from deer wandering across operational areas.

However, a major difficulty in assessing the scale of the current problem was the lack of accident statistics. Collision with a deer is only a reportable traffic accident where personal injury occurs, and this appeared to be a rare event.

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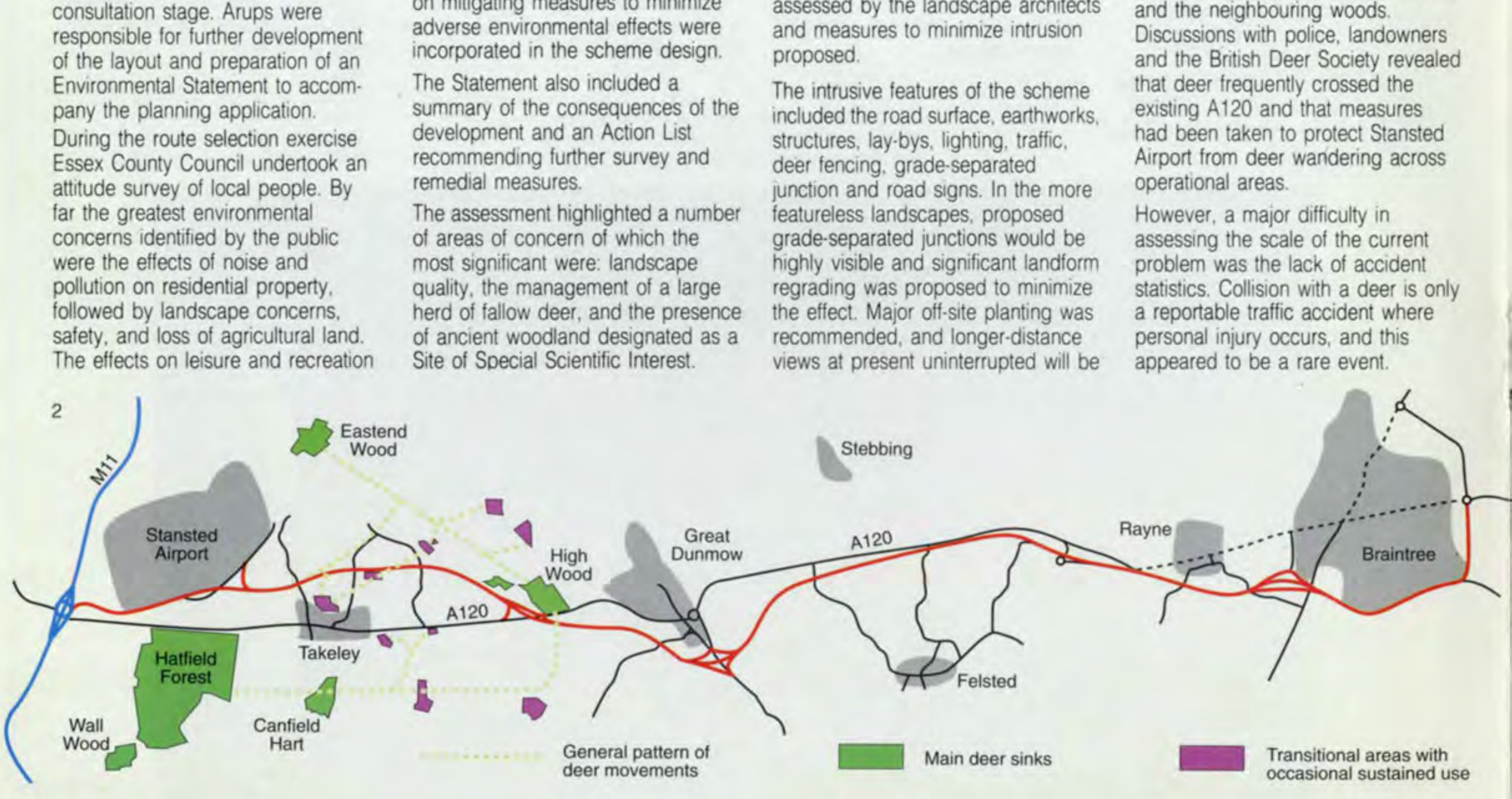

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Insurance claims for damage to vehicles are seldom made because the deer are not owned. Consequently, traffic accident data tend to under-estimate the actual state of affairs. Given the current accident frequency it was considered that the new A120 would result in an increase in the risk of major accidents.

Knowledge of the distribution of deer in the vicinity of the proposed A120 was vital to assess the potential accident problem. As deer tend to vary their movement patterns at different times of the year, it was important to understand the seasonality of their movements. Consequently, following the advice of the Deer Society, local experts were appointed to undertake surveys in spring 1990 and in the rutting season of late autumn 1990. Arup staff also participated in a weekend exercise to capture, mark and release deer. The strength of these animals soon became evident when attempts were made to immobilize them for tagging.

Following a review of deer management strategies for the M25 and the A34, as well as those in Staffordshire and the New Forest, a variety of control measures were considered.

These included warning signs, fencing, underpasses or bridges, culling, relocation of the deer or the highway, and *laissez-faire*.

Relocation of the highway to a new position was not considered to offer any specific benefits, and the problem became one of managing the situation within the proposed alignment. Following a review of UK and North American literature, and discussions with the Deer Society, it also became apparent that there are few reliable means of control. The flat nature of the terrain meant that underpasses were impracticable and that overbridges would be a cause of visual intrusion and increased agricultural land take. There was little evidence that such a provision would have been effective in either case.

Ultimately it was decided to introduce continuous deer fencing between Stansted Airport and Great Dunmow, leaving side-road overbridges available for use by the deer. If the deer did not utilize the overbridges, the practical effect would be to create two separate herds.

This was not considered a problem by the Deer Society given the present size and fecundity of the population.

Segregation was also seen to have some advantages for the future co-ordination of deer management.

Discussion of the problem with the Deer Society indicated that a 2.1m high tensile wire fence was preferred as a means of reducing the probability of deer gaining access to the highway. To reduce visual impact, the wire would be coated in black plastic and strung between slim steel posts, the whole positioned so its effect on the landscape is minimized.

High Wood SSSI

There are two ancient woodland Sites of Special Scientific Interest (SSSI) situated in the vicinity of the proposed new A120, namely Hatfield Forest and High Wood, both of which lie to the west of Great Dunmow. The proposed A120 would result in traffic being moved away from the Forest, but the initial alignment crossed the edge of High Wood SSSI. High Wood SSSI comprises 42ha of ash-maple and pedunculate oak-hornbeam wood. The Highways and Environmental Assessment teams were faced with placing the new road between the corner of the SSSI and a small group of residential properties to the south west, which severely restricted the scope for modifying the road alignment. There was also a design objective set by the County Council, that a grade-separated junction was to be provided to the west of High Wood linking with the existing A120 and allowing for all movement patterns.

Following in-depth consultations with the Nature Conservancy Council (now English Nature) and the County Council, a new alignment was agreed which would minimize impacts on the SSSI, residential property and recreational land. The trade-off exercise had to balance the effect of visual intrusion and noise on housing in relation to the physical loss of part of the SSSI or part of a long distance walk (Flitch Way) following the line of a disused railway, which is also of ecological interest. The final compromise which resulted in an overall loss of $1200m^2$ of SSSI was agreed by all parties to be the minimum consistent with other constraints in the area.

Conclusion

As noted earlier, the concerns raised by the local populace during the consultation stage focused upon pollution and landscape matters. In contrast, the major issues which emerged from the environmental assessment were deer management, nature conservation and landscape factors. These conclusions reveal the way in which the significance of environmental issues can change during the process of environmental assessment as more data become available. It is to be welcomed that Essex County Council adopted a very progressive attitude towards the assessment exercise in accepting the Arup team's proposals for a detailed investigation of deer management, creative conservation and landscaping measures. Without this approach, and the helpful assistance of the numerous consultees, this scheme could have presented far greater environmental concerns.

Credits

Client:
Essex County Council
Design and environmental assessment consultants:
Ove Arup & Partners
Landscape consultants:
The Landscape Partnership

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1. Deer crossing the road in low visibility: potential traffic accident.
2. Proposed A120 alignment.
3. High Wood — Site of Special Scientific Interest, west of Great Dunmow.
4. River Chelmer, Essex. Proposed route traverses Chelmer, south of Great Dunmow.
5. Group of fallow deer in the wild.
6. Deer fence along M25: note tunnel which has potential for use by deer.
7. Rolling countryside along existing A120 corridor east of Great Dunmow.

Photos:
1: Ove Arup & Partners; 5: British Deer Society
3, 4, 7: Tadhg O'Mathúna
6: Graham Blamey

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Ecology of Peterborough Southern Township

Introduction

The extensive disused brickpits south of Peterborough in Cambridgeshire have been identified as the site of a proposed new township to cater for the projected growth of the city into the next century. The proposals include phased development of residential, commercial, industrial and leisure areas within a hierarchy of district and local centres. Green corridors and space for landscape improvement and recreation and amenity uses are major components of the development.

The land is owned by the London Brick Company Ltd. and the development is proposed by Peterborough Southern Township Ltd., both of which are subsidiaries of Hanson plc — our ultimate client.

Ove Arup & Partners have been providing extensive design input for several years, incorporating infrastructure engineering, geotechnical engineering, transportation and highway design, acoustics (via Arup Acoustics) and environmental science. The project is led by Civil Engineering Infrastructure with support from other groups, as appropriate. This paper deals only with the ecological aspects of the proposed development which have been primarily the responsibility of Arup Environmental.

Site description

The site covers an area of some 1300ha, currently occupied by disused and operational brick clay workings. Brick making has been carried out in the area for over 100 years, in general working from east to west across the site. The excavated clay is transported by conveyor to nearby kilns where, after milling and pressing, the 'green' bricks are fired to produce the traditional fletton brick.

Many of the clay pits have been filled progressively with slurried pulverized fuel ash brought by rail from the Trent Valley power stations, and then restored to agriculture. This has given rise to a range of engineering and environmental issues which we hope to report in subsequent papers. However, some of the older pits remain water-filled and have been colonized by aquatic and marginal vegetation.

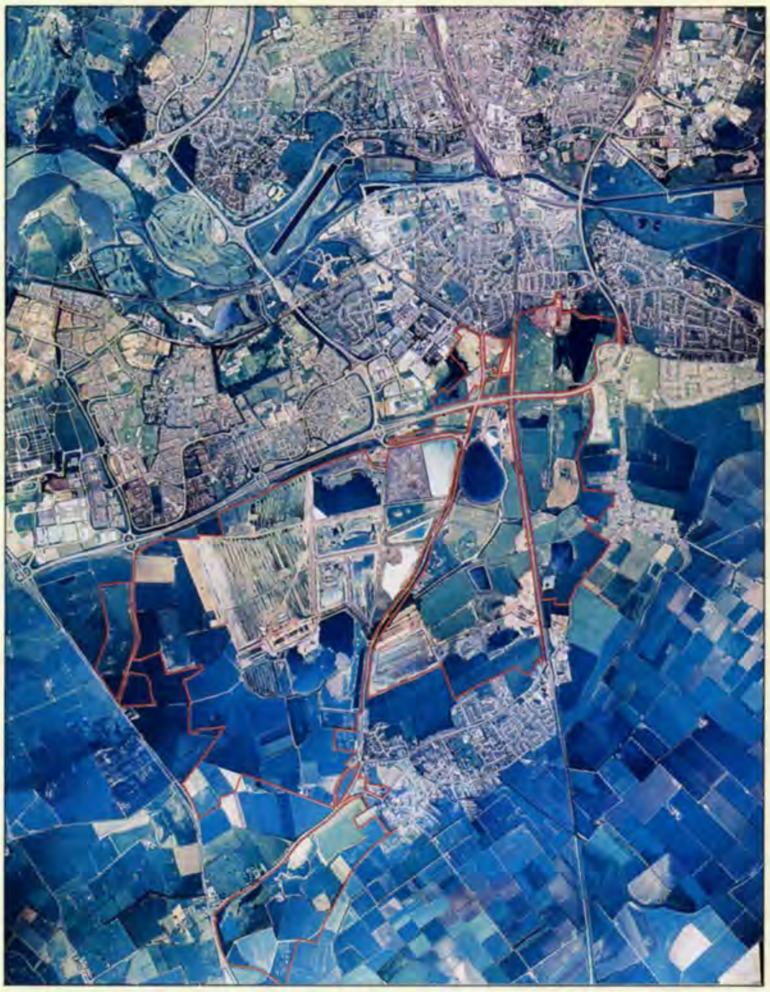
The most recently excavated pits have an interesting 'ridge and furrow' topography resulting from the excavation process, in which the dragline used to extract the brick clay casts aside lower quality 'callow' clay in long ridges several metres high as it works along the excavation face. The ridges and the water-filled furrows between them have also been colonized by a diverse flora and fauna. This combination of habitat types extending across a wide area of relatively undisturbed land has produced a virtually unique environment within a county where most land is under intensive agricultural use. Perhaps not surprisingly, the area has developed considerable ecological interest.

Environmental assessment

The proposed township development falls within Schedule 2 of the Town and Country Planning (Assessment of Environmental Effects) Regulations (*SI 1988/1199*). This being the case, an Environmental Statement was required to accompany an outline planning application. It was prepared by Shankland Cox Ltd., masterplanners for the township, and Ove Arup & Partners in November 1989 and amended in June 1991 to accompany a masterplan for the development and its subsequent revision.

Ecology and nature conservation

As part of the overall masterplanning and environmental assessment process, Arup Environmental designed and supervised extensive Phase 1 botanical surveys over the entire township site. Fieldwork was carried out by local experts from the Bedfordshire and Huntingdonshire Wildlife Trust (BHWT) in March 1989.



1. Aerial view of brick clay workings with Southern Township site edged in red

2. Naturally regenerated clay pit with important aquatic flora — a proposed SSSI

3. Sample of *Chara canescens*

4. Typical landscape of 'callow' ridges left after brick clay excavation

5. Recently excavated clay face with kiln chimneys in background

6. Mature ridge and furrow area containing great crested newts with netting in progress

7. Adult male great crested newt (*Triturus cristatus*)

Photos:
1. Ove Arup & Partners
2, 6, 7: Paul Johnson
3, 4, 5: Ingrid Byng

The data obtained allowed mapping the distribution of species and habitat types and enabled the main areas of nature conservation interest to be identified. Subsequent studies have also been carried out on the ornithological and invertebrate interest of the site. The information has been used by the project team to design appropriate protective measures prior to, during and after site development. This process is on-going and has been carried out in close liaison with English Nature (formerly the Nature Conservancy Council).

Much of the ecological interest centred on the extensive wetland areas present within the disused brickpits, and in the summer of 1989 more detailed Phase 2 ecological studies were undertaken in two selected places: the 'ridge and furrow' area of the excavated Orton Pit and the established lakes to the east of the main Peterborough – London railway line.

In the 'ridge and furrow' area, the water-filled furrows and pools were found to be of considerable botanical interest. A distinct succession was apparent from the younger, species-poor, western furrows nearest to the working face of the clay pit to the longer-established pools in the east and north, which contained a diverse flora.

A notable find was that of the stonewort, *Chara canescens*, a complex, filamentous green alga found in many of the younger pools. This is the first record for the species in Britain since 1956. Two other rare stoneworts were also identified, *Chara pedunculata* and *Chara aspera var curta*. The latter had not been recorded from the Peterborough area since 1909.

Following discussion with Arup Environmental, it was agreed that specialists from English Nature should survey the aquatic flora of the four eastern lakes using boats and grappling hooks to collect samples. As a result of the survey, the three largest lakes are eventually to be designated as a Site of Special Scientific Interest (SSSI), on the basis of the rich assemblage of aquatic flora that they support.

Following the publication of the Environmental Statement for the township development which contained details of the botanical surveys, English Nature requested further surveys to examine the possibility of great crested newts (a species protected under the Wildlife and Countryside Act, 1981) being present in the wetland area.

An initial survey by expert herpetologists from English Nature carried out in April/May 1990 did indeed produce a peak night count of 600 great crested newts (indicating a possible population of up to 6000 individuals) in the northern sector of Orton Pit's ridge and furrow area. This gave the site a rating as the second-best in Britain and as a result of the survey, English Nature proposed to designate up to 30ha of Orton Pit as a SSSI. This land had previously been identified in the masterplan as being zones for light industrial and residential use.

Creative conservation

The ecological importance of certain areas of the proposed development site has been recognized by our client and we are advising the project team to ensure that proposals contain comprehensive measures to protect, enhance and augment the important habitats. The new landscape proposed for the site will include substantial provision for creative conservation measures. Full liaison is taking place with Shankland Cox, the Arup design engineers and English Nature.

Key areas of concern were highlighted in March 1990 when we produced a nature conservation strategy paper for discussion with English Nature. This covered issues such as the need for a landscape masterplan, a zoning policy for use of the lakes, a recreation policy, further ecological survey and research and a maintenance/management strategy.

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Great crested newts
The proposed designation of a substantial area of otherwise prime development land as a SSSI has resulted in further discussions with English Nature. Additional information on the newt population was clearly needed before strategic decisions were taken on development proposals. We sought expert assistance from specialists, Herpetofauna Consultants International (HCI), and since September 1990 extensive fieldwork has been undertaken to map newt habitats, identify breeding sites, and assess the distribution and population structure of the newt colony. Night counting at breeding ponds and pit fall trapping on land are two of the methods used in this work.

Initial survey results indicated that the newt population is more widely distributed than first thought and the numbers counted make the Orton Pit colony by far the largest population in the UK.

In order to protect the colony and allow for its long-term survival, an area identified by the design team following discussions with English Nature has been set aside as a reserve. Extending to over 20ha, this is to be notified as a SSSI by English Nature and managed accordingly. On completion it will be the largest such dedicated reserve in the UK.

Part of the reserve is on derelict land remaining after clay extraction. The terrain is dangerous and currently there is no public access. Proposals for the reserve include engineering works to maintain the hydrological integrity of the site and to make it safe for future access by the public. Detailed management and landscape design proposals are currently being drawn up by the design team.

A translocation programme to relocate newts from outside the reserve area to within is at present being finalized in liaison with English Nature. The programme has been drawn up following several months of survey work by HCI and it is envisaged that a minimum of two years will be required to complete the project.

Monitoring of the reserve population and long-term management of the reserve would of course be continued after the translocation process is finished.

Ridge and furrow excavated area
Although parts of the excavated areas contain rare aquatic and emergent plant species, the transient nature of the habitat type (i.e. freshly excavated water-filled furrows) means that English Nature would not oppose development of this part of the site. Nevertheless, the importance of protecting, as far as is practicable, the rare stonewort species by providing alternative habitats in more appropriate locations in the development area was recognized. Because of the lack of scientific data on stoneworts (especially *Chara canescens*), we implemented an ecological research programme in May 1990, following discussions with English Nature. Over the past year an extensive transplantation and monitoring programme including water and sediment analysis has been carried out to determine the physical and chemical requirements of the plant. The aim of the study is to enable a colony of *Chara canescens* to be established at a 'safe site'. To date, some limited success has been achieved with the trial transplants.

Eastern lakes
The masterplan proposals allow for both the retention of these water bodies and their management in a way which will not prejudice the proposed SSSI designation. English Nature have indicated that low key recreational usage of the lakes (including sailing, fishing and use of perimeter footpaths) would be compatible with their ecological status. The effect of road construction nearby and work to improve safety of lake margins has also been assessed and a package of ameliorative measures agreed with English Nature.

A comprehensive scheme for regularly monitoring water and sediment quality of the eastern lakes has also been put in place. This is providing baseline data to assess the likely impact of built development in the vicinity, including discharge of surface drainage and the use of the lakes for stormwater attenuation.

Other areas
In addition to those areas of special ecological interest, the development proposals make provision for creative conservation measures elsewhere on the site. Two small woodlands will be retained and augmented with considerable areas of new tree planting. The woodland edge habitats and main woodland blocks created will provide valuable conservation areas and act as wildlife corridors through the site. The Stanground Lode, which is the main watercourse in the brickpits area, will also provide a valuable linear habitat/wildlife corridor traversing the Southern Township site. New lakes will also be formed in various locations. These will serve a number of functions, including recreational and drainage attenuation, but certain areas will also be set aside specifically for nature conservation and be managed as such.

Conclusion
This project has been and continues to be a particularly interesting and challenging exercise which has demonstrated the importance of effectively addressing ecological considerations in achieving a successful outcome to major development proposals.

The ecological constraints are, of course, only one of the many technical issues addressed by the design team over the past few years. However, the ecological characteristics of the site have played a major role in shaping the conceptual and physical planning of the Peterborough Southern Township.

We have been fortunate in having a client who has demonstrated considerable fortitude, despite the many ecological 'surprises', and has reacted with sensitivity and a willingness to invest heavily in surveys and research work so that an equitable solution could be reached with the statutory authorities. We look forward to continued involvement in implementing the proposed ecological management programme for the township in the future.

Credits
Client:
Peterborough Southern Township Ltd. (Hanson plc)
Environmental and engineering consultants:
Ove Arup & Partners
Masterplanners and landscape architects:
Shankland Cox Ltd.
Development consultants:
Chester Fanshaw
Ecological survey:
The Bedfordshire and Huntingdonshire Wildlife Trust
Great crested newt ecology:
Herpetofauna Consultants International

Environmental aspects of a landfill site

Roger Findlay

Introduction

In 1988 Ove Arup and Partners were appointed to act as consulting civil and structural engineers for the development of a 6.1ha site in the south of England.

It comprised a small business park, a superstore and new offices for the local County Council.

The site

The site is within the flood plain of a river which flows through a gap in the local range of hills, and is crossed by a tributary stream from the river. A desk study verified that it had been used for controlled filling during the 1960s and 1970s; aerial photograph interpretation showed that the fill possibly consisted of domestic refuse, as well as revealing the order in which various sectors had been filled.

Information was obtained from a series of site investigations:

(1) October 1988 — North and south of the stream: 10 boreholes, 21 trial pits and 10 gas standpipes. This established a typical soil succession:

Fill: 3.5-4.5m thick

Alluvial clay + silt: 10m thick

Chalk: above 10m thick.

The fill was capped with a layer of inert material, and the alluvium contained lenses of peat, especially in the deposit's lower half. Chemical testing was carried out as well as landfill gas monitoring.

(2) February 1989 — North and south of the stream: 12 gas standpipes to monitor landfill gas over a three-month period.

(3) November 1989 — North of the stream only: nine boreholes and nine gas standpipes to identify any landfill gas migration into unfilled areas of the site. It showed that this had not happened, although there were high methane concentrations in isolated areas, attributable to marsh gas from the peat.

(4) March 1991 — South of the stream only: nine boreholes, 11 trial pits and four gas standpipes. This gave information on soils, landfill gas concentrations and chemical contamination for the design of the superstore.

Chemical testing identified that soil contamination was generally low, but water quality in the stream poor; gas monitoring showed low emission rates but high concentrations of methane. In addition, methane was being generated in the alluvium under the refuse. General foundation conditions were very poor due to the soft, compressible alluvium layer.

Initial design consideration

Methane, a component of landfill gases, is explosive when combined with oxygen in the air in proportions from 5-15% methane volume for volume. The 5% figure is known as the Lower Explosive Limit (LEL). Clearly this must be addressed in any development on landfill sites. The problem of dealing with landfill gas can be handled in two ways:

Either landfill can be removed, or measures can be built into the development to protect buildings and occupants.

Initially, the first approach was examined. We felt that commercially the sensible thing to do was to leave a clean site, or at least to remove just enough landfill to form an island of clean fill on which buildings could sit.

Problems quickly arose, and it proved to be an expensive solution. The local authority were not keen to have lorryloads of refuse transported around local roads and they intimated that they would use their powers to prevent it. Even after the total removal of landfill, measures would be necessary under Building Regulations to protect buildings against the ingress of marsh gas.

In spring 1989 a decision was taken to develop designs retaining the landfill. Planning applications were made to the local authority, which alerted them to the situation. They had not encountered this type of problem before and there was some delay while they considered how they would deal with all development on local landfill sites which they felt had future development potential.

Regulations and planning requirements

Design for methane or other landfill gases is not addressed by Building Regulations, which deal with gases arising from natural sources such as peat. In addition, design against landfill gas necessitates measures outside the buildings to protect adjacent areas or sites, and the need for maintenance of systems — neither covered by Building Regulations. Nevertheless, due to the mere presence of gas, local authorities' building control tend to have a keen interest in the design of protective measures. A further difficulty arose because there was no code of practice with which to compare the design.

2. Location of gas stand pipes.

Towards the end of 1989 the local authority came up with the idea of attaching a Section 52 agreement to the planning consent. This was based on the DoE's new *Waste Management Paper 27*, and was in effect a code of practice with which the design team would comply and the checking authority could use for assessment.

Building Regulations approval was given only after compliance with each clause within the Section 52 agreement. Approval was not given by building control, but came from a collection of council agencies: the planning and legal departments, environmental health, and building control. On this project we were also negotiating with Southern Water, National Rivers Authority and the local highways department.

The Section 52 agreement not only defined objectives and conditions, but also contained clauses which transferred local authority responsibilities to the building developer and his professional team. These obligations are separate under Building Regulations. The Section 52 agreement sets out the following:

- Requirements of a site investigation
- The objectives of the gas control systems
- The process of approval
- Requirements for self-certification of methane measures
- Requirements for certification of construction compliance
- Requirements for a building management organization.

Building protection system

The main objective was to keep the landfill gas round the building diluted with air, so that the mixture would be less than 20% LEL, and to ensure that there would be a suitable overlap of protective measures. The system chosen consisted of three separate levels of protection for ensuring the safety of building and occupants:

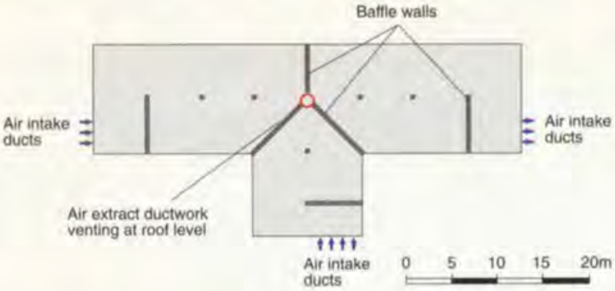
(a) Between the building and the clay capping layer (ground level) there is an actively ventilated void acting as a medium where local gas concentrations are diluted with air to produce a mixture below 20% LEL. The void is always maintained at a negative pressure relative to the building and is the first line of defence.

(b) A gas impermeable membrane is installed on top of the slab and beneath a protective floor screed — the second line of defence.

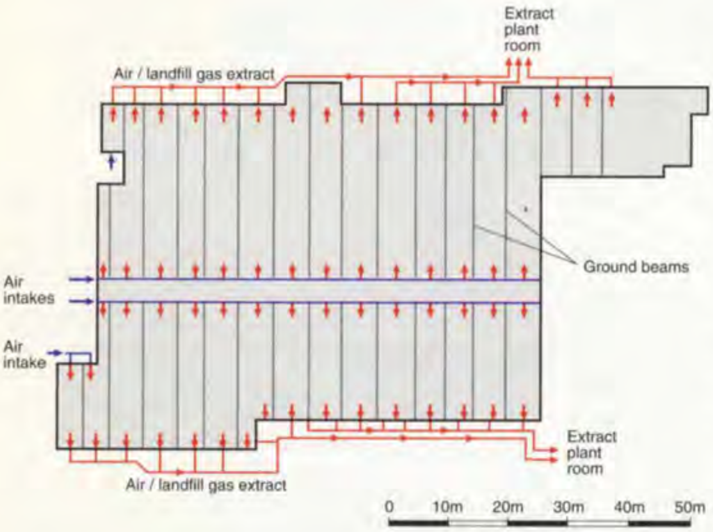
(c) The third line of defence is a gas detector and alarm system within the building. Failure of the other measures would be picked up by this system.

Underslab ventilation system

We first considered passive ventilation of the underslab void, which seemed to be in line with much current thinking; we set out to apply a quantitative approach. This either relies on the wind blowing to create a pressure differential in the void



3. Diagram of office underslab ventilation.



4. Diagram of superstore underslab ventilation.

under the building, thereby causing air movement through and out of the void, or it assumes that providing a route for the gas to diffuse will prevent a build-up in gas concentration.

Meterological data studies of the area showed that wind could not be relied upon to keep gas concentrations below the building to less than 20% LEL. Indeed, it would take only two hours for them to increase from the design value of 20% up to 100% LEL.

We could not rely purely upon the effectiveness of the membrane and concrete slab to keep gas out of the building because neither of these could be tested for long-term effectiveness. We concluded, therefore, that a passive system could not give the necessary reliability.

Our confidence in previous methods was proving ill-founded. Either we were dealing with a non-conventional project or our own expectations of system reliability and the requirements of Section 52 were higher than previously accepted.

We therefore opted for an active system, with air drawn through the void using fans. The voids of the office block and the superstore were ventilated following the same principles but differing in detail, mainly in the method of void-forming. The smaller office block has an air permeable, cobble-filled void which would reduce the cost of forming the ground floor slab. The larger superstore has a completely open void formed by a composite precast/in situ concrete floor supported by ground beams and piled foundations.

Under the office block the space is divided into three equal zones (Fig. 3). Air is drawn through each by a fan connected to a centrally-placed plenum/collection chamber. The air enters the void blanket through ventilation openings at the three extremities of the building. (To calculate the required fan capacity, air flow through rocks was studied to estimate the added air resistance through this medium.) The fan draws air continuously from the plenum through a duct within an enclosed shaft. It is then discharged through the roof at high level. A back-up fan and power supply has been provided. The system is always under negative pressure so that any potential leak will allow air to be drawn in rather than allow an air/methane mixture to escape. The same principles have been used under the superstore where there is a 250mm deep open void beneath the suspended ground floor slab, separated into compartments about 5m wide by 25m long and mechanically vented by main ducts at the front and at the back of the building. Each compartment is connected to the main duct by a spur, with air flow controlled by dampers to ensure that the compartments are equally vented so that methane concentration can be kept below the LEL. Sensors will also be installed at each spur duct in order to control the fans.

The fans will operate continuously at low speed, pulling the air/gas mixture over the sensors in the extract ducts. If any sensor detects a methane level greater than 20% LEL, it will switch the fans to high speed; they run until the level reduces to 5% LEL or for 30 minutes, whichever is the greater.

The fans' operation speed is based on the emission rate of methane from the ground; during site investigations this was so low as to be undetectable. It is known that precast driven piles can provide a flow path for both landfill gases and naturally-occurring methane from peat beds, but an assessment of this did not yield enough gas to allow meaningful calculations to be made. However, landfill gas will be forced out of the ground by a rising water table. This could possibly result from rapidly rising flood water in both the adjacent stream and the river at the same time. An assessment was made of the emission rate on an extreme case of flooding, with the water table rising at a rate of 2.0m in 24 hours.

The areas of the business park which have been designed are not situated on the landfill and we were able to show that landfill gases were not migrating there. The methane occurring naturally in the alluvium is catered for by Building Regulations. In order to meet the requirements, a cobble-filled, passively-vented void is found beneath the slab and a gas membrane as described in the next section laid over the slab.

Gas impermeable membrane

This is sandwiched between the top of the structural slab and a 100mm protective overslab, and consists of a 9μ aluminium foil coated on both sides with a polyethylene film to give physical protection during installation. For the office block it is factory-prewelded in segments to sizes compatible with the building plan. Recesses have been provided at the bottom of all columns and walls to allow it to be tucked in and properly sealed. In the superstore it will be laid in sections from rolls because of the greater area.

Monitors and controls

Apart from those in the ventilation system, gas-detecting sensors are installed in the building in areas of high risk: confined spaces, penetrations through the ground floor slab, and special areas such as electrical switch rooms. The sensors are linked to a control board with alarms: visual at low levels of landfill gas and aural at high levels.

External works

Lateral migration of landfill gases out of or into a site is a major concern.

Perimeter trenches backfilled with cobblestones are vented at 20m centres to provide preferential paths; these trenches were the subject of much argument. *Waste Management Paper 27* dictates the need for a gas-proof barrier. This may be clearly justified in some instances but in this case, where landfill was present outside the confines of the site, the argument was not sustainable.

All manholes have perforated covers other than those near the building, which are vented to more distant soft landscaping using ventilation pipes positioned within the car park construction. In the car parks, isolated passive gas wells are provided and vented next to soft landscape areas.

All light standards are protected from gas ingress. Services trenches, which are potential conduits for landfill gas, are sealed with a clay plug at entry and exit positions from the site.

Contamination

Although landfill gas matters took much of the time, attention was paid to the possibilities of contamination from the landfill itself. Site investigations showed a generally low level of contamination with elevated levels in isolated instances. Contaminants which gave rise to further consideration were:

(1) Phenols which occurred at elevated levels in one or two trial pits. These will permeate through plastic pipes and affect water mains. Further examinations showed them to be in the relatively harmless form of discarded road materials.

(2) Ammonia in a number of water samples: Ammonia salts are highly aggressive towards concrete, but here the concentration in the ground water was very low and class 2 concrete was specified.

Conclusion

By mid-1991 the office block structure had been completed, and the underfloor ventilation system balanced. The resistance of the cobble fill in the void was much less than expected. Also the volume of methane in the extracted air was very low, never exceeding 0.4% LEL — altogether a very satisfying situation. Work on the superstore had started on site, but the business park had not progressed beyond design.

5. Office block gas membrane.

Environmental assessment of marine fish culture

Paul Johnson
Grant Robertson

1. Location of fish culture zones in Hong Kong

Introduction

One of the largest environmental studies carried out by the Partnership to date outside the UK was completed by the Hong Kong office in 1990. Arups were commissioned by the Environmental Protection Department of the Hong Kong Government to lead a research project into the environmental impact of the marine fish culture industry generally and specifically to investigate the pollution implications. The skills provided by Arups Hong Kong covered project management, environmental assessment, water pollution control, and fisheries expertise. Technical support was provided by specialist consultants including Hydraulics Research (Asia) Ltd. and Water Research Centre (Asia) Ltd. — responsible for two and three-dimensional mathematical modelling of coastal waters — and Furano (laboratory facilities, marine microbiology, fish physiology and field studies).

The bulk of the study was to be completed within a six-month period and involved the co-ordination of several key tasks running simultaneously. These included a worldwide literature review of the environmental impact of 'mariculture', an industry survey, and field and laboratory studies to establish the extent of water pollution caused by the input of organic and inorganic wastes. Existing mathematical models of water quality were assessed and developed to allow predictions to be made on the effects of growth in the industry. The importance of mariculture in contributing to the overall pollution of Hong Kong waters and particularly the promotion of toxic algal blooms was a crucial concern to be addressed. The project's concluding purpose was to make recommendations for the future management of marine fish culture in an environmentally acceptable way, taking into account local constraints.

The industry in Hong Kong

There are some 28 fish culture zones in Hong Kong covering an area of about 180ha. Most are located in the sheltered north-eastern sector of the colony, in relatively shallow water (often less than 3m deep). In 1989 there were approximately 1770 licensed operators with an additional 4300 people directly or indirectly supported by the industry. The operators utilize about 3200 floating raft cages to rear some 10 species of fish, the most common being sea bream (45%), groupers (30%), snappers (15%) and others such as giant perch (10%).

Expansion in the industry has been dramatic, with production rising from 563 tonnes in 1977 to some 3000 tonnes in 1989 — valued at HK$182M. This is only about 1.4% of sea fisheries' production in Hong Kong but accounts for about 9.4% of market value and 40% of the live fish requirement.

Fish culture rafts are typically of timber construction supported by flotation drums or polystyrene foam anchored to the seabed. The average raft size is about 250m^2 and each incorporates a number of mesh cages (average 3m × 3m × 3m) suspended from the raft. Apart from the sea bream fry, which are collected from local coastal waters, most of the other fry are imported from other S.E. Asian countries.

The industry is regulated by the Marine Fish Culture Ordinance (1982) which is designed to control the proliferation of fish farming and limit water pollution. The Ordinance is also designed to limit the structures erected on the surface of the rafts — but there are, at present, some 470 illegal dwellings and over 1900 people living on the rafts!

The principal environmental problems generated include conflict with other use of the water resource (amenity, recreation, shipping and reclamation) and water pollution — especially depletion of oxygen, causing stress and mortality in fish. Disposal of wastes is also a particular issue; plastic bags, domestic waste, dead fish, netting, etc., are often dumped in the culture water. This problem is compounded by the waste from humans and guard dogs also being discharged into the water.

Water pollution studies

In order to assess the extent of existing water pollution, four fish culture zones with differing physical and hydrographical characteristics were chosen for field studies. The zones were Ma Wan (estuarine with strong currents); Sok Kwu Wan (poor water quality and a long history of mariculture); Three Fathoms Cove (poor tidal flushing and prone to fish kills); and Tap Mun (good circulation of oceanic water, few dwellings).

At each location, water and sediment samples were taken at seven or eight locations on intersecting transects and at different stages of a full tidal cycle. The aim was to detect both spatial and temporal changes in water quality and sediment characteristics to estimate the degree of environmental impact. Samples taken both from the surface and by scuba-diving teams were analyzed for a range of inorganic, organic, physical, microbiological, and marine biological parameters.

In general, the analytical results showed considerable water pollution due to a very high organic and nutrient loading which results in low levels of dissolved oxygen. The major impact however, was on the seabed, where the sediments were anoxic (lacking oxygen), generating toxic hydrogen sulphide, and not surprisingly, deficient in marine organisms.

A number of field experiments were also carried out in order to aid in the quantification of pollution loading generated by sources such as wasted food, faecal materials, nutrients leached into the water during feeding, and cleaning of fouled cages.

The foraging efficiences (i.e. % food wastage) of black sea bream and red grouper were examined in a special polyethylene enclosure with a detachable bottom collector. Minced and chopped fish were fed to the test species and the residue collected and weighed. Fry were shown to be the most effective foragers — wasting some 20% of food, the adult fish wasting between 31% and 38%. This wastage is equivalent to about 13 500 tonnes per year — a considerable source of oxygen depletion, only exceeded by the respiration of the fish grown in the cages.

The level and scale of organic pollution did vary considerably between the test fish culture zones; pollution effects were much less pronounced at Tap Mun and Ma Wan where good water circulation and flushing of pollutants was occurring. Adverse effects were most obvious directly under the fish cages, but pollution could be detected 1-1.5km away from the rafts — a relatively small distance considering the high organic loading.

To put the organic loading into context, the overall biological oxygen demand from mariculture is about 3000 tonnes — equivalent to that of a town of 182 000 people discharging untreated sewage into the sea (or a city of 3.64M discharging treated sewage). In comparison with Hong Kong as a whole, mariculture is responsible for about 3% of the organic wastes discharged to coastal waters. Although this figure is relatively small, concerns have been voiced that in the restricted fish culture zones, the high organic loadings could lead to a serious de-oxygenation of shallow coastal waters, which would be damaging to the local marine environment.

In addition to oxygen depletion, two other concerns exist — these are the discharge of nitrogen compounds and settleable solids.

Nitrogen wastes are released mainly by fish excretion as urea and ammonia and are readily absorbed by phytoplankton. Increased levels of nitrogen in the water from a range of pollution sources is the main factor causing increases in the occurrence of algal blooms.

Although mariculture only contributes about 3% of the total nitrogen loading to marine waters (sewage is the major source), its effect in shallow, sheltered areas is to exacerbate the algal bloom problem. In the four culture zones examined, nitrogen inputs from fish farming negated approximately ⅓ of the benefits of the government advanced treatment programmes to remove nitrogen from sewage treatment works effluent.

2△

3△

4△

5 ◁

6 ▷

The deposition of solid wastes, as previously described, blankets the seabed with anoxic sediment. The loading is about 20% of that discharged from sewage and industrial wastes.

This is one of the most intractable problems hindering an economically viable solution and further work is required to determine the degree of damage which may arise to the marine environment as a result.

Algal blooms

Algal blooms — unusually prolific growths of phytoplankton — are a natural phenomenon which occur around the world in both fresh and sea-water. Many are harmless, forming in times of high light intensity and disappearing without adverse effects on other aquatic life. However, some blooms can cause fish deaths because they draw much of the oxygen from the water or they irritate and clog the gills. Other types of algae produce toxins which may be lethal to fish or accumulate in shellfish — causing illness or death in humans: it is these which are referred to as 'red tides'.

Part of this study was to assess the effect of mariculture in promoting algal blooms, including 'red tides' — the latter being of increasing concern in Hong Kong. The relationship is not well-understood and although the quantities of nitrogen being released from fish farms would, in isolation, cause blooms to occur, the complicating factors of other major pollution sources have to be taken into account. For this reason, a mathematical modelling exercise was undertaken to investigate further the effect of discharges on water quality.

Mathematical modelling

Two types of model were used in this study — deterministic to describe water movement and biological processes, and statistical to examine the relationship between nitrogen loading and phytoplankton growth.

To demonstrate the use of the models in a mariculture zone, Three Fathoms Cove was chosen as a suitable experimental area because of the extensive amount of water quality data already to hand, which could help in model calibration.

A two-dimensional model of tidal flows was first set up to cover the area producing data on water velocity and salinity in each cell of an area grid at different depths. Output from the model was then used as base data for a three-dimensional tidal water quality model, which also utilizes the

2. Fish farm at Ma Nam Wat, Port Shelter, eastern Hong Kong.

3. Food for fish being prepared on raft.

4. Water and sediment sampling at Three Fathoms Cove.

5. Preparing net cage for foraging efficiency experiment.

6. Well-kept fish farm at Kat O, (north east Hong Kong).

effluent loading data obtained from the field studies to simulate the water quality in Three Fathoms Cove. Once calibrated, the model could be used to assess the impact of changes in feeding practices or the type of food used. Running it with varying inputs confirmed that the effects of fish culture were fairly localized and in fact quite difficult to isolate from the background water quality fluctuations.

However, as a result of the statistical modelling, a clear correlation was demonstrated between the levels of total inorganic nitrogen in the water and the concentrations of chlorophyll — used as an indicator of algal presence. The extent of bay flushing — or the retention time during which algae can respond to high nitrogen concentrations — is of great importance in determining the susceptibility of certain bays or inlets to algal blooms.

Knowledge of all the sources of nitrogen loading and application of a correction factor for flushing effects meant that it was possible to predict the potential for algal blooms to occur. A trigger level of 0.4-1.0mg nitrogen per litre of sea water was identified, above which excessive algal growth could be expected and using nitrogen loading data, a classification of bays under threat was prepared. In such bays, the input of nitrogen from fish culture could be of great importance in promoting algal blooms and 'red tides'. There is an obvious case for limiting the industry or modifying its operations in these areas.

Recommendations

In an attempt to reduce the environmental impact of fish farming a number of recommendations were proposed. Of these perhaps the most important was that all existing and proposed culture zones should be reviewed in the light of suggested new criteria requiring greater flows of clean water through cages and greater depth of water between the cage bottom and the seabed.

A reduction in stocking density in areas with poor flushing and poor water quality, and improvements in husbandry practice — particularly better controls over feeding techniques — were also proposed. Monitoring of bottom sediments and better waste management practices were considered to be particularly important.

Study conclusions

The overall environmental impact from mariculture activities is considered to be fairly localized and arises from (a) the designation of fish culture zones in inappropriate locations unable to accept polluting loads, (b) failure of the industry to comply with legislation in relation to unauthorized structures, waste disposal, etc., and (c) inefficient fish husbandry leading to pollution and hence algal blooms.

A range of polluting activities were identified which can be particularly severe in shallow and sheltered waters. In these cases, local fish farms will suffer but looked at overall, direct deoxygenation of coastal waters was not seen as a serious problem.

Of much greater concern was the loss of nitrogen from fish farming. The possible stimulation of algal blooms with their potentially toxic side-effects was considered to be the most serious environmental problem.

Surprisingly, given the concerns previously expressed in Hong Kong, the study also concluded that the fish culture industry does not intrude excessively into the coastal landscape. Indeed the majority of farms were considered to be unobtrusive.

The study concluded with the view that fish farming was an important resource, and modest expansion of the industry was possible. However, better enforcement of legislation, and more effective management and operation of farms using the criteria given in the Arup report, would be essential for the fish culture industry to operate in an environmentally acceptable manner in the future.

Credits

Consulting engineers and environmental scientists:
Ove Arup and Partners Hong Kong

Mathematical modelling:
Hydraulics Research (Asia) Ltd.
Water Research Centre (Asia) Ltd.

Analytical chemists and marine biologists:
Furano

Photos:
Ove Arup & Partners Hong Kong

Great Common Farm

Stephanie Mills

Introduction

The Arup Urban Design Group within Arup Associates was appointed in autumn 1989 to prepare a masterplan for a new settlement at Great Common Farm, near the City of Cambridge.

This is one of eight proposals along the A45 corridor which went to Public Inquiry last spring, and is now being considered by the DoE for selection to relieve development pressure on Cambridge. Only one will be built, plus another north of Cambridge along the A10, the subject of an earlier Inquiry in which Ove Arup and Partners was also involved. The settlement will be larger than a village, with a population of about 10 000, and although intended to accommodate a wide variety of different activities, it is still seen as an adjunct to Cambridge.

The site

The 400ha site lies some 10km to the west of the city, outside the green belt and south of the A45 on the south-facing slopes of Great Common Farm and the disused Bourn Airfield, an American World War II base. The settlement is seen as a means of recycling despoiled land. Bourn village lies about 2km to the south and Highfields village shares the eastern boundary. The topography, undulating and crossed by three streams, is characterized by open fields except for Bucket Hill Plantation, an area of natural woodland in the south east corner. The site is quite exposed, with prevailing winds from the south west and north east.

1. Location plan.

2. Aerial view of the site.

The approach

The Arup proposal attempts to distinguish itself by its rigorous approach to *urban design,* the generally accepted name for the process of giving physical design direction to urban growth, conservation and change. A built environment is created by a continuous decision-making process: the urban designer is the prime agent who orchestrates the many players involved in this, with a strong vision of and philosophy about what ought to happen. The urban designer should write the rules for significant choices that shape the environment, within an institutional framework that can be modified as times and needs change. This process, as it pertains to Great Common Farm, is described below.

Formulation of objectives

The prime aim has been to design a place that is 'of the age' and forward-looking, yet which reinterprets valuable lessons from the past. This is a reaction to many recent settlements where attempts have been made to design pastiche 'villages', disregarding the changing structure of British households and lifestyles (i.e. smaller households, increase in the number of single parent families, greater number of working women, more people working from home).

Our aim was to create a settlement distinguished by its:

- Environmental quality and sensitivity
- Coherence and unity
- Inbuilt adaptability and choice
- Minimal impact on surroundings
- Ecological awareness
- Advanced technologies
- Efficiency
- Strong landscape and architectural framework
- Varied housing and community facilities
- Integrated social housing
- Safety and security
- Ease and choice of movement.

Comparative assessment of settlement forms

Organic, radial, linear, and grid forms were investigated on the basis of their relative coherence, accessibility, efficiency and flexibility, with the grid eventually being selected. Its democratic and rational nature proved the most appropriate, provided that it has a focus, a degree of hierarchy and clearly defined limits. The grid is very flexible and efficient, giving a coherence which contrasts with and is softened by the topography, and existing and proposed landscape features. It also offers important potential for shelterbelt planting, given the exposed nature of the site.

The core of the vehicular circulation is based on a series of extendable loops rather than an even pattern of roads. Potential rigidity is thus avoided and a hierarchy of circulation created, whilst maintaining the implied order of the grid. Some streets are through routes while others discourage all but local access.

Site analysis and zoning strategy

A pattern of land use follows from the site analysis. Traffic congestion on the A45 is to be eased by the development of a dual carriageway to Cambridge, with a single grade-separated junction giving access to the heart of the new settlement.

An 18-hole golf course is proposed alongside the A45 to create a 300m wide, building-free zone. It will serve as a noise buffer and provide a prime frontage for adjoining residential development.

The proposed town centre is situated at the arrival point, creating a central focus and concentrating communal activity. South of it is the town park which provides a major focus in the hierarchy of public open space.

A 34ha business park and the higher density housing, plus ground level retail, cafes and restaurants, share this green frontage.

The business park is located on the former airfield, the flatter terrain being better suited to its larger building types, with a lake planned where the runways were. Existing light industry is retained within the confines of Bucket Hill Plantation, extended to provide a natural buffer to the adjacent Highfields village.

120ha is set aside for residential development, located on the undulating terrain of Great Common Farm. A stream runs diagonally through the area and forms a green corridor, together with prime agricultural land left largely undeveloped.

Various community facilities are located within this corridor which also incorporates a network of public footpaths, bridlepaths and cycleways.

Each residential neighbourhood or development zone fronts onto some form of public open space, be it golf course, woodland, park or natural water course.

These watercourses drain towards a proposed ecological zone to the south of the settlement which incorporates stormwater attentuation ponds, woodland and public open space with playing fields. The zone contains the proposed development and prevents it from sprawling into the surrounding countryside and merging with nearby villages.

Creation of a masterplan framework

The masterplan uses the proposed landscape structure and public areas (i.e. roads, parks, squares, communal buildings) to create a coherent framework for development. This structure aims to unify the different contributions of future designers within a set of ground rules. It is intended to be flexible while providing a consistency and common identity for the settlement.

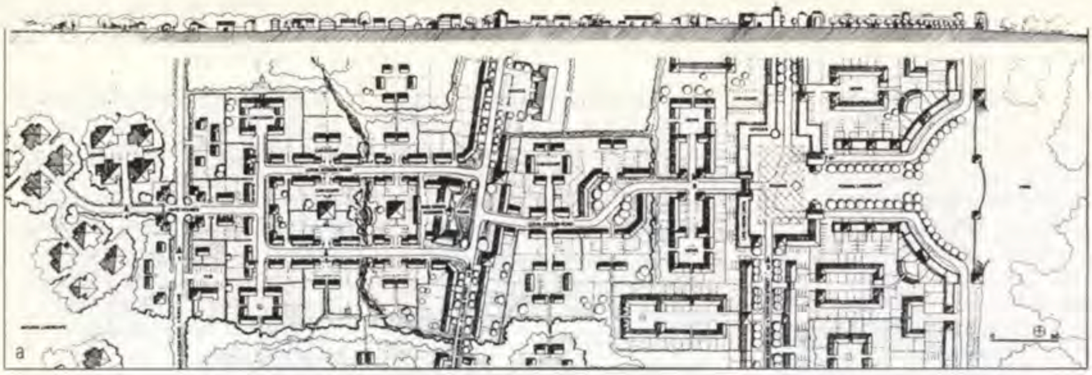
At Great Common Farm this framework is provided by the:

- Ordering device of the grid
- Road layout and movement system
- Shelterbelt system using a combination of woodland, street trees and hedges (this in part forms the basis of the grid.)
- Hierarchy of public open spaces
- Siting of communal facilities
- Disposition of land uses and housing densities.

3. The masterplan

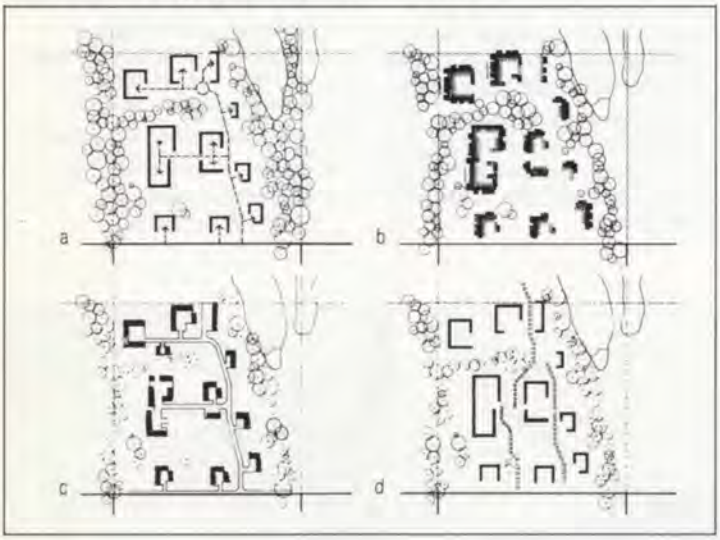
Key:

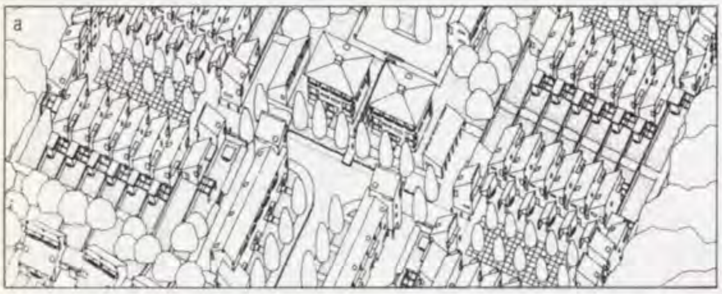
1. Town centre
2. Golf clubhouse
3. 18-hole golf course as buffer to A45
4. New interchange to dualled A45
5. Entry 'green'
6. Business park
7. Town park and lake
8. Higher density housing
9. Medium density housing
10. Low density housing
11. Existing industry
12. Industrial expansion
13. Great Common Farm
14. Primary school
15. Riding stables
16. Woodland planting and open space
17. Avenue planting
18. Playing fields
19. Existing woodland
20. New woodland
21. Stormwater attenuation ponds

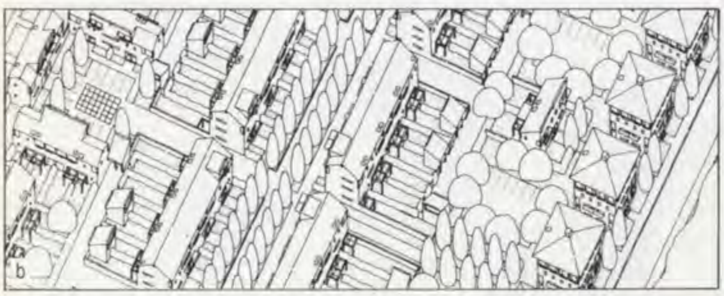


4. MacCormac Jamieson Prichard proposals (above):
a Plan showing low, medium, and high density housing, left to right
b Low density housing c Medium density housing

5. Aldington, Craig and Collinge low density proposals (below):
a Vehicular access b Buildings c Parking d Pedestrian routes







6. Allies and Morrison proposals (above): a Medium density b High density

7. A 9m high shelterbelt affects wind speed for 30m in front of the trees and 90m downwind.

Exploratory housing studies

Every effort has been made to encourage a variety of housing types and densities which reflect a prevalence of smaller households (average 2.3 persons). Having established a desirable range of housing densities, we decided to test their application to the masterplan. Three architects (Aldington, Craig and Collinge; Allies and Morrison; MacCormac Jamieson Prichard) were invited to carry out detailed housing studies by designing a prototypical slice through low, medium and higher densities. These range from 14 to 48 units/ha.

The outcome demonstrates that richness and variety can be achieved, and that each neighbourhood or cluster can benefit from both major public open space and a network of smaller semi-public spaces, including shared car courts. This emphasis on shared open space helps to reduce the fragmentation and unusable parcels of land prevalent in car-orientated settlements.

Centrally monitored design at all levels is an integral part of the urban design process and would normally be achieved by a combination of briefing and co-ordinating meetings with participating consultants, design guidelines and other controls.

Recommendations for a green policy

Many of the design proposals included in the masterplan stem from the desire to adopt an environmentally sound approach. Policy recommendations include:

- Conservation of ecological areas
- Retention of prime agricultural land as public open space
- Extension of woodland
- Utilization of the drainage attenuation system to create an ecological wetland
- Development of a shelterbelt system to protect the settlement from harsh winds
- Alternatives to the car by providing a local bus service, cycleways, public footpaths and bridleways
- Reduction in number of trips generated by encouraging a greater mix and integration of land uses and widespread provision of the latest communications technology to facilitate working from home
- Encouragement of energy conservation in buildings.

Phasing and implementation strategy

A development company would be formed at the outset to implement, manage and control the project and to provide ongoing management and maintenance of the common parts (i.e. landscape, services, roads, community facilities).

The design concept and implementation strategy allows the masterplan to be realised in stages. Major elements in the infrastructure are established early on, but the plan allows for each phase to form a completed cell of mixed development from the centre outwards, so that the costs are spread and a sense of place is created from the outset. Disruption by successive phases of development is minimized.

The extendable loop road facilitates this growth strategy, as well as suggesting that at each stage the settlement appears complete yet provides for flexibility in the pace of development. The inclusion of the business park gives the development a certain critical mass and makes the provision of many more facilities and amenities feasible. Some financial cross-subsidy and overall 'planning gain' is possible.

Means of communication

Urban design is largely about the communication of ideas. This involves dialogue with and feedback from interested parties. The process is thus a cyclical one involving consultation, design and review.

The communication process for Great Common Farm was aimed at:

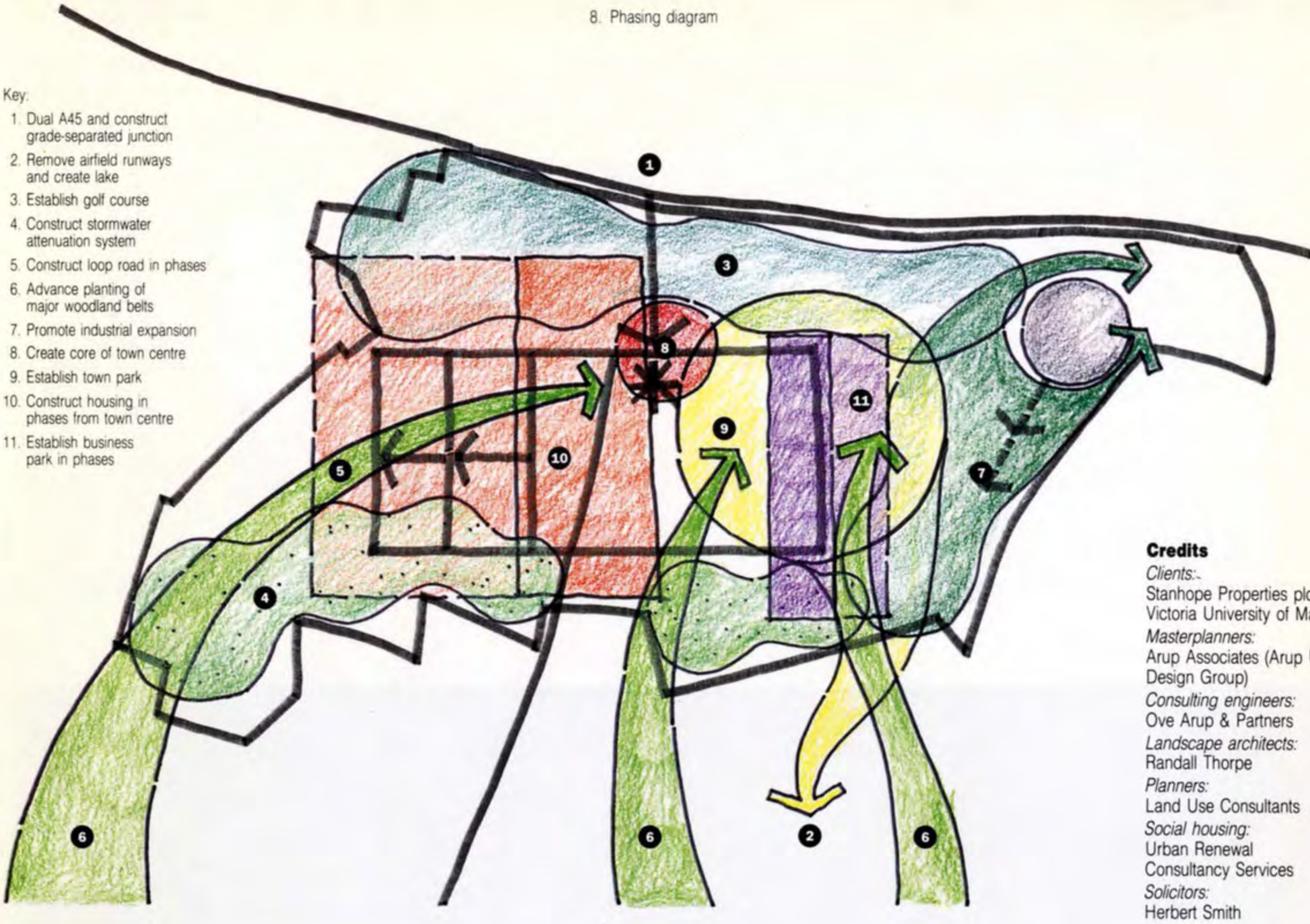
- achieving a clear understanding between the different members of the project team who were grappling with very different issues within a tight programme (ours was a late contender);
- community liaison with those who are likely to be impacted by the proposals and other interested parties;
- briefing counsel and key witnesses for and during the Public Inquiry.

We decided at the outset to evolve a means of conveying the masterplan concepts in a storyboard format. Each set of ideas was thus communicated by means of clear punchlines substantiated with diagrams, drawings and text in panel form for public presentation or as pages to be bound in a report. These were intended for all parties and were used as part of the proof of evidence in the Public Inquiry.

The client also produced and distributed a number of comprehensive newsletters on the proposal as a means of community liaison and to keep interested parties informed about the latest events in the proceedings.

The outcome of the Public Inquiry has yet to be announced.

8. Phasing diagram



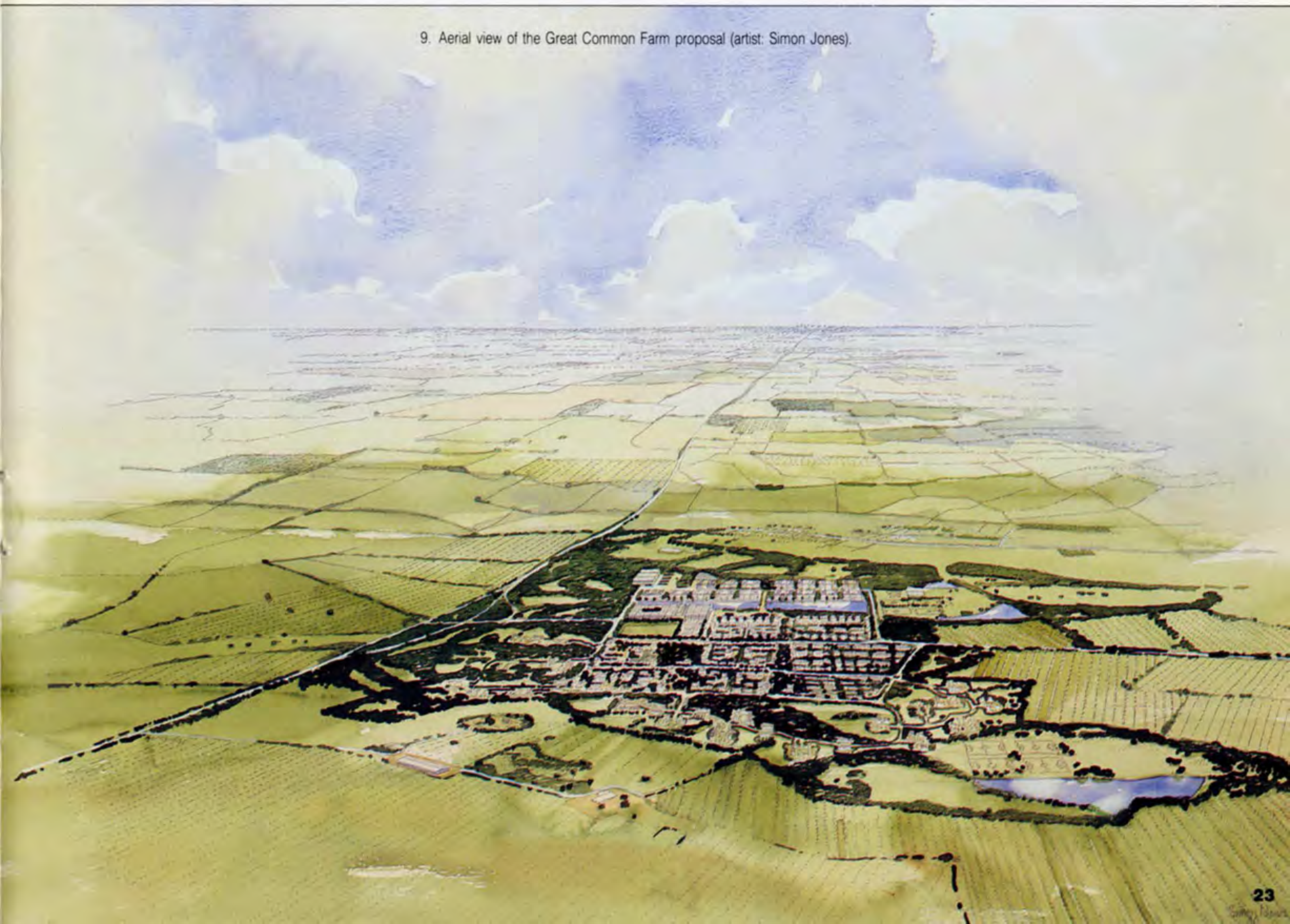
Key:

1. Dual A45 and construct grade-separated junction
2. Remove airfield runways and create lake
3. Establish golf course
4. Construct stormwater attenuation system
5. Construct loop road in phases
6. Advance planting of major woodland belts
7. Promote industrial expansion
8. Create core of town centre
9. Establish town park
10. Construct housing in phases from town centre
11. Establish business park in phases

Credits

Clients:
Stanhope Properties plc &
Victoria University of Manchester
Masterplanners:
Arup Associates (Arup Urban Design Group)
Consulting engineers:
Ove Arup & Partners
Landscape architects:
Randall Thorpe
Planners:
Land Use Consultants
Social housing:
Urban Renewal Consultancy Services
Solicitors:
Herbert Smith

9. Aerial view of the Great Common Farm proposal (artist: Simon Jones).



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