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Fenny Compton Landfill - Analysis of application and submitted documentation

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1. Development Proposal

1.1 The development

1.1.1 The application

The application[1] site covers 49.2 hectares, 33.2 ha of which will be developed, and of this 21.4 ha will be actually used for the deposit of waste. It is proposed to fill the planned 1,600,000m^3 of void space with 'inert' material and incinerator bottom ash - on the application it is stated that the fill will comprise 90% bottom ash. The rate of fill is estimated at 150,000m^3 per year, giving the site an operational lifetime of 10 or 11 years.

1.1.2 Waste composition

If we were to assume that the inert material was used for 'daily cover' only, then very roughly 75-80% of the fill material could be bottom ash. The fact that the application states that 90% of the fill will be ash concerns me. If only 10% of the waste were inert fill, there may be insufficient daily cover to effectively cover the filled areas and prevent the emission of particulates/odours[2].

If, as the applicants suggest, any shortfalls are made up with clay dug from the site, then this could lead to drainage and stablisation problems within the site. The presence of layers of clay in the waste fill, with low permeability, would create small 'perched' water tables within the fill. This could lead to problems stablising the waste fill, and if it were to be widespread then it is conceivable that there could be problems pumping leachate from the site. At the extreme, due to the presence of quantities of saturated fill in parts of the site, excess pressure could be put upon the drainage layer and the leachate extraction pipes, causing deformation of the pipes. If the differential stress across parts of the site were great enough it is also possible that water could begin to pond against the basal seal, and the basal seal itself may deform.

1.1.3 Highways

Page 1 of the application notes that lorries will access the site via junctions 11 or 12 of the M40. This is not without its problems. Although there is little argument against this with regard to traffic generation on the A423(T) itself, it could lead to problems on the roads from the motorway junctions. It would mean an increase in HGV traffic through Bishop's Itchington/Depper's Bridge, and around Southam. From the south, traffic flows from junction 11 in Banbury are already causing congestion problems. Alongside other developments proposed in around Banbury the routing of lorries via junction 11 will create even further congestion problems.

A solution to this problem would be to set up a rail link to the site from the junction at Fenny Compton - but according to representatives of Terry Adams Ltd. this is not possible because of the problems negotiating with British Rail/Railtrack, and getting the waste material onto trains in the first place (few incinerators have rail access).

1.1.4 Geology/hydrogeology

In terms of the local geology, in general it could be said to be more suitable than other sites nearby (for example in the ironstone quarries around Hornton), but it has not been shown that the clay formation is suitable for waste deposit - despite what is claimed on page 2 of the application statement.

The suitability of the site has been determined primarily from the local 1:50,000 geological survey sheet. It must be pointed out that the mapping of strata on these sheets is primarily based on the inference of certain geological conditions within the area - no detailed surveys exist for this area. The strata in this area gently dip to the south, and much of the overlying rock has been eroded away to expose the lower lias clay. Although the lower lias clay strata are 100 to 150 metres thick where they are protected beneath the ironstone, in the area around Fenny Compton/Gaydon, weathering and erosion have reduced the thickness to between 25 and 50 metres. This reduces the capacity of the strata to buffer the movement of pollutants. This of course assumes that there are no geological features that have not been detected at the surface, such as small fault lines or folds.

In terms of groundwater, it is generally stated that clay has a 'low permeability'. However, this does not mean that the clay is a solid mass, devoid of water (like igneous rocks for example, where interlocking crystal structures prevents groundwater percolation). It is a sedimentary rock, and so will hold water in the pore spaces. In fact, the porosity of clay is one of the highest of any sedimentary rock - between 50-60% by volume.

It is also acknowledged in the application statement that the ground in the area becomes saturated with water. This has an important effect on leakage from the site. Where a landfill is located above the groundwater level, leakage is always out of the site. However, where a site is located below the groundwater table, as at least one-third of this site might be, seepage is into the cell. This means that the volume of leachate needing treatment will be higher because of additional water seeping into the site. This would continue until the waste mass inside the site becomes saturated to a level the same as the surrounding water table.

The perfect strata within which to fill leachable waste would have an *isotropic* permeability - that is the resistance to the passage of water would be the same in all directions. The reason for this is that any resultant leakage would flow or diffuse equally in all directions and prevent 'trending' of high concentrations of leachate within specific strata. The borehole logs in the statement note the presence of sand, gravel and shell fragments in the upper 10 metres of the clay strata. This means that the permeability of the clay in the vertical and horizontal plane is likely to be different. Of significance is the permeability in the horizontal plane, since this will be the key to stopping lateral movement of seepage from the basal liner. Although permeability tests have been carried out on the clay, it is not clear if these assessed the permeability in different axes, but I would assume it is only in the vertical axis - the least significant in terms of long-term groundwater movement.

Areas where landfilling operations will be visible

1.1.5 Landscape

This site is located within a valley with higher ground to the east and the south-west. This will makes the landfill area visible from these areas, and the proposed screening measures will make very little difference. In fact, as there is so little tree/scrub cover in the bottom of the valley, the widespread planting of the area could increase the relative 'contrast' between the land and the vegetative cover, making the site stand out more.

As a purely indicative exercise, I have used a simple trigonomic analysis[3] to show those areas which will still be able to see into the site during its operational phase, even with the planned 5-10 metres screens of earth and planting. These areas are shaded in the map on the previous page. This map is only a 'desk-top' analysis of the visual intrusion of this development - a more detailed analysis taking into account the exact phasing and screening of the site may produce a greater demonstrable impact.

At the bottom of page 5 it states that, "Any loss of visual amenity from distant view points will be only slight and of brief duration". This statement I find both vague, and difficult to accept as fact. If operations on this site carry on for up to ten years, how can any impact be 'brief'. Likewise, any detraction from the general open landscape of the valley floor must be considered as a visual intrusion, and even after the site is completed, the new landform will look out of place with the natural undulations of the surrounding landscape.

1.1.6 Site operations

In general the specifics of site management are not a matter for planning permission, and it will be difficult for the County planning authority to make any detailed planning conditions on these points. These matters are nearly always subject to waste licensing conditions, and by national guidance the planning system must not duplicate functions exercised by other authorities.

Reading through the proposed methods of working/management practices, nothing shows itself as being exceptional or out of the ordinary. Much of the detail is either current best practice, or is laid down in national 'waste management papers'[4].

With regard to noise, it would have been useful if some simple modelling of noise contours could have been carried out. Although near to the site - within the 'shadow zone' below the earth bunds and planting - noise will be attenuated, at a few hundred metres from the site, or on the south/south-east, noise could carry, especially where there is a following wind.

1.1.7 Pollution control

The details of the pollution control measures for this site are fairly standard, given the types of waste and the underlying geology. The detail of my criticism of this section is given in the following section ('Landfill Liners and Pollution Impacts').

Of concern to the local planning authority must be the proposals for leachate treatment and

discharge. This is governed by other authorities, but the principle of how exactly it is proposed to dispose of leachate should be precisely determined as part of the planning permission since it will effect the extent of treatment works necessary to process the leachate.

There are four possible options for disposing of the leachate...

- Transport to a licensed facility for dealing with such material - unlikely in practice because of the cost;

- Disposal to a nearby foul sewer, if the local sewage works were capable of taking the additional load and chemical contamination, and subject to a 'trade waste' consent being granted under the Water Industry Act 1991 by the local sewerage undertaker;

- Transport to a nearby sewage works for discharge directly into the works - but this again would require a contract and consent from the sewage undertaker concerned. The nearest major sewage works are at Warwick and Banbury;

- Following on-site treatment, treated effluent could be discharge to a nearby brook, or the canal, but this would require a consent under the Water Resources Act 1991.

If the material being discharged to sewer, or to a watercourse, contained 'prescribed substances' (such as mercury or cadmium) above the levels set in law, a further consent would also be needed from Her Majesty's Inspectorate of Pollution.

A certain route for disposal should be identified now so that the implications in terms of the potential for pollution, and the need to construct additional facilities on site, can be considered with the planning application currently before the authority.

1.1.8 Planning and waste management framework

This issue is covered in detail in section 3 of this report.

In general, the planning issues, which are at the core of this application, have not been considered in any realistic detail. There are also, in my opinion, fundamental errors relating to the relationship between the applications for development not included within the local development plan, and the lengths to which proposed development is therefore constrained, or not, by the development plan.

1.2 Composition of the fill material

Although the landfill, as proposed, will take only incinerator bottom ash and inert waste, I have my doubts about the viability of this proposal as it stands. Incinerators, to operate, must be able to dispose of the residues produced. The main design guidance for landfills is the recently issued Waste Management Paper 26B - '*Landfill design, construction, and operational practice*'[5]. The design of this landfill could, according to the guidance, be suitable for the deposit of putrescible or 'special' wastes. I find it strange therefore that the applicants limit themselves to the deposit of 'inert' wastes and incinerator bottom ash.

I have another question with regard to the proposal to only take incinerator bottom ash. 'Waste to Energy' incinerators, for a given waste input, produce about 30% bottom ash and 5% fly ash - but this proportion varies. For example, fluidised bed incinerators produce a greater proportion of fly ash. The only restriction on taking fly ash is the need to have a landfill designed and operated to take special waste - and this site could easily be reclassified to take special waste by slightly altering the proposed management systems, and perhaps adding a 'flexible membrane liner' to the base of each cell.

At the meeting organised in Fenny Compton village hall, I questioned[6] representatives of Terry Adams Ltd. about the possibilities of taking other waste types - the response to which was a general 'we have no plans to do so'. However, once planning permission is granted, so long as no *enforceable* planning conditions or planning obligations have been entered into to restrict waste types, the site operators could apply for a waste license, or modify any waste license subsequently granted, to take this material.

To accept other types of waste, the applicants would only need further planning permission if the changes to take other waste types involve 'development' within the meaning of section 55 of the Town and Country Planning Act 1990. But the changes necessary to make the development as proposed suitable for special wastes could be easily achieve by modifying the waste license - and any development which did take place would be so minimal that it would fall within 'permitted development rights' granted under the General Permitted Development Order 1995.

This issue is further elaborated upon in section 3.

1.3 'Sustainability' and risk assessment

There are two issues relating to the consideration of this planning application which have not been properly considered within the application statement:

- *Is this development sustainable?*: Planning guidance, and national guidance on the environment and sustainable development, require that the effects of development on natural resources, and future generations, be considered where these are significant;

- *Is this development safe?*: In a recent DoE publication, "A guide to Risk Assessment and Risk Management for Environmental Protection" , relating to polluting developments, their effects on the environment, and the application of the precautionary principle, it notes that consideration needs to be given to the likelihood of present and future risk to the environment and to human populations. This has not been produced.

1.3.1 Sustainable development

In terms of sustainable development, landfill must be considered unsustainable - this is because it involves the disposal of materials which may have some value as energy, or secondary resources, and landfill generally involves creating areas of contaminated land

which affect the use and reuse of land today and in the future.

If we consider this development, then the materials involved could have other uses. For example, if the bottom ash is 'non-hazardous', why cannot this material be reused as some form of secondary aggregate - as conventional power station 'pulverised fuel ash' is. In Japan, the ash from waste incinerators is turned into a slag which is then used for land reclamation. In a planning application for an incinerator near Carlisle, the applicant proposed to use the bottom ash as a lightweight aggregate for use in concrete block/sprayed concrete structures.

Likewise, if much of the inert material entering this site is uncontaminated, then with simple screening it could be reused as a source of secondary aggregate, and a low to medium quality soil for landscaping/construction purposes. For example, Tarmac Construction, which is currently working on the Derby southern bypass, is screening much of its waste earth so that it can be reused rather than just taking it straight to landfill.

Merely disposing of these materials, without recourse to the possible options for reuse, is not a sustainable approach.

1.3.2 Risk assessment

Planning Policy Guidance 23[7] makes it clear that the assessment of the potential for pollution, and moreover the *risk* that a development may pose, is a legitimate 'material consideration' in the determination of planning permission.

The recent Department of the Environment Publication, "A Guide to Risk Assessment and Risk Management for Environmental Protection"[8], is directly relevant to this case. The materials being brought to this site pose certain risks to the local environment, and to local communities - for example...

- The risk of spillage and pollution from the transport of the waste;
- The risk of contamination or pollution arising from the emplacement of the waste;
- The risk arising from abnormal operation of the site - for example failures of pollution control or dust mitigation measures'
- The risk from airborne pollution from gases leaking from the site;
- The long-term risk of contamination percolating or diffusing into the groundwater and hence to local watercourses.

The guidance document recommends that for each identified 'risk' component, strategies are identified to eliminate or mitigate the potential for adverse effects. This has not been done in this case. Although strategies to identify 'known' effects of landfill have been identified, this has not been done in a structured way. If an environmental assessment had been carried out and submitted with the application, then these issues would have been investigated in more detail.

2. Landfill liners and pollution impacts

Rather than consider the design of this site specifically - impractical since the detail needed

would only be supplied at the waste licensing stage, or with a detailed environmental impact statement - it would be better to look at recent information to emerge from the USA on landfill in general. According to the information presented by the applicant, the site can be satisfactorily developed as a landfill site, meeting 'modern' landfill standards. Unfortunately these 'standards', defined within Waste Management Papers 26, 26A and 26B[8], are all flawed.

2.1 Construction considerations and landfill liner failures.

Often, landfill site applications assert that proper construction materials will be used, the correct construction procedures will be followed, and a comprehensive construction quality assurance (CQA) program will be implemented.

However, from the literature it seems that even the best liner and leachate collection system will ultimately fail due to natural deterioration and result in leachate leakage from a lined landfill. Further, from the published literature, it is found that double-lined, including composite-lined, landfills with good CQA are expected to leak leachate at 20 gallons/acre/day shortly after being placed in service.

While applicants' assertions that the landfill liner will be constructed so that it will not fail to prevent migration of leachate from the proposed landfill, manufacturers of the highest performance 'flexible membrane liners' (FMLs) provide only 20 year warranties against defects in their liners. Even those warranties are pro-rated over that period, and require that the landfill owner/operator identify the location of liner defect and remove the wastes above the defective area so that the liner company can make repairs. Therefore, it may be concluded that despite the comprehensive construction quality assurance (CQA) program that many applicants claim will be adhered to in the construction of the proposed landfill, it like all others of that type, will be expected to leak from the time of construction and the liner performance will deteriorate over time.

In the UK, the leading conference of academics and industry officials is the Harwell Waste Management Symposium. At the meeting in May 1993, there was complete disagreement amongst the various delegates about what the true situation was regarding the safety of landfill liners. While some delegates suggested that current standards were sufficient, others produced new research showing that the lifetimes of liners is uncertain. While the experts cannot agree, it is up to local authorities, upon the guidance given in the Governments White Paper, "This Common Inheritance", to apply the precautionary principle and judge each case on the merits of the information provided.

2.2 Analysing why all landfills leak.

The US. Environmental Protection Agency (EPA) has paid for a series of engineering studies[9] to find out the best way to make a landfill. They wanted to know what was the "*best demonstrated available technology*" (BDAT) for making landfills. These studies reach some surprising conclusions.

'Dry tomb' contained landfills can be made of a huge sheet of plastic underlain by ordinary

soil, or it can be a just a layer of compacted soil (usually clay soil). The third combination, plastic liner and compacted clay soil, is called a "*composite liner*". A composite liner is not a double liner - it is a single liner made up of two parts. To create a double liner, you would use two composite soil liners together, separated by a layer of sand or gravel. Geoservices did not examine the first type of liner (plastic sheet on ordinary soil) because ordinary soil provides poor support for a plastic liner carrying many tonnes of weight, so they restricted their analysis to compacted clay liners vs. composite liners.

Very simply, the EPA wanted to know which liners were the best ones available - compacted clay liners or composite soil liners.

Clay liners:
Geoservices didn't have much good to say about clay liners. The flow of liquids through a liner (the liner's permeability) is measured in metres per second (m/s^{-1}) . The EPA's (and the UK's) current requirement for a liner for a hazardous waste landfill is that it pass liquids through it no faster than $1.0x10^{-9}m/s^{-1}$ (read ten to the minus nine metres per second, or one billionth of a metre per second). However, based on actual experience in the field, Geoservices concludes that this ideal permeability is often not achieved for a variety of reasons. Therefore, they assume that the actual permeability in the real world lies between $1.0x10^{-9}$ and $1.0x10^{-8}m/s^{-1}$. Geoservices concludes that the most significant observation is that, with compacted clay bottom liners, leakage out of the landfill will be larger if there is leakage through the top liner, even in landfills meeting current EPA design requirements, including permeability of $1.0x10^{-9}$ m/s^{-1}. In terms of the average American landfill, Geoservices estimated that nearly 1000 litres of fluid would leak through each hectare each day. Their calculations show that, with 12.5cm of water standing on the bottom liner, it will take 15 years for leakage to break through a 1 metre thick compacted clay bottom liner, but once break through has occurred, 1000 litres per hectare per day will pass through the liner continuously thereafter (this is just a basic working of D'Arcy's law on fluid flow through porous soils).
It won't take very long to contaminate a large drinking water supply if you pour 1000 to 10,000 litres of toxics into it day after day, year after year. Thus Geoservices has shown that clay liners are an environmental liability - not a solution to landfill containment.

Composite liners:
Geoservices reports that all plastic liners (also called Flexible Membrane Liners, or FML's) always have some leaks....
"A common misconception regarding FML's is that they are impermeable, that is, no fluid will pass through an intact FML. However, it is important to realize that all materials used as liners are at least slightly permeable to liquids or gases and a certain amount of permeation through liners should be expected. Additional leakage results from defects such as cracks, holes, and faulty seams."
It is this concept in the minds of decision makers - that the liners are 'impermeable', which is leading to landfills being sited near or over major aquifers, and risking the future of that aquifer as a potable water resource.
FML's often develop defects called "pinholes" during manufacture. These result from thin places ("fisheyes"), bubbles, foreign material, or lumps of carbon in the raw molten plastic from which the FML is rolled ("calendered") into sheets. Furthermore, when a large landfill liner is created by joining strips of FML together with glue or by welding, the resulting seams often leaks. Geoservices provides some data on typical seam defect rates.
They look at six case studies. Based on these six case studies, they drew the following

"tentative conclusions"...

- "*An average of one leak per 30 feet of seam can be expected if there is no quality assurance program (quality assurance being a third party coming along behind with special equipment to check the adequacy of the seams).*"
- "*Even with good quality assurance, 'an average of one leak per 300 metres of seam can be expected with reasonably good installation, adequate quality assurance, and repair of noted defects'. That is to say, under the best circumstances, you will get one leak per 300 metres of seam - if the landfill liner is made up of FML that are 7 to 10 metres wide, you can expect three or four defective seams in every hectare the liner covers.*"
- "*Based on actual data, Geoservices conclude that a "standard" leak in a FML has an area of one square centimetre, and that the "standard" number is two holes per hectare. They point out that the "standard" hole size and "standard" number per hectare are based on the assumption that "intensive quality assurance monitoring" will be performed during liner installation, so clearly we are talking about the best case, not the worst case, here.*"
- "*Design flaws, poor construction practice, or poor quality assurance would result in larger holes, greater numbers of holes, or even large tears.*"

Geoservices then goes on through an elaborate mathematical analysis to figure out how much fluid will pass through a composite liner under the best possible conditions and under less than ideal (but still optimistic) conditions. They conclude that the "best demonstrated available technology" (BDAT) for composite landfill liners will allow leakage rates somewhere between 0.25 and 11 litres per hectare per day. Thus they conclude that an average 25 hectare landfill site will have a leak rate somewhere between 6.25 and 275 litres per day, or between 2280 and 100,450 litres per year. And this is the "best demonstrated available technology" - the very best we can have when everything we do goes right.

2.3 Flaws in leachate collection systems.

If a landfill begins to fill up with fluid, the weight of the fluid puts pressure on the bottom of the landfill, increasing the likelihood of bottom liner failure, so any fluid inside a landfill is a potential source of trouble.

To prevent fluid from causing problems, every modern landfill has a system for draining liquids out of the landfill. Perforated pipes run over the bottom of the site, just above the liner, to collect the leachate in the same manner as drainage pipes are used to lower the water table in fields. In theory, these pipes carry off the leachate to a wastewater treatment plant, where the leachate is processed to remove the toxic chemicals.

One of the least-studied aspects of landfill design is how to make a leachate collection system that will work for many decades (much less many hundreds of years). The fact is, leachate collection systems can clog up in less than a decade and, when that happens, fluids begin to build up inside the landfill - a dangerous situation, as has been noted above.

Leachate collection systems fail in several known ways. First, they can clog up from silt or mud. Second, they can clog up because of the growth of micro-organisms in the pipes. Third, they can clog because of a chemical reactions leading to the precipitation of minerals in the pipes. Fourth, the pipes themselves can be weakened by chemical attack (acids, solvents, oxidizing agents, or corrosion) and may then be crushed by the tons of waste piled above

them.

The book, "Avoiding Failure of Leachate Collection and Cap Drainage Systems"[9], discusses these four failure mechanisms.

The first problem, silt, can sometimes be avoided, or at least reduced, by installing a "filter layer" above the leachate collection system. The filter layer may be made up of gravel or of a rug-like plastic material called "geotextile". Since the oldest leachate collection systems date from the early 1970's, there is very little available experience with the long-term performance of leachate collection systems. The hope is that a "filter layer" will solve the silt-clogging problem, but after many decades the entire filter layer itself may clog. Only time will tell.

The growth of micro-organisms seems to be an uncontrollable problem. The conditions for growth of slime forming micro-organisms are not well understood. Even if they were understood, we could not control chemical and physical conditions (temperature, pH, etc.) at the bottom of a landfill because of the thousands of tons of wastes heaped up in the landfill.

The problem of chemical precipitation also appears to be uncontrollable. The chemical conditions that lead to precipitation may be known, but again the conditions in the leachate collection system cannot be controlled because the system is not accessible once wastes have begun to be dumped into the landfill.

Finally, there is the straightforward problem of loading many tonnes of waste onto the leachate collection pipes. As more waste is piled into the site, the ground beneath the landfill settles to accommodate the stress. This can cause bending, splitting or complete fracture of the pipes.

2.4 Landfill risk characterisation.

In the mid-1980's, the US EPA Groundwater Research Laboratory, working with what is now the National Ground Water Association, convened a panel of experts to review information on the geological and hydrological characteristics of the saturated and unsaturated parts of aquifers that tend to promote pollution of groundwaters by contaminants at the surface of the soil. While the focus of that effort was directed toward pesticides, fertilizers, and other contaminants that are used at or above the soil surface, the results of the panel's deliberations provide considerable guidance on the potentially significant factors that affect the transport of landfill leachate-derived contaminants (once they have penetrated a liner) through the Vadose zone (the zone between the aerated soil and the unsaturated capillary fed zone above the water table) and then down gradient in the saturated aquifer system. The results were reported by Aller et al.[10].

The expert panel developed what has become known as the "DRASTIC" approach for evaluating groundwater pollution potential using hydrogeological settings. The acronym "DRASTIC" is derived from the words describing seven factors that influence the potential for groundwater contamination by activities at the soil surface. Those are:

- Depth to water table;
- Recharge, net;

- Aquifer media;
- Soil media (nature of topsoil);
- Topography (slope of soil);
- Vadose zone media;
- Conductivity (hydraulic) of the aquifer.

Many of those factors are pertinent to evaluating whether landfills in certain geological areas are more likely to cause groundwater pollution than landfills at other locations. For certain kinds of chemicals present at the surface of the topsoil, there can be significant attenuation/removal of contaminants by the organic matter in the topsoil. However, the soil media factor is not expected to be important for landfills since typically the surface soils (i.e., top soils) are removed at any landfill location in which part of the landfill is located below the soil surface.

The depth to water table, rate of precipitation recharge, the nature of Vadose zone and aquifer media, and the rate of fluid transport (hydraulic conductivity) are factors that can significantly affect the rate at which groundwater becomes polluted by leaks in landfill liners. For example, the greater the distance between the bottom of the waste and the water table, the less potential there is for groundwater pollution for many chemicals. This arises from the fact that, depending on the nature of the Vadose zone media, for many constituents there can be significant attenuation in the Vadose zone. Some chemicals are transformed-degraded in that zone, some are volatilised, others are precipitated, others are sorbed on the Vadose zone media. Therefore, the greater the depth to the water table for a particular Vadose zone media, the greater the possible attenuation (removal) of certain components of municipal landfill leachate.

Vadose zone and aquifer media composed of high permeability-sand and gravel, fractured bedrock or limestone would be expected to allow greater passage of leachate and leachate associated contaminants than media composed of low permeability silt-clay which could be expected to attenuate some of the chemical contaminants of concern. The DRASTIC factors of net recharge and topography, are fixed by landfill design and therefore not important siting factors for landfills.

Thus, generally, landfills located in areas characterized by a shallow depth to water table, high rate of precipitation recharge, and Vadose zone and aquifer media composed of high permeability-sand and gravel, fractured bedrock or limestone, tend to pose the greatest threat to groundwater pollution. Landfills located in areas characterized by a thick Vadose zone, and Vadose zone and aquifer media composed of low-permeability silt-clay tend to pose a lesser threat to groundwater quality. However, groundwaters down gradient in any aquifer that is hydraulically connected to the area beneath a municipal solid waste landfill will ultimately be polluted by the landfill. **For lined "dry tomb' landfills, the issue is not whether groundwater pollution will occur, it is when it will occur. Thus, where there is interest in protecting the groundwater quality for use by future generations it is important to site " dry tomb" landfills where there are no groundwaters that are or could be used for domestic water supply purposes in the area.**

2.5 The risk of pollution from the proposed landfill

The pollution from this site is directly related to the waste placed within it. Any estimation of the pollution risk for the site *as proposed* is only a statement of a certain set of conditions. If at any time the waste types being deposited in the site were changed, then the pollution produced could be of a different type, and more likely a greater or lesser magnitude than that noted here.

With many landfill sites, the base of the site is often well above the water table. In these situations the trend is for contamination to leak *out* of the site. However, in this case it has been accepted by the applicant that the water table in the area is high, and the ground is sometimes visible waterlogged - a situation caused where the water table reaches the ground surface, or where precipitation cannot adequately flow away through/off the soil.

This presents particular problems with this landfill. For example, if groundwater builds up behind a liner it can cause the liner to fail - either by the application of positive pressure to the back of the liner, or by causing the liner to break down as water is forced into it.

It would be a factual error - and given the circumstances misleading - for the applicants to state that the liner would *prevent* contamination from leaking out of the site. All liner materials are subject to degradation over time, and ultimately their breakdown can lead to the release of contamination held in the landfill. With clay liners, the fact that clay has a '*low permeability*' (it is not an 'impermeable' material) means that the question is more one of '*when will the contamination leak*'.

Taking the thickness of the liner, and its permeability, it is possible to estimate how long the liner will hold before leakage of the leachate occurs. This is calculated using the following formula...

$$y = \frac{t}{K \times 31{,}536{,}000}$$

where:

y = time to leak in years
t = thickness of liner (m)
K = permeability of liner, 1×10^{-9} (m s^{-1})

Using this formula, we can show that **the liner will begin to leak leachate in 32 years.**

As stated by the applicant, the filled area of the site is 214,000m^2, the clay liner will consist of 1 metre of 'engineered' clay, the liner permeability will be 1×10^{-9} ms^{-1}, and in normal circumstances there will be 1 metre of leachate standing in the base of the site. We can expect the liquid in the site to flow through the liner in a manner predicable by *D'Arcy's Law*. That is...

$$Q = K \times A \times \frac{h + t}{t}$$

where:

Q = flow out of liner (m^3 m^{-2} s^{-1})
h = height of leachate above liner (m)
t = thickness of liner (m)
K = permeability of liner material (m s^{-1})
A = cross sectional area of flow (m^2)

Taking the conditions as stated, **once the liner is breached, it will leak 0.214 litres of leachate per second - or 6,750m^3 of leachate per year.**

Due to the high water table, the mechanism by which the site will leak is not straightforward - this is illustrated in the diagram on the following page.

Illustration of liner seepage mechanisms

When the cell is first constructed (illustration A) there will be groundwater outside the liner, but none to balance this inside the liner. The pressure gradient will therefore be highest outside the lined cell, and lowest in the cell, causing the groundwater to leak inwards. Likewise, if the cell is filled with waste, and is then kept dry by pumping, the insides of the cell will still be at or near atmospheric pressure, and so water will still leak into the cell.

However, once pumping stops within the site, the water seeping in through the liner, or through the cap of the site, will begin to saturate the waste mass. The key point in this process is shown in illustration B. When the waste in the site is saturated to the same level as the groundwater, pressure equalises, and there is no seepage - movement of contamination can only then be by diffusion (which is relatively slow).

However, even though water no longer leaks into the site because pressure differences across the liner have equalised, rain still can percolate in through the cap. This will saturate further the waste in the site until (illustration C) the water level is higher within the site than in the surrounding soil. At this point leachate will begin to flow out of the cell into the groundwater.

This final situation also shows the importance on construction/maintenance of the landfill cap. Rain infiltration can be expected to be in the order of 20mm per year[12]. But if the cap becomes damaged, either by settlement as the waste breaks down, or through mechanical damage caused by excavation or the roots of trees/shrubs, then rain infiltration could begin to reach the theoretical 'effective percolation' rate of over 200mm per year[12]. This will increase the rate of leakage.

The ultimate level of leakage is a balance between the inflow and the leakage of fluid. Where the leakage exceeds inflow, an equilibrium will be reached where leakage equals inflow. The maximum level of leakage will therefore be the area of the site (A) multiplied by the cap infiltration (r).

One final point to make with regards to the hydrological regime at this site is the possible flow/diffusion of contamination into the surface layers. As the 'stiffness' of the clay (demonstrated by the borehole logs) increases with depth, so it is harder for the groundwater to move with depth. But near to the surface the higher permeability, and the effects of vegetation and landforms removing fluid from the soil provide a mechanism for increasing groundwater flow near the surface.

The site is very shallow - as stated within the application statement only 5 metres deep. There exists then the possibility of contamination moving near or up to the surface as the saturation

level of the clay changes during the year. The proximity of watercourses to the site means that if contamination was to leak into the surface layers then there would be a mechanism for it to be transported away from the site (albeit diluted). There is also the possibility of contamination - particularly heavy metals - being taken up in vegetation in fields near to the site. This poses the risk of contamination being transferred to food if crops are grown near to the site, or animals graze near to/on the site.

Finally - how much pollution could the site cause? There has been much work recently on the 'lifecycle analysis' of waste management technologies - in particular by companies such as Proctor and Gamble[13]. If we take the results of this research for the landfill of bottom ash, we can extrapolate to give an indication of the sorts of contamination we can expect in the leachate from the site. The table on the following page calculates (in the first part) how much leachate we might expect from the site, and then (in the second part) how much pollution this may cause.

This is of course only an illustration of what *could* be - to produce a more detailed analysis it would be necessary to have a more exact analysis of the types of material it was proposed to fill the site with, together with details of the leachability of the contaminants in the material. But the figures, as shown, are a fair *guesstimate*.

The figures in the bottom half of the table give the level of contaminants produced during different phases of the life of the landfill...

- *Active leachate* refers to the pollution produced in the leachate pumped from the site when it is operational. Over the 10 years it is calculated that 164,000m^3 of leachate will be produced, and this will carry nearly 37 tonnes of contamination. This may not sound a lot, but if we consider a contaminant like mercury or chromium, the leachate coming out of the site will be very near or above the drinking water quality standard set in law, while very toxic compounds like phenol will exceed the limits. Even with on-site treatment, it could still mean that toxic and bioaccumulative substances will be introduced to local watercourses directly, or via local sewage works.
- *Aftercare leachate* refers to the leachate pumped after the site has been filled and capped, until such time as it gets its 'certificate of completion'. After that, pumping will stop.
- *Min. post-saturation leak* is the leakage through the liner once pumping has ceased, assuming that the landfill cap stays intact and keeps its 20mm/year infiltration rate.
- *Max. post-saturation leak* is the leakage through the liner once pumping has ceased, but the assumption here is that the cap has broken down, and the infiltration rate equals the effective rainfall - around 300 to 340mm/year for this area of Britain.

Even following closure and aftercare, the amount of material which could feasibly leak into the groundwater is in the region of a tonne per year.

In the final analysis, the pollution from this site will be proportional to the contamination of the material entering the site. If the proportion of bottom ash, as stated, is deposited in the site, and the bottom ash is of 'average' quality, then we may expect pollution levels as seen above. However, if incinerator fly ash were also added to the material, then contamination levels could be very much higher. The addition of raw putrescible waste, or any type of chemical or liquid wastes, would also increase pollutant levels.

The only solution to the problem of contaminants leaching from the site is to stablise the material entering the site to reduce its biological and chemical pollution potential

to the absolute minimum. This means treating all organic wastes entering the site to prevent their degradation in the landfill. With incinerator ash and chemical waste, steps need to be taken to prevent material leaching from the waste mass. An effective way to do this would be to vitrify the ash coming from the incinerator into a silica rich slag (but this reduces the energy output of the incinerator), or to encapsulate the ash in some form of solid mass, for example by turning it into blocks using cement and some form of stable resin (but this is very expensive).

3. Planning and waste management policy issues

3.1 Determination of the planning application

Given that a planning application must be decided primarily on '*material planning considerations*', it is curious that the application statement gives less than a page to development plan considerations. This, I believe, is a demonstration of the 'weak' position this application has in terms of conformity with the development plan.

The Town and Country Planning Act, 1990 (as amended by the Planning and Compensation Act 1991), states in section 54A that...
"*Where making any determination under the planning Acts, regard is to be had to the development plan, the determination shall be made in accordance with the plan unless material considerations indicate otherwise*".

Section 54A is further reinforced by section 70(2) of the 1990 Act...
"*In dealing with such an application the authority shall have regard to the provisions of the development plan, so far as material to the application, and to any other material considerations*".

On both these counts, the application must fail. This site is not allocated for any type of development within either the Warwickshire Structure Plan, or the Stratford upon Avon District Local Plan. In the application statement it is stated that...
"*The proposed site is located in an undesignated area and, as such, is not constrained by planning policy*".

This, I believe, shows lack of understanding on the meaning and scope of the development plan. In fact, just because an area is not zoned on the 'proposals map', it does not mean that the site is unaffected by the development plan. In consideration of any application, the development will be considered on its merits - but in any and every application, section 54A and section 70(2) of the 1990 Act still apply. Thus although the site is not zoned in the local development plans, it must still be judged upon the non-site specific policies contained within the plans.

Within the Warwickshire Structure Plan[14] there are a number of policies, not considered by the applicant, that might cause refusal of this application...

- Policy E5: Protection of Special Landscape Areas. The 'special landscape area' does not include the site, but it does include much of the high ground which has views onto the site. Although the applicant claims that the landscape plan produced will mitigate any adverse visual impact, this is not conclusively confirmed by the inclusion of any 'sight-line' analysis.

- Policy E11: Waste recycling. This development can be categorised absolutely as a disposal facility - no attempt has been made to consider the main alternatives to landfilling these materials.

- Policy E12: Pollution. It can be demonstrated that the site will cause some pollution. It is for the planning authority to assess the effect of this in land-use planning terms.

- Policies T1 and T6: The routing of lorries on non-trunk routes can be considered contrary to the policies put forward to control the usage of the roads network. The problem ultimately is finding a routing agreement which uses only the trunk road network.

Structure plan policies, by their 'generalised' nature, do not provide the detail necessary to make clear decisions on planning applications. Therefore it is necessary to consider the structure plan policies alongside subsidiary policies in the local plans.

Stratford upon Avon District Local Plan[15]

In terms of the application statement, mention is made of plan policies on the 'special landscape areas', Policy ENV9 (trees) and Policy ENV16 (ecological enhancement). But notional compliance with a very few of the policies in the plan does not mean that permission should be granted.

In terms of the local plan (deposit draft + adoption changes) as a whole, this development would be unacceptable on the following basis...

- Policy ENV1:This development will be harmful to the locality because of the emission of dust, noise and possibly odours during its operation, and over time it will emit various environmental pollutants to the ground, and possibly to the air;

- Policy ENV2: It has not been demonstrated by the applicant that there will be no pollution of the environment as substances leak from the site. In fact the design of the site makes it possible to demonstrate that there must be leakage from the site;

- Policy ENV3: The failure to submit an environmental statement, and the minimal discussion of the possible effects of pollution, mean that the applicant has not satisfactorily demonstrated that any pollution that may arise is "acceptable" in terms of this policy;

- Policy ENV5: The 'special landscape area' does not include the site, but it does include much of the high ground which has views onto the site. Although the applicant claims that the landscape plan produced will mitigate any adverse visual impact, this is not conclusively

confirmed by the inclusion of any 'sight-line' analysis. The very basic assessment conducted for this report shows that from the Burton Dasset County Park, and other areas of high ground, it will be possible to view landfilling operations on the site;

- Policy T8: By increasing HGV traffic on local 'B' roads, especially through Bishops Itchington, the development will increase HGV traffic on local 'environmentally sensitive' roads;

In terms of the local plan, I do not believe that this development should be permitted.

Warwickshire Waste Local Plan

Although the application statement makes reference to the draft waste local plan[16], the fact that this has not yet gone out under its 'consultation draft' - and thus has not had any detailed comments from the Waste Regulation Authority, local waste companies, or the Department of the Environment - means that it is premature to put any weight upon statements made within the document. Therefore, references made to this document should be disregarded.

Planning Policy Guidance 23

The national guidance directly relevant to this matter is PPG23 on 'Planning and Pollution Control'. This outlines particular 'environmental' and 'pollution' matters that are relevant to determination of planning permissions. Taking the relevant quote from the PPG...
"*3.1 Decisions on planning applications for developments which may give rise to pollution, like all planning decisions, must be made in accordance with the development plan, unless material considerations indicate otherwise. They must also be made in accordance with relevant EC Directives...*
3.2 Material considerations may include:
- *the availability of land for potentially polluting development, taking into account its proximity to other development or land use, which may be affected;*
- *the sensitivity of the area, in particular as reflected in landscape, agricultural land quality, nature conservation or archaeological designations, if evidence suggests that there is a risk of such features being affected by pollution;*
- *the loss of amenity which the pollution would cause;*
- *any particular environmental benefits, such as, the regeneration of derelict land, or transport improvements;*
- *the design of the site and the visual impact of the development, including, for example, the transport mode and the impact on the road network and on the surrounding environment;*
- *the condition of the site itself, where it is known to be or likely to be contaminated, and any potential remediation;*
- *the proposed after use of the site, and feasibility of achieving restoration to the required standard where its intended use has limited duration;*
- *the potential use of mineral workings sites for landfill;*
- *the hours of operation required by the development where these may have an impact on neighbouring land use;*
- *the possibility that nuisance might be caused, for example, by the release of smoke, fumes, gasses dust, steam, smell or noise, where not controlled under Part I of the EPA 1990, or, in the case of waste facilities by birds, vermin or overblown litter; and*

○ *transport requirements arising from the need to transport polluting substances or waste, including the scope for transport by rail or water.*
Material considerations also include the potential economic and social benefits of the development, such as the provision of a product or service, the generation of secondary trade with local businesses, the recovery of energy from waste and the contribution to energy efficiency, and employment. Local authorities will need to make sure that proper weight is given to these factors in order to maintain an appropriate balance between economic and environmental considerations.
3.3 There may be other considerations to be taken into account to the extent that they have land-use implications. These are likely to be the responsibility, of the relevant pollution control authority who will be able to advise on the extent to which they are able to address these considerations through their own mechanisms. These include:-
○ *the possibility of land contamination arising from the proposed development, and protection and remediation measures as appropriate;*
○ *the impact of any discharge of effluent or leachates, which may pose a threat to current and future surface or underground water resources or to adjacent areas;*
○ *the risk of toxic releases, whether on site or on access roads; and*
○ *the waste generated by the development, including that arising from the preparation and construction phases, and proposed arrangements for storage, treatment and disposal. The weight attached to such considerations will be reduced to the extent that they are capable of being addressed by the pollution control authority in carrying out its statutory responsibilities.*

In terms of the above considerations, this development does not fare well. This is mainly due to the lack of information - characterised mainly by the failure to submit an environmental statement even though this development falls well within the indicative criteria for a 'schedule 2' project. More importantly there are many claims made within the application statement, not supported by empirical data or references, which upon investigation can be shown to be incomplete or not fully accurate to the situation on the ground.

If we go further into PPG23, other considerations are also mentioned...
"*3.15 Applicants do not normally have to prove the need for their proposed development, or discuss the merits of alternative sites. However, a number of judicial decisions have established certain categories of development where a duty to consider the existence of alternative sites may arise (Greater London Council v SOSE and LDDC. (1985) 52 P&CR 158; [1986] JPL 193. Trusthouse Forte Hotels v SOSE (l986) 53 P&CR 293; [1986] JPL 834; [1986] 2 EGLR l85). The nature of such developments and national or regional need may make the availability, or lack of availability, of suitable alternative sites material to the planning decision. In the case of an application for a waste facility, special statutory duties apply (set out in the Waste Management Licensing Regulations 1994, see paragraphs 5 . 3 - 5 . 8) .*
3.16 Environmental statements, which must accompany particular applications (see Annex 9), can identify matters that will be relevant to the determination of the application. They may - and as a matter of practice normally should - include an outline discussion of the main alternatives studied by the developer and an indication of the reasons for choosing the development proposed, taking account of environmental effects.
3.17 In setting standards for a particular process, pollution control authorities operate under requirements that they should have regard to the particular local environmental circumstances. Standards must be set with the aim of ensuring that there is no danger to human health, harm to the environment or unacceptable statutory nuisance. Higher

standards of environmental protection should be set if the local environment is more sensitive, for example, if the releases would affect. a designated area or if storage of chemicals would present risks to an aquifer. Provisions exist under pollution control legislation to require account to be taken of improved technology and knowledge about the effects of pollution.
3.18 However, there may be circumstances where a development that is likely to satisfy pollution control requirements may still be considered by the planning authority to present an unacceptable risk in planning terms, because of social, economic or environmental factors incorporated in that risk. In considering the weight to attach to the risk of a pollution incident, the planning authorities should rely on the advice of the pollution control authorities. The perception of risk should not be material to the consideration of the planning application unless the land-use consequences of such perceptions can be clearly demonstrated. Where such consequences are considered unacceptable and cannot be overcome by appropriate planning conditions, permission may have to be refused. In these circumstances, the planning authority will need to demonstrate the land use planning reasons (not subject to pollution control) which have led them to conclude that the development is unacceptable.
3.19 It is not the role of the planning authority to undertake detailed risk assessment of releases into the environment. In any assessment of a particular risk, full regard should be given to the responsibility of the relevant pollution control authority or the Health and Safety Executive in respect of assessing that risk; planning authorities should not seek to substitute their interpretation of such risk assessment for that of the relevant authority."

On the basis of these criteria, the application does not fare well either. What is important is that the facility is not part of any proposed development within the County. This first and foremost offends the '*proximity principle*' - the notion that areas where waste arises should make facilities available to deal with them. At the meeting in Fenny Compton village hall, representatives of the company referred to taking incinerator ash from Birmingham, Nottingham, Coventry, and possibly new incinerators from around Oxford and London.

In terms of nuisance effects, no data has been presented to demonstrate that odour and noise nuisance can be controlled so as not to cause offence to nearby residents. Likewise, in terms of the 'risk' of 'potential pollution', no data has been produced to substantiate the claims that the 'containment' landfill design will achieve the aim of isolating the wastes from the environment.

In terms of this policy guidance, none of the criteria for the adjudication of planning applications can be satisfactorily met - in terms of the exclusion of reasonable doubts - in order to grant this permission with certainty.

3.2 Minerals Implications

At the moment it is not proposed to dig clay from this site for export to other landfills. However, it has been acknowledged by the applicant that this clay, when engineered, is suitable for landfill liners. There may therefore arise the possibility of an application being made at a future date for the excavation and export of clay from this site.

Should planning permission be granted for this development, to prevent the possibility of minerals rights being exercised on this site - which in terms of local amenity would only

worsen a situation made bad by intensifying development - the applicant should be made to enter into a section 106 agreement to legally prevent the excavation and export of clay from this site.

3.3 Waste Types

The main concern I have with this application as it stands is the 'logic' of taking 85% of the ash produced by a waste incinerator - the bottom ash - and refusing to take the other 15% - the fly ash. As made very clear in the Government's response to a proposals by the European Commission to outlaw 'codisposal' (the usual waste practice) in favour of 'mono-fill' (which is essentially what this is), policy in this country has been to mix all waste types together in one hole.

In practice mono-fill is better because it allows more specific site design to ensure the safe disposal of the chosen waste type, rather than having to built a high quality landfill when only 15% of the waste you put in needs that level of containment.

As it stands this site, with a few modifications possible through a waste license variation, could be made to accept special wastes, and thus the other 15% of the incinerator ash which at present they propose not to take. So long as it meant no new development outside of that which is covered by permitted development rights, such a change would be easily achievable on this site.

An example of this was a site on which I fought an appeal, in support of the local waste regulation authority, at Beaufort Quarry in Chepstow[17]. The company, which had permission to infill with inert waste, sought a waste license modification to allow the disposal of incinerator ash, fragmentation waste and asbestos. Because this was done as a waste license modification, and because the changes could easily be accommodated without any further planning permission, it bypassed any further planning controls, and more importantly, any need for an environmental assessment (which, because of the asbestos, would have been mandatory under schedule 1 of the Regulations).

My fear is that the company will seek permission, and then a waste license, and then perhaps immediately, or after a few years have elapsed, they will seek a modification to permit the disposal of the fly ash as well as the bottom ash. In order to prevent this, if permission is subsequently granted, I suggest that the applicants be made to enter into a section 106 agreement to restrict the development to the waste types requested. This is on the basis that planning conditions could not correctly be enforced on this matter because the selection/authorisation of waste types is a matter for the waste regulation authority.

4. Conclusion and recommendations

Conclusions...

In general this application represents all the common features of 'modern' landfill applications

- with the exception the applicants have not submitted an environmental statement. This type of development falls within 'Schedule 2' of the Town and Country Planning (Assessment of Environmental Effects) Regulations, 1988, which means that a statement is not mandatory. But in this case the site exceeds the 'indicative criteria' - the deposit of 75,000 tonnes a year of waste. For this reason I would have expected the applicant to have submitted a detailed environmental statement, properly conforming to Schedule 3 of the 1988 Regulations.

The decision as to whether or not this application is permitted must be primarily made on planning grounds. The consideration of environmental matters is restricted to those which planning guidance (mainly Planning Policy Guidance 23) considers to be material.

In the application statement it is stated, because this site is not allocated for any use within the structure plan/local plan, that it is not constrained by planning policy. This is an error on the part of the applicant. Where land is not allocated for development within the plan, all other plan policies still apply - therefore this development *is* constrained by development plan policy.

On a purely land-use planning basis I believe that this application should not be permitted. This is because of...

- The impact upon the local landscape, and visual amenity;
- The development will be a 'bad neighbour' in an area where there is no previous history of this type of development. For example, the reuse of a quarry for waste deposit produces little disturbance beyond that which has already existed previously - but this site will produce impacts on the environment and local communities which are out of character with this area;
- In terms of the development plan, and national planning guidance, the site is not allocated for development, and represents a significant intrusion into the open countryside;
- Although the restoration/afteruse of this site may bring some benefits, this must be weighed against the potential for harm on the environment and surrounding communities. It is my opinion that on balance this development will bring more disamenities in the short term (with environmental nuisance) and a significant legacy in the long term (by the creation of a contaminated site and the potential for pollution), and so the benefits do not outweigh the costs.

Also, in terms of local waste policy, it is premature to rely on the draft waste local plan since it has not even been for public consultation, and in terms of national policy we should wait for the adoption of the new Environmental Agency's 'statutory waste strategy' before we commit to any long-term options for the disposal of waste.

On the balance of 'material considerations', this application should be refused. I can see no legitimate argument for supporting this site in this location. Even if the geological conditions were to favour a landfill in this area, which at the moment has not been conclusively demonstrated, then there is still the obstacle of land-use planning - something which could not be easily satisfied because of the sensitive location of the site.

Recommendations...

My recommendation to the planning authority is to refuse the application. Also, local residents should pledge their support for the local authorities at any subsequent planning appeal/public inquiry due to refusal of permission. This would lengthen any subsequent

public inquiry, and make the costs higher should the applicants lose.

If the authority are minded to approve this application, then conditions must be applied, and perhaps more properly a section 106 agreement sought, to ensure that the waste types, as described in the application, are the only types of waste deposited within this site. Further restriction should be applied to ensure that the development is not extended or added to in any way, and that the land near to the site is not further developed following completion of the site. The authority should also seek bonds or some sort of indemnity to ensure that if pollution of the environment occurs at any time during operation, during the aftercare period, or any time after closure, then the authority will have sufficient financial resources immediately available to remedy the impact of the pollution and protect the environment and public health.

Paul Mobbs.
March 1996

5. References

1. Application submitted by Terry Adams Ltd to Warwickshire County Council - consisting of the application form, a twenty page written statement, and a number of maps/plans.

2. In my experience of other landfill sites, a ratio of fill to daily cover of 4:1 is enough to ensure sufficient cover. On sites where less cover is available problems with daily cover requirements have been encountered. The ratio is of course dependent upon the thickness of the waste layer filled daily - in this sense 10% cover to 90% fill could be suitable, sol long as the fill was laid in very thick layers.

3. The baseline for modelling was taken as the 100m contour, plotted from the centre of the area of waste filling. A visual barrier of 5-10 metres was assumed as a realistic value for the effect of screening in the first 10 years of operation, and the seasonal effects such as the thinning of vegetative cover. From this a basic 'cone' was extended from the site - any land higher than the intersecting plane of the cone was taken as being within the 'visible' area. Corrections have also been made for the screening effects of surrounding hills, and some buildings, but not trees or hedgerows.

4. There are a range of waste management papers covering licensing, landfill design, and specific wastes and recycling options. A further guidance was issued by the Department of the Environment at the end of 1995 - 'Waste Management Planning: Principles and Practice', which discusses the general requirements for 'modern' waste disposal facilities.

5. Waste Management Paper 26, Department of the Environment, 1996.

6. Data taken from my own private notes: During the meeting in the village hall on Wednesday 20th March, 1996, I talked to each of the representatives from Terry Adams Ltd., questioning them on basic issues surrounding landfill development and noting down their responses.

7. Department of the Environment, Planning Policy Guidance no.23, "Planning and Pollution Control", HMSO, July 1994.

8. Department of the Environment - "A guide to Risk Assessment and Risk Management for Environmental Protection", published by HMSO, ISBN 0 11 753091 3 - £9.95

8. Waste Management Paper 26 - 'Landfilling Waste', Department of the Environment 1986; Waste Management Paper 26A - 'Landfill Completion', Department of the Environment 1993; Waste Management Paper 26B - 'Landfill Design, Construction and Operating Practice', Department of the Environment 1995.

9. Geoservices Inc. - "Background Document on Bottom Liner Performance in Double Lined Landfills and Surface Impoundments". National Technical Information Service, April 1987.

10. Jeffrey Bass - "Avoiding Failure of Leachate Collection and Cap Drainage Systems", 1989, Noyes Data Corporation, Park Ridge, NJ07656.

11. L. Aller, T. Bennett, J. Lehr, R. Petty, G. Hackett, "DRASTIC: A standardised system for evaluating groundwater pollution potential using hydrogeological setting", EPA 600/2-87-035, US EPA Groundwater Research Laboratory Oklahoma, 1987.

12. Cap infiltration figure is taken from Waste Management Paper 26B. Rather than calculate a figure for effective rainfall on this site, a figure for rainfall of 750mm y^{-1} was taken (based on ordnance survey maps) and multiplied by 0.42 (ratio of effective rainfall to annual rainfall, calculated from figure 6.3a of Waste Management Paper 26B).

13. Dr. P. White, Dr. M. Franke & P. Hindle (Proctor & Gamble UK, Germany & Belgium), "Integrated Solid Waste Management: A Lifecycle Inventory", Blackie Academic & Professional 1994.

14. Warwickshire Structure Plan 1989-2001, including Alterations No.1, September 1991.

15. The Stratford upon Avon Local Plan is currently in deposit draft, with adoption modifications (January 1993) following the publication of the public inquiry Inspector's report. There may therefore be an argument that it is premature to consider this plan, but from studying the adoption changes I see it as unlikely that any of the policies relating to this development will be radically changed.

16. 'Warwickshire Waste Local Plan - The Issues', November 1994. Reference could also be made to the drafts currently going through the County Council. In either case, we are primarily dealing with 'strategy' documents that have not been for public consultation, and so it would be premature to consider these drafts as a valid development plan.

17. Appeal against rejection by Monmouth Borough Council of an application for modification to a waste disposal license at Old Beaufort Quarry, Chepstow. Welsh Office Reference WEP 116-113-8. This appeal is still awaiting determination by the Secretary of State for Wales.

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