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ENVIRONMENT AGENCY

Report No. AMA/J95/R2

RADIOLOGICAL ASSESSMENT OF RADIOACTIVE WASTE DISPOSAL FROM NON-NUCLEAR PREMISES IN ANGLIAN REGION VOLUME 2 - RESULTS

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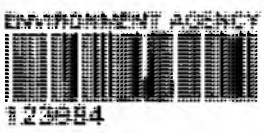

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FOREWORD

In the UK, premises keeping or using radioactive substances are required to be registered in accordance with the provisions of the Radioactive Substances Act 1993 (RSA 93). In addition, accumulation and disposal of radioactive waste, including direct discharges of liquid or gaseous effluent streams contaminated with radioactivity, can only be made in accordance with an authorisation under that Act. In England and Wales, the Environment Agency administers the Act.

In applying for an authorisation, the owner of the premises is required to carry out a radiological assessment of the consequences of the proposed disposal. Such an assessment is usually given in terms of the maximum radiation dose to members of the public. The actual level of authorisation is then set by the Agency at a level which ensures that public exposure is within statutory dose limits and also that the disposals/discharges are no higher than necessary to meet operational needs.

The contributions to public exposure arising from discharges of radioactivity from the nuclear industry have been extensively assessed over a number of years. This has been based on both environmental monitoring and radiological assessments. The non-nuclear premises, such as industry, hospitals, universities and research institutions (who also use radioactive materials), have not been subject to such extensive assessment and monitoring.

Anglian Region of the Environment Agency therefore decided to carry out a more wide-ranging study of the impact of discharges from these premises. This is in keeping with our aspirations of looking at the environmental outcomes of the authorisations we issue. It also helps to give a more complete picture of the impact of authorised discharges of radioactive materials into the environment. This study also acts as a pilot for a methodology the Agency is considering adopting to look at radiation dose assessment for the public more generally.

The aim has been to assess the radiological impact that would result to the most exposed members of the public from each authorised premise in the Anglian Region. It assumes that the levels of radioactivity discharged are at the maximum levels permitted by the authorisation. At the majority of premises, discharges are well below the authorised levels and so the actual radiation doses will be well below the estimates presented in the report.

This report has been prepared for the Anglian Region of the Environment Agency by Alan Martin Associates. Anglian Region is publishing the report in the spirit of openness and of making environmental information available to the public. It is hoped that it will help inform discussions on the impact of radioactive discharges from these categories of authorised processes.

The report supports the view that provided these discharges are properly assessed and authorised, then the level of risk for members of the general public is low.

Innes Garden

Manager, Process Industry Regulation / Radioactive Substances Regulation
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SUMMARY

This Report has been prepared by Alan Martin Associates for the Anglian Region of the Environment Agency (EA) under Contract Ref. P0035/DOSE/CT. The objective of the work covered by the contract is to undertake an assessment of the radiation doses to critical groups from authorised disposals and discharges of radioactive waste from premises other than nuclear sites within the Anglian Region. The present report comprises Volume 2 and sets out the detailed results of the assessment of the radiation doses that would result from disposals of radioactivity at the limits of the authorisations for all non-nuclear premises in the Anglian region. The assessments are based on the methodology and data presented in Volume 1, using the details on authorisations compiled in Volume 3.

Generally, the assessments have considered bounding situations and, in some cases, the pathways identified as making the major contributions might not be currently applicable. Nevertheless, in most cases, there remains the potential for the pathway to become applicable. Similarly, the parameters used in assessing the impacts through the various pathways are generally such as to provide upper limit estimates. In some authorisations, in addition to specified radionuclides there is an allowance for "other" radionuclides, excluding alpha emitters. This provides flexibility to users, particularly to hospitals, where new techniques may need to be used at short notice to suit particular situations. Where such a category is specified in an authorisation, the assessment has been based on a radionuclide giving a relatively high impact per unit release. For release to atmosphere, the assessment is based on I-125 and for liquid releases Co-58.

For releases to atmosphere, the results show that the impact of discharges at the limits of authorisation would, in most cases, result in doses to most exposed groups of less than 1 μSv per year. For a small number of premises, the impacts are estimated to be a few μSv per year and only in one case does the estimated impact exceed 10 μSv per year. The only area in which there is a sufficient concentration of authorised premises such that the combined impacts might need to be considered is Cambridge. However, it is shown that the combined radiological impact would be less than 1 μSv per year.

The assessments of discharges of radioactive liquid effluents via public sewage treatment works indicate that discharges at the limits of authorisations would result in doses exceeding 10 μSv per year at seven of the public sewage treatment works. In all of these cases, the impact is mainly from I-131 through the irrigation pathway. The highest impact is 203 μSv per year from discharges to the River Cam from Milton sewage treatment works. Analysis of the impacts of the combined discharges from all the public sewage treatment works on a river system shows that they do not result in significantly increased impact down the catchment system. In general, the impact declines down the catchment as a result of increasing dilution.

The highest overall estimated impact from liquid effluent discharges is about 250 μSv per year due to the sewage sludge pathway from the private sewage treatment plant at Conoco Ltd, Grimsby. The main contributor to the dose is H-3 for which the authorised limit is 1.8 TBq per year. Direct discharges to the North Sea from the Conoco Ltd. Plant at Theddlethorpe would, at the limits of authorisation, result in a dose of about 50 μSv per year to a critical group of fish consumers. In this latter case, the impact is due to naturally occurring radioactivity from the processing of natural gas.

There is only one authorisation for disposal to landfill in the region and the assessed impact of this is shown to be very low.

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1. INTRODUCTION

This Report has been prepared by Alan Martin Associates for the Anglian Region of the Environment Agency (EA) under Contract Ref. P0035/DOSE/CT. The objective of the work covered by the report is to undertake an assessment of the radiation doses to critical groups from authorised disposals and discharges of radioactive waste from premises other than nuclear sites within the Anglian Region.

An interim report was issued in March 1998 (Ref. 1) and this included a review of previous work, the development of a general methodology and its application to a pilot area. The overall results of the study are presented in three volumes as follows:

> Volume 1 - Radiological assessment of radioactive waste disposal from non-nuclear premises in Anglian Region - Methodology (Ref. 2);
> Volume 2 – Radiological assessment of radioactive waste disposal from non-nuclear premises in Anglian Region - Results (this volume) and
> Volume 3 – Radiological assessment of radioactive waste disposal from non-nuclear premises in Anglian Region - Data on authorisations (Ref. 3).

The present report comprises Volume 2 and sets out the detailed results of the assessment of the radiation doses that would result from disposals of radioactivity at the limits of the authorisations for all non-nuclear premises in the Anglian region. The assessments are based on the methodology and data presented in Volume 1, using the details on authorisations existing on the Public Register compiled in Volume 3. It should be noted that circumstances within premises change and variations are made to authorisations. For these reasons, the details of authorisations contained in Volume 3, and hence the estimates of impact, represent a snapshot of the situation as of summer 1998.

2. BASIS OF RADIOLOGICAL ASSESSMENT

In general, the radiation exposure pathways that need to be considered in assessing the radiological impact of authorised disposals of wastes from non-nuclear premises are those arising from:

- Release to atmosphere, considering the impacts at both residential and agricultural locations;
- Release to sewer, with subsequent discharge of treated effluent and use of sewage sludge;
- Release to river, including external exposure, drinking water, fish consumption and irrigation pathways;
- Release to coastal or estuarine waters, taking account of external exposure and fish consumption; and
- Disposal of solid waste to landfill.

In the case of release to atmosphere, the exposure pathways can include inhalation, external dose and ingestion of radioactivity as a result of contamination of crops or animal products. Releases to water can lead to ingestion dose due to consumption of water, fish or agricultural produce irrigated by water from the receiving body. In the case of discharges to sewer drains, depending on the radionuclide, the activity is partitioned between sewage sludge and the liquid effluent from the sewage treatment plant. The most important pathways for sewage sludge are those resulting from its use as agricultural fertiliser.

2.1 General approach

The assessment of the radiological impact of disposals or discharges of wastes containing radioactivity involves a number of stages, as follows:

- compilation of data on the authorised and/or actual rates of disposal and the characteristics of discharge;
- study of the receiving environment and compilation of the information and data needed for quantitative assessment;
- setting up of methodologies for assessment of the various disposal routes and exposure pathways;
- running of the assessments; and
- presentation and discussion of results.

These stages are discussed in the following sub-sections.

An important recent development is the availability of a personal computer based assessment system, PC CREAM, which has been written by the National Radiological Protection Board under contract to the European Commission. This is intended to provide a user-friendly method of assessing the radiological impact of routine releases of radioactivity into the environment. PC CREAM (Ref. 4) is a computer implementation of a suite of models for performing radiological impact assessments for routine and continuous discharges of radioactivity to the environment. The models and data are set out in Ref. 5, which should be considered as part of the code documentation. The system allows assessment of the impact of releases to atmosphere, sea or rivers. Pathways that cannot be directly assessed are irrigation and application of sewage sludge to agricultural land.

2.2 Compilation of data on authorised disposals

The EA maintains a computerised database of registrations and authorisations under RSA 93 and the record may be searched by region, county, local authority, river catchment or by areas specified by National Grid Reference (GR) co-ordinates. This system allows identification of all premises within a defined study area holding authorisations for disposal. Detailed information on each of the identified premises may then be obtained from the files held in the Public Register, which is maintained at various EA regional offices. The information is mainly contained in the application form for authorisation (Form RSA3) and in the Certificate of Authorisation issued by the EA.

A complete list of authorised premises within the Anglian region, dated 30 April 1998, is shown in Appendix A. For the purposes of the present study a unique identification number was given to each of the non-nuclear sites. The current authorisation certificate for each site provided the annual disposal limit for each relevant radionuclide and any conditions specified for that disposal route. The current RSA 3 form, when available, provided further details of the site location and disposal arrangements. Actual disposals from each site were obtained from the annual report to the Environment Agency (emission inventories), where that was available.

The site information required for assessment purposes was compiled on data forms specific to each of the following disposal routes:

- disposals to atmosphere;
- liquid disposals to sewer or direct to watercourses;
- disposal by incineration;
- disposal to landfill (within the region).

The extracted data include details of the atmospheric discharge arrangements and distances to the nearest residence and point of public access, and information on the sewage discharge system. These summary data sheets are contained in a separate volume (Volume 3).

Within the Anglian region, as of summer 1998, there were 103 premises authorised to dispose of radioactive wastes, of which the following disposal routes are used:

- 83 sites discharging to sewer (discharges to sewer involve 28 public sewage treatment plants, 10 private sewage treatment plants and 6 sites discharging directly to an estuary or the sea);
- 38 sites discharging to atmosphere (including 6 sites with incinerators);
- one site disposing of solid waste to a landfill site.

The present assessment does not include radioactive wastes that are transported out of the region for disposal.

The following authorised sites were not included in the present assessment as the relevant data were not at that time available:

Mobil Oil, Coryton Refinery, Essex (Study Ref. 61);
Agricultural and Food Research Council, Bury St, Edmunds (Study Ref. 90);
Animal Health Trust, Balaton Lodge, Newmarket (Study Ref. 91).

2.3 Compilation of data on the receiving environment

In compiling information on the receiving environment, the aim is to identify the groups of the population likely to receive the highest dose as a result of the disposals and to derive quantitative data for assessment purposes.

Although a visit to the sites and the general area is recommended, it is not generally feasible or necessary to compile complete sets of information either on the environment or on the occupancy factors and dietary habits of local population groups. Instead, stylised assessments are performed using generally conservative assumptions in order to obtain an upper bound estimate of dose. This type of assessment would generally confirm the low radiological significance of the authorised disposals but in any case where the dose appears to be unusually high, a more detailed assessment of the conditions of release and of the receiving environment would be required.

Release to atmosphere

For release to atmosphere, the relevant information is:

- the details of release that affect atmospheric dispersion, i.e. stack height, building dimensions, and release characteristics;
- the meteorological characteristics of the area, including windrose and stability category and rainfall frequencies (default meteorological data sets are available within PC CREAM and these are normally adequate for initial assessment);
- the location of the nearest normally occupied habitation; in this case, a distinction has been made between premises in urban and rural locations and for each type of location standard distances have been defined, see Section 5 of Volume 1.

All of the pathways resulting from release to atmosphere can be assessed by means of PC-Cream though not all radionuclides of interest to this study are contained in the default files supplied with the system.

Release to water

Where a release occurs to a water body, normally a river, the relevant characteristics of the river flow need to be established. Information on river flows in the UK is compiled by the Institute of Hydrology (NERC, Wallingford) in the National Water Archive published as the Hydrological Yearbook (web site: www.nwl.ac.uk). River flow data are obtained from a network of gauging stations listed in the Concise Register of Gauging Stations and an extract from the list of gauging stations in the Anglian region is shown in Appendix B.

Discharge to sewer

Discharge to sewer results in release of treated water to a river, estuary or sea and the production of sludge from the sewage treatment process. Information on each sewage treatment works was obtained from the Water Quality/Pollution Control Register for the Anglian Region and included the sewage and sludge treatment processes and production rates; the relevant data are shown in Appendix C. In the case of premises discharging to their own private sewage treatment plant, the relevant information was obtained from the RSA3 application form.

For each sewage treatment plant through which radioactive waste is discharged, the data required for assessment purposes were assembled on the data forms, which are compiled in Volume 3. Each form shows the total authorised input of radioactive waste arising from the premises discharging to that sewage treatment works and also the actual input, where that information is available.

The proportions of activity appearing in the liquid effluent and in the solid wastes depend largely on the distribution coefficient Kd for a particular radionuclide. Based on information in Refs. 6 to 8, a model representation of a sewage treatment works and of sludge utilisation has been derived to allow estimation of the quantity of sludge arising and the fractions of activity appearing in each phase. For radionuclides with a low Kd, almost all of the activity will remain in the aqueous phase and be discharged as treated sewer water, normally to a river. For nuclides with high Kd, the opposite is the case and almost all of the activity is retained in the solid phase. The approach adopted is to allocate each nuclide to one of three categories, as follows:

- low Kd, for which 100% release in liquid effluent is assumed, in addition to which it is conservatively assumed that 10% remains in sludge;
- high Kd, for which 100% retention in sludge is assumed, but with a conservative allowance for 10% to be released in liquid effluent; and
- intermediate or highly uncertain Kd, for which it is assumed that there is both 100% release and 100% retention in sludge.

For many of the radionuclides of interest, there is significant uncertainty over the Kd value that is appropriate to the conditions in a STW and the allocation to the three categories requires a large degree of judgement. The allocations are shown in the following table.

Kd, $m^3 kg^{-1}$	Examples of elements	Fraction released in liquid phase	Fraction retained in sludge
< 3	H, C, F, Na, P, S, Cl, Ca, Br, Sr, Tc, I, Cs, Ra, U	1	0.1
3 - 30	Cr, Fe, Co, Ru, In, Tl,	1	1
>30	V, Mn, Ga, Se, Th	0.1	1

2.4 Setting up and running the assessment

The setting up and running of the assessments is described in Volume 1, in which detailed results are presented of the radiological impact of discharges through the various routes for unit discharge or disposal rate. These unit data provide the basis for the detailed estimates presented in the following sections of this report.

3. ASSESSMENT OF RELEASES TO ATMOSPHERE

3.1 Assessment basis

Given the large number of sites to be assessed, the approach has been to undertake generic assessments and to estimate the radiological impact of unit release rate of the range of nuclides covered by the authorisations.

For the majority of premises, release to atmosphere occurs at low elevation, either from building vents or from low stacks. In these cases, a standard release height of 15m is taken. For a small number of premises, the release is from stacks of between 20 and 100m high. To cover all situations, generic data are given in Volume 1 for four release heights – 15, 30, 60 and 100m – and all premises are considered to fit one of these cases.

Where the release occurs from building vents or low stacks, entrainment of the airflow in the building wake can affect radionuclide concentrations downwind, as discussed in Volume 1. For typical category D conditions and a wind speed of 4m/s, the effect of entrainment will be to increase the concentration at 300 m downwind by about 20%, as compared to that for a point release at a stack height of 15 m, with the effect decreasing with increasing distance. Thus the effect is not significant compared with the overall uncertainty of dispersion models, and in all cases of low-level discharge a height of 15m is taken in the ASSESSOR module of PC-CREAM.

Two types of exposure scenario are considered, corresponding to residential and agricultural locations. At the residential location, the exposure routes considered include external dose, inhalation and ingestion pathways as a result of consumption of limited quantities of garden produce. At the agricultural location, unless there is site-specific information to the contrary, it is usual to assume that a high proportion of food is produced on the farm. This could include fruit, vegetables, milk, and meat. For present purposes, in order to obtain bounding estimates, consumption at agricultural locations is taken to be at critical group consumption rate for all foodstuffs.

Generally, the nearest residential location is taken as 300m from the point of discharge and this distance is used for the lower elevation (15 and 30m) releases. For the higher elevation discharges, the peak impacts occur at longer ranges and the residential location is taken to be at 500m for a 60m-stack release and at 1000m for the 100m-stack release.

For assessment of the impact at agricultural locations, a distinction is made between premises in urban and rural locations. For urban locations, the nearest farming is usually at least 1000m distant whilst for premises in rural locations, distances to the nearest farm could, more typically, be 500m. Again, the actual distance used for assessment purposes depends on the release height. Full details of the assessment basis for releases to atmosphere are shown in Table 1.

The results of the generic assessments are set out in Tables 2 to 6 of Volume 1 and give the contributions and total impacts for a release rate of 1 MBq per year for the scenarios described above.

3.2 Radiological impacts of releases to atmosphere at limits of authorisation

The results of the assessments of the radiological impacts for releases to atmosphere at the limits of authorisation are summarised in Tables 2.1 to 2.43 for each of the authorised premises. These give the dose estimates for both residential and agricultural locations, and show contributions from each nuclide and the totals. For many premises, in addition to limits for specified radionuclides, there is a limit on "any other non-alpha emitter". In these cases, the impact is assessed assuming that the "other" radionuclide is I-125, since this is a commonly used radionuclide with a relatively high impact per unit of discharge.

In the majority of cases, the overall impacts are extremely low, generally well below 1 μSv per year. For five of the forty-three premises, the assessed impacts at the limits of authorisation are above 1 μSv per year and these premises are listed in Table 3. The highest impact is for Conoco Ltd at Grimsby for which the estimated impact from releases at the limit of the discharge authorisation is about 13 μSv per year for an agricultural location. The next highest impacts are those from the Incinerator at the Babraham Institute, Cambridge (8.5 μSv per year) and the premises at Surelite Ltd, Corby (7 μSv per year). In the latter case, where the only nuclide authorised for disposal is H-3, the actual discharge in the only year for which data are available is less than 0.1% of the authorised limit. No details are currently available from the EA Register on the actual levels of discharge from Conoco Ltd, but the actual impact is thought to be well below the assessed level of 13 μSv per year. It is known that the incinerator at the Babraham Institute has now closed.

In all of the cases shown in Table 3, the main contribution to dose comes from ingestion of foodstuffs at the agricultural location.

4. ASSESSMENT OF RELEASES TO WATER BODIES

4.1 Assessment basis

As in the case of releases to atmosphere, the approach to assessing the radiological impact of discharges of radioactive liquid effluents has been to undertake generic assessments on a unit basis. For the majority of premises, release is authorised to the public sewerage system and, in some cases, the effluent from several premises is directed to a single Sewage Treatment Works (STW), see Volume 1 for details. In some cases, collection and treatment is undertaken within small private STW on the premises. After treatment in the STW, the effluent is discharged to river, estuary or sea. In a few cases, release is authorised directly to a river, estuarine or marine environment.

Appendix C contains details of discharge points from premises discharging directly and from STW, showing the receiving water body and the dilution flow rate.

Release to river

For release to river, as occurs from the majority of STW in the Anglian region, the key parameter is the mean river flow. For discharge to estuary or sea, the dispersion and dilution depends mainly on tidal factors and a simplified basis for assessment of sites in the region is discussed in Volume 1. The locations of the discharge points in the region are shown in Figures 1 and 2.

The direct exposure pathways from releases to rivers are external exposure to river sediment, use of filtered river water for drinking and, in principle, consumption of fish. In addition, pathways resulting from irrigation of crops are considered. In all cases, the basis of assessment is such as to provide a bounding assessment of the radiological impact, both in relation to the pathways included and the parameter values within the pathways. Thus it may be noted that water abstraction for the purposes of public water supply does not occur from some of the smaller rivers but the pathway has been included in all cases. Similarly, with regard to the fish consumption pathway, only coarse fish are caught in the rivers of the Anglian region and these are not generally considered edible. However, as there are some radionuclides for which fish consumption would be the dominant pathway, the approach has been to allow for fish consumption but at low rate of 2 kg/y for adults.

As in the case of discharge to atmosphere, there is a large number of discharging locations and the approach has been to undertake generic assessments, the results of which can be scaled to actual discharge situations. For rivers, reference results have been derived for unit release rate (1 MBq per year) of each radionuclide for an annual average river flow of 1 m^3 per second. The receptor point is taken at 1 km downstream from the discharge but tests show that the results are not very sensitive to this assumption. A similar approach is used for sea or estuarine discharges, and reference results are based on an exchange/dilution flow from the local compartment of 1 m^3 per second. Thus for a particular discharge location, the dose is calculated by scaling the reference result proportionally to the authorised discharge and inversely to the river flow rate or marine exchange rate.

The results of the generic assessments for the direct river exposure pathways for unit discharge rate and unit river flow rate are presented in Table 9 (a) and (b) of Volume 1. Similar unit data are given in Table 11 (a) and (b) of Volume 1 for the impacts of spray irrigation using river water. The results are for a nominal spray irrigation rate of 5 mm per day, and assume that irrigation using river water would only be undertaken on farms and only for irrigation of green vegetables, root vegetables and fruit. It should be emphasised that the results presented in Tables 9 and 11 of Volume 1 are for the release of 1 MBq per year into a river of unit flow rate. Where the release occurs via a STW, allowance needs to be made for the fractional release, as discussed in Section 2.3 above, and also for the actual flow rate in the river.

The assessment basis for the pathways deriving from liquid effluent release is summarised in Table 4.

Release to estuary or sea

Within the Anglian region, one site is authorised to discharge to sea and four to estuaries. In these cases, the pathways considered are external exposure to sediment and consumption of fish. For consistency with the approaches adopted for other cases, the method adopted has been to estimate the impacts that would result from a discharge rate of 1 MBq per year into a compartment with an exchange or dilution rate of 1 $m^3 s^{-1}$. The results are shown in Table 12 of Volume 1, which contains further discussion. It is concluded in Volume 1 that for initial assessment of the impact of discharges to sea from any part of the coast covered by the Anglian region, an exchange/dilution flow of 300 $m^3 s^{-1}$ can reasonably be adopted.

Estuarine environments are more complex and variable than marine environments because of the presence of both fresh water run-off from rivers and the tidal incursions of saline water. Of the discharge locations for which assessment is required for the purposes of this study, most are located such that they are clearly predominantly saline. The reference results for discharge to sea are therefore applicable in these cases, subject to deriving an exchange/dilution flow rate

appropriate to each discharge location. Suitable values for initial assessment at particular sites are proposed in Appendix C.

As in the case of release to rivers, the results in Table 12 of Volume 1 are for release of 1 MBq per year into the receiving water body. Where the release occurs via a STW, allowance needs to be made for the release fraction.

Application of sewage sludge as agricultural fertiliser

For the assessment of the impact of sewage sludge application, a basis is set out in Volume 1. This considers an application rate of 10 t dry weight per hectare as being reasonable for either liquid sludge or sludge cake. The Sludge (Use in Agriculture) Regulations prohibit the harvesting of vegetable or fruit crops for a period of 10 months after sludge application and, for assessment purposes, this has been taken as the time between sludge application and harvesting. The resulting dose factors, which are normalised to a STW with a raw sewage input of 10^5 m^3 per day shown in Table 13 (a) and (b) of Volume 1. It should be noted that these results already take account of the fraction of activity retained in sewage sludge.

To apply the results to the use of sludge from a particular STW, the results need to be multiplied by the activity input in MBq per year and divided by the size of the STW relative to the reference plant (10^5 m^3 per day raw sewage input). The input rates to STW in the region are listed in Appendix C.

Dose to workers from sewer disposal

Discharge of liquid radioactive effluents to sewerage systems can also result in the exposure of workers at the STW and those engaged in the maintenance of the system. The exposure of a typical worker at the sewage treatment plant and that of a sewer maintenance worker have been assessed using the simple models discussed in Appendix D of Volume 1, in which the inhalation, ingestion and external radiation pathways are considered. In view of low doses expected, simple exposure models, together with fairly pessimistic occupancy factors, have been employed, which may be scaled according to the particular radionuclide concentration in the sewage sludge. The same models may be extended to estimate doses to the agricultural workers involved in the use of sewage products. Detailed results of this assessment are contained in Appendix D of Volume 1.

4.2 Radiological impacts of liquid releases at limits of authorisation

The results of the assessments of the radiological impacts of discharges of radioactivity in liquid effluents at the limits of authorisation are summarised in Tables 5 to 7, as follows:

- Tables 5.1 to 5.4 contain the results for those discharges occurring directly to water bodies (*i.e.*not through a STW, though some treatment may be applied); in all of these cases, the discharge is to marine or estuarine environments;
- Tables 6.1 to 6.28 give the impacts for discharges via STW as a result of authorised releases to the public sewerage system;
- Tables 7.1 to 7.10 show the estimated impacts of releases from premises having their own private STW; and
- Table 8 summarises the results for premises or STW for which the radiological impact of discharges at the limits of authorisation exceeds 10 μSv per year.

As for atmospheric release, some of the authorisations include an "other non-alpha emitting radionuclide" category. In these cases, the unspecified nuclide has been taken, conservatively, as Co-58.

Direct release

The results in Tables 5.1 to 5.4 show that for three of the premises that release directly to marine or estuarine environments the impacts are trivial. In one case, Conoco Ltd (Theddlethorpe, Lincs.), the dose to the critical group of fish consumers from release directly to the North Sea is estimated to be about 48 μSv per year. Here the dose is entirely attributable to the enhanced concentrations of naturally occurring radioactivity in aqueous wastes arising from the processing of natural gas.

Release to public sewerage system

The results of assessments of the radiological impact of authorised discharges via public STW are shown in Tables 6.1 to Table 6.28. In the majority of these cases, the estimated impacts are very low. For seven of the public STW, it is estimated that the impact would exceed 10 μSv per year if all premises authorised to dispose to the sewerage system released at the limit of their authorisations, see Table 8. The most significant are from Milton STW, Cambridge (203 μSv/y, Canwick STW, Lincoln (80 μSv/y) and Cliff Quay STW, Ipswich (65 μSv/y). In all of these cases, the impact arises mainly from I-131 and the major contribution to dose is from the use of river water for irrigation of agricultural land.

Release to private sewage system

The impacts of authorised discharges from those premises having their own private STW.are shown in Tables 7.1 to 7.10. Only in one case, Conoco Ltd., discharging to the Humber Estuary at Grimsby, does the estimated impact exceed 10 μSv per year. Here the main contribution to dose is H-3, for which the limit of authorisation is quite large at 1.8 TBq per year. The contribution assessed from the "other radionuclide" category (taken as Co-58), with a limit of 0.12 TBq, is about 40 μSv per year. For both radionuclides the sewage sludge pathway is dominant.

Dose to workers from sewer disposal

Based on the methods and detailed results set out in Appendix D of Volume 1, estimates of the doses to sewage plant workers and sewer maintenance workers are shown in Table 9.

Doses to sewage plant workers are generally less than 10 μSv per year, with maximum values at Milton STW, Cambridge, (13 μSv per year) and Papworth Everard STW (65 μSv per year). All these doses are well below the appropriate "dose objective" of 500 μSv per year.

Doses to sewer maintenance workers are lower than those to sewage plant workers, the highest estimate being 4 μSv per year for Milton STW. A fairly pessimistic estimate of occupancy was used for those calculations, as discharges are unlikely to be uniform in practice, it being more likely that the occur as a series of "spikes" one or more of which may occur during the maintenance period.

5. OVERLAPPING IMPACTS

Because of the large number of premises holding discharge authorisations in the Anglian Region, it is of interest to consider whether there are situations in which individuals exposed to several sources could receive higher doses than those received by the critical groups for individual sources of discharge.

5.1 Atmospheric releases

For releases to atmosphere, the estimated impacts at the limits of authorisation are low. As indicated in Table 3, only for five premises is the estimated impact greater than 1 μSv per year and the five premises are widely distributed. The greatest concentration of discharge points is in the City of Cambridge, particularly those concentrated around Addenbrookes Hospital (Study References 11 CAM, 50 CAM and 54 CAM) for which the individual impacts, based on the assumption that there is an agricultural location nearby, are:

Addenbrookes Hospital (11 CAM)	2.7E-06 μSv/y
Addenbrookes Hospital Incinerator (11 CAM)	4.4E-01μSv/y
University of Cambridge (50 CAM).	3.2E-04 μSv/y
Wolfson Brain Imaging Unit (54 CAM)	4.1E-02 μSv/y

The premises are on the southern extremity of Cambridge and there is agricultural land within about 1 km. The combined impact of the authorised releases to atmosphere from these premises, based on an agricultural scenario, is therefore less than 0.5 μSv per year.

5.2 Aqueous releases

The position with aqueous releases is different to that for atmospheric releases for two reasons:

- the estimated impacts of the releases from individual STW/premises are generally rather higher, see Table 8; and
- the degree of dilution with increasing distance from the source is much less for release to river than for atmospheric release.

Modelling of sedimentation and resuspension processes over the large distances involved is both complex and subject to major uncertainty. Scoping calculations using PC-Cream indicate that for the majority of radionuclide species of interest, the decrease in concentration in water is relatively small over distances of tens of kilometres, assuming constant volume flow. For example, for I-125, the concentration reduces by about 12% after 30 km in typical river conditions. The following illustration of the cumulative effects of discharges down the water catchment is based on the radioactivity being conserved in the water phase and so will tend to over-estimate the cumulative impact downstream. It should also be noted that the impact of sewage sludge application applies only locally to STW and does not contribute to cumulative exposures at locations well downstream of the discharge point.

The situation is best illustrated by reference to the Great Ouse and its tributaries, since a high proportion of the discharges occur into this system, including those from the Bedford, Huntingdon, Cambridge and Newmarket areas. Figure 2 shows the estimated impacts at various points in the system. With the exception of the value of 203 μSv/y from the Milton STW immediately to the north of Cambridge, all of the results refer to the river pathways plus irrigation at the point, *i.e.* excluding the sewage sludge pathway.

It can be seen that from discharges in the Bedford, Huntingdon and South Cambridge areas, the cumulative impacts are generally in the range 1 to 2 μSv/y. However, authorised discharges from the Milton STW would result in an annual dose to the critical group of over 200 μSv/y, including the sewage sludge pathway. Further downstream, but still in the R. Cam, the impact is 105 μSv/y as a result of exclusion of the sewage sludge pathway. After the Cam joins the R. Great Ouse, there is substantial dilution by the larger flow in the Great Ouse and the impact from all upstream sources is about 20 μSv/y, almost all of which is attributable to Milton STW.

At Kings Lynn, the contribution from sources upstream remains at about 20 μSv/y, almost entirely attributable to the authorised release from Milton STW, and there is a small additional contribution of less than 1 μSv/y from discharges from Kings Lynn STW.

The important point is that because the majority of sources of discharge are on tributaries, generally having relatively low flow, the general effect is that there is no increase in impact downstream. Where there is a major source, such as the Milton STW, it can make a major contribution to the impact at all points downstream in the catchment system. Again, the magnitude of the impact declines as the cumulative flow increases.

6. ASSESSMENT OF DOSES FROM DISPOSAL TO LANDFILL

6.1 Assessment basis

Estimates of the doses to workers and to members of the public have been reported in the results of studies for the then HMIP. These included the review undertaken by Associated Nuclear Services in 1987 (Ref.9) and the later study by the NRPB (Ref. 10). For the purposes of the present study, the data from Ref. 10 have been employed since they are based on the most recent dosimetric information.

For members of the public, the pathways included in the assessment in Ref. 10 include, inhalation of landfill gases (H-3, C-14 and S-35 only), dust inhalation, external exposure, ingestion of food grown on a disturbed landfill, and ingestion of leachate water. For waste management workers, the impacts covered in Ref. 10 include those arising at the various management stages, including collection, transport, sorting and disposal operations. The results in Ref. 10 are for annual disposals of 100 GBq of H-3 and C-14, 1 GBq of Ra-226, Th-232 and natural uranium, and 10 GBq of other radionuclides.

Based on the results in Ref.10, radiological impacts to disposal workers and members of the public have been derived for disposals of 1 MBq per year of selected radionuclides to a single disposal facility. These are given in Table 14 of Volume 1. For workers the impact shown in the table is that from the operation giving the highest dose. For members of the public, the pathways included in the assessment in Ref. 4 include, inhalation of landfill gases (H-3, C-14 and S-35 only), dust inhalation, external exposure, ingestion of food grown on a disturbed landfill, and ingestion of leachate water.

Only one site in the Anglian region (Cambridge University Waste Store, Madingley) has an authorisation for landfill disposal and this is for disposal at the Milton landfill site. The authorisation has separate limits for:

- the sum of H-3 and C-14,
- emitters (other than alpha emitters) having a half life of <100 days; and
- emitters (other than alpha emitters) having a half life of >100 days.

Given the range of nuclides for which disposals by other routes are authorised in the region, it is recommended that for the purpose of estimating an upper limit to the potential dose from landfill disposals, the following approach should be used:

- for the total of H-3 and C-14, the dose factors for C-14;
- for nuclides of half-life <100 days, the dose factor for P-32 for worker dose and for S-35 for dose to members of the public;
- for nuclides of half-life >100 days, the Co-60 dose factors to both worker and public

dose (although Sr-90 has a somewhat higher dose factor than Co-60, in practice there is little use of Sr-90).

6.2 Radiological impacts of disposals to landfill at limits of authorisation

On the basis discussed above, an assessment of the radiological impact of disposals to landfill from the Madingley Waste Store is shown in Table 10. The assessed doses from disposals at the limits of authorisation are about 150 μSv per year to workers, mainly due to the half-life > 100 days category, and about 0.1 μSv per year to members of the public. Reported disposals for the period 1994 to 1997 show that the actual rates of disposal are about 50% of the limit for the H-3 plus C-14 category and about 10% for the other categories. The actual doses are therefore estimated to be about 15 μSv per year to workers and well below 0.1 μSv per year to members of the public.

7. DISCUSSION

Based on methods and data contained in Volume 1, results are presented in this volume of assessments of the radiological impacts of disposals of radioactivity from non-nuclear premises in the Anglian region. The impacts have been estimated for disposals at the limits of authorisation. Generally, the assessments have considered bounding situations and, in some cases, the pathways identified as making the major contributions might not be currently applicable. Nevertheless, in most cases, there remains the potential for the pathway to become applicable. In selecting the parameters values used in assessing the impacts through the various pathways, the aim has been to set realistic values. However, where there are significant uncertainties, it is has been necessary to adopt conservative values. The overall effect is that the assessed radiological impacts will generally be upper limit estimates. In some authorisations, there is an allowance for "other" radionuclides, excluding alpha emitters. This provides flexibility to users, particularly to hospitals, where new techniques may need to be used at short notice to suit particular situations. Where such a category is specified in an authorisation, the assessment has been based on a radionuclide giving a relatively high impact per unit release. For release to atmosphere, the assessment is based on I-125 and for liquid releases Co-58.

For releases to atmosphere, the results discussed in Section 3 show that the impact of discharges at the limits of authorisation would, in most cases, result in doses to most exposed groups of less than 1 μSv per year. For a small number of premises, the impacts are estimated to be a few μSv per year and only in one case does the estimated impact exceed 10 μSv per year. This is at Conoco Ltd., Grimsby for which the estimated impact is about 13 μSv per year, mostly due to the "other" radionuclide category. The only area in which there is a sufficient concentration of authorised premises such that the combined impacts might need to be considered is Cambridge. Here there is a group of four premises on the site of Addenbrookes Hospital, each of which has an authorisation for discharge of radioactivity to atmosphere. However, it is shown that for discharges from all four premises at the limits of authorisation, the total radiological impact would be less than 1 μSv per year.

The position with liquid effluents, discussed in Section 4, is more complex. The majority of premises discharge to the public sewerage system and some STW receive radioactive effluents from several premises. In these cases, the assessments are presented for each STW, rather than for each premise. In other cases, premises are authorised to discharge either directly to the environment or via their own private sewage treatment plant.

The assessments of discharges via public STW indicate that discharges at the limits of authorisations would result in doses exceeding 10 μSv per year at seven of the public STW. In all of these cases, the impact is mainly from I-131 through the irrigation pathway. The highest impact is about 200 μSv per year from discharges to the River Cam from Milton STW. The authorisations for I-131 discharge from hospitals in the area are in the range of tens to hundreds of GBq. Detailed analysis of the impacts of the combined discharges from all the public STW shows that they do not result in an increasing impact down the catchment system. In general, the impact declines down the catchment as a result of increasing dilution.

The highest overall estimated impact from liquid effluent discharges is about 250 μSv per year due to the sewage sludge pathway from the private sewage treatment plant at Conoco Ltd, Grimsby. The main contributor to the dose is H-3 for which the authorised limit is 1.8 TBq. Direct discharges to the North Sea from the Conoco Ltd. Plant at Theddlethorpe would, at the limits of authorisation, result in a dose of about 50 μSv per year to a critical group of fish consumers. In this latter case, the impact is due to naturally occurring radioactivity from the processing of natural gas.

There is only one authorisation for disposal to landfill in the region and as, discussed in section 7, the assessed impact of this is very low.

Overall, the results of the study show that even with conservative choice of parameter values, and assuming that all premises discharge at the limits of their authorisations, the maximum dose to any member of the public is well below the dose limit of 1 mSv per year.

8. REFERENCES

1. Burholt, G D and Martin, A. Progress Report: Radiological assessment of radioactive waste disposals from non-nuclear premises in Anglian Region, Alan Martin Associates, Report No. AMA/J95/TN1, March 1998.
2. Burholt, G D and Martin, A. Radiological assessment of radioactive waste disposals from non-nuclear premises in Anglian Region; Volume 1 - Methodology. Alan Martin Associates, Report No. AMA/J95/R1, April 1999.
3. Burholt, G D and Martin, A. Radiological assessment of radioactive waste disposals from non-nuclear premises in Anglian Region; Volume 3- Data on authorisations. Alan Martin Associates, Report No. AMA/J95/R3, April 1999.
4. PC-Cream, Consequences of releases to the environment - assessment methodology. European Commission, EUR 17791, NRPB-SR296, 1997.
5. Simmonds, J R, Lawson, G, Mayall, A. Methodology for assessing the radiological consequences of routine releases of radionuclides to the environment. Report EUR 15760 EN, Commission of the European Communities, 1995.
6. Dickson, D M J. A study of the radiological implications of releases of radionuclides to sewer systems. DOE Report No. DOE/HMIP/RR/94.002, 1994.
7. IAEA, Handbook of parameter values for the prediction of radionuclide transfer in temperate environments, Technical Report Series No 364, International Atomic Energy Agency, Vienna,1994.
8. The agricultural value of sewage sludge - A farmers guide. Water Research Council.
9. Sumerling, T J and Sweeney, B J. The estimation of radiological impact from the disposal of radionuclides with domestic and commercial wastes. DOE Report No. DOE/RW/87.069 (volumes 1 and 2), 1987.
10. Harvey, M P et al. A review of the radiological implications of disposal practices for very low level solid radioactive waste. DOE Report No. DOE/HMIP/RR/95.006, 1995.

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a) Distance from release point to assessment location			
Location of premises	Release height, m	Distance to reference habitation, m	
		Residential	Agricultural
Urban	15	300	500
	30	300	1000
	60	500	1000
	100	1000	1000
Rural	15	300	500
	30	300	500
	60	500	500
	100	1000	1000
b) Occupancy and inhalation factors			
Pathway		Residential	Agricultural
Inhalation (incl resus)	m^3/h	7300	7300
External β and γ	Hours per year	8760	8760
	Fraction indoors	0.8	0.7
	Loc. factor, cloud γ	0.2	0.2
	Loc factor, depos γ	0.1	0.1
c) Annual consumption rates of locally grown produce			
Cow meat	kg/y	-	45
Cow milk	l/y	-	240
Cow milk products	kg/y	-	60
Cow liver	kg/y	-	10
Green vegetables	kg/y	40	80
Root vegetables	kg/y	65	130
Fruit	kg/y	37.5	75

TABLE 1 BASIS OF ASSESSMENT OF RADIOLOGICAL IMPACT - ATMOSPHERIC RELEASE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	25,000	4.0E-04	0.0	4.0E-04	1.1E-04	0.0	1.1E-04
Rb-81 / Kr-81m	250,000	5.7E-03	0.0	5.7E-03	1.3E-03	0.0	1.3E-03
Total dose	-	6.1E-03	0.0	6.1E-03	1.4E-03	0.0	1.4E-03

Note. Urban site. Stack height 15m.

TABLE 2.1 BEDFORD HOSPITAL, BEDFORD (01 BED): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
C-14	600	5.4E-04	2.2E-03	2.7E-03	3.5E-04	7.2E-03	7.8E-03
Total dose	-	5.4E-04	2.2E-03	2.7E-03	3.5E-04	7.2E-03	7.8E-03

Note. Rural site. Stack height 15m.

TABLE 2.2 CRANFIELD UNIVERSITY, SILSOE (04 BED): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	40,000	1.0E-03	1.0E-03	2.0E-03	6.4E-04	2.8E-03	3.5E-03
C-14	60,000	5.4E-02	2.2E-01	2.7E-01	3.5E-02	7.2E-01	7.8E-01
Total dose	-	5.5E-02	2.2E-01	2.7E-01	3.5E-02	7.2E-01	7.8E-01

Note. Rural site. Stack height 15m.

TABLE 2.3 UNILEVER RESEARCH, SHARNBROOK, BEDFORD (05 BED): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	250	4.0E-06	0.0	4.0E-06	2.7E-06	0.0	2.7E-06
Total dose	-	4.0E-06	0.0	4.0E-06	2.7E-06	0.0	2.7E-06

Note. Rural site. Stack height 15m.

TABLE 2.4 ADDENBROOKES HOSPITAL, CAMBRIDGE (11 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	4.800	1.4E-06	1.4E-06	2.9E-06	1.4E-06	6.2E-06	7.6E-06
C-14	1.320	1.5E-05	5.7E-05	7.1E-05	1.5E-05	2.9E-04	3.0E-04
P-32, P-33	2.520	2.5E-04	1.1E-03	1.4E-03	2.5E-04	1.6E-02	1.6E-02
S-35	3.240	3.9E-05	1.7E-04	2.1E-04	3.9E-05	1.2E-01	1.2E-01
Cr-51	1.200	5.8E-06	7.0E-07	6.6E-06	5.8E-06	1.1E-05	1.7E-05
In-111	1.440	3.7E-06	0.0	3.7E-06	3.7E-06	0.0	3.7E-06
I-125	8.400	3.6E-04	2.2E-02	2.2E-02	3.6E-04	2.6E-01	2.6E-01
I-131	600	7.8E-05	6.6E-04	7.2E-04	7.8E-05	1.1E-02	1.1E-02
Other except α	900	3.9E-05	2.3E-03	2.3E-03	3.9E-05	2.8E-02	2.8E-02
Total dose	-	7.8E-04	2.5E-02	2.6E-02	7.9E-04	4.4E-01	4.4E-01

Note. Rural site. For assessment purposes, "other" is represented by I-125. Stack height 100m.

TABLE 2.5 ADDENBROOKES HOSPITAL INCINERATOR, CAMBRIDGE (11 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
C-14	182.5	1.6E-04	6.6E-04	8.2E-04	1.1E-04	2.2E-03	2.4E-03
Total dose	-	1.6E-04	6.6E-04	8.2E-04	1.1E-04	2.2E-03	2.4E-03

Note. Rural site. Stack height 15m.

TABLE 2.6 AGREVO UK, COTTENHAM, CAMBRIDGE (14 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	10	1.6E-07	0.0	1.6E-07	1.1E-07	0.0	1.1E-07
Total dose	-	1.6E-07	0.0	1.6E-07	1.1E-07	0.0	1.1E-07

Note. Rural site. Stack height 15m.

TABLE 2.7 HINCHINGBROOKE HOSPITAL, HUNTINGDON (25 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	9,000	2.2E-04	2.2E-04	4.5E-04	1.4E-04	6.4E-04	7.8E-04
C-14	1,000	9.0E-04	3.6E-03	4.5E-03	5.8E-04	1.2E-02	1.3E-02
Total dose	-	1.1E-03	3.8E-03	4.9E-03	7.2E-04	1.3E-02	1.4E-02

Note. Assumed 90% H-3, 10% C-14.
Rural site. Stack height 15m.

TABLE 2.8 HUNTINGDON LIFE SCIENCES, ALCONBURY (27 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	435.780	2.5E-03	2.6E-03	5.2E-03	2.1E-03	9.6E-03	1.2E-02
C-14	48.420	1.0E-02	4.1E-02	5.3E-02	8.7E-03	1.7E-01	1.8E-01
S-35	2.400	5.5E-04	1.0E-03	1.6E-03	4.6E-04	5.3E-01	5.3E-01
Other except α	156	1.3E-04	6.2E-03	6.4E-03	1.1E-04	6.2E-02	6.2E-02
Total dose	-	1.3E-02	5.1E-02	6.6E-02	9.5E-03	7.7E-01	7.8E-01

Note. Assumed 90% H-3 and 10% C-14. For assessment purposes, "other" is represented by I-125. Rural site. Stack height 30m.

TABLE 2.9 HUNTINGDON LIFE SCIENCES INCINERATOR, ALCONBURY (27 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	40	6.0E-07	0.0	6.0E-07	4.0E-07	0.0	4.0E-07
Total dose	-	6.0E-07	0.0	6.0E-07	4.0E-07	0.0	4.0E-07

Note. Rural site. Stack height 15m.

TABLE 2.10 PAPWORTH HOSPITAL, PAPWORTH EVERARD (39 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
I-125	450	1.6E-03	7.2E-02	7.2E-02	9.9E-04	5.4E-01	5.4E-01
Total dose	-	1.6E-03	7.2E-02	7.2E-02	9.9E-04	5.4E-01	5.4E-01

Note. Rural site. Stack height 15m.

TABLE 2.11 PEPTIDE THERAPEUTICS LTD., CAMBRIDGE (42 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	5,400	1.4E-04	1.4E-04	2.7E-04	8.6E-05	3.8E-04	4.7E-04
C-14	600	5.4E-04	2.2E-03	2.7E-03	3.5E-04	7.2E-03	7.8E-03
P-32	2,400	4.8E-03	2.4E-02	2.9E-02	4.1E-03	2.2E-01	2.2E-01
S-35	2,400	2.3E-03	2.9E-03	5.3E-03	1.5E-03	1.3	1.3
Cr-51	1,200	1.3E-04	1.5E-05	1.4E-04	1.0E-04	1.6E-04	2.5E-04
I-125	4,440	1.6E-02	7.1E-01	7.1E-01	9.8E-03	5.3	5.3
Other except α	1,320	4.6E-03	2.1E-01	2.1E-01	2.9E-03	1.6	1.6
Total dose	-	2.8E-02	9.4E-01	9.6E-01	1.8E-02	8.5	8.5

Note. Assumed 90% H-3 and 10% C-14. For assessment purposes, "other" is represented by I-125. Rural site. Stack height 15m.

TABLE 2.12 THE BABRAHAM INSTITUTE, BABRAHAM (47 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	3,700	9.2E-05	9.2E-05	1.8E-04	5.9E-05	2.6E-04	3.2E-04
Total dose	-	9.2E-05	9.2E-05	1.8E-04	5.9E-05	2.6E-04	3.2E-04

Note. Rural site. Stack height 15m.

TABLE 2.13 UNIVERSITY OF CAMBRIDGE AT ADDENBROOKES HOSPITAL, CAMBRIDGE (50 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release; µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	29,600	7.4E-04	7.4E-04	1.5E-03	2.0E-04	9.2E-04	1.1E-03
Xe-133	10,000	1.3E-05	0.0	1.3E-05	3.5E-06	0.0	3.5E-06
Total dose	-	7.5E-04	7.4E-04	1.5E-03	2.0E-04	9.2E-04	1.1E-03

Note. Urban site. Stack height 15m.

TABLE 2.14 UNIVERSITY OF CAMBRIDGE, CENTRAL SITE PREMISES, CAMBRIDGE (51 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
O-15	240	1.4E-03	9.6E-03	1.1E-02	1.1E-03	3.8E-02	4.1E-02
Total dose	-	1.4E-03	9.6E-03	1.1E-02	1.1E-03	3.8E-02	4.1E-02

Note. Rural site. Stack height 30m.

TABLE 2.15 WOLFSON BRAIN IMAGING UNIT, ADDENBROOKES HOSPITAL, CAMBRIDGE (54 CAM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	37,000	9.2E-04	9.2E-04	1.8E-03	5.9E-04	2.6E-03	3.2E-03
C-14	3,700	3.3E-03	1.3E-02	1.7E-02	2.1E-03	4.4E-02	4.8E-02
Total dose	-	4.2E-03	1.4E-02	1.9E-02	2.7E-03	4.7E-02	5.1E-02

Note. Rural site. Stack height 15m.

TABLE 2.16 AGREVO UK, CHESTERFORD, SAFFRON WALDEN (55 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	11,880	3.0E-04	3.0E-04	5.9E-04	1.9E-04	8.4E-04	1.0E-03
C-14	1,320	1.2E-03	4.7E-03	5.9E-03	7.7E-04	1.6E-02	1.7E-02
Other except α	444	1.6E-03	7.1E-02	7.1E-02	9.8E-04	5.3E-01	5.3E-01
Total dose	-	3.1E-03	7.6E-02	7.7E-02	1.9E-03	5.5E-01	5.5E-01

Note. Rural site. Assumed 90% H-3 and 10% C-14. For assessment purposes, "other" is represented by I-125. Stack height 15m.

TABLE 2.17 AGREVO UK INCINERATOR, CHESTERFORD, SAFFRON WALDEN (55 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	6,000	9.6E-05	0.0	9.6E-05	6.6E-05	0.0	6.6E-05
Xe-133	160,000	2.1E-04	0.0	2.1E-04	1.3E-04	0.0	1.3E-04
Total dose	-	3.1E-04	0.0	3.1E-04	2.0E-04	0.0	2.0E-04

Note. Rural site. Stack height 15m.

TABLE 2.18 BASILDON AND THURROCK HOSPITAL, BASILDON (56 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Po-210	675	3.6E-01	4.5E-01	8.1E-01	2.0E-01	6.7E-01	8.8E-01
Total dose	-	3.6E-01	4.5E-01	8.1E-01	2.0E-01	6.7E-01	8.8E-01

Note. Urban site. Stack height 30m.

TABLE 2.19 CARLESS REFINERY, HARWICH (57 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	1,750	2.8E-05	0.0	2.8E-05	1.9E-05	0.0	1.9E-05
Total dose	-	2.8E-05	0.0	2.8E-05	1.9E-05	0.0	1.9E-05

Note. Rural site. Stack height 15m.

TABLE 2.20 COLCHESTER HOSPITAL, COLCHESTER (58 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	500	8.0E-06	0.0	8.0E-06	2.2E-06	0.0	2.2E-06
Total dose	-	8.0E-06	0.0	8.0E-06	2.2E-06	0.0	2.2E-06

Note. Urban site. Stack height 15m.

TABLE 2.21 ESSEX COUNTY HOSPITAL, COLCHESTER (59 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	1,700	2.7E-05	0.0	2.7E-05	1.9E-05	0.0	1.9E-05
Total dose	-	2.7E-05	0.0	2.7E-05	1.9E-05	0.0	1.9E-05

Note. Rural site. Stack height 15m.

TABLE 2.22 MID-ESSEX HOSPITALS, CHELMSFORD (60 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
C-14	12,000	1.1E-02	4.3E-02	5.4E-02	7.0E-03	1.4E-01	1.6E-01
Total dose	-	1.1E-02	4.3E-02	5.4E-02	7.0E-03	1.4E-01	1.6E-01

Note. Rural site. Stack height 15m.

TABLE 2.23 RHONE POULENC AGRICULTURE, MANNINGTREE (63 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	600,000	3.5E-03	3.5E-03	7.2E-03	2.9E-03	1.3E-02	1.6E-02
Ar-41	600,000	1.1E-02	0.0	1.1E-02	8.4E-03	0.0	8.4E-03
Br-82	600,000	3.7E-01	5.8E-02	4.3E-01	3.8E-01	2.4	2.8
Kr-85	600,000	7.2E-05	0.0	7.2E-05	5.9E-05	0.0	5.9E-05
Xe-133	600,000	4.0E-04	0.0	4.0E-04	2.9E-04	0.0	2.9E-04
Total dose	-	3.8E-01	6.1E-02	4.5E-01	3.9E-01	2.4	2.8

Note. Authorisation refers to total annual discharge of above radio-nuclides as 600,000 MBq. Rural site. Stack height 30m.

TABLE 2.24 SHELL HAVEN REFINERY, STANFORD-LE-HOPE (64 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	900	2.2E-05	2.2E-05	4.5E-05	6.2E-06	2.8E-05	3.4E-05
C-14	100	9.0E-05	3.6E-04	4.5E-04	2.5E-05	5.1E-04	5.4E-04
Tc-99m	6,000	9.6E-05	0.0	9.6E-05	2.7E-05	0.0	2.7E-05
Xe-133	239,000	3.1E-04	0.0	3.1E-04	8.4E-05	0.0	8.4E-05
Total dose	-	5.2E-04	3.8E-04	9.0E-04	1.4E-04	5.4E-04	6.8E-04

Note. Assumed 90% H-3 and 10% C-14.
Urban site. Stack height 15m.

TABLE 2.25 SOUTHEND HOSPITAL, WESTCLIFF (65 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	100	2.5E-06	2.5E-06	5.0E-06	1.6E-06	7.1E-06	8.7E-06
Tc-99	1.2	3.4E-06	1.8E-04	1.8E-04	2.2E-06	2.3E-04	2.3E-04
Total dose	-	5.9E-06	1.8E-04	1.8E-04	3.8E-06	2.4E-04	2.4E-04

Note. Rural site. Stack height 15m.

TABLE 2.26 UNIVERSITY OF ESSEX, COLCHESTER (66 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Any except α	444	1.6E-03	7.1E-02	7.1E-02	9.8E-04	5.3E-01	5.3E-01
Total dose	-	1.6E-03	7.1E-02	7.1E-02	9.8E-04	5.3E-01	5.3E-01

Note. Rural site. Stack height 15m. For assessment purposes, "other" is represented by I-125.

TABLE 2.27 UNIVERSITY OF ESSEX INCINERATOR, COLCHESTER (66 ESS): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	300,000	1.7E-03	1.8E-03	3.6E-03	1.5E-03	6.6E-03	8.1E-03
Ar-41	400,000	7.2E-03	0.0	7.2E-03	5.6E-03	0.0	5.6E-03
Kr-79	148,000	7.8E-04	0.0	7.8E-04	6.5E-04	0.0	6.5E-04
Kr-85	800,000	9.6E-05	0.0	9.6E-05	7.9E-05	0.0	7.9E-05
Other except	32,000	2.7E-02	1.3	1.3	2.2E-02	12.8	12.8
Total dose	-	3.6E-02	1.3	1.3	2.9E-02	12.8	12.8

Note. Rural site. For assessment purposes, "other" represented by I-125. Stack height 30m.

TABLE 2.28 CONOCO LTD., GRIMSBY (67 HUM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	450,000	1.4E-04	1.4E-04	2.7E-04	1.4E-04	5.8E-04	7.2E-04
Na-24	2,220	1.6E-04	0.0	1.6E-04	1.6E-04	0.0	1.6E-04
Kr-79	450,000	1.7E-04	0.0	1.7E-04	1.7E-04	0.0	1.7E-04
Kr-85	1,200,000	1.0E-05	0.0	1.0E-05	1.0E-05	0.0	1.0E-05
La-140	2,220	2.2E-04	0.0	2.2E-04	2.2E-04	2.4E-05	2.4E-04
Total dose	-	7.0E-04	1.4E-04	8.3E-04	7.0E-04	6.0E-04	1.3E-03

Note: Authorisation refers to La-140/Na-24 total.
Rural site. Stack height 100m.

TABLE 2.29 LINDSEY OIL REFINERY, IMMINGHAM (68 HUM): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	2,000	5.0E-05	5.0E-05	1.0E-04	3.2E-05	1.4E-04	1.7E-04
C-14	20	1.8E-05	7.2E-05	9.0E-05	1.1E-05	2.4E-04	2.6E-04
Total dose	-	6.8E-05	1.2E-04	1.9E-04	4.3E-05	3.8E-04	4.3E-04

Note. Rural site. Stack height 15m.

TABLE 2.30 INSTITUTE OF FOOD RESEARCH, NORWICH (78 NOF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	960	2.4E-05	2.4E-05	4.8E-05	1.5E-05	6.8E-05	8.3E-05
C-14	120	1.1E-04	4.3E-04	5.4E-04	6.9E-05	1.4E-03	1.6E-03
S-35	120	1.2E-04	1.4E-04	2.6E-04	7.4E-05	6.6E-02	6.6E-02
Other nuclides	12	4.2E-05	1.9E-03	1.9E-03	2.6E-05	1.4E-02	1.4E-02
Total dose	-	2.9E-04	2.5E-03	2.7E-03	1.8E-04	8.1E-02	8.2E-02

Note. Assumed 80% H-3, 10% C-14 and 10% S-35. For assessment purposes, "other" is represented by I-125. Rural site. Stack height 15m.

TABLE 2.31 INSTITUTE OF FOOD RESEARCH INCINERATOR, NORWICH (78 NOF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	200,000	5.0E-03	5.0E-03	1.0E-02	3.2E-03	1.4E-02	1.7E-02
C-14	6,000	5.4E-03	2.2E-02	2.7E-02	3.5E-03	7.2E-02	7.8E-02
Other except α	1	3.5E-06	1.6E-04	1.6E-04	2.2E-06	1.2E-03	1.2E-03
Total dose	-	1.0E-02	2.7E-02	3.7E-02	6.7E-03	8.7E-02	9.6E-02

Note. Rural site. Stack height 15m. For assessment purposes, "other" is represented by I-125

TABLE 2.32 JOHN INNES CENTRE, NORWICH (79 NOF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	20	3.0E-07	0.0	3.0E-07	9.0E-08	0.0	9.0E-08
Total dose	-	3.0E-07	0.0	3.0E-07	9.0E-08	0.0	9.0E-08

Note. Urban site. Stack height 15m.

TABLE 2.33 QUEEN ELIZABETH HOSPITAL, KINGS LYNN (80 NOF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	300	4.8E-06	0.0	4.8E-06	1.3E-06	0.0	1.3E-06
Total dose	-	4.8E-06	0.0	4.8E-06	1.3E-06	0.0	1.3E-06

Note. Urban site. Stack height 15m.

TABLE 2.34 NORFOLK AND NORWICH HOSPITAL, NORWICH (82 NOF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	105,000	2.6E-03	2.6E-03	5.2E-03	1.7E-03	7.5E-03	9.1E-03
Other except α	100	3.5E-04	1.6E-02	1.6E-02	2.2E-04	1.2E-01	1.2E-01
Total dose	-	2.9E-03	1.9E-02	2.1E-02	1.9E-03	1.3E-01	1.3E-01

Note. Authorisation refers to H-3 and tritiated water. For assessment purposes, "other" is represented by I-125. Rural site. Stack height 15m.

TABLE 2.35 UNIVERSITY OF EAST ANGLIA, NORWICH (84 NOF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	2,000	3.2E-05	0.0	3.2E-05	9.0E-06	0.0	9.0E-06
Total dose	-	3.2E-05	0.0	3.2E-05	9.0E-06	0.0	9.0E-06

Note. Urban site. Stack height 15m.

TABLE 2.36 KETTERING GENERAL HOSPITAL, KETTERING (85 NOH): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, μSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	81,000,000	2.0	2.0	4.0	1.3	5.8	7.0
Total dose	-	2.0	2.0	4.0	1.3	5.8	7.0

Note. Rural site. Stack height 15m.

TABLE 2.37 SURELITE LTD., CORBY (88 NOH): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	40	1.0E-06	1.0E-06	2.0E-06	6.0E-07	2.8E-06	3.4E-06
C-14	5	4.5E-06	1.8E-05	2.2E-05	2.9E-06	6.0E-05	6.5E-05
Total dose	-	5.5E-06	1.9E-05	2.4E-05	3.5E-06	6.3E-05	6.8E-05

Note. Assumed 90% H-3 and 10% C-14.
Rural site. Stack height 15m.

TABLE 2.38 HUNTINGDON LIFE SCIENCES LTD., EYE (95 SUF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
All except α	888	3.1E-03	1.4E-01	1.4E-01	8.3E-04	2.7E-01	2.7E-01
Total dose	-	3.1E-03	1.4E-01	1.4E-01	8.3E-04	2.7E-01	2.7E-01

Note. Urban site. For assessment purposes, "other" is represented by I-125. Stack height 15m.

TABLE 2.39 SUFFOLK COLLEGE, IPSWICH (98 SUF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Xe-133	100,000	1.3E-04	0.0	1.3E-04	3.5E-05	0.0	3.5E-05
Total dose	-	1.3E-04	0.0	1.3E-04	3.5E-05	0.0	3.5E-05

Note. Urban site. Stack height 15m.

TABLE 2.40 IPSWICH HOSPITAL, IPSWICH (99 SUF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	300,000	7.5E-03	7.5E-03	1.5E-02	2.1E-03	9.3E-03	1.1E-02
Total dose	-	7.5E-03	7.5E-03	1.5E-02	2.1E-03	9.3E-03	1.1E-02

Note. Urban site. Stack height 15m.

TABLE 2.41 VCH LTD., BRANDON (100 SUF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
Tc-99m	10	1.6E-07	0.0	1.6E-07	4.5E-08	0.0	4.5E-08
Total dose	-	1.6E-07	0.0	1.6E-07	4.5E-08	0.0	4.5E-08

Note. Urban site. Stack height 15m.

TABLE 2.42 WEST SUFFOLK HOSPITAL, BURY ST. EDMUNDS (102 SUF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Nuclide	Authorised release MBq y-1	Dose to adult from authorised release, µSv y-1					
		Residential location			Agricultural location		
		Inh + ext	Ingestion	Total	Inh + ext	Ingestion	Total
H-3	59,400	5.9E-05	6.5E-05	1.2E-04	5.4E-05	2.3E-04	2.9E-04
C-14	6,600	2.5E-04	9.9E-04	1.3E-03	2.2E-04	4.4E-03	4.6E-03
Iodine (total)	12,000	1.8E-03	9.7E-02	1.0E-01	1.6E-03	9.4E-01	9.4E-01
Other except α	10,200	1.5E-03	8.3E-02	8.5E-02	1.3E-03	8.0E-01	8.0E-01
Total dose	-	3.6E-03	1.8E-01	1.8E-01	3.1E-03	1.7	1.7

Note. Urban site. Assumed 90% H-3 and 10% C-14. For assessment purposes, "other" is represented by I-125. Stack height 60m.

TABLE 2.43 WHITE ROSE ENVIRONMENTAL INCINERATOR, IPSWICH HOSPITAL, IPSWICH (103 SUF): RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGE TO ATMOSPHERE

Premises	Dose to adult from authorised release, μSv y-1		Principal nuclides	Comments
	Residential	Agricultural		
Babraham Institute Incinerator, Cambridge, Ref. No. 47CAM	0.96	8.5	I-125, "other"	Assumes 100% release of authorised input. No data on actual releases.
Shell Haven Refinery Ref. No. 64ESS	0.45	2.8	Br-82	Actual releases in 1995, 1996 and 1997 reported to be zero.
Conoco Ltd, Grimsby Ref. No. 67HUM	1.3	12.8	"Other"	Assessment of 'other' based conservatively on I-125. No data on actual releases.
Surelite Ltd, Corby Ref. No. 88NOH	4.0	7.0	H-3	Reported release in 1994 < 0.1% of limit. No data for other years.
White Rose Environmental Incinerator, Ipswich Ref. No. 103SUF	0.18	1.7	Total Iodine and "other"	Assumes 100% release of authorised input. Reported release in 1996 2% of limit for iodines. No data for other years.

Note: In all above cases, dominant pathway is ingestion of foodstuffs at agricultural location

TABLE 3 SUMMARY OF PREMISES FOR WHICH ASSESSED IMPACT FROM ATMOSPHERIC RELEASES AT LIMIT OF AUTHORISATION EXCEEDS 1 μSv PER YEAR

a) River pathways - direct		
Pathway		
Drinking water	Litres per year	600
Freshwater fish consumption	kg per year	2
Occupancy on river bank	hours per year	500
b) Sewage sludge application and irrigation by river-water		
Sludge application rate	kg (dry weight) per m^2 per year	1
Irrigation rate	mm per day	5
Occupancy on irrigated / fertilised land	hours per year	1000
Consumption rates of locally grown produce		
Green vegetables	kg per year	80
Root vegetables	kg per year	130
Fruit	kg per year	75
c) Marine / estuarine pathways		
Fish consumption - local	kg per year	50
Fish consumption - regional	kg per year	50
Occupancy on sediments	hours per year	1000
Inhalation of sea spray	hours per year	2000

TABLE 4 BASIS OF ASSESSMENT OF RADIOLOGICAL IMPACT FOR PATHWAYS FROM LIQUID RELEASES

Nuclide	Authorised Discharge MBq y^{-1}	Dose to adult from discharge to estuary $\mu Sv\ y^{-1}$		
		Fish consumption	Gamma exposure to sediment	Total
Po-210	0.096	3.8E-03	Neg	3.8E-03

Note: Mean dilution flow conservatively taken as $10m^3$ per second.

TABLE 5.1 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES OF LIQUID EFFLUENTS FROM CARLESS REFINERY DIRECT TO STOUR ESTUARY

Nuclide	Authorised Discharge MBq y^{-1}	Dose to adult from discharge to estuary $\mu Sv\ y^{-1}$		
		Fish consumption	Gamma exposure to sediment	Total
Ra-226	9,000	9	4.8E-03	9
Ra-228	9,000	21	7.0E-03	21
Ra-224	9,000	n/e	n/e	n/e
Pb-210	9,000	6	6.0E-06	6
Bi-210	9,000	n/e	n/e	n/e
Po-210	9,000	12	-	12
Total dose	-	48	1.2E-02	48

Note. Mean dilution flow taken as 300 m^3 per second.

TABLE 5.2 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO NORTH SEA FROM CONOCO LTD, THEDDLETHORPE, LINCS

Nuclide	Authorised Discharge MBq y^{-1}	Dose to adult from discharge to estuary µSv y^{-1}		
		Fish consumption	Gamma exposure to sediment	Total
H-3	12,000	2.0E-06	0.0	2.0E-06
Alpha (total)	4.4	4.4E-03	2.3E-06	4.4E-03
Other (total)	222	8.9E-05	1.7E-06	9.1E-05
Total dose	-	4.5E-03	4.0E-06	4.5E-03

Notes: Mean dilution flow estimated to be 300 m^3 per second, based on data for Sizewell.
Assessment based on Ra-226 for alpha and Co-58 for other.

TABLE 5.3 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES FROM CEFAS, LOWESTOFT DIRECT TO NORTH SEA

Nuclide	Authorised Discharge MBq y^{-1}	Dose to adult from discharge to estuary µSv y^{-1}		
		Fish consumption	Gamma exposure to sediment	Total
H-3	888,000	1.5E-04	0.0	1.5E-04
Total of Na-24, Br-82, Mn-56, In-113 and La-140 (2)	88,800	8.8E-04	3.0E-07	8.8E-04
Total dose	-	1.0E-03	3.0E-07	1.0E-03

Notes:
1. Mean river flow estimated to be at least 300 m^3 per second.
2. Assessment based on Br-82

TABLE 5.4 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES FROM SHELL HAVEN REFINERY DIRECT TO THAMES ESTUARY

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		Fish consumption	Gamma exposure to sediment	Sewage sludge	Total
Tc-99m	276,000	1.4E-03	5.5E-05	<1E-04	1.5E-03
Other except alpha (total)	8,880	1.1	2.0E-02	1.3	2.4
Total dose	-	1.1	2.0E-02	1.3	2.4

Note. Sewage input is 28,400 m^3/day; effluent discharge is to Pitsea Creek (tidal) and mean flow assumed to be 1 m^3 per second.

TABLE 6.1 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO BASILDON STW, ESSEX

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
Cr-51	840	5.8E-05	9.1E-05	1.2E-03	1.2E-03
Co-57	12	3.1E-05	1.0E-05	6.5E-04	6.9E-04
Ga-67	3,600	1.2E-04	6.6E-05	1.2E-03	1.3E-03
Tc-99m	288,000	1.0E-02	4.3E-05	<8E-05	1.0E-02
In-111	1,776	9.7E-04	1.0E-02	1.1E-03	1.1E-02
I-123	2,400	3.3E-04	4.2E-05	<6E-07	3.7E-04
I-125	36	4.2E-04	1.4E-03	1.8E-05	1.8E-03
I-131	1,800	3.0E-02	6.4E-02	6.5E-04	9.4E-02
Tl-201	7,200	3.1E-03	6.2E-04	1.2E-03	4.9E-03
Other except alpha (total)	1,200	6.2E-03	3.4E-03	1.4E-01	1.5E-01
Total dose	-	4.9E-02	7.9E-02	1.5E-01	2.6E-01

Note. Sewage input is 35,000 m^3/day; effluent discharge is to R. Great Ouse and mean river flow is 10.2 m^3 per second.

TABLE 6.2 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO BEDFORD STW

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
Tc-99m	300,000	2.2E-01	9.2E-05	<3E-04	2.2E-01
I-123	2,400	6.9E-04	8.8E-05	<2E-06	7.8E-04
I-125	180	4.4E-03	1.5E-02	3.1E-04	2.0E-02
I-131	9,600	3.3E-01	7.2E-01	1.2E-02	1.1
Other except alpha (total)	12,000	1.3E-01	7.2E-02	4.8	5.0
Total dose	-	6.8E-01	8.1E-01	4.8	6.3

Note. Sewage input is 10,000 m^3/day; effluent discharge is to R. Witham and mean river flow is 4.9 m^3 per second.

TABLE 6.3 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO BOSTON STP

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
P-32	2,400	2.3E-02	3.1E-02	<5E-07	5.4E-02
Cr-51	36	5.6E-06	8.8E-06	3.9E-05	5.3E-05
Co-57	6	3.5E-05	1.2E-05	2.5E-04	3.0E-04
Co-58	3	3.5E-05	1.9E-05	2.6E-04	3.1E-04
Ga-67	3,600	2.7E-04	1.5E-05	8.8E-04	1.2E-03
Tc-99m	240,000	1.9E-02	8.0E-05	<5E-05	1.9E-02
I-123	6,000	1.9E-03	2.4E-04	<1E-06	2.1E-03
I-125	840	2.2E-02	7.6E-02	3.2E-04	9.8E-02
Tl-201	6,000	5.9E-03	1.2E-03	7.4E-04	7.8E-03
Total dose	-	7.2E-02	1.1E-01	2.5E-03	1.8E-01

Note. Sewage input is 46,500 m^3/day; effluent discharge is to R. Nene and mean river flow is 4.5 m^3 per second.

TABLE 6.4 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO BROADHOLME STW, KETTERING

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
P-32	2,400	8.1E-02	1.1E-01	<2E-06	1.9E-01
Tc-99m	240,000	6.6E-02	2.8E-04	<2E-04	6.6E-02
I-131	36,000	4.7	10.1	4.2E-02	14.8
Other except alpha (total)	3,000	1.2E-01	6.8E-02	1.1	1.3
Total dose	-	5.0	10.3	1.1	16.4

Note. Sewage input is 11,000 m^3/day; effluent discharge is to R. Lark and mean river flow is 1.3 m^3 per second.

TABLE 6.5 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO RIVER LARK FROM BURY ST. EDMUNDS STP

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
Tc-99m	336,000	6.7E-02	2.8E-04	<1E-04	6.7E-02
I-123	7,200	5.6E-03	7.2E-04	<2E-06	6.3E-03
I-125	252	1.7E-02	5.7E-02	1.5E-04	7.4E-02
I-131	252,000	23.8	51.1	1.1E-01	75.0
Other except alpha (total)	28,800	8.5E-01	4.7E-01	3.9	5.2
Total dose	-	24.6	51.6	4.0	80

Note. Sewage input is 29,400 m^3/day; effluent discharge is to R. Witham (South Delph) and mean river flow is 1.8 m^3 per second.

TABLE 6.6 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO CANWICK STW, LINCOLN

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
Tc-99m	300,000	1.1E-01	4.5E-04	<6E-05	1.1E-01
I-125	600	7.2E-02	2.4E-01	2.0E-04	3.1E-01
I-131	3,600	6.1E-01	1.3	8.8E-04	1.9
Other except alpha (total)	2,500	1.3E-01	7.3E-02	1.9E-01	3.9E-01
Total dose	-	9.2E-01	1.6	1.9E-01	2.7

Note. Sewage input is 52,050 m^3/day; effluent discharge is to R. Chelmer and mean river flow is 1.0 m^3 per second.

TABLE 6.7 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO CHELMSFORD STW

Nuclide	Authorised input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
H-3	1,200	2.9E-04	1.4E-02	1.5E-01	1.6E-01
C-14	1,200	1.5E-01	5.0E-02	4.2E-01	6.2E-01
Tc-99m	840,000	2.2E-01	9.1E-04	<8E-04	2.2E-01
I-131	156,000	18.9	40.7	1.8E-01	59.8
Other except alpha (total)	4,082	1.5E-01	8.5E-02	1.5	1.8
Sr-90 and all other alpha (total)	96	6.7E-01	6.7E-01	1.3	2.7
Total dose	-	20.2	41.5	3.6	65.3

Note. Sewage input is 10,760 m^3/day; effluent discharge is to R. Orwell (tidal) and mean river flow is 1.4 m^3 per second.

TABLE 6.8 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO CLIFF QUAY STW, IPSWICH

Nuclide	Authorised input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
H-3	396	1.7E-04	7.9E-03	1.9E-02	2.7E-02
Total dose	-	1.7E-04	7.9E-03	1.9E-02	2.7E-02

Note. Sewage input is 28,500 m^3/day; effluent discharge is to R. Nene (Willow Brook) and mean river flow is 0.8 m^3 per second.

TABLE 6.9 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO CORBY STW

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
H-3	162,030	8.0E-03	3.7E-01	4.1	4.6
C-14	18,030	4.4E-01	1.5E-01	1.3	1.8
S-35	3,000	1.0E-02	1.9E-03	5.8E-04	1.3E-02
Cr-51	888	9.0E-05	1.4E-04	8.2E-04	1.0E-03
Tc-99m	30,000	1.6E-03	6.5E-06	<5E-06	1.6E-03
I-125	8,044	1.4E-01	4.7E-01	2.6E-03	6.1E-01
Other except alpha (total)	2,534	1.9E-02	1.1E-02	1.9E-01	2.2E-01
Any alpha (total)	12	1.7E-02	1.7E-02	3.2E-02	6.6E-02
Total dose	-	6.3E-01	1.0	5.6	7.3

Note. Sewage input is 54,610 m^3/day; effluent discharge is to R. Great Ouse and mean river flow is 6.9 m^3 per second.

TABLE 6.10 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO COTTON VALLEY STW, MILTON KEYNES

Nuclide	Authorised Input to STW MBq y-1	Dose to adult from discharge to sewer, μSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
P-32	4,800	2.2E-02	2.9E-02	<8E-07	5.1E-02
Tc-99m	360,000	1.4E-02	5.7E-05	<6E-05	1.4E-02
I-123	3,600	5.4E-04	6.8E-05	<6E-07	6.1E-04
I-125	480	6.1E-03	2.1E-02	1.4E-04	2.7E-02
I-131	24,000	4.3E-01	9.3E-01	5.3E-03	1.4
Other except alpha (total)	3,600	2.0E-02	1.1E-02	2.5E-01	2.8E-01
Total dose	-	4.8E-01	9.9E-01	2.5E-01	1.7

Note. Sewage input is 58,000 m^3/day; effluent discharge is to R. Nene and mean river flow is 9.4 m^3 per second.

TABLE 6.11 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO FLAG FEN STW, PETERBOROUGH

Nuclide	Authorised input to STW MBq y^{-1}	Dose to adult from discharge to sewer, μSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
Tc-99m	240,000	1.1E-01	4.5E-04	<2E-04	1.1E-01
I-123	6,000	1.0E-02	1.3E-03	<4E-06	1.1E-02
I-125	144	2.2E-02	7.3E-02	1.8E-04	9.5E-02
I-131	1,200	2.5E-01	5.5E-01	1.1E-03	8.0E-01
Other except alpha (total)	16,800	1.1	6.2E-01	4.7	6.4
Total dose	-	1.5	1.2	4.7	7.4

Note. Sewage input is 14,300 m^3/day; effluent discharge is to R. Witham and mean river flow is 0.8 m^3 per second.

TABLE 6.12 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO GRANTHAM STW

Nuclide	Authorised input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
Tc-99m	264,000	3.0E-02	1.2E-04	<5E-05	3.0E-02
I-123	6,000	2.6E-03	3.4E-04	<1E-06	2.9E-03
I-125	120	4.5E-03	1.5E-02	4.2E-05	2.0E-02
I-131	132,000	7.0	15.1	3.3E-02	22.1
Other except alpha (total)	25,500	4.2E-01	2.3E-01	2.1	2.7
Total dose	-	7.4	15.3	2.1	24.8

Note. Sewage input is 50,000 m^3/day; effluent discharge is to R. Nene and mean river flow is 3.2 m^3 per second.

TABLE 6.13 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO GREAT BILLING STW, NORTHAMPTON

Nuclide	Authorised input to STP MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge *	Total
P-32	11,940	8.7E-01	1.1	(<3E-04)	2.0
P-33	7,080	5.2E-02	8.3E-02	(1.3E-03)	1.4E-01
S-35	8,520	3.3E-01	6.4E-02	(2.1E-01)	3.9E-01
Total dose	-	1.3	1.3	(2.1E-01)	2.5

Note. Sewage input is 432 m^3/day; effluent discharge is to R. Cam and mean river flow is 0.6 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.14 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO GREAT CHESTERFORD STW, SAFFRON WALDEN

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, μSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
H-3	24,000	8.2E-03	3.8E-01	1.2	1.6
P-32	3,300	1.5E-01	1.9E-01	<1E-06	3.4E-01
Cr-51	2,700	1.9E-03	3.0E-03	5.0E-03	9.9E-03
Ga-67	3,000	1.0E-03	5.6E-04	1.3E-03	2.9E-03
Se-75	300	1.4E-02	2.3E-03	3.0E-02	4.6E-02
Sr-89	2,520	1.4E-01	1.8E-01	1.1E-03	3.2E-01
Tc-99m	360,000	1.3E-01	5.4E-04	<1E-04	1.3E-01
In-111	3,600	2.0E-02	2.1E-01	3.0E-03	2.3E-01
I-125	180	2.2E-02	7.3E-02	1.1E-04	9.5E-02
I-131	28,620	4.9	10.4	1.3E-02	15.3
Tl-201	6,900	3.0E-02	6.1E-03	1.5E-03	3.7E-02
Other except alpha (total)	24,684	1.3	7.2E-01	3.6	5.6
Total dose	-	6.6	12.2	4.8	23.4

Note. Sewage input is 27,300 m^3/day; effluent discharge is to R. Colne and mean river flow is 1.0 m^3 per second.

TABLE 6.15 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO HAVEN STW, COLCHESTER

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, μSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge	Total
P-32	1,200	3.5E-03	4.6E-03	<1E-06	8.1E-03
Tc-99m	360,000	8.7E-03	3.6E-05	<3E-04	8.7E-03
I-125	60	4.8E-04	1.6E-03	9.8E-05	2.1E-03
I-131	3,600	4.1E-02	8.8E-02	4.3E-03	1.3E-01
Other except alpha (total)	4,800	1.7E-02	9.4E-03	1.8	1.8
Total dose	-	7.1E-02	1.0E-01	1.8	1.9

Note. Sewage input is 10,700 m^3/day; effluent discharge is to R. Ouse and mean river flow is 14.9 m^3 per second.

TABLE 6.16 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO GODMANCHESTER STW, HUNTINGDON

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge *	Total
H-3	3,600	4.9E-03	2.3E-01	(14.2)	2.3E-01
P-32	600	1.1E-01	1.4E-01	(<2E-05)	2.5E-01
P-33	1,200	2.1E-02	3.4E-02	(2.7E-04)	5.5E-02
S-35	1,200	1.1E-01	2.2E-02	(3.6E-02)	1.3E-01
-Cr-51	9,600	2.7E-02	4.2E-02	(1.4)	6.9E-02
Fe-59	6	1.0E-03	1.3E-03	(5.3E-02)	2.3E-03
Tc-99m	12,000	1.7E-02	7.2E-05	(<3E-04)	1.7E-02
In-111	1,200	2.7E-02	2.8E-01	(7.5E-02)	3.1E-01
I-125	720	3.5E-01	1.2	(3.6E-02)	1.6
Other except alpha (total)	1,200	2.5E-01	1.4E-01	(13.8)	3.9E-01
Total dose	-	9.2E-01	2.1	(29.4)	2.9

Note. Sewage input is 350 m^3/day; effluent discharge is to R. Kennett and mean river flow is 0.25 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.17 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO KENTFORD STW, NEWMARKET

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
P-32	2,400	6.9E-03	9.0E-03	<9E-07	1.6E-02
Cr-51	960	4.4E-05	6.9E-05	1.9E-03	2.0E-03
Co-57	12	2.0E-05	6.7E-06	8.7E-04	8.9E-04
Ga-67	9,600	2.1E-04	1.2E-04	4.2E-03	4.5E-03
Tc-99m	240,000	5.6E-03	2.4E-05	<9E-05	2.6E-03
I-123	6,000	5.5E-04	7.0E-05	<2E-06	6.2E-04
I-125	72	5.6E-04	1.9E-03	4.8E-05	2.5E-03
I-131	12,000	1.1E-05	2.9E-01	5.9E-03	3.0E-01
Other except alpha (total)	2,400	8.3E-03	4.6E-03	3.7E-01	3.8E-01
Total dose	-	2.2E-02	3.1E-01	3.8E-01	7.0E-01

Note. Sewage input is 26,000 m^3/day; effluent discharge is to R. Ouse and mean river flow is 15.3 m^3 per second.

TABLE 6.18 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO KINGS LYNN STW

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y-1			
		River water	Irrigation - river water	Sewage sludge *	Total
P-32	444	3.9E-02	5.1E-02	(<2E-06)	9.0E-02
S-35	888	8.2E-02	8.0E-03	(5.3E-03)	9.0E-02
I-125	120	2.9E-02	9.7E-02	(1.2E-03)	1.3E-01
Total dose	-	1.5E-01	1.6E-01	(6.5E-03)	3.1E-01

Note. Sewage input is 1,800 m3/day; effluent discharge is to R. Mel and mean river flow is 0.5 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.19 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO MELBOURN STW, ROYSTON

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
H-3	1,352,964	1.4E-01	6.7	51.9	58.7
C-14	28,308	1.5	5.1E-01	3.0	5.0
F-18	43,200	4.0E-03	<1E-06	<1E-05	4.0E-03
P-32	59,000	8.1E-01	1.1	<1E-05	1.9
P-33	59,000	8.1E-02	1.3E-01	1.3E-04	2.1E-01
S-35	81,800	5.9E-01	1.2E-01	2.4E-02	7.3E-01
V-48	5	5.8E-06	8.1E-06	3.3E-04	3.5E-04
Cr-51	28,900	6.3E-03	9.9E-03	4.1E-02	5.7E-02
Ga-67	31,200	3.3E-03	1.8E-03	9.9E-03	1.5E-02
Tc-99m	960,000	1.1E-01	4.5E-04	<3E-04	1.1E-01
In-111	26,400	4.6E-02	4.8E-01	1.6E-02	5.5E-01
In-113m	26,400	2.8E-03	<1E-06	<7E-06	2.8E-03
I-125	42,200	1.6	5.3	2.0E-02	6.9
I-131	540,000	28.7	61.6	1.9E-01	90.5
Other except alpha (total)	279,600	4.6	2.6	31.2	38.4
Total dose	-	38.1	78.5	86.3	203

Note. Sewage input is 36,000 m^3/day; effluent discharge is to R. Cam and mean river flow is 3.2 m^3 per second.

TABLE 6.20 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO MILTON STW, CAMBRIDGE

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge *	Total
H-3	540	6.1E-04	2.9E-02	(1.2E-01)	3.0E-02
C-14	60	3.4E-02	1.2E-02	(3.7E-02)	4.6E-02
P-32	600	8.8E-02	1.1E-01	(<9E-07)	2.0E-01
P-33	600	8.8E-03	1.4E-02	(7.6E-06)	2.3E-02
S-35	600	4.6E-02	9.0E-03	(1.0E-03)	5.5E-02
I-125	24	8.8E-03	3.2E-02	(6.9E-05)	4.1E-02
Total dose	-	1.9E-01	2.0E-01	(1.6E-01)	3.9E-01

Note. Sewage input is 6,100 m^3/day; effluent discharge is to R. Snail and mean river flow is 0.30 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.21 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO NEWMARKET STW

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge *	Total
Ga-67	7,200	4.9E-03	2.7E-03	(1.6E-01)	7.6E-03
Tc-99m	300,000	2.2E-01	9.1E-04	(<6E-03)	2.2E-01
In-111	1,800	2.0E-02	2.1E-01	(8.1E-02)	2.3E-01
I-125	720	1.7E-01	5.8E-01	(2.5E-02)	7.5E-01
Tl-201	9,600	8.4E-02	1.7E-02	(1.1E-01)	1.0E-01
Other except alpha (total)	4,800	5.1E-01	2.8E-01	(38.6)	7.9E-01
Total dose	-	1.0	1.1	(38.9)	2.1

Note. Sewage input is 500 m^3/day; effluent discharge is to R. Great Ouse and mean river flow is 0.5 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.22 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO PAPWORTH EVERARD STP

Nuclide	Authorised Discharge MBq y^{-1}	Dose to adult from discharge to estuary $\mu Sv\ y^{-1}$		
		Fish consumption	Gamma exposure to sediment	Total
Tc-99m	360,000	6.0E-06	2.4E-07	6.2E-06
I-125	60	7.8E-05	1.9E-09	7.8E-05
I-131	24,000	2.7E-02	5.0E-07	2.7E-02
Other except alpha (total)	24,000	9.6E-03	1.8E-04	9.8E-03
Total dose	-	3.9E-02	1.8E-04	3.8E-02

Note. Sewage input is (none) m^3/day; effluent discharge is to Humber Estuary and exchange rate is 300 m^3 per second.

TABLE 6.23 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO HUMBER ESTUARY FROM PYEWIPE STP

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, $\mu Sv\ y^{-1}$			
		River water	Irrigation - river water	Sewage sludge *	Total
H-3	270	3.1E-05	1.4E-03	(2.1E-01)	1.4E-03
C-14	30	1.7E-03	5.8E-04	(6.3E-02)	2.3E-03
Total dose	-	1.7E-03	2.0E-03	(2.7E-01)	3.7E-03

Note. Sewage input is 1,800 m^3/day; effluent discharge is to R. Ivel and mean river flow is 3.0 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.24 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO SANDY STW, BEDFORD

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, $\mu Sv\ y^{-1}$			
		River water	Irrigation - river water	Sewage sludge *	Total
C-14	240	5.1E-02	1.7E-02	(5.1E-01)	6.8E-02
Total dose	-	5.1E-02	1.7E-02	(5.1E-01)	6.8E-02

Note. Sewage input is 1,800 m^3/day; effluent discharge is to R. Flitt and mean river flow is 0.8 m^3 per second. . *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.25 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO SILSOE STW, CLOPHILL

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer. µSv y^{-1}			
		Fish consumption	Gamma exposure to sediment	Sewage sludge	Total
Tc-99m	480,000	8.3E-06	3.0E-07	<1.3E-04	<1.3E-04
I-131	200,000	2.3E-01	4.8E-06	7.0E-02	3.0E-01
Other except alpha (total)	36,000	1.4E-02	2.8E-04	4.0	4.0
Total dose	-	2.5E-01	2.8E-04	4.1	4.3

Note. Sewage input is 36,500 m^3/day; effluent discharge is to Thames Estuary at Southend and exchange rate is estimated to be about 300 m^3 per second.

TABLE 6.26 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO SOUTHEND STP

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y-1			
		River water	Irrigation – river water	Sewage sludge *	Total
H-3	324	2.2E-04	1.0E-02	(1.3E-01)	1.0E-02
C-14	36	1.2E-02	4.2E-03	(3.8E-02)	1.6E-02
Other except alpha (total)	29	3.1E-03	1.7E-03	(3.3E-02)	4.8E-03
Total dose	-	1.5E-02	1.6E-02	(2.0E-01)	3.1E-02

Note. Sewage input is 3,550 m3/day; effluent discharge is to R. Great Ouse and mean river flow is 0.5 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 6.27 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO UTTONS DROVES STW, LOLWORTH

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
H-3	313,200	1.6E-02	7.7E-01	5.9	6.7
C-14	5,043	1.3E-01	4.5E-02	2.6E-01	4.3E-01
P-32	98,400	6.7E-01	8.7E-01	<1E-05	1.5
P-33	98,400	6.7E-02	1.1E-01	1.1E-04	1.8E-01
S-35	37,380	1.3E-01	2.6E-02	5.4E-03	1.6E-01
Ga-67	6,000	3.1E-04	1.7E-04	9.4E-04	1.4E-03
Mo-99/Tc-99m	624,000	3.5E-02	1.4E-04	<8E-05	3.5E-02
I-123	4,800	1.0E-03	1.3E-04	<6E-07	1.1E-03
I-125	360	6.6E-03	2.2E-02	8.6E-05	2.9E-02
I-131	300,000	7.8	16.8	5.2E-02	24.6
Other except alpha (total)	29,510	2.4E-01	1.3E-01	1.6	1.9
Any alpha (total)	0.14	2.1E-04	2.1E-04	2.8E-04	7.0E-04
Nat U	(24g)	1.3E-05	9.6E-04	1.3E-03	2.3E-03
Nat Th	(24g)	6.3E-05	2.0E-04	1.4E-02	1.4E-02
Total dose	-	9.0	18.7	7.8	35.5

Note. Sewage input is 73,000 m^3/day; effluent discharge is to R. Yare and mean river flow is 6.5 m^3 per second.

TABLE 6.28 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO WHITTLINGHAM STW, NORWICH

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge *	Total
H-3	19,980	1.1E-02	5.3E-01	(153.2)	5.4E-01
C-14	2,220	6.3E-01	2.1E-01	(46.9)	8.4E-01
Other except alpha (total)	1,332	1.2E-01	6.5E-02	(29.7)	1.8E-01
Total dose	-	7.6E-01	8.0E-01	(229.8)	1.6

Note. Sewage input is 180 m^3/day; effluent discharge is to R. Cam and mean river flow is 0.60 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.1 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF AGREVO UK, CHESTERFORD

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge *	Total
H-3	3,996	5.7E-03	2.6E-01	(22.1)	2.7E-01
C-14	444	3.1E-01	1.1E-01	(6.7)	4.2E-01
Other except alpha (total)	8,880	2.0	1.1	(142.8)	3.1
Total dose	-	2.3	1.5	(171.6)	3.8

Note. Sewage input is 250 m^3/day; effluent discharge is to R. Granta and mean river flow is 0.24 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.2 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF BABRAHAM INSTITUTE, CAMBRIDGE

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		Fish consumption	Gamma exposure to sediment	Sewage sludge	Total
H-3	1,800,000	3.2E-04	0.0	207	207
Na-24	88,800	5.9E-06	2.9E-06	4.7E-04	4.8E-04
Mn-56	22,200	3.0E-08	1.5E-09	<2E-05	<2E-05
Br-82	177,600	1.8E-03	5.0E-07	2.7E-02	2.9E-02
Tc-99m	2,400,000	4.2E-05	1.6E-06	<2E-03	<2E-03
In-113m	192,000	Neg	Neg	<2E-04	<2E-04
Other except alpha (total)	120,000	4.8E-02	9.2E-04	40.2	40.2
Total dose	-	5.0E-02	9.2E-04	247	247

Note. Sewage input is 12,000 m^3/day; effluent discharge is to Humber Estuary and exchange rate is estimated to be 300 m^3 per second.

TABLE 7.3 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF CONOCO LTD, GRIMSBY

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge *	Total
H-3	43	2.1E-06	9.9E-05	(1.8E-01)	1.0E-04
C-14	5	1.2E-04	4.2E-05	(5.7E-02)	1.6E-04
Other except alpha (total)	288	2.2E-03	1.2E-03	(3.5)	3.4E-03
Total dose	-	2.3E-03	1.3E-03	(3.7)	3.7E-03

Note. Sewage input is 333 m^3/day; effluent discharge is to R. Great Ouse and mean river flow is 6.9 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.4 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF CRANFIELD BIOTECHNOLOGY CENTRE, CRANFIELD

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge *	Total
H-3	108,000	4.8E-02	2.3	(497)	2.3
C-14	12,000	2.7	9.1E-01	(152)	3.6
Other except alpha (total)	4,800	3.3E-01	1.9E-01	(64)	5.2E-01
Total dose	-	3.0	3.4	(713)	6.4

Note. Sewage input is 300 m^3/day; effluent discharge is to Alconbury Brook and mean river flow is 0.76 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.5 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF HUNTINGDON LIFE SCIENCES, ALCONBURY

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation – river water	Sewage sludge *	Total
H-3	3,240	1.7E-03	7.9E-02	(14.9)	8.1E-02
C-14	360	9.4E-02	3.2E-02	(1.1E-01)	1.3E-01
Other except alpha (total)	12	9.8E-04	5.4E-04	(1.6E-01)	1.5E-03
Total dose	-	9.6E-02	1.1E-01	(15.2)	2.1E-01

Note. Sewage input is 300 m^3/day; effluent discharge is to R. Dove and mean river flow is 0.65 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.6 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF HUNTINGDON LIFE SCIENCES, EYE

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge *	Total
H-3	2.4	1.8E-06	8.5E-05	(3.3E-01)	8.7E-05
C-14	6	2.3E-03	7.7E-04	(2.3)	3.1E-03
I-125	24	6.4E-03	2.2E-02	(4.2E-02)	2.8E-02
Total dose	-	8.7E-03	2.3E-02	(2.6)	3.1E-02

Note. Sewage input is 10 m^3/day; effluent discharge is to Kings Dyke and mean river flow is 0.45 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.7 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF INSTITUTE OF TERRESTRIAL ECOLOGY, HUNTINGDON

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		Fish consumption	Gamma exposure to sediment	Sewage sludge *	Total
H-3	450,000	7.9E-05	0.0	(103.5)	7.9E-05
Na-24	22,200	1.4E-06	7.0E-07	(2.3E-04)	2.1E-06
Mn-56	22,200	3.0E-08	1.5E-08	(<4E-05)	4.5E-08
Br-82	44,400	4.4E-04	1.0E-07	(1.3E-02)	4.4E-04
In-113m	88,800	Neg	Neg	(<2E-04)	Neg
Ba-137m	22,200	2.3E-01	1.7E-03	(47.7)	2.3E-01
Total dose	-	2.3E-01	1.7E-03	(151)	2.3E-01

Note. Sewage input is 6,000 m^3/day; effluent discharge is to Humber Estuary and exchange/dilution rate is estimated to be 300 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.8 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF LINDSEY OIL REFINERY, IMMINGHAM

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge *	Total
H-3	2,400	8.6E-05	4.0E-03	(5.5)	4.1E-03
C-14	2,400	4.3E-02	1.5E-02	(15.2)	5.8E-02
P-32	1,200	5.5E-03	7.3E-03	(<2E-05)	1.3E-02
P-33	1,200	5.6E-04	8.9E-04	(1.6E-04)	1.5E-03
S-35	1,080	2.6E-03	5.1E-04	(1.9E-02)	3.1E-03
Cl-36	444	3.3E-04	7.8E-02	(112.5)	7.8E-02
Ca-45	900	1.4E-03	1.9E-03	(4.6E-03)	3.3E-03
Cr-51	1,200	8.8E-05	1.4E-04	(1.0E-01)	2.3E-04
Mn-54	444	2.5E-03	1.9E-04	(11.0)	2.7E-03
Fe-59	1,200	5.3E-03	7.0E-03	(6.2)	1.2E-02
Y-90	1,200	7.5E-02	2.9E-01	(264)	3.6E-01
Ru-103	720	5.7E-05	1.7E-03	(1.3)	1.8E-03
In-111	1,200	7.1E-04	7.3E-03	(4.5E-02)	8.0E-03
I-125	1,200	1.5E-02	5.1E-02	(3.5E-02)	6.6E-02
Total dose	-	1.5E-01	4.6E-01	(416)	5.7E-01

Note. Sewage input is 600 m^3/day; effluent discharge is to R. Great Ouse and mean river flow is 9.5 m^3 per second. *Capacity of STW insufficient to support sludge pathway; excluded from total dose.

TABLE 7.9 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES TO STW OF UNILEVER RESEARCH, BEDFORD

Nuclide	Authorised Input to STW MBq y^{-1}	Dose to adult from discharge to sewer, µSv y^{-1}			
		River water	Irrigation - river water	Sewage sludge	Total
Tc-99m	2,040	Not assessed, dose expected to be extremely low			
Total dose	-				

TABLE 7.10 RADIOLOGICAL IMPACT OF AUTHORISED DISCHARGES FROM WOODLAND HOSPITAL, KETTERING TO OWN SOAKAWAY

Premises	Dose to adult from authorised release, μSv/y	Principal nuclides and pathway
Direct discharges		
Conoco Ltd, Theddlethorpe, Lincs. to North Sea [Ref. 72LIN]	48	Ra progeny activity from natural gas processing; fish consumption. No data available on actual discharges.
Discharges via public sewerage system		
Bury St Edmunds STW, to River Lark	16	Assessed impact mainly due to I-131 from West Suffolk Hospital. Based on actual discharges in 1996/97, the impact would be well below 1 μSv/y.
Canwick STW, Lincoln to River Witham	80	Assessed impact mainly due to I-131 from St Georges Hospital and Lincoln and Louth Hospital. No data available on actual discharges.
Cliff Quay STW, Ipswich, to River Orwell	65	Assessed impact mainly due to I-131 from Ipswich Hospital. Actual discharges of I-131 over 1994-96 averaged about 25% of the authorised limit, implying actual dose of about 15 μSv/y.
Great Billing STW, Northampton, to River Nene	25	Assessed impact mainly due to I-131 from Northampton General Hospital. No data available on actual discharges.
Haven STW, Colchester, to River Colne	23	Assessed impact mainly due to I-131 from Essex County Hospital. Actual discharge of I-131 in 1996 was about 40% of authorised limit, implying impact of about 6 μSv/y.
Milton STW, Cambridge, to River Cam	203	Main contributions to assessed dose are from I-131 and I-125, (~50%), H-3 (~30%) and 'other except alpha' (~20%). The main discharges of I-125 and 131 are from Addenbrookes Hospital and actual discharges are up to about 40% of the authorised limits. For H-3 and 'other' the main source is University of Cambridge. Actual discharges in recent years have been about 5% of the authorised limit for H-3, and about 10% for 'other'. The actual dose is therefore likely to be less than 50 μSv/y.
Whittlingham STW, Norwich, to River Yare	35	Assessed impact mainly due to I-131 from Norfolk and Norwich Hospital. Reported discharges of I-131 in 1996 were about 36% of the authorised limit, implying an actual impact of about 10 μSv/y from this nuclide.
Discharges via private STW		
Conoco Ltd, Grimsby, to Humber Estuary [Ref. 67HUM]	247	This assessed impact arises mainly from H-3 in sewage sludge and is likely to be very conservative. It is not known whether the sludge is used for agricultural purposes. No data available on actual discharges.

TABLE 8 SUMMARY OF PREMISES FOR WHICH ASSESSED IMPACT FROM LIQUID RELEASES AT LIMIT OF AUTHORISATION EXCEEDS 10 μSv PER YEAR

Name of sewage plant	Total annual dose to worker, μSv per year		
	Sewage plant	Sewer maintenance	Dominant radio-nuclide
Public STP:			
Basildon	1.1	0.20	Tc-99m
Bedford	0.82	0.18	Tc-99m
Boston	3.8	0.25	Tc-99m
Broadholme	0.51	0.14	Tc-99m
Bury St. Edmunds	3.0	0.27	Tc-99m
Camwick	4.0	1.2	I-131
Chelmsford	0.57	0.19	Tc-99m
Cliff Quay	4.3	1.0	Tc-99m
Corby	<0.01	<0.01	H-3
Cotton Valley	0.08	0.04	Tc-99m
Flag Fen	0.72	0.31	Tc-99m
Grantham	2.4	0.21	Tc-99m
Great Billing	1.5	0.71	I-131
Great Chesterford	0.01	<0.01	P-32
Haven	2.2	0.43	Tc-99m
Huntingdon	3.5	0.24	Tc-99m
Kentford	7.1	0.01	Tc-99m
Kings Lynn	1.1	0.20	Tc-99m
Melbourn	<0.01	<0.01	-
Milton	13.0	4.0	Other, I-131
Newmarket	<0.01	<0.01	-
Papworth Everard	65.0	0.19	Tc-99m
Pyewipe (pump station)	n/a	0.40	Tc-99m
Sandy	<0.01	<0.01	-
Silsoe	<0.01	<0.01	-
Southend	3.4	1.1	I-131
Uttons Drove	0.01	<0.01	-
Whittlingham	3.1	1.9	Mo-99, I-131
Private STP:			
Agrevo	n/a	0.01	Other
Babraham Institute	n/a	<0.01	-
Conoco	n/a	0.13	Na-24, Tc-99m
Cranfield	n/a	<0.01	-
Huntingdon Life Sciences, Alconbury	n/a	0.03	Other
Huntingdon Life Sciences, Eye	n/a	<0.01	-
Inst. Terrestrial Ecology	n/a	<0.01	-
Lindsey Oil	n/a	0.05	Na-24, Br-82
Unilever Research	n/a	<0.01	-
Woodland Hospital	n/a	0.02	Tc-99m

TABLE 9 DOSE TO SEWAGE PLANT WORKERS AND SEWER MAINTENANCE WORKERS

Nuclide	Authorised disposal MBq per year	Dose to adult from authorised disposals to landfill, μSv y-1	
		Disposal worker	Member of public
H-3 and C-14 (total) (1)	7200	6E-04	1.1E-03
Other except alpha (2) (half-life < 100days)	19,200	10	0.1
Other except alpha (3) (half-life > 100days)	1848	144	2E-03
Totals (rounded)	-	150	0.1

Notes: 1. Based on dose factor for C-14
2. Based on P-32 for workers and S-35 for members of public
3. Based on Co-60.

TABLE 10 RADIOLOGICAL IMPACT OF AUTHORISED DISPOSALS TO LANDFILL FROM UNIVERSITY OF CAMBRIDGE WASTE STORE, MADINGLEY

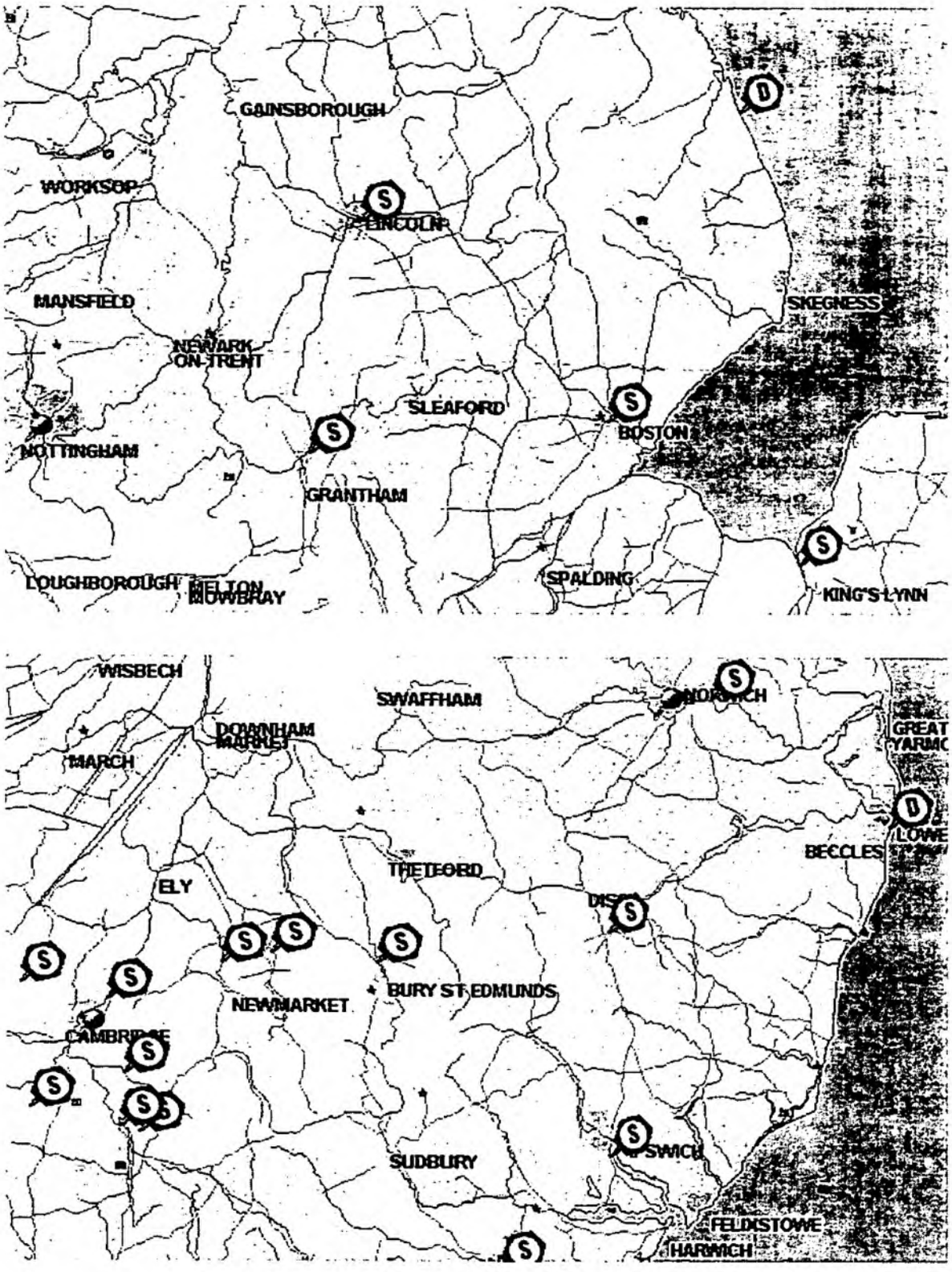

FIGURE 1 LOCATION OF LIQUID EFFLUENT DISCHARGE POINTS

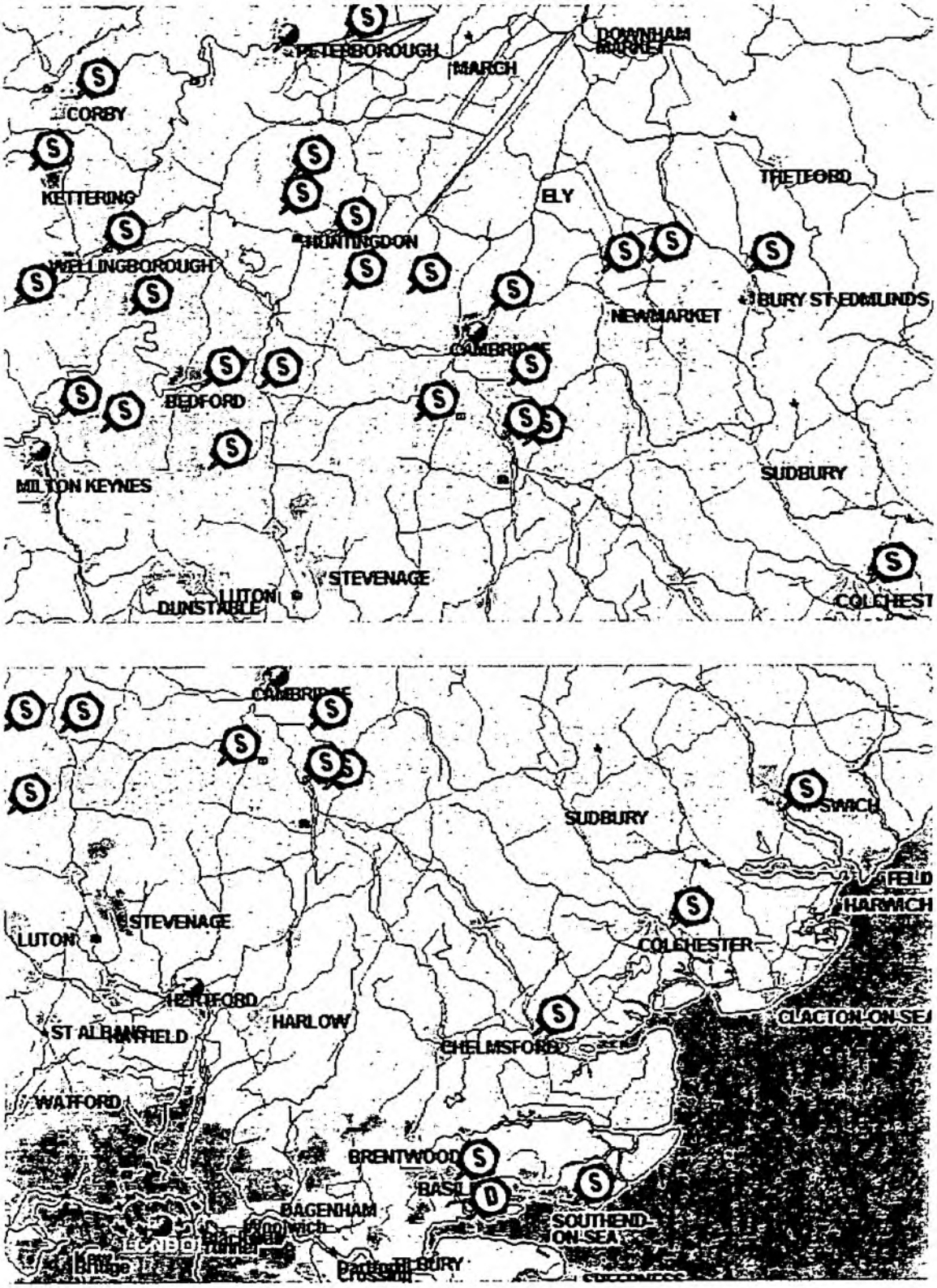

FIGURE 1 (Cont.) LOCATION OF LIQUID EFFLUENT DISCHARGE POINTS

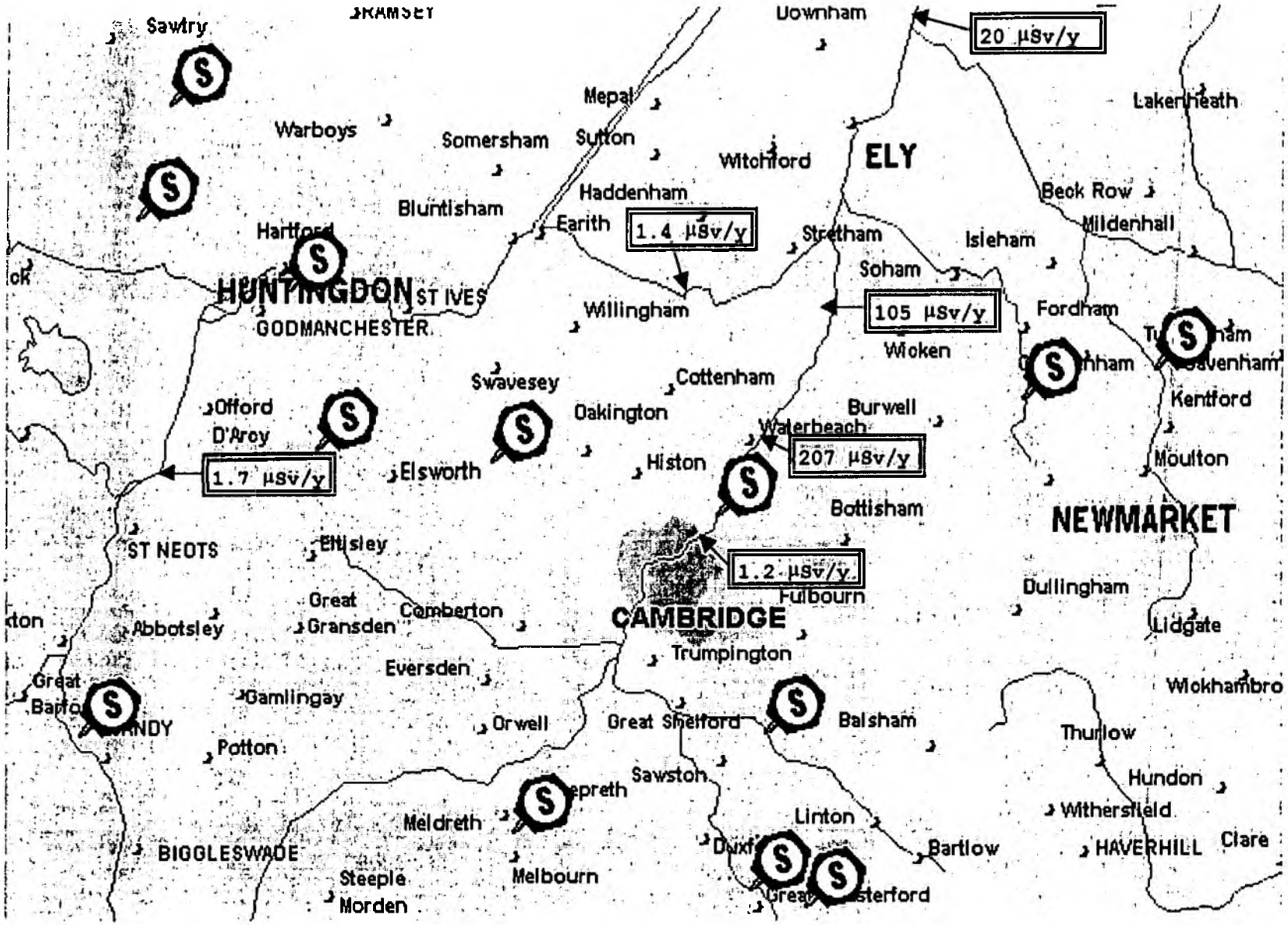

FIGURE 2 CUMULATIVE DOSE RATE DOWN CATCHMENT OF R. GREAT OUSE

APPENDIX A - LIST OF AUTHORISED SITES IN ANGLIAN REGION

(Hand-written numbers in left margin are reference numbers for study)

RSA93 S.13 - Effective Anglian Region

	Operator Name	Operator Complete Address	Permissn	Local Authority Cod
01	BEDFORD HOSPITAL NHS TRUST	SOUTH WING , KEMPSTON ROAD BEDFORD MK42 9DJ	AT3957	BEDFORDSHIRE
02	CHEMEX INTERNATIONAL PLC	74 SUNDERLAND ROAD SANDY BEDFORDSHIRE SG19 1QY	AY9103	BEDFORDSHIRE
03	CRANFIELD BIOTECHNOLOGY CENTRE	CRANFIELD UNIVERSITY CRANFIELD BEDFORD BEDFORDSHIRE MK43 0AL	AC2314	BEDFORDSHIRE
04	SOIL SURVEY AND LAND RESEARCH CENTRE	CRANFIELD UNIVERSITY , SILSOE BEDFORD MK45 4DT	AL4163	BEDFORDSHIRE
05	UNILEVER RESEARCH COLWORTH LABORATORY	COLWORTH HOUSE SHARNBROOK BEDFORD BEDFORDSHIRE MK44 1LQ	AT1920	BEDFORDSHIRE
06	EG AND G LTD	20 VINCENT AVENUE CROWNHILL MILTON KEYNES BUCKINGHAMSHIRE MK8 0AB	AE4628	BUCKINGHAMSHI...
07	HOECHST MARION ROUSSEL LTD	WALTON MANOR, WALTON MILTON KEYNES MK7 7AJ	AW3252	BUCKINGHAMSHI...
08	MILTON KEYNES GENERAL NHS TRUST	MILTON KEYNES GENERAL HOSPITAL, STANDING WAY, EAGLESTONE MILTON KEYNES MK6 5LD	BA2768	BUCKINGHAMSHI...
09	PHARMACIA AND UPJOHN LTD	DAVY AVENUE, KNOWLHILL MILTON KEYNES BUCKINGHAMSHIRE MK5 8PH	AV4652	BUCKINGHAMSHI...
10	THE OPEN UNIVERSITY	OPEN UNIVERSITY CAMPUS , WALTON HALL MILTON KEYNES MK7 6AA	AS8457	BUCKINGHAMSHI...
11	ADDENBROOKES NHS TRUST HOSPITAL	ADDENBROOKES HOSPITAL, HILLS ROAD CAMBRIDGE CB2 2QQ	AY6767	CAMBRIDGESHIRE
12	ADVANCED TECHNOLOGIES (CAMBRIDGE) LTD	210 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CAMBRIDGESHIRE CB4 4WA	AX3932	CAMBRIDGESHIRE
13	AFFINITY SENSORS	SAXON WAY BAR HILL CAMBRIDGE CAMBRIDGESHIRE CB3 8SL	AV4920	CAMBRIDGESHIRE
14	AGREVO UK LTD	THE REDLANDS, OAKINGTON ROAD COTTENHAM CAMBRIDGE CAMBRIDGESHIRE CB4 4TW	AM6455	CAMBRIDGESHIRE
15	AI QUALITEK LTD	LONDON ROAD PAMPISFORD CAMBRIDGE CAMBRIDGESHIRE CB2 4EF	AY7941	CAMBRIDGESHIRE
16	AXIS GENETICS PLC	BABRAHAM CAMBRIDGE CB2 4AZ	AX5471	CAMBRIDGESHIRE
17	BRITISH GAS PLC	EASTERN DIVISION, NENE WEST AGI, FERRY LANE NEWTON WISBECH CAMBRIDGESHIRE PE13 ...	AJ0647	CAMBRIDGESHIRE
18	~~CAMBRIDGE ANTIBODY TECHNOLOGY LTD~~	~~THE SCIENCE PARK MELBOURN ROYSTON HERTFORDSHIRE SG8 6JJ~~	~~AQ0081~~	~~CAMBRIDGESHIRE~~
	CAMBRIDGE ANTIBODY TECHNOLOGY LTD	THE SCIENCE PARK MELBOURN ROYSTON HERTFORDSHIRE SG8 6JJ	AX6826	CAMBRIDGESHIRE
19	CAMBRIDGE SCIENTIFIC INSTRUMENTS LTD	UNITS 7 AND 8, SEDGEWAY BUSINESS PARK, WITCHFORD ELY CAMBRIDGESHIRE CB6 2HY	AT3833	CAMBRIDGESHIRE
20	CANTAB PHARMACEUTICALS LTD	184 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CB4 4GN	AT4287	CAMBRIDGESHIRE
21	CHIROSCIENCE LTD	UNIT 252/254 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CB4 4WE	AY5167	CAMBRIDGESHIRE
22	DALGETY FOOD INGREDIENTS LTD	FOOD INGREDIENTS DEVELOPMENT CENTRE, BLOCK B, STATION ROAD CAMBRIDGE CB1 2JN	AZ2422	CAMBRIDGESHIRE
23	GENOME RESEARCH LTD	THE SANGER CENTRE, WELLCOME TRUST GENOME CAMPUS HINXTON SAFFRON WALDEN ESS...	AN2862	CAMBRIDGESHIRE
24	HEXAGEN TECHNOLOGY LTD	214 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CAMBRIDGESHIRE CB4 4WA	AW8564	CAMBRIDGESHIRE
25	~~HINCHINGBROOKE HEALTH CARE NHS TRUST~~	~~HINCHINGBROOKE HOSPITAL , HINCHINGBROOKE PARK HUNTINGDON CAMBRIDGESHIRE PE18...~~	AM8032	CAMBRIDGESHIRE
	HINCHINGBROOKE HEALTH CARE NHS TRUST	HINCHINGBROOKE HOSPITAL , HINCHINGBROOKE PARK HUNTINGDON CAMBRIDGESHIRE PE18...	AZ8439	CAMBRIDGESHIRE
26	HORSERACING FORENSIC LABORATORY LTD	NEWMARKET ROAD, FORDHAM ELY CAMBRIDGESHIRE CB7 5WW	AX3878	CAMBRIDGESHIRE
27	HUNTINGDON LIFE SCIENCES LTD	WOOLLEY ROAD , ALCONBURY HUNTINGDON CAMBRIDGESHIRE PE18 6ES	AW9714	CAMBRIDGESHIRE
28	IMUTRAN LIMITED	DOUGLAS HOUSE, 18 TRUMPINGTON ROAD CAMBRIDGE CB2 2AH	BA2750	CAMBRIDGESHIRE
29	~~INSTITUTE OF TERRESTRIAL ECOLOGY~~	~~MONKS WOOD ABBOTS RIPTON HUNTINGDON CAMBRIDGESHIRE PE17 2LS~~	~~AQ7094~~	~~CAMBRIDGESHIRE~~
	INSTITUTE OF TERRESTRIAL ECOLOGY	MONKS WOOD ABBOTS RIPTON HUNTINGDON CAMBRIDGESHIRE PE17 2LS	AS2157	CAMBRIDGESHIRE
30	LCG CLINICAL LABORATORY UNIT	211 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CB4 4ZA	BA2636	CAMBRIDGESHIRE
31	MARSHALL OF CAMBRIDGE AEROSPACE LTD	THE AIRPORT CAMBRIDGE CB5 8RX	AZ4891	CAMBRIDGESHIRE
32	~~MEDICAL RESEARCH COUNCIL~~	~~MRC CENTRE, HILLS ROAD CAMBRIDGE CAMBRIDGESHIRE CB2 2QH~~	~~AE6128~~	~~CAMBRIDGESHIRE~~
33	MEDICAL RESEARCH COUNCIL	STRANGEWAYS RESEARCH LABORATORY, WORTS CAUSEWAY CAMBRIDGE CAMBRIDGESHIRE...	AI4573	CAMBRIDGESHIRE
34	MEDICAL RESEARCH COUNCIL	MRC CENTRE, HILLS ROAD CAMBRIDGE CAMBRIDGESHIRE CB2 2QH	AZ2236	CAMBRIDGESHIRE
35	MRC DUNN NUTRITION CENTRE	DUNN NUTRITIONAL LABORATORY, DOWNHAMS LANE, MILTON ROAD CAMBRIDGE CB4 1XJ	AN4156	CAMBRIDGESHIRE
36	MRC HUMAN GENOME MAPPING PROJECT RESO...	HINXTON CAMBRIDGE CB10 1SB	AZ0896	CAMBRIDGESHIRE
37	NAPP RESEARCH CENTRE	UNITS 127 AND 137, CAMBRIDGE SCIENCE PARK, MILTON RD CAMBRIDGE CB4 4GW	AC8967	CAMBRIDGESHIRE
38	NIAB	HUNTINGDON ROAD CAMBRIDGE CAMBRIDGESHIRE CB3 0LE	AC9203	CAMBRIDGESHIRE
39	PAPWORTH HOSPITAL NHS TRUST	PAPWORTH EVERARD CAMBRIDGE CB3 8RE	AO3872	CAMBRIDGESHIRE

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	PARKE-DAVIS NEUROSCIENCE RESEARCH CENT...	CAMBRIDGE UNIVERSITY FORVIE SITE , ROBINSON WAY CAMBRIDGE CB2 2QB	AR8943	CAMBRIDGESHIRE
41	PARKE-DAVIS NEUROSCIENCE RESEARCH CENT...	CAMBRIDGE UNIVERSITY FORVIE SITE , ROBINSON WAY CAMBRIDGE CB2 2QB	AY9740	CAMBRIDGESHIRE
42	PEPTIDE THERAPEUTICS LTD	324 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CB4 4WG	AZ3143	CAMBRIDGESHIRE
43	PETERBOROUGH HOSPITALS NHS TRUST	PETERBOROUGH DISTRICT HOSPITAL, THORPE ROAD PETERBOROUGH CAMBRIDGESHIRE PE...	AV4245	CAMBRIDGESHIRE
44	PLANT BREEDING INTERNATIONAL	MARIS LANE, TRUMPINGTON CAMBRIDGE CB2 2LQ	AO0849	CAMBRIDGESHIRE
45	QUADRANT HOLDINGS CAMBRIDGE LTD	MARIS LANE CAMBRIDGE CAMBRIDGESHIRE CB2 2JB	AA6327	CAMBRIDGESHIRE
–	~~SCL BIOSCIENCE SERVICES LTD~~	~~211 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CB4 4ZA~~	~~AG9018~~	~~CAMBRIDGESHIRE~~
46	SCL BIOSCIENCE SERVICES LTD	211 CAMBRIDGE SCIENCE PARK, MILTON ROAD CAMBRIDGE CB4 4ZA	AX9132	CAMBRIDGESHIRE
47	THE BABRAHAM INSTITUTE	BABRAHAM HALL BABRAHAM CAMBRIDGE CB2 4AT	AO3694	CAMBRIDGESHIRE
48	THOROUGHBRED BREEDERS ASSOCIATION	EQUINE FERTILITY UNIT, WOODDITTON ROAD NEWMARKET SUFFOLK CB8 9BH	AD8075	CAMBRIDGESHIRE
49	UNIVERSITY OF CAMBRIDGE	WASTE STORE, HIGH CROSS, MADINGLEY ROAD CAMBRIDGE CAMBRIDGESHIRE CB3 0HB	AG4289	CAMBRIDGESHIRE
50	UNIVERSITY OF CAMBRIDGE	ADDENBROOKES HOSPITAL SITE, HILLS ROAD CAMBRIDGE CAMBRIDGESHIRE CB2 2QQ	AW3589	CAMBRIDGESHIRE
51	UNIVERSITY OF CAMBRIDGE	CENTRAL SITE PREMISES CAMBRIDGE CB2 3DY	BA3748	CAMBRIDGESHIRE
52	UNIVERSITY OF CAMBRIDGE	WEST SITES CAMBRIDGE CB3 0ES	AW3619	CAMBRIDGESHIRE
53	UNIVERSITY OF CAMBRIDGE	DEPARTMENT OF ZOOLOGY MADINGLEY CAMBRIDGE CAMBRIDGESHIRE CB3 8AQ	AM7664	CAMBRIDGESHIRE
54	WOLFSON BRAIN IMAGING CENTRE	ADDENBROOKE S NHS TRUST, HILLS ROAD CAMBRIDGE CB2 2QQ	AR6126	CAMBRIDGESHIRE
55	AGREVO UK LTD	CHESTERFORD PARK LITTLE CHESTERFORD SAFFRON WALDEN ESSEX CB10 1XL	AV8712	ESSEX
–	~~AGREVO UK LTD~~	~~CHESTERFORD PARK LITTLE CHESTERFORD SAFFRON WALDEN ESSEX CB10 1XL~~	~~AO4321~~	~~ESSEX~~
56	BASILDON AND THURROCK GENERAL HOSPITAL...	BASILDON HOSPITAL, NETHER MAYNE BASILDON ESSEX SS16 5NL	AT1202	ESSEX
57	CARLESS REFINING AND MARKETING LTD	REFINERY ROAD HARWICH ESSEX CO12 4QG	AE7228	ESSEX
58	ESSEX RIVERS HEALTHCARE NHS TRUST	COLCHESTER GENERAL HOSPITAL, TURNER ROAD COLCHESTER CO4 5JL	AR1701	ESSEX
59	ESSEX RIVERS HEALTHCARE NHS TRUST	ESSEX COUNTY HOSPITAL, LEXDEN ROAD COLCHESTER CO3 3NB	AR1710	ESSEX
–	~~HUNTING BRAE LTD~~	~~ATOMIC WEAPONS ESTABLISHMENT, FOULNESS SOUTHEND-ON-SEA ESSEX SS3 9XE~~	~~AI2759~~	~~ESSEX~~
–	~~MAGNOX ELECTRIC PLC~~	~~BRADWELL NUCLEAR POWER STATION , GASEOUS DISPOSAL AUTHORISATION , BRADWELL ON...~~	~~AB0804~~	~~ESSEX~~
–	~~MAGNOX ELECTRIC PLC~~	~~BRADWELL NUCLEAR POWER STATION , LIQUID DISPOSAL AUTHORISATION REVISION , BRADW...~~	~~AB0812~~	~~ESSEX~~
–	~~MAGNOX ELECTRIC PLC~~	~~BRADWELL NUCLEAR POWER STATION BRADWELL ON SEA SOUTHMINSTER ESSEX CM0 7HP~~	~~AB1142~~	~~ESSEX~~
–	~~MAGNOX ELECTRIC PLC~~	~~DISTRICT SURVEY LABORATORY (PEAKES), WATERSIDE ROAD, BRADWELL ON SEA SOUTHMIN...~~	~~AX8438~~	~~ESSEX~~
–	~~MAGNOX ELECTRIC PLC~~	~~BRADWELL POWER STATION , , BRADWELL ON SEA SOUTHMINSTER ESSEX CM0 7HP~~	~~AE8194~~	~~ESSEX~~
–	~~MAGNOX ELECTRIC PLC~~	~~BRADWELL NUCLEAR POWER STATION BRADWELL ON SEA SOUTHMINSTER ESSEX CM0 7HP~~	~~AP3605~~	~~ESSEX~~
60	MID ESSEX HOSPITALS NHS TRUST	BROOMFIELD HOSPITAL, COURT ROAD CHELMSFORD CM1 5ET	AR8218	ESSEX
61	MOBIL OIL CO LTD	CORYTON REFINERY , THE MANORWAY CORYTON STANFORD-LE-HOPE ESSEX SS17 9LL	AC8169	ESSEX
–	MOD	ATOMIC WEAPONS ESTABLISHMENT , FOULNESS SOUTHEND-ON-SEA SS3 9XE	AI8617	ESSEX
62	NICHOLS INSTITUTE DIAGNOSTICS LTD	WHITE HOUSE, HIGH STREET NEWPORT SAFFRON WALDEN ESSEX CB11 3PQ	AF9854	ESSEX
63	RHONE POULENC AGRICULTURE LTD	ALDHAMS FARM , DEAD LANE LAWFORD MANNINGTREE ESSEX CO11 2NF	AH8816	ESSEX
64	SHELL UK LTD DOWNSTREAM OIL	SHELL HAVEN REFINERY STANFORD-LE-HOPE ESSEX SS17 9LD	AQ8026	ESSEX
65	SOUTHEND HEALTH CARE NHS TRUST	SOUTHEND HOSPITAL, PRITTLEWELL CHASE WESTCLIFF-ON-SEA ESSEX SS0 0RY	AT9548	ESSEX
66	UNIVERSITY OF ESSEX	WIVENHOE PARK COLCHESTER ESSEX CO4 3SQ	AM4428	ESSEX
67	CONOCO LTD	HUMBER REFINERY , SOUTH KILLINGHOLME GRIMSBY SOUTH HUMBERSIDE DN40 3DW	AW7258	HUMBERSIDE
68	LINDSEY OIL REFINERY LTD	NORTH KILLINGHOLME IMMINGHAM GRIMSBY SOUTH HUMBERSIDE DN40 3LW	AZ0357	HUMBERSIDE
69	MILLENNINIUM INORGANIC CHEMICALS	LAPORTE ROAD IMMINGHAM GRIMSBY SOUTH HUMBERSIDE DN40 2PR AN40 32	AE0207	HUMBERSIDE
70	~~MILLENNINIUM INORGANIC CHEMICALS~~	~~PO BOX 26 GRIMSBY NORTH HUMBERSIDE DN37 8DP~~	~~AE0215~~	~~HUMBERSIDE~~
71	NORTH EAST LINCOLNSHIRE NHS TRUST	GRIMSBY HOSPITAL, SCARTHO ROAD GRIMSBY SOUTH HUMBERSIDE DN33 2BA	AZ2112	HUMBERSIDE
72	CONOCO (UK) LTD	PICKERILL DUNES VALVE PIT, THEDDLETHORPE GAS TERMINAL, THEDDLETHORPE MABLETHO...	AV3567	LINCOLNSHIRE
	CONOCO (UK) LTD	PICKERILL DUNES VALVE PIT, THEDDLETHORPE GAS TERMINAL, THEDDLETHORPE MABLETHO...	AW9471	LINCOLNSHIRE
73	GRANTHAM AND DISTRICT HOSPITAL NHS TRUST	101 MANTHORPE ROAD GRANTHAM LINCOLNSHIRE NG31 8DG	AR2058	LINCOLNSHIRE

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	LINCOLN AND LOUTH NHS TRUST	ST GEORGE S HOSPITAL , LONG LEYS ROAD LINCOLN LN1 1EF	AM8474	LINCOLNSHIRE
75	LINCOLN AND LOUTH NHS TRUST	COUNTY HOSPITAL, GREETWELL ROAD LINCOLN LN2 5OY	AU0678	LINCOLNSHIRE
76	PILGRIM HEALTH NHS TRUST	PILGRIM HOSPITAL, SIBSEY ROAD BOSTON LINCOLNSHIRE PE21 9OS	AP7245	LINCOLNSHIRE
77	BRITISH SUGAR PLC	BRITISH SUGAR TECHNICAL CENTRE, NORWICH RESEARCH PARK COLNEY NORWICH NORFOL...	AE0142	NORFOLK
78	INSTITUTE OF FOOD RESEARCH	NORWICH LABORATORY, NORWICH RESEARCH PARK, COLNEY LANE NORWICH NR4 7UA	AE4130	NORFOLK
79	JOHN INNES CENTRE	NORWICH RESEARCH PARK COLNEY NORWICH NR4 7UH	AS5946	NORFOLK
80	KING S LYNN AND WISBECH HOSPITALS NHS TR...	QUEEN ELIZABETH HOSPITAL, GAYTON ROAD KING S LYNN NORFOLK PE30 4ET	AX2430	NORFOLK
81	MAFF	FOOD SCIENCE LABORATORY , COLNEY LANE NORWICH NR4 7UQ	AB5628	NORFOLK
82	NORFOLK AND NORWICH HEALTH CARE NHS TR...	NORFOLK AND NORWICH HOSPITAL, BRUNSWICK ROAD NORWICH NR1 3SR	AU4789	NORFOLK
83	SHELL UK EXPLORATION AND PRODUCTION	GAS TERMINAL, PASTON ROAD, BACTON NORWICH NR12 0JE	AL1261	NORFOLK
84	UNIVERSITY OF EAST ANGLIA	EARLHAM , NORWICH NR4 7TJ	AS8694	NORFOLK
85	KETTERING GENERAL HOSPITAL NHS TRUST	KETTERING GENERAL HOSPITAL, ROTHWELL ROAD KETTERING NORTHAMPTONSHIRE NN16 8UZ	AT2659	NORTHAMPTONS...
86	MALLINCKRODT MEDICAL UK LTD	11 NORTH PORTWAY CLOSE, ROUND SPINNEY NORTHAMPTON NN3 8RQ	AR3259	NORTHAMPTONS...
87	NORTHAMPTON GENERAL HOSPITAL NHS TRUST	CLIFTONVILLE NORTHAMPTON NORTHAMPTONSHIRE NN1 5BD	AW9552	NORTHAMPTONS...
88	SURELITE LTD	PRIORS HAW ROAD CORBY NORTHAMPTONSHIRE NN17 5JG	AE0274	NORTHAMPTONS...
89	WOODLAND HOSPITAL	ROTHWELL ROAD KETTERING NORTHAMPTONSHIRE NN16 8XF	BA2008	NORTHAMPTONS...
90	AGRICULTURAL AND FOOD RESEARCH COUNCIL	BROOMS BARN HIGHAM BURY ST: EDMUNDS SUFFOLK IP28 6NP	AH8158	SUFFOLK
91	ANIMAL HEALTH TRUST	BALATON LODGE SNAILWELL ROAD , NEWMARKET SUFFOLK CB8 7DW	AD0147	SUFFOLK
92	ANIMAL HEALTH TRUST	LANWADES PARK , KENTFORD NEWMARKET SUFFOLK CB8 7UU	AZ8447	SUFFOLK
93	CENTRE FOR ENVIRONMENT, FISHERIES AND AQ...	LOWESTOFT LABORATORY, PAKEFIELD ROAD LOWESTOFT SUFFOLK NR33 0HT	AJ6823	SUFFOLK
94	GREENWOOD ELLIS AND PARTNERS	REYNOLDS HOUSE, 166 HIGH STREET NEWMARKET SUFFOLK CB8 9AH	AC3582	SUFFOLK
95	HUNTINGDON LIFE SCIENCES LTD	, EYE SUFFOLK IP23 7PX	AY1838	SUFFOLK
–	~~MAGNOX ELECTRIC PLC~~	~~SIZEWELL A POWER STATION LEISTON SUFFOLK IP16 4UE~~	~~AA8565~~	~~SUFFOLK~~
–	~~MAGNOX ELECTRIC PLC~~	~~DISTRICT SURVEY LABORATORY, LOVER S LANE LEISTON SUFFOLK~~	~~AJ7994~~	~~SUFFOLK~~
–	~~MAGNOX ELECTRIC PLC~~	~~SIZEWELL A NUCLEAR POWER STATION LEISTON SUFFOLK IP16 4UE~~	~~AA8176~~	~~SUFFOLK~~
–	~~MAGNOX ELECTRIC PLC~~	~~SIZEWELL A POWER STATION , LEISTON SUFFOLK IP16 4UE~~	~~AF6642~~	~~SUFFOLK~~
–	~~MAGNOX ELECTRIC PLC~~	~~SIZEWELL A POWER STATION , AUTHORISATION TO DISCHARGE GASES LEISTON SUFFOLK~~	~~AE7638~~	~~SUFFOLK~~
–	~~MAGNOX ELECTRIC PLC~~	~~SIZEWELL C SITE , LEISTON SUFFOLK IP16~~	~~AH5027~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B SITE , LEISTON SUFFOLK IP16 4UR~~	~~AB6680~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B POWER STATION , LEISTON SUFFOLK IP16 4UR~~	~~AX4190~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B POWER STATION , LEISTON SUFFOLK IP16 4UR~~	~~AS3846~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B POWER STATION , LEISTON SUFFOLK IP16 4UR~~	~~AS3820~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B POWER STATION , LEISTON SUFFOLK IP16 4UR~~	~~AS3456~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B POWER STATION LEISTON SUFFOLK IP16 4UR~~	~~AL0648~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B POWER STATION , LEISTON SUFFOLK IP16 4UR~~	~~AJ3930~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~SIZEWELL B POWER STATION , LEISTON SUFFOLK IP16 4UR~~	~~AJ3921~~	~~SUFFOLK~~
–	~~NUCLEAR ELECTRIC LTD~~	~~GEC SITE , SIZEWELL B POWER STATION LEISTON SUFFOLK IP16 4UE~~	~~AF6634~~	~~SUFFOLK~~
96	ROSSDALE AND PARTNERS	BEAUFORT COTTAGE, LABORATORIES, HIGH STREET NEWMARKET SUFFOLK CB8 8JS	AL0419	SUFFOLK
97	ROSSDALE AND PARTNERS	BEAUFORT COTTAGE DIAGNOSTIC CENTRE, COTTON END STABLES, EXNING NEWMARKET SU...	AS4273	SUFFOLK
98	SUFFOLK COLLEGE	ROPE WALK IPSWICH SUFFOLK IP4 1LT	AE0100	SUFFOLK
99	THE IPSWICH HOSPITAL NHS TRUST	THE IPSWICH HOSPITAL, HEATH ROAD IPSWICH IP4 5PD	AP3126	SUFFOLK
100	VCH LTD	UNIT 5, HIGHBURY ROAD BRANDON SUFFOLK IP27 0ND	AV7589	SUFFOLK
101	WARDLE STOREYS PLC	STOREYS INDUSTRIAL PRODUCTS LTD, BRANTHAM WORKS, BRANTHAM MANNINGTREE ESSEX...	AL2136	SUFFOLK
102	WEST SUFFOLK HOSPITALS NHS TRUST	WEST SUFFOLK HOSPITAL , HARDWICK LANE BURY ST. EDMUNDS SUFFOLK IP33 2QZ	AW0725	SUFFOLK
103	WHITE ROSE ENVIRONMENTAL	THE IPSWICH HOSPITAL, HEATH ROAD IPSWICH IP4 5PD	BA2776	SUFFOLK

APPENDIX B – ABBREVIATED LIST OF GAUGING STATIONS

Station Number	Station Name	Mean Flow ($m^3/3$)	Period of Record
030001	Witham at Claypole Mill	1.755	1959 - 1995
030002	Barlings Eau at Langworth Bridge	1.284	1960 - 1995
030003	Bain at Fulsby Lock	1.264	1962 - 1995
030005	Witham at Saltersford total	0.779	1973 - 1995
030006	Slea at Leasingham Bridge	0.589	1974 - 1995
032001	Nene at Orton	9.385	1939 - 1995
032002	Willow Brook at ~~Corthingbey~~ Fotheringhay	0.784	1938 - 1995
032004	Ise Brook at Harrowden Old Mill	1.350	1943 - 1995
032006	Nene/Kislingbury at Upton	1.379	1939 - 1995
032007	Nene Brampton at St Andrews	1.162	1939 - 1995
032008	Nene/Kislingbury at Dodford	0.612	1945 - 1995
032811	Nene/Kislingbury at Upton Bypass	0.480	1969 - 1995
032813	Nene/Brampton at St Andrews Mill Bypass	0.616	1971 - 1995
033002	Bedford Ouse at Bedford	10.200	1933 - 1995
033003	Cam at Bottisham	3.616	1936 - 1987
033007	Nar at Marham	1.156	1953 - 1995
033009	Bedford Ouse at Harrold Mill	9.460	1955 - 1993
033014	Lark at Temple	1.279	1960 - 1995
033015	Ouzel at Willen	2.049	1962 - 1995
033016	Cam at Jesus Lock	2.860	1959 - 1983
033020	Alconbury Brook at Brampton	0.760	1963 - 1993
033022	Ivel at Blunham	3.033	1965 - 1995
033023	Lea Brook at Beck Bridge	0.249	1962 - 1995
033026	Bedford Ouse at Offord	14.140	1970 - 1995
033028	Flit at Shefford	0.829	1966 - 1995
033035	Ely Ouse at Denver Complex	14.140	1958 - 1995
033037	Bedford Ouse at Newport Pagnell	4.870	1969 - 1995
033039	Bedford Ouse at Roxton	11.380	1972 - 1995
033050	Snail at Fordham	0.302	1974 - 1995
033051	Cam at Chesterford	0.601	1964 - 1995
033055	Granta at Babraham	0.242	1976 - 1995
033060	Kings Dike at Stanground	0.445	1969 - 1995

Station Number	Station Name	Mean Flow ($m^3/3$)	Period of Record
034001	Yare at Colney	1.400	1959 - 1995
034002	Tas at Shotesham	0.725	1957 - 1995
034004	Wensum at Costessey Mill	4.029	1960 - 1995
034005	Tud at Costessey Park	0.349	1961 - 1995
034007	Dove at Oakley Park	0.654	1966 - 1995
035001	Gipping at Constantine Wier	1.384	1961 - 1995
037002	Chelmer at Rushes Lock	1.879	1932 - 1995
037005	Colne at Lexden	1.036	1959 - 1995

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APPENDIX C - DETAILS OF LOCATIONS RELEASING LIQUID EFFLUENTS IN ANGLIAN REGION

C.1 Direct discharge to water body

C.2 Discharge via Public STW

C.3 Discharge via Private STW

Name of premises	Receiving water body	Flow / dilution rate in receiving body, m^3 per second
C.1 Direct discharge to water body		
Carless Refinery (57ESS)	Stour Estuary	10 (estimated)
Conoco (72LIN)	North Sea	300 (estimated)
MAFF (93SUF)	North Sea	300 (estimated)
Millenium Inorganic (69/70HUM) *	Humber Estuary	300 (estimated)
Mobil Oil (61ESS)	Thames Estuary	300 (estimated)
Shell (64ESS)	Thames Estuary	300 (estimated)

Name of sewage treatment works	Raw sewage input, m^3 per day	Receiving water body	Flow / dilution rate in receiving body, m^3 per second
C.2 Discharge via Public STP:			
Basildon	28,400	Pitsea Creek (tidal) (no GS)	1 (assumed)
Bedford	35,000	R Great Ouse	10.2
Boston	10,000	R Witham	4.9
Broadholme	46,500	R Nene	4.5
Bury St. Edmunds	11,000	R Lark	1.28
Camwick	29,400	R Witham (via South Delph)	1.78
Chelmsford	52,050	R Chelmer	1.04
Cliff Quay	10,760	R Orwell (tidal)	0.78
Corby	28,500	R Nene (via Willow Brook)	1.38
Cotton Valley	54,610	R Great Ouse	6.9
Flag Fen	58,000	R Nene	9.4
Grantham	14,300	R Witham	0.78
Great Billing	50,000	R Nene	3.2
Great Chesterford	432	R Cam	0.60
Haven	27,300	R Colne	1.04
Huntingdon	10,700	R Ouse	14.9
Kentford	350	R Kennett (via Lea Brook)	0.249
Kings Lynn	26,000	R Ouse	15.3
Melbourn	1,800	R Mel	0.5 (assumed)
Milton	36,000	R Cam	3.2
Newmarket	6,100	R Snail (via Public No.1 Drain)	0.3
Papworth Everard	500	R Great Ouse (via West Brook)	0.5 (assumed)
Pyewipe (pumping station)		Humber Estuary (no GS)	300 (estimated)
Sandy	1,800	R Ivel	3.0
Silsoe	1,800	R Flitt	0.83
Southend	36,500	Thames Estuary (no GS)	300 (estimated)
Uttons Drove	3,550	Tributary (no name) of R Great Ouse	0.5 (assumed)
Whittlingham	73,000	R Yare (tidal)	6.5

Name of sewage treatment works	Raw sewage input, m3 per day	Receiving water body	Flow / dilution rate in receiving body, m^3 per second
C.3 Discharge via Private Sewage Treatment Works			
Agrevo	180	R Cam (via un-named stream)	0.60
Babraham Institute	250	R Granta	0.242
Conoco	12,000	Humber Estuary (via S Killingholme main drain) (no GS)	300 (estimated)
Cranfield	333	R Great Ouse (via Chicheley Brook)	6.9
Huntingdon Life Sciences, Alconbury	300	Alconbury Brook (via Cock Brook)	0.76
Huntingdon Life Sciences, Eye	300	R Dove (via Cock Brook) CHECK	0.65
Inst. Terrestrial Ecology	10	Kings Dyke (via Ewingswode Stream)	0.45
Lindsey Oil	6,000	Humber Estuary (via N Killingholme Drain) (no GS)	300 (estimated)
Unilever Research	600	R Great Ouse (via Sharn Brook)	9.5
Woodland Hospital	20	Soakaway on site (no GS)	Not applicable