



Nuclear Site Specific Hydrographic Parameters for use with the WAT/ADO Models

**Science commissioned by:
Food Standards Agency**

**CEFAS Contract RB101
Environment Report RL12/03**

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CEFAS contract RB102**

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1 Introduction

The purpose of this report is to provide a set of site specific hydrographic parameters for use with CEFAS' aquatic assessment models (WAT and ADO) applied to each nuclear installation within the United Kingdom. This information is intended to be used as a starting point for re-authorisation assessments and to assist the habits team in defining the area covered by habits surveys. Descriptions of parameters and the use of the model can be found in the WAT/ADO user guide¹.

Each site has text describing its location, purpose and a description of the local area around the site. A map of the site and the surrounding area is also included followed by tables containing the data for the current liquid discharge authorisation and the site specific hydrographic parameters for the aquatic environment.

It is important to note that the data given is not meant to be definitive but to be used as a guide or initial estimate. This is because some parameters may change over time or require modification when more accurate data is available. New authorisations should be validated by comparison with environmental data where available to ensure that the models are realistically simulating the 'real-world' situation.

Further updates of the guide will be available periodically.

¹ Grzechnik, M.P. (2002). A User Guide for Radiological Assessments, PC Version 1.0.

2 Aldermaston and Burghfield

2.1 Aldermaston

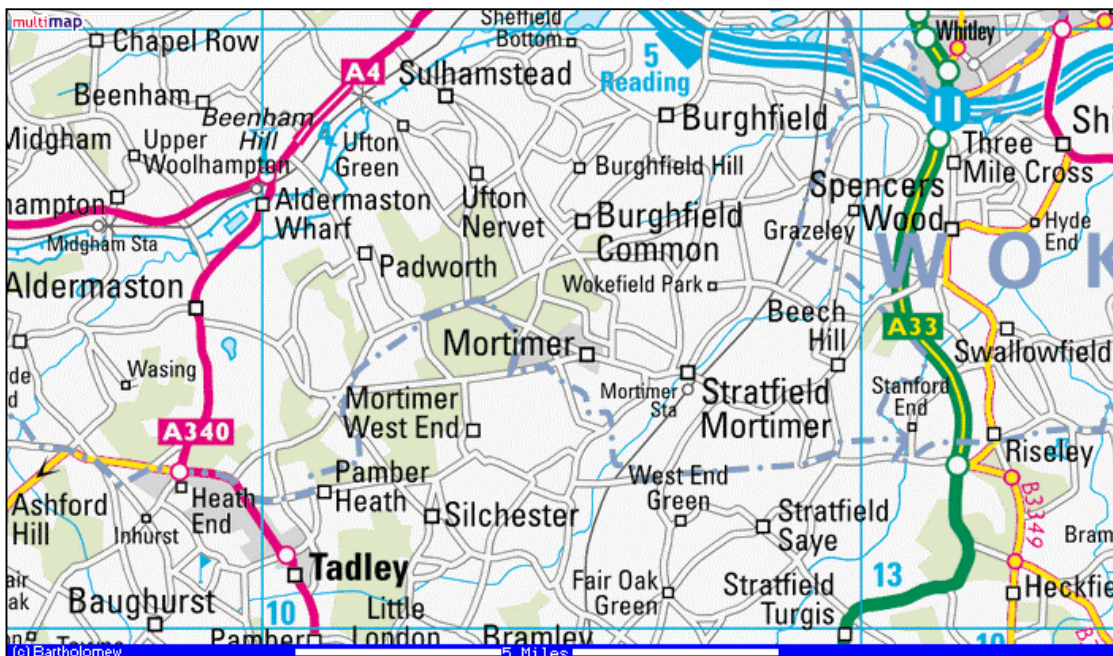
- Owner – AWE Management Limited
- Date started production – 1950

2.2 Burghfield

- Owner – Ministry of Defence
- Date started production – 1960

Aldermaston and Burghfield are both involved in processing nuclear material in support of the national defence programme. The sites are situated 3 miles apart in the Thames valley, approximately 5 miles south of Reading and 15 miles north of Basingstoke. The Aldermaston site has 3 liquid discharge routes, via pipeline to the River Thames at Pangbourne, via the public sewer to the sewage works at Silchester and also to the Aldermaston stream. Burghfield has not discharged any liquid effluents since 1 April 2000 and is considered unlikely to do so again. Gaseous discharges are released via stacks at both sites. The local area around both Aldermaston and Burghfield consists mainly of arable land.

Fig 1 Map of the Aldermaston and Burghfield local area



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2.3 Current liquid discharge limits for Aldermaston

Nuclide	Aldermaston (Pipeline) (TBq)	Aldermaston (Silchester) (TBq)	Aldermaston (Stream) (TBq)
Alpha	6.0 10 ⁻⁵	4.0 10 ⁻⁵	N/A
Beta	N/A	1.2 10 ⁻⁴	N/A
Tritium	0.05	0.05	0.01
Plutonium-241	2.4 10 ⁻⁴	N/A	N/A
Other radionuclides	6.0 10 ⁻⁵	N/A	N/A

2.4 Hydrographic Data

As the site discharges into a non-tidal inland waterway then the WAT and ADO models used to run saltwater assessments become invalid. An excel based freshwater river model has been developed, *Freshwater_master.xls*. Guidance on how to use this model is given in Appendix A.

Parameter	Value
Model	Freshwater_master.xls
Flow rate (m ³ s ⁻¹)	12 (R.Thames) 0.072 (Aldermaston Stream)
Suspended sediment load (g m ⁻³)	20 (R.Thames) 10 (Aldermaston Stream)
Fish consumption data (kg/yr)	Adults –1 15 yr olds – 0.5 10 yr olds – 0.5 1 yr olds – 0
Occupancy Rate (hrs/yr)	Adults– 360 15 yr olds– 360 10 yr olds– 360 1 yr olds– 3.6
Modifying factor (dependent on bankside conditions i.e concrete, mud, grass)	1.0
Dry/Wet mass ratio	1.66
Mud wet density	0.6

2.5 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

3 Amersham

3.1 Amersham

- Owner – Amersham Plc
- Date started production – 1940

Amersham Plc is a pharmaceuticals company manufacturing radioactively labelled materials for use in medicine, research and industry. The main establishment in Britain is situated approximately 1 mile outside Amersham, Buckinghamshire. The site discharges liquid effluent into the Grand Union Canal and the River Colne via the local sewers and the Maple Lodge sewage works. Gaseous discharges are released via stacks at the station. The local area around Amersham is mainly urban industry, housing and some arable fields.

Fig 2 Map of the Amersham local area



3.2 Current liquid discharge limits for Amersham

Nuclide	Amersham Liquid discharge limit (TBq)
Alpha	3.0×10^{-4}
Beta >0.4 MeV	0.1
Tritium	0.2
Iodine-125	0.2
Caesium-137	0.005
Other radionuclides	0.3

3.3 Hydrographic Data

As the site discharges into a non-tidal inland waterway, the WAT and ADO models used to run saltwater assessments become invalid. An excel based freshwater model has been developed, *Freshwater_master.xls*. Guidance on how to use this model is given in the Appendix.

Parameter	Value
Model	Freshwater_master.xls
Flow rate (m ³ s ⁻¹)	6.8
Suspended sediment load (g m ⁻³)	10
Fish consumption data (kg/yr)	Adults –1 15 yr olds – 0.5 10 yr olds – 0.5 1 yr olds – 0.4
Occupancy Rate (hrs/yr)	Adults –1350 15 yr olds – 300 10 yr olds – 300 1 yr olds – 300
Modifying factor (dependent on bankside conditions i.e concrete, mud, grass)	0.1 (concrete banks)
Dry/Wet mass ratio	1.66
Mud wet density	0.6

3.4 References

Round (1999). Nycomed Amersham Plc, Amersham Laboratory Authorisation Application 1998: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL5/99.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

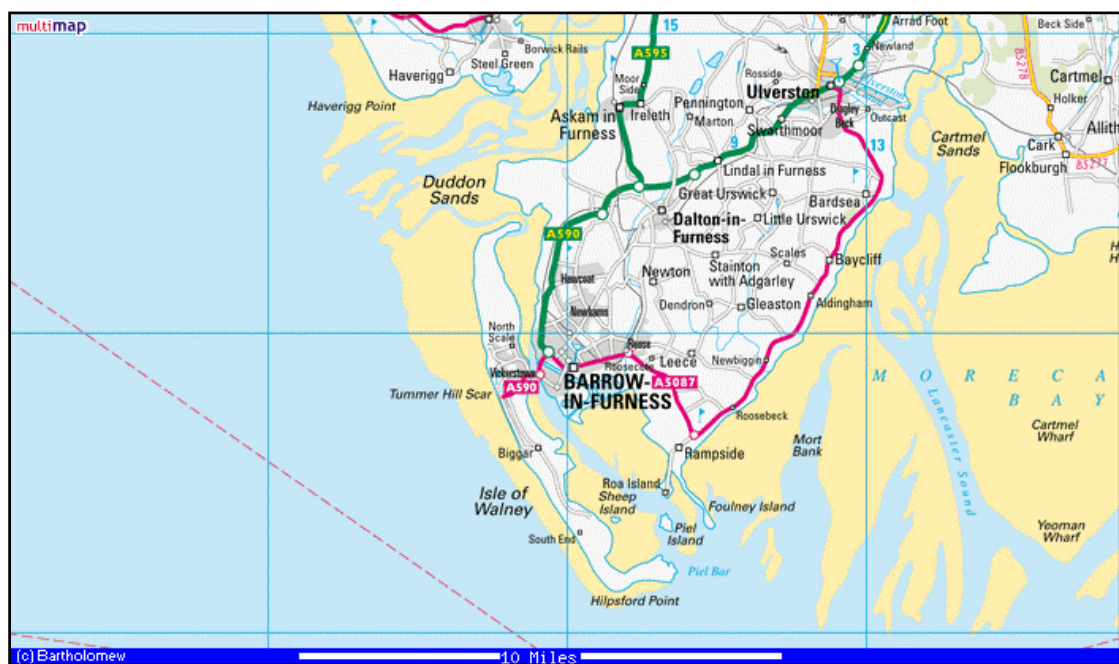
4 Barrow in Furness

4.1 Barrow in Furness

- Owner – BaE Systems Marine Ltd

Barrow in Furness is situated on the north-western tip of Morecambe Bay in the north of England. It is approximately 25 miles west of Lancaster. The site builds and refits nuclear powered submarines, and is the site of the harbour for the Pacific Nuclear Transport Limited (PNTL) ships. It discharges liquid effluent into Morecambe Bay via the public sewer system and the Walney Channel. In the vicinity of the outfall the bed of the Walney Channel is mainly mud with occasional sandy patches. Gaseous discharges are released via stacks at the site. The local area around the site at Barrow in Furness is mainly marine-based industry.

Fig 3 Map of the Barrow in Furness local area



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4.2 Current liquid discharge limits for Barrow in Furness

Nuclide	Barrow Liquid discharge limit (TBq)
Tritium	0.02
Manganese-54	$2.5 \cdot 10^{-7}$
Cobalt-58	$7.0 \cdot 10^{-7}$
Cobalt-60	$7.0 \cdot 10^{-8}$
Tin-113	$2.5 \cdot 10^{-7}$
Antimony-124	$2.0 \cdot 10^{-6}$
Other radionuclides	$3.5 \cdot 10^{-6}$

4.3 Hydrographic Data

To calculate the hydrographic data for the Barrow in Furness area, hydrographic chart map No. 3164 should be used. This map, together with information from the local harbour master, may be used calculate the exchange volume and mean depth. Data on sedimentation rates and suspended loads have been obtained from the site's last re-authorisation application. When running the WAT model, the single compartment model should be applied since the discharge point enters a channel in which conditions are similar to those of an estuary.

Parameter	Value
Model	Single compartment
Dispersion factor: changes per day	0.4
Exchange volume, km ³	0.1
Suspended sediment load (ppm=mg l ⁻¹)	12.5
Sedimentation rate (kg m ⁻² y ⁻¹)	10
Mean depth (m)	20
Estuarine silt sedimentation rate (m y ⁻¹)	0.04

4.4 References

Barrow in Furness Harbourmaster. Personal Communication, 2002

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

5 Berkeley / Oldbury

5.1 Berkeley

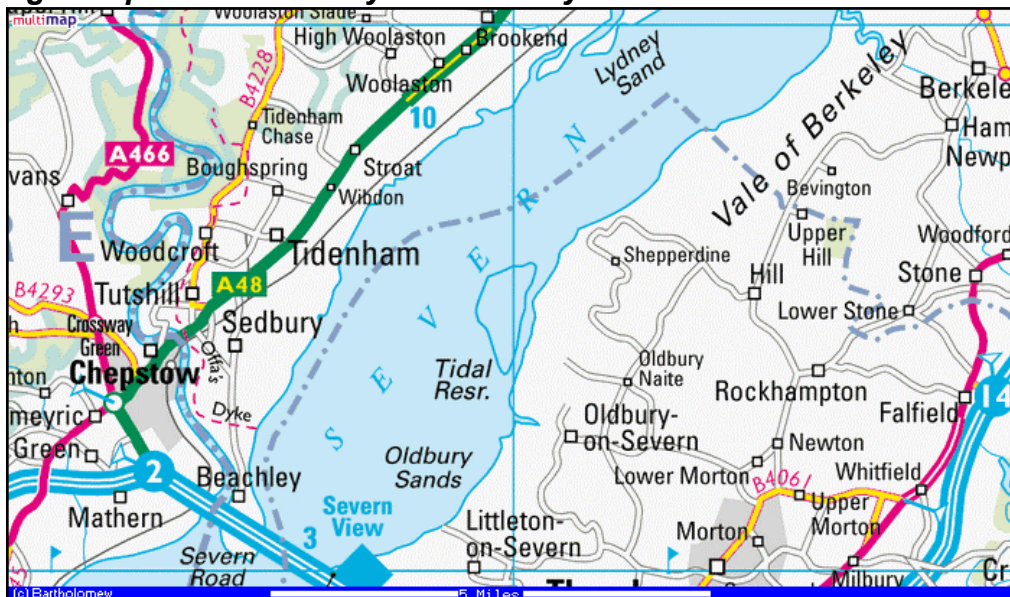
- Owner – Magnox Electric / BNFL
- Date started production – 1962
- Date closed – 1989 (de-fuelled in 1992)

5.2 Oldbury

- Owner – British Energy Generation Ltd / BNFL
- Date started production – 1967
- Capacity (mw) – 434

Berkeley and Oldbury are separate sites situated within 5 miles of each other on the Severn estuary in the West of England. They are approximately 15 miles north of Bristol and 15 miles south of Gloucester. The power station at Berkeley ceased generating electricity in 1989 although radioactive wastes are still generated and discharged as part of the decommissioning process. Also on the Berkeley site is the Berkeley Technology Centre which contributes to the discharge authorisation for the site. Oldbury is about 4 miles south-west of Berkeley. Each station discharges liquid effluent into the River Severn via separate outfalls, which are approximately 100 metres offshore. The riverbed in the vicinity of the outfalls is mainly mud with occasional patches of sand. Gaseous discharges are released via stacks at each station. The local area around Berkeley and Oldbury is mainly arable fields, the nearest town to Berkeley being Dursley which is 4 miles from the site and the nearest to Oldbury is Thornbury which is 3 miles east of the site

Fig 4 Map of the Berkeley and Oldbury local area



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5.3 Current liquid discharge limits for Berkeley and Oldbury

<i>Nuclide</i>	<i>Berkeley Liquid discharge limit (TBq)</i>	<i>Oldbury Liquid discharge limit (TBq)</i>
Tritium	8	25
Caesium-137	0.2	0.7
Other radionuclides	0.4	1.3

5.4 Hydrographic Data

To calculate the tidal diamond data for the Berkeley / Oldbury area, hydrographic chart No. 1166 should be used. Tidal diamond C would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to the coastline at the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using $Td.xls$ as described in Appendix C. When running the WAT model, the single compartment model should be used due to the two sites being situated on the banks of the River Severn.

<i>Parameter</i>	<i>Value</i>
Model	Single compartment
Dispersion factor: changes per day	0.4
Diffusion coefficient ($m^2 s^{-1}$)	1
Exchange volume, km^3	0.1
Suspended sediment load ($ppm=mg l^{-1}$)	200
Sedimentation rate ($kg m^{-2} y^{-1}$)	5.0
Mean depth (m)	5.0
Estuarine silt sedimentation rate ($m y^{-1}$)	0.04

5.5 References

Hunt & Round (1998). Magnox Power Station Authorisation Applications, January 1998: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL3/98.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

6 Bradwell

6.1 Bradwell

- Owner – Magnox Electric / BNFL
- Date started production – 1962
- Date production ceased - 2002
- Capacity (mw) – 246

Bradwell is situated on the Blackwater estuary on the eastern coast of England approximately 15 miles east of Chelmsford. The power station at Bradwell ceased generating electricity in 2002 although radioactive wastes are still generated and discharged as part of the decommissioning process. The station discharges liquid effluent into the River Blackwater via a pipeline, this is discharged 200 metres offshore. The riverbed in the vicinity of the pipeline is mainly mud with occasional patches of sand. Gaseous discharges are released via stacks at each station. The local area around Bradwell consists mostly of arable fields, the nearest town to Bradwell being Burnham on Crouch, which is 8 miles from the site.

Fig 5 Map of the Bradwell local area



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6.2 Current liquid discharge limits for Bradwell

Nuclide	Bradwell Liquid discharge limit (TBq)
Tritium	30
Caesium-137	0.75
Other radionuclides	1

6.3 Hydrographic Data

To calculate the tidal diamond data for the Bradwell area, hydrographic chart No. 3741 should be used. Tidal diamond B would be the most appropriate as it fulfils most of the selection criteria, namely it is not too far offshore and the coastline is similar to that at the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using $Td.x/s$ as described in Appendix C. When running the WAT model, the single compartment model should be used due to the site being situated on the banks of the River Blackwater.

Parameter	Value
Model	Single compartment
Dispersion factor: changes per day	0.012
Exchange volume, km ³	0.67
Suspended sediment load (ppm=mg l ⁻¹)	80
Sedimentation rate (kg m ⁻² y ⁻¹)	5.0
Mean depth (m)	9.0
Estuarine silt sedimentation rate (m y ⁻¹)	0.04

6.4 References

Hunt & Round (1998). Magnox Power Station Authorisation Applications, January 1998: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL3/98.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

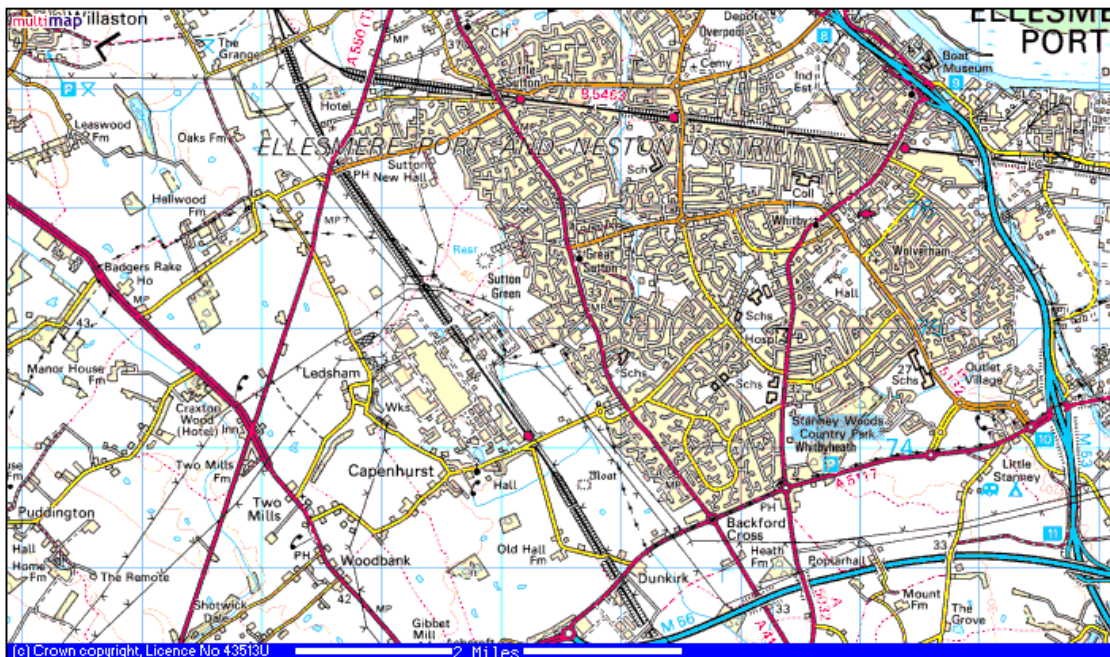
7 Capenhurst

7.1 Capenhurst

- Owner – BNFL (enrichment facility operated by Urenco (Capenhurst) Ltd)
- Ceased operations 1982

The site at Capenhurst consists of centrifuge plants and a redundant gaseous diffusion plant. Urenco took over the ownership and operations of the centrifuge plants in 1993, whilst BNFL decommissioned the gaseous diffusion plant. The site is also used as a uranic storage service for the nuclear industry. Capenhurst is approximately 10 miles north of Chester on the Wirral peninsular in the north-west of England. The site discharges liquid effluent into the River Mersey via the Rivacre brook, a small feeder stream to which the site directly discharges. The riverbed in the vicinity of the discharge point is mainly muddy sand. Gaseous discharges are released via stacks at the site. The local area around Capenhurst is mainly arable farmland, the nearest town to Capenhurst being Ellesmere Port, which is 4 miles to the north-east of the site.

Fig 6 Map of the Capenhurst local area



7.2 Current liquid discharge limits for Capenhurst

Nuclide	Capenhurst Liquid discharge limit (TBq)
Uranium	0.02
Uranium daughters	0.02
Non-Uranic alpha	0.003
Technetium-99	0.1
Tritium	87.5

7.3 Hydrographic Data

As the site discharges into a non-tidal inland waterway then the WAT and ADO models used to run saltwater assessments become invalid. An excel based freshwater river model has been developed, *Freshwater_master.xls*. Guidance on how to use this model is given in Appendix A.

Parameter	Value
Model	Freshwater_master.xls
Flow rate (m ³ s ⁻¹)	0.0222
Suspended sediment load (g m ⁻³)	1.7
Fish consumption data (kg/yr)	Adults –1
Occupancy Rate (hrs/yr)	Children– 500
Modifying factor (dependent on bankside conditions i.e concrete, mud, grass)	1.0
Dry/Wet mass ratio	1.66
Mud wet density	0.6

7.4 References

BNFL (2000). Discharges and Monitoring of the Environment in the United Kingdom, Annual Report 2000, British Nuclear Fuels Ltd.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

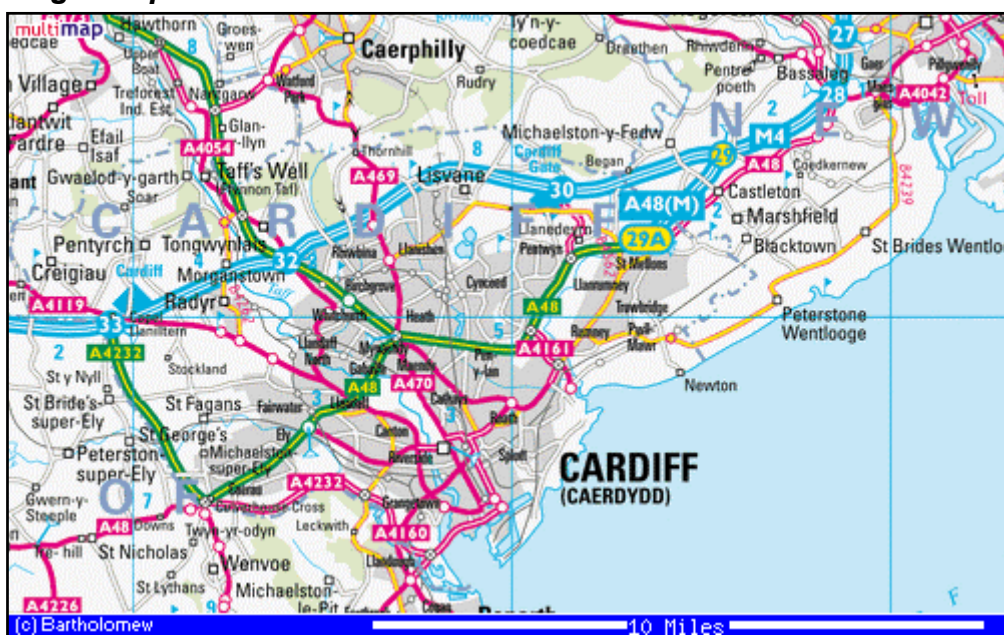
8 Cardiff

8.1 Cardiff

- Owner – Amersham Plc
- Date started production – 1980

Amersham Plc is a pharmaceuticals company manufacturing radioactively labelled materials for use in medicine, research and industry. The Welsh subsidiary is situated on the outskirts of Cardiff. The site discharges liquid effluent via the public sewer into the Severn estuary. Occasionally in periods of heavy rain, stormwater containing small amounts of radioactivity may overflow from the sewer into the River Taff. Gaseous discharges are released via stacks at the station. The local area around Cardiff is mainly urban industry and housing and some arable fields.

Fig 7 Map of the Cardiff local area



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8.2 Current liquid discharge limits for Cardiff

Nuclide	Cardiff Liquid discharge limit (TBq)
Tritium	900
Carbon-14	2
Phosphorus-32/33	0.01
Iodine-125	0.05
Other radionuclides	5.0×10^{-4}

8.3 Hydrographic Data

To calculate the tidal diamond data for the Cardiff area, hydrographic chart No. 1182 should be used. Tidal diamond B would be the most appropriate as it fulfils most of the selection criteria, namely it is not too far offshore and the coastline is similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using $Td.x/s$ as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity ($m\ s^{-1}$)	0.026
Diffusion coefficient ($m^2\ s^{-1}$)	10
Half tidal excursions (m)	4300
Initial spreading radius (m)	50
Start time for discharges: t_s	0.08
End time for discharges: t_e	0.33
Distance to critical group (m)	0
Suspended sediment load ($ppm=mg\ l^{-1}$)	500
Sedimentation rate ($kg\ m^{-2}\ y^{-1}$)	15.0
Mean depth (m)	5.0
Estuarine silt sedimentation rate ($m\ y^{-1}$)	0.02

8.4 References

Hunt G J (2001). Amersham PLC, Cardiff Laboratories Nuclear Licensed Site Authorisation Application 2001: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL14/01.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

9 Chapelcross

9.1 Chapelcross

- Owner – Magnox Electric plc / BNFL
- Date started production – 1959
- Capacity (mw) – 168

Chapelcross is situated on the northern coast of the Solway Firth in the south-west of Scotland approximately 15 miles north-west of Carlisle and 15 miles east of Dumfries. There are four magnox type reactors operating on site. The site discharges liquid effluents via a 5km pipeline into the Solway Firth just south of Annan, the pipeline discharges directly onto the Solway Firth shoreline. The shoreline in the vicinity of the end of the pipeline is mostly sediment flats. Gaseous discharges are released via stacks at the site. The local area around Chapelcross consists mainly of arable fields, the nearest town being Annan.

Fig 8 Map of the Chapelcross local area



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9.2 Current liquid discharge limits for Chapelcross

Nuclide	Chapelcross Liquid discharge limit (TBq)
Alpha	0.1
Beta	25
Tritium	5.5

9.3 Hydrographic Data

To calculate the box parameters for the Chapelcross area, hydrographic chart No. 1346 should be used. Using the chart, all the parameters needed to calculate the volume and depth of the box can be obtained. Sediment data can be found either from previous reports, comparison with other sites in similar areas or by contacting the site or Environment Agency. When running the WAT model, the single compartment model should be used as the pipeline outfall from the site is situated on the banks of the Solway Firth.

Parameter	Value
Model	Single compartment
Dispersion factor: changes per day	
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	1
Exchange volume, km^3	
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	200
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	5.0
Mean depth (m)	5
Estuarine silt sedimentation rate (m y^{-1})	0.04

9.4 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

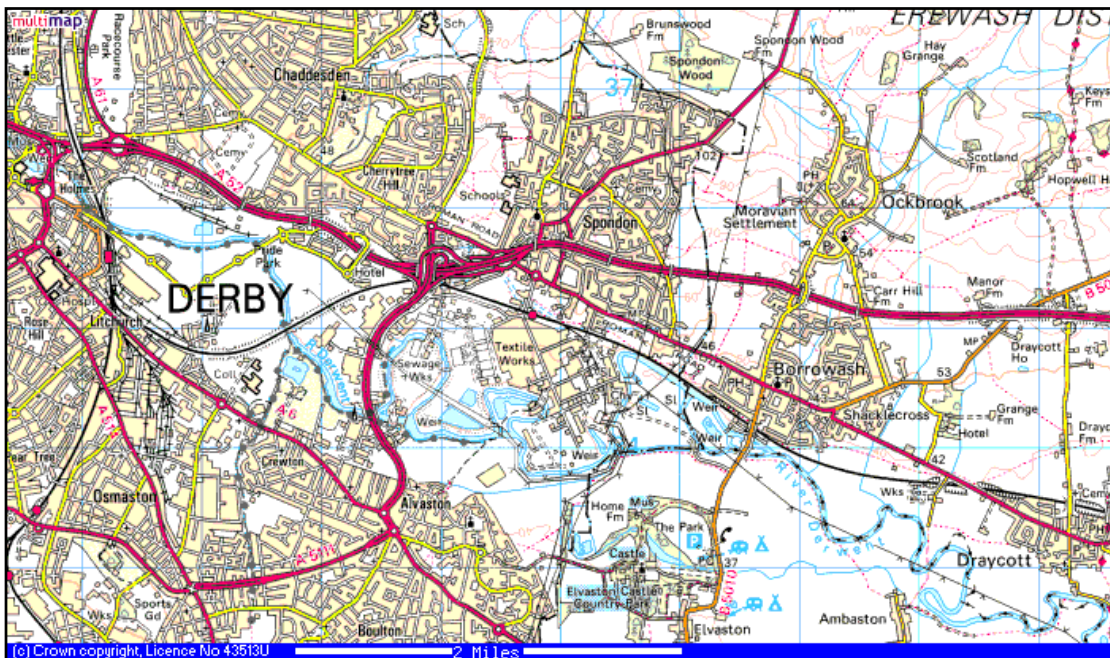
10 Derby

10.1 Derby

- Owner – Rolls-Royce Marine Power Operations Limited

Rolls Royce Derby manufactures fuel for nuclear powered submarines. The site is situated in the Midlands approximately 2 miles east of Derby. The site discharges liquid effluent into the public sewer, which then enters the River Derwent via the Raynesway sewage works. Gaseous discharges are released via stacks at the site. The local area around Derby generally consists of industrial estates.

Fig 9 Map of the Derby local area



10.2 Current liquid discharge limits for Derby

Nuclide	Manufacturing Division Liquid discharge limit (MBq)	Neptune Nuclear Licensed Site Liquid discharge limit (MBq)
Any Alpha emitting radionuclide	2000 6000 during decommissioning (Typically U-234 (0.71%) U-235 (93%) and U-238 (6.29%))	100 (Typically U-234)
Any beta-gamma emitting radionuclide	N/A	2000 (Typically Co-60)

10.3 Hydrographic Data

As the site discharges into a non-tidal inland waterway then the WAT and ADO models used to run saltwater assessments become invalid. An excel based freshwater river model has been developed, *Freshwater_master.xls*. Guidance on how to use this model is given in Appendix A.

Parameter	Value
Model	Freshwater_master.xls
Flow rate (m ³ s ⁻¹)	19.19
Suspended sediment load (g m ⁻³)	15.2
Fish consumption data (kg/yr)	Adults –1 15 yr olds – 0.5 10 yr olds – 0.5 1 yr olds – 0.4
Occupancy Rate (hrs/yr)	Adults– 1000 15 yr olds– 650 10 yr olds– 650 1 yr olds– 300
Modifying factor (dependent on bankside conditions i.e concrete, mud, grass)	1.0
Dry/Wet mass ratio	1.66
Mud wet density	0.6

10.4 References

Winpenny (2001). Rolls-Royce Marine Power Operations Limited, Nuclear Fuel Production Plant Site and Neptune Nuclear Licensed Site Authorisation Applications 2000: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL 25/00.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

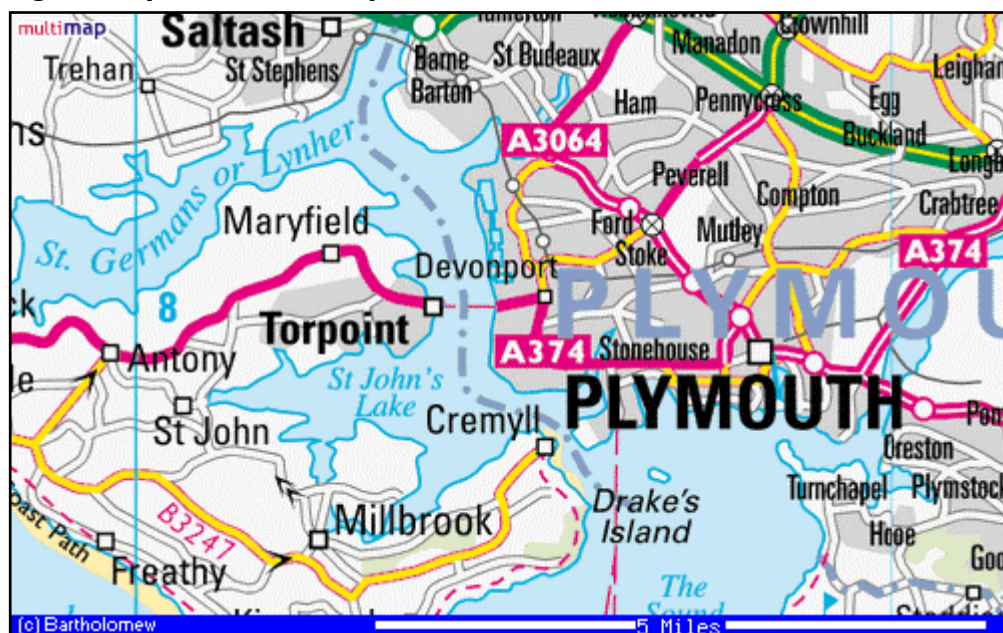
11 Devonport

11.1 Devonport

- Owner – Devonport Royal Dockyard Ltd

Devonport is a nuclear submarine berth situated on the River Tamar in Devon, England, it is approximately 1 mile west of Plymouth. As well as being a berthing point for nuclear submarines the dockyard has the capacity to dismantle the submarines when decommissioned. The site discharges liquid effluent into the River Tamar via pipeline and sewer. The riverbed in the vicinity of the discharge point is mainly mud with occasional sandy patches. The local area around Devonport is mainly urban housing and local marine-based industry.

Fig 10 Map of the Devonport local area



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11.2 Current liquid discharge limits for Devonport

Nuclide	Devonport Liquid discharge limit (TBq)
Total (excl. H-3 & Co-60)	0.001
Tritium	0.12
Cobalt-60	0.006

11.3 Hydrographic Data

To calculate the tidal diamond data for the Devonport area, hydrographic chart No. 1901 should be used. Tidal diamond B would be the most appropriate as it fulfils most of the selection criteria, it is not too far downstream and it is as far up the estuary as is possible to quantify. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the single compartment model should be used as the site is situated on the banks of the River Tamar.

Parameter	Value
Model	Single compartment
Dispersion factor: changes per day	0.8026
Exchange volume, km ³	0.02939
Suspended sediment load (ppm=mg l ⁻¹)	30
Sedimentation rate (kg m ⁻² y ⁻¹)	0
Mean depth (m)	10
Estuarine silt sedimentation rate (m y ⁻¹)	0.01

11.4 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

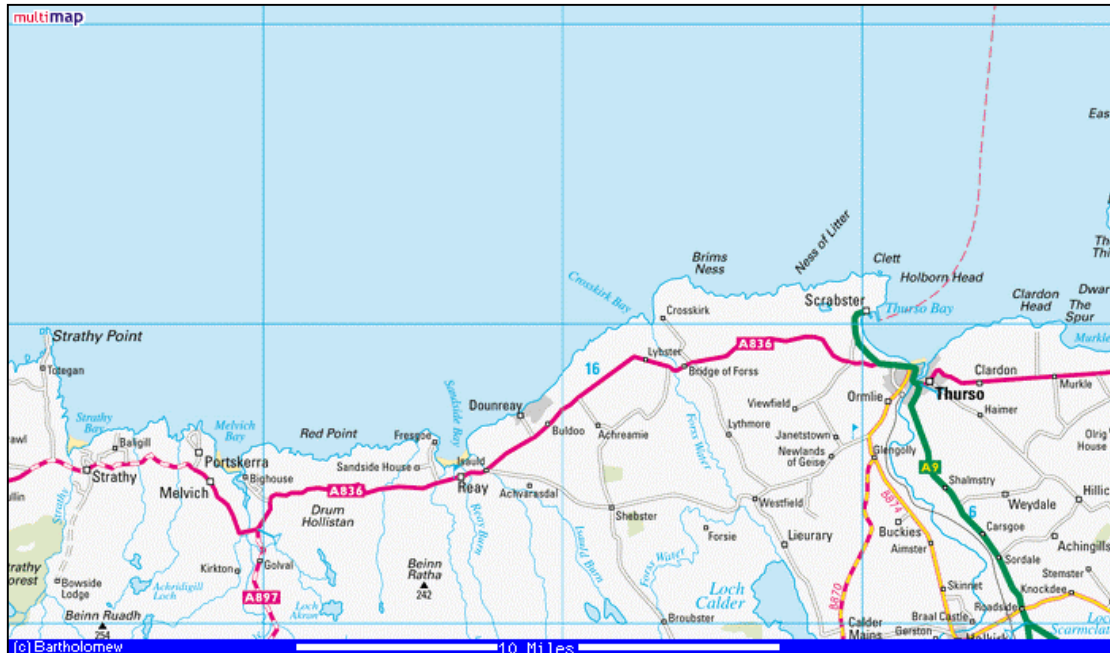
12 Dounreay

12.1 Dounreay

- Owner – United Kingdom Atomic Energy Authority
- Date started production – (1955)
- Capacity (mw) – 1300

Dounreay is situated on the northern coast of Scotland approximately 10 miles west of Thurso. The power station at Dounreay ceased generating electricity in 1998 although radioactive wastes are still generated and discharged as part of the decommissioning process. Other contributions to the sites discharges are from the Ministry of Defence owned Vulcan Naval Test Reactor Establishment, which occupies a small part of the site. The site discharges liquid effluent into the Pentland Firth area of the North Atlantic Ocean via three pipelines; a main pipeline and two subsidiary ones. The main pipeline discharges 500 metres offshore at a depth of 21m. The seabed in the vicinity of the outfall is mainly sand with occasional patches of rock. Gaseous discharges are released via stacks at the station. The local area around Dounreay mainly consists of arable fields, the nearest town being Thurso.

Fig 11 Map of the Dounreay local area



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12.2 Current liquid discharge limits for Dounreay

Nuclide	Dounreay Liquid discharge limit (TBq)
Alpha	0.27
Beta	49
Tritium	30.8
Cobalt-60	0.46
Strontium-90	7.7
Zirconium-95 + Niobium-95	0.4
Ruthenium-106	4.1
Silver-110m	0.13
Caesium-137	23
Cerium-144	0.42
Plutonium-241	2.3
Curium-242	0.04

12.3 Hydrographic Data

When calculating the tidal diamond data for the Dounreay area, it was determined that the data provided by the chart was inaccurate. The tidal diamonds showed that the direction of the residual flow was from east to west, i.e. from the North Sea through the Pentland Firth into the North Atlantic Ocean. This is at odds with other, more recent oceanographic data from the same area. In 2002 CEFAS was asked to do an oceanographic survey in the area of the Dounreay pipeline. It was decided to use this data as a basis for the input files rather than use the spurious tidal diamond data.

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.052
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	10
Half tidal excursions (m)	6700
Initial spreading radius (m)	50
Start time for discharges: t_s	0
End time for discharges: t_e	1
Distance to critical group (m)	10000- Consumption 2500 – Collection 2500 – Handling 1000 – Geos
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	1
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	0
Mean depth (m)	22.9
Estuarine silt sedimentation rate (m y^{-1})	0.02

12.4 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

Rees, J (2001). Minipod deployment 2 at Dounreay, Dec 2001. CEFAS Report C1214.

13 Dungeness

13.1 Dungeness A

- Owner – Magnox Electric plc / BNFL
- Date started production – 1965
- Capacity (mw) – 450

13.2 Dungeness B

- Owner – British Energy Generation Ltd
- Date started production – 1983
- Capacity (mw) – 1110

Dungeness is situated on the south-east coast of England approximately 15 miles north-east of Hastings and 15 miles south-west of Folkestone. There are two nuclear power stations situated here. The 'A' station is owned by Magnox Electric plc BNFL and powered by twin Magnox reactors, the 'B' station is owned by British Energy Generation Ltd and is powered by twin advanced gas-cooled reactors (AGR). Each station discharges liquid effluent into the English channel via adjacent offshore outfalls. The seabed in the vicinity of the outfalls is mainly stones with occasional patches of sand. Gaseous discharges are released via stacks at each station. The local area around Dungeness is mainly marshland and nature reserves, the nearest town being Lydd which is 5 miles from the site.

Fig 13 Map of the Dungeness local area



13.3 Current liquid discharge limits for Dungeness 'A' and 'B'

Nuclide	Dungeness 'A' Liquid discharge limit (TBq)	Dungeness 'B' Liquid discharge limit (TBq)
Tritium	35	650
Sulphur-35	-	2
Cobalt-60	-	0.03
Caesium-137	1.2	-
Other radionuclides	1.4	0.25

13.4 Hydrographic Data

To calculate the tidal diamond data for the Dungeness area, hydrographic chart No. 1892 should be used. Tidal diamond C would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the advection-diffusion model should be used, as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.04
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	5
Half tidal excursions (m)	4500
Initial spreading radius (m)	50
Start time for discharges: t_s	0
End time for discharges: t_e	1
Distance to critical group (m)	0
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	80
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	10.0
Mean depth (m)	10.0
Estuarine silt sedimentation rate (m y^{-1})	0.02

13.5 References

Hunt & Round (1998). Magnox Power Station Authorisation Applications, January 1998: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL3/98.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

14 Faslane

14.1 Faslane

- Owner – Ministry of Defence (HM Naval base)
- Date opened - 1967

Faslane, on the shore of Gare Loch in the Strathclyde region of Scotland, is also known as HM Naval Base Clyde. It is situated on the western coast of Scotland approximately 25 miles north-west of Glasgow. The base is the home to Swiftsure class nuclear submarines, Trident armed submarines, minesweepers and the Northern Diving group. The Faslane site not only provides berthing facilities for the submarines but it can also undertake out of the water repairs and maintenance. The site discharges liquid effluent via a short pipeline into the Gare Loch, which feeds into the Firth of Clyde area of the Irish sea. The seabed in the vicinity of the outfall is mainly small stones with occasional sandy patches. Faslane releases no gaseous discharges. The local area around Faslane is mainly rural countryside and hillside farming areas, the nearest town being Helensburgh.

Fig 14 Map of the Faslane local area



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14.2 Current liquid discharge limits for Faslane

Nuclide	Faslane Liquid discharge limit (TBq)
Tritium	1
Alpha	$2.0 \cdot 10^{-4}$
Beta	$5.0 \cdot 10^{-4}$
Cobalt-60	$5.0 \cdot 10^{-4}$

14.3 Hydrographic Data

To calculate the tidal diamond data for the Gare Loch area, hydrographic chart No. 2000 should be used. When running the WAT model, the single compartment model should be applied as the site is situated on the banks of the Gare Loch, a marine loch enclosed on three sides producing estuarine-like conditions.

Parameter	Value
Model	Single compartment
Dispersion factor: changes per day	0.04
Exchange volume, km ³	0.45
Suspended sediment load (ppm=mg l ⁻¹)	10
Sedimentation rate (kg m ⁻² y ⁻¹)	0.2
Mean depth (m)	30
Estuarine silt sedimentation rate (m y ⁻¹)	0.04

14.4 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

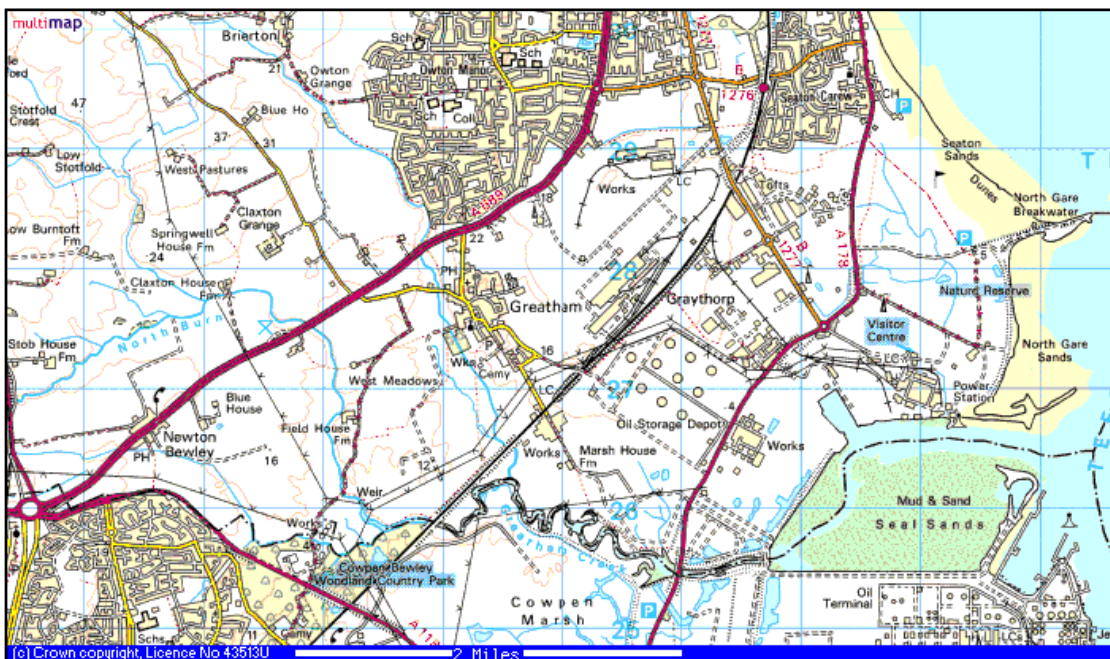
15 Hartlepool

15.1 Hartlepool

- Owner – British Energy Generation Ltd
- Date started production – 1983
- Capacity (mw) – 1210

Hartlepool is situated on the north-east coast of England approximately 10 miles north of Middlesbrough and 20 miles south of Sunderland. There is one nuclear power station situated here owned by British Energy Generation Ltd and powered by twin advanced gas-cooled reactors. The station discharges liquid effluent into the North Sea via a pipeline, which extends to 200 metres offshore. The seabed in the vicinity of the outfalls is mainly sand with occasional patches of gravel. Gaseous discharges are released via stacks at each station. The local area around the site consists of mainly industrial works and nature reserves, the nearest town being Seaton Carew, which is 1 mile from the site.

Fig 15 Map of the Hartlepool local area



15.2 Current liquid discharge limits for Hartlepool

Nuclide	Hartlepool Liquid discharge limit (TBq)
Tritium	1200
Sulphur-35	3.0
Cobalt-60	0.03
Other radionuclides	0.3

15.3 Hydrographic Data

To calculate the tidal diamond data for the Hartlepool area, hydrographic chart No. 2567 should be used. Tidal diamond C would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.03
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	1
Half tidal excursions (m)	7100
Initial spreading radius (m)	50
Start time for discharges: t_s	0.54
End time for discharges: t_e	0.92
Distance to critical group (m)	0 – consumption 12000 – mud external
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	80
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	1.0
Mean depth (m)	10.0
Estuarine silt sedimentation rate (m y^{-1})	0.02

15.4 References

Hunt & Round (1998). Magnox Power Station Authorisation Applications, January 1998: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL3/98.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

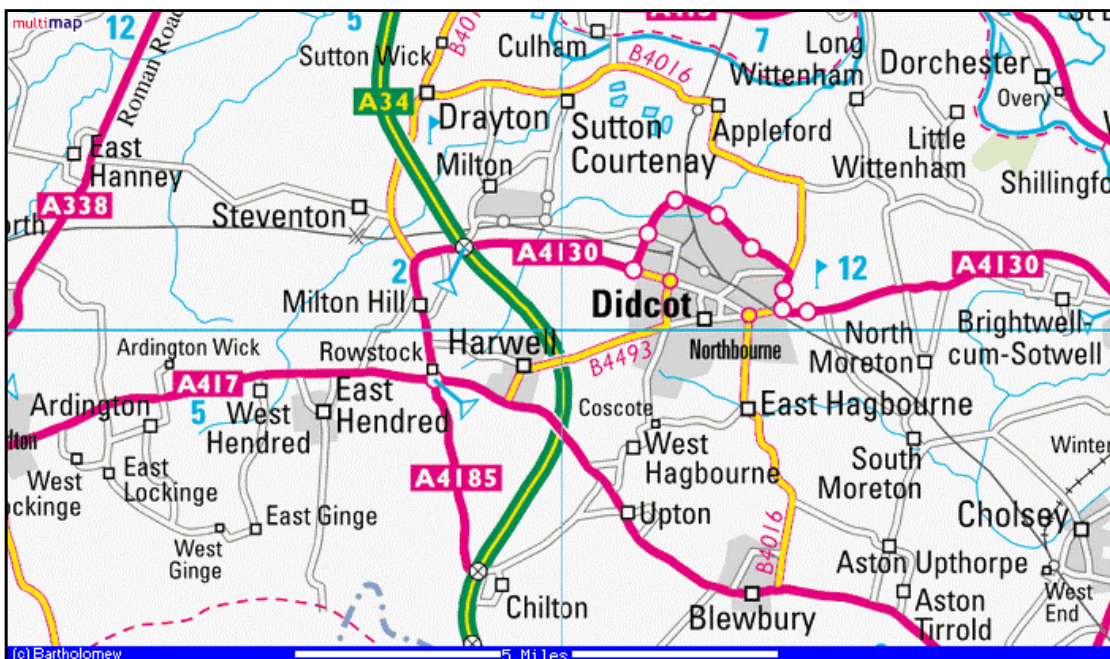
16 Harwell

16.1 Harwell

- Owner – United Kingdom Atomic Energy Authority
- Date started production – (1946)

UKAEA Harwell is a complex of radiochemical laboratories and facilities for handling highly active material. It is situated in the Thames valley approximately 20 miles east of Swindon and 15 miles south of Oxford. AEA Technology also occupies part of the site and their discharges are included within the site's limits. The site discharges liquid effluent via pipeline and also to the Lydebank Brook. Both discharge routes eventually join the River Thames at Sutton Courtenay. Gaseous discharges are released via stacks at the site. The local area around Harwell consists mainly of arable fields, the nearest town being Didcot which is 2 miles from the site.

Fig 16 Map of the Harwell local area



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16.2 Current liquid discharge limits for Harwell

Nuclide	Harwell (pipeline) Liquid discharge limit (TBq)	Harwell (Lydebank brook) Liquid discharge limit (TBq)
Alpha	0.001	$5.0 \cdot 10^{-4}$
Beta	0.02	0.002
Tritium	4	0.1
Cobalt-60	0.007	N/A
Caesium-137	0.007	N/A

16.3 Hydrographic Data

As the site discharges into a non-tidal inland waterway then the WAT and ADO models used to run saltwater assessments become invalid. An excel based freshwater model has been developed, *Freshwater_master.xls*. Guidance on how to use this model is given in Appendix A.

Parameter	Value
Model	Freshwater_master.xls
Flow rate (m ³ s ⁻¹)	4.75 (R.Thames) 0.1 (Lydebank Brook)
Suspended sediment load (g m ⁻³)	10 (both discharge routes)
Fish consumption data (kg/yr)	Adults –1 (R.Thames) 10.5 (Lydebank Brook) 15 yr olds – 0.5 (R.Thames) 5.3 (Lydebank Brook) 10 yr olds – 0.5 (R. Thames) 5.3 (Lydebank Brook) 1 yr olds – 0.4 (R. Thames) 3.9 (Lydebank Brook)
Occupancy Rate (hrs/yr)	Adults– 650 (R.Thames) 1600 (Lydebank Brook) 15 yr olds– 300 (both discharge routes) 10 yr olds– 300 (both discharge routes) 1 yr olds– 300 (both discharge routes)
Modifying factor (dependent on bankside conditions i.e concrete, mud, grass)	1.0 (grass banks for both discharge routes)
Dry/Wet mass ratio	1.66
Mud wet density	0.6

16.4 References

Round (1999). UKAEA Harwell, Authorisation Application 1999: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL6/99.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

17 Heysham

17.1 Heysham 1

- Owner - British Energy Generation Ltd
- Date started production – 1983
- Capacity (mw) – 1150

17.2 Heysham 2

- Owner – British Energy Generation Ltd
- Date started production – 1988
- Capacity (mw) – 1250

Heysham is situated on the north-western coast of England approximately 1 mile south-west of Heysham and 10 miles north of Blackpool. There are two nuclear power stations situated here, both the '1' and '2' stations are owned by British Energy Generation Ltd and both stations are powered by twin advanced gas-cooled reactors (AGR). Each station discharges liquid effluent into Morecambe Bay via pipeline to a combined outfall, which is approximately 500 metres offshore. The seabed in the vicinity of the outfall is mainly mud with occasional sandy patches. Gaseous discharges are released via stacks at each station. The local area around Heysham is mainly light industrial use, the nearest town being Heysham, which is 1 mile from the site.

Fig 17 Map of the Heysham local area



17.3 Current liquid discharge limits for Heysham

Nuclide	Heysham '1' Liquid discharge limit (TBq)	Heysham '2' Liquid discharge limit (TBq)
Tritium	1200	1200
Sulphur-35	2.8	2.3
Cobalt-60	0.03	0.03
Other radionuclides	0.3	0.3

17.4 Hydrographic Data

To calculate the tidal diamond data for the Heysham area, hydrographic chart No. 1525 should be used. Tidal diamond C is the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using $Td.x/s$ as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity ($m\ s^{-1}$)	0.01972
Diffusion coefficient ($m^2\ s^{-1}$)	5
Half tidal excursions (m)	5593
Initial spreading radius (m)	50
Start time for discharges: t_s	0.00
End time for discharges: t_e	1.00
Distance to critical group (m)	0
Suspended sediment load ($ppm=mg\ l^{-1}$)	150
Sedimentation rate ($kg\ m^{-2}\ y^{-1}$)	5.0
Mean depth (m)	7.0
Estuarine silt sedimentation rate ($m\ y^{-1}$)	0.04

17.5 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

18 Hinkley Point

18.1 Hinkley Point A

- Owner – Magnox Electric plc
- Date started production – 1964
- Date ceased production - 2000
- Capacity (mw) – 1300

18.2 Hinkley Point B

- Owner – British Energy Generation Ltd
- Date started production – 1976
- Capacity (mw) – 1220

Hinkley Point is situated on the northern coast of Somerset approximately 10 miles north-west of Bridgwater and 15 miles east of Minehead. There are two nuclear power stations situated here. The 'A' station is owned by Magnox Electric plc and powered by 2 Magnox reactors, it ceased production in 2000 and is in the process of decommissioning. The 'B' station is owned by British Energy Generation Ltd and is powered by an advanced gas-cooled reactor (AGR). Each station discharges liquid effluent into the English Channel via a combined outfall, which is 500 metres offshore. The seabed in the vicinity of the outfalls is mainly rock with occasional sandy patches. Gaseous discharges are released via stacks at each station. The local area around Hinkley Point is mainly arable fields and nature reserves, the nearest town being Nether Stowey, which is 5 miles from the site.

Fig 18 Map of the Hinkley Point local area



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18.3 Current liquid discharge limits for Hinkley Point 'A' and 'B'

<i>Nuclide</i>	<i>Hinkley Point 'A' Liquid discharge limit (TBq)</i>	<i>Hinkley Point 'B' Liquid discharge limit (TBq)</i>
Tritium	25	620
Sulphur-35	-	5
Cobalt-60	-	0.033
Caesium-137	1.5	-
Other radionuclides	1.0	0.235

18.4 Hydrographic Data

To calculate the tidal diamond data for the Hinkley Point area, hydrographic chart No. 1152 should be used. Tidal diamond D would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to the coastline at the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. Although the site is situated at the entrance to the Bristol Channel it is considered to be open water for assessment purposes therefore the advection-diffusion model should be used.

<i>Parameter</i>	<i>Value</i>
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.03
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	5
Half tidal excursions (m)	8500
Initial spreading radius (m)	50
Start time for discharges: t_s	0.08
End time for discharges: t_e	0.33
Distance to critical group (m)	0
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	200
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	5.0
Mean depth (m)	5.0
Estuarine silt sedimentation rate (m y^{-1})	0.04

18.5 References

Hunt & Round (1998). Magnox Power Station Authorisation Applications, January 1998: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL3/98

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

19 Hunterston

19.1 Hunterston 'A'

- Owner – Magnox Electric
- Date started production – 1964
- Date ceased production - 1990

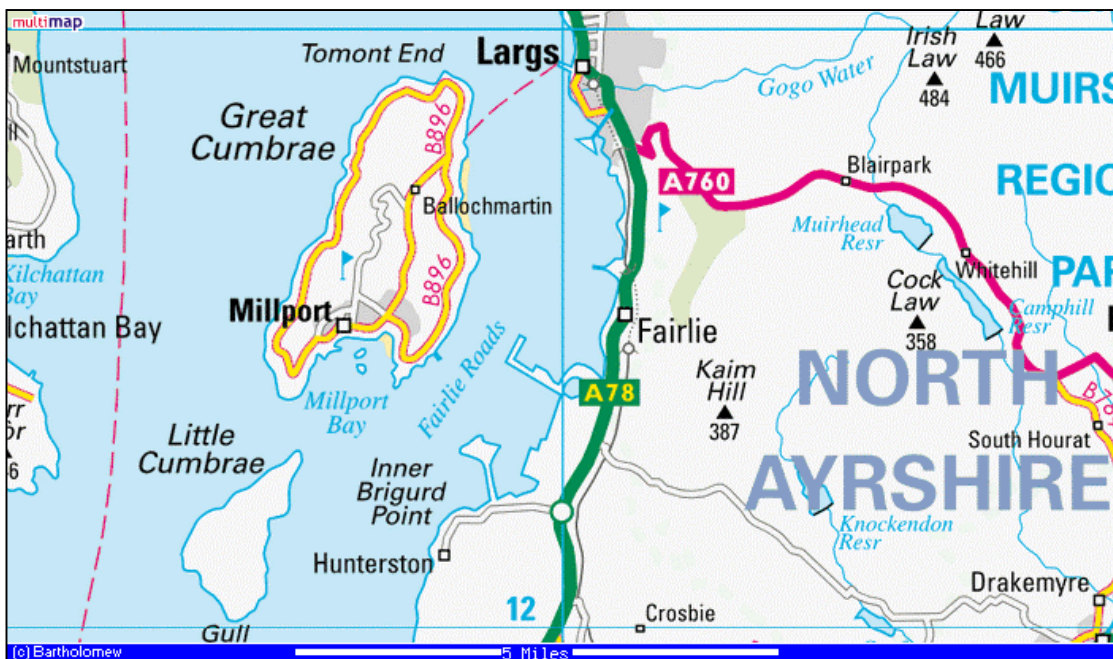
19.2 Hunterston 'B'

- Owner – British Energy Generation (UK) Ltd
- Date started production – 1976
- Capacity (mw) – 1190

Hunterston is situated on the western coast of Scotland approximately 6 miles south of Largs. There are two separate power stations here. Hunterston 'A' is owned by Magnox Electric. It ceased generating electricity in 1990 although radioactive wastes are still generated and discharged as part of the decommissioning process. Hunterston 'B' is owned by British Energy Generation (UK) Ltd and is powered by a pair of advanced gas cooled reactors. The site discharges liquid effluent into the Firth of Clyde area of the Irish sea via a shared outfall. The seabed in the vicinity of the outfall is mainly sand with occasional patches of mud. Gaseous discharges are released via stacks at the station.

The local area around Hunterston is mainly arable fields and light industrial areas, the nearest town being Largs.

Fig 19 Map of the Hunterston local area



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19.3 Current liquid discharge limits for Hunterston

Nuclide	Hunterston 'A' Liquid discharge limit (TBq)	Hunterston 'B' Liquid discharge limit (TBq)
Total activity	2	N/A
Tritium	5	800
Alpha	N/A	0.001
Beta	N/A	0.45
Sulphur-35	N/A	10
Cobalt-60	N/A	0.03

19.4 Hydrographic Data

To calculate the tidal diamond data for the Hunterston area, hydrographic chart No. 2126 should be used. Tidal diamond E would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.03
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	5
Half tidal excursions (m)	8500
Initial spreading radius (m)	50
Start time for discharges: t_s	0.08
End time for discharges: t_e	0.33
Distance to critical group (m)	0
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	200
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	5.0
Mean depth (m)	5.0
Estuarine silt sedimentation rate (m y^{-1})	0.04

19.5 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

20 Rosyth

20.1 Rosyth

- Owner – Babcock Rosyth Defence Ltd (BRDL) / MOD

Rosyth is a nuclear submarine berth situated on the Firth of Forth in Scotland, approximately 10 miles north-west of Edinburgh and 20 miles east of Glasgow. As well as being a berthing point for nuclear submarines, the dockyard has the capacity to be able to dismantle the submarines when decommissioned. The site discharges liquid effluent into the Firth of Forth via a low active effluent discharge line. The riverbed in the vicinity of the discharge point is mainly mud. Gaseous discharges are released via stacks at the site. The local area around Rosyth consists mainly of urban housing and local industry, the nearest town to Rosyth being Dunfermline which is 2 miles to the north of the site.

Fig 20 Map of the Rosyth local area



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20.2 Current liquid discharge limits for Rosyth

Nuclide	Rosyth Liquid discharge limit (TBq)
Alpha	$1 \cdot 10^{-6}$
Beta	$5.0 \cdot 10^{-4}$
Tritium	0.04
Cobalt-60	0.005

20.3 Hydrographic Data

To calculate the tidal diamond data for the Rosyth area, hydrographic chart No. 734 should be used. Tidal diamond F would be the most appropriate as it fulfils most of the selection criteria, it is not too far downstream and it is as far up the estuary as is possible to quantify. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the single compartment model should be used due to the site being situated on the banks of the Firth of Forth.

Parameter	Value
Model	Single compartment
Dispersion factor: changes per day	0.045
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	10
Exchange volume, km^3	0.9
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	50
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	0.2
Mean depth (m)	20
Estuarine silt sedimentation rate (m y^{-1})	0.04

20.4 References

Allison, Hunt & Winpenny (2001). Babcock Rosyth Defence Limited – Nuclear Licensed Site Authorisation Application 2001: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL05/01.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

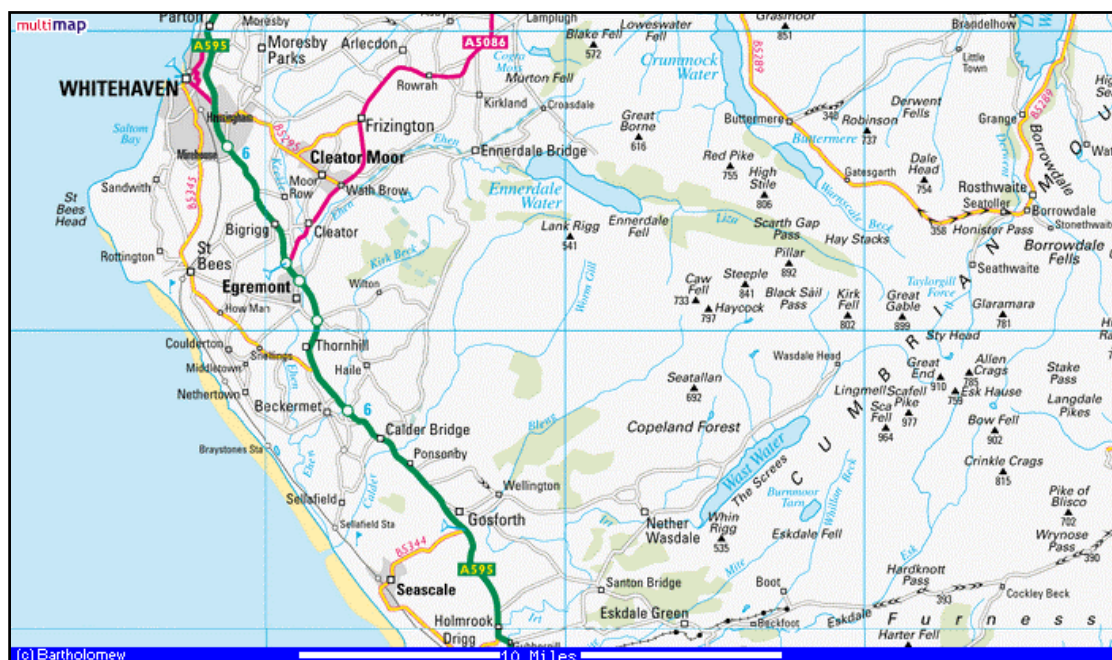
21 Sellafield

21.1 Sellafield

- Owner – BNFL / UKAEA
- Date started production – 1956 (Calder Hall)

Sellafield is situated on the western coast of northern England approximately 10 miles south of Whitehaven and 15 miles north of Barrow in Furness. The site is split into distinct areas; reprocessing of used nuclear fuel, waste management and decommissioning, and the operation at Calder Hall of four Magnox reactors, which supply the National Grid. The Windscale laboratories of UKAEA are also situated on the site. There are two pathways of liquid effluent disposal at the site, via the main pipeline which discharges into the Irish Sea approximately 2 kilometres offshore, and via the Seaburn sewer which is essentially a surface water drain. The sewer discharges into the confluence of the Rivers Calder and Ehen. The seabed in the vicinity of both the sewer outfall and the pipeline is mainly mud. Gaseous discharges are released via stacks at the station. The local area around Sellafield consists of mainly arable fields, the nearest town being Whitehaven.

Fig 21 Map of the Sellafield local area



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21.2 Current liquid discharge limits for Sellafield

Nuclide	Sellafield 'pipeline' Liquid discharge limit (TBq)	Sellafield 'sewer' Liquid discharge limit (TBq)
Alpha	1	0.0033
Beta	400	0.0135
Tritium	$3.0 \cdot 10^4$	0.132
Carbon-14	20.8	N/D
Cobalt-60	13	N/D
Strontium-90	48	N/D
Zirconium-95 + Niobium-95	9	N/D
Technetium-99	90	N/D
Ruthenium-106	63	N/D
Iodine-129	2.0	N/D
Caesium-134	6.6	N/D
Caesium-137	75	N/D
Cerium-144	8	N/D
Plutonium alpha	0.7	N/D
Plutonium-241	27	N/D
Americium-241	0.3	N/D
Uranium	2040	N/D

21.3 Hydrographic Data

To calculate the tidal diamond data for the Sellafield area, hydrographic chart No. 1346 should be used. Tidal diamond D would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.03
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	5
Half tidal excursions (m)	8500
Initial spreading radius (m)	50
Start time for discharges: t_s	0.08
End time for discharges: t_e	0.33
Distance to critical group (m)	0
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	200
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	5.0
Mean depth (m)	5.0
Estuarine silt sedimentation rate (m y^{-1})	0.04

21.4 References

Food Standards Agency and Scottish Environment Protection Agency (2002).
Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards
Agency and SEPA, London and Stirling.

22 Sizewell

22.1 Sizewell A

- Owner – Magnox Electric plc / BNFL
- Date started production – 1965
- Capacity (mw) – 420

22.2 Sizewell B

- Owner – British Energy Generation (UK) Ltd
- Date started production – 1995
- Capacity (mw) – 1188

Sizewell is situated on the east coast of England approximately 20 miles north of Ipswich and 25 miles south of Lowestoft. There are two nuclear power stations situated here. The 'A' station is owned by Magnox Electric plc and powered by twin Magnox reactors, and the 'B' station is owned by British Energy Generation Ltd and is powered by a Pressurised Water Reactor. Each station discharges liquid effluent into the North Sea via adjacent offshore outfalls. The seabed in the vicinity of the outfalls is mainly sand with occasional patches of gravel. Gaseous discharges are released via stacks at each station. The local area around Sizewell is mainly arable fields and heathland, the nearest town being Leiston which is 2 miles from the site.

Fig 22 Map of the Sizewell local area



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22.3 Current liquid discharge limits for Sizewell 'A' and 'B'

Nuclide	Sizewell 'A' Liquid discharge limit (TBq)	Sizewell 'B' Liquid discharge limit (TBq)
Tritium	35	80
Caesium-137	1.0	N/D
Other radionuclides	0.7	0.2

22.4 Hydrographic Data

To calculate the tidal diamond data for the Sizewell area, hydrographic chart No. 1543 should be used. Tidal diamond B would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.03
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	1
Half tidal excursions (m)	7100
Initial spreading radius (m)	50
Start time for discharges: t_s	0.54
End time for discharges: t_e	0.92
Distance to critical group (m)	0 – consumption 12000 – mud external
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	80
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	1.0
Mean depth (m)	10.0
Estuarine silt sedimentation rate (m y^{-1})	0.02

22.5 References

Hunt & Round (1998). Magnox Power Station Authorisation Applications, January 1998: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL3/98.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

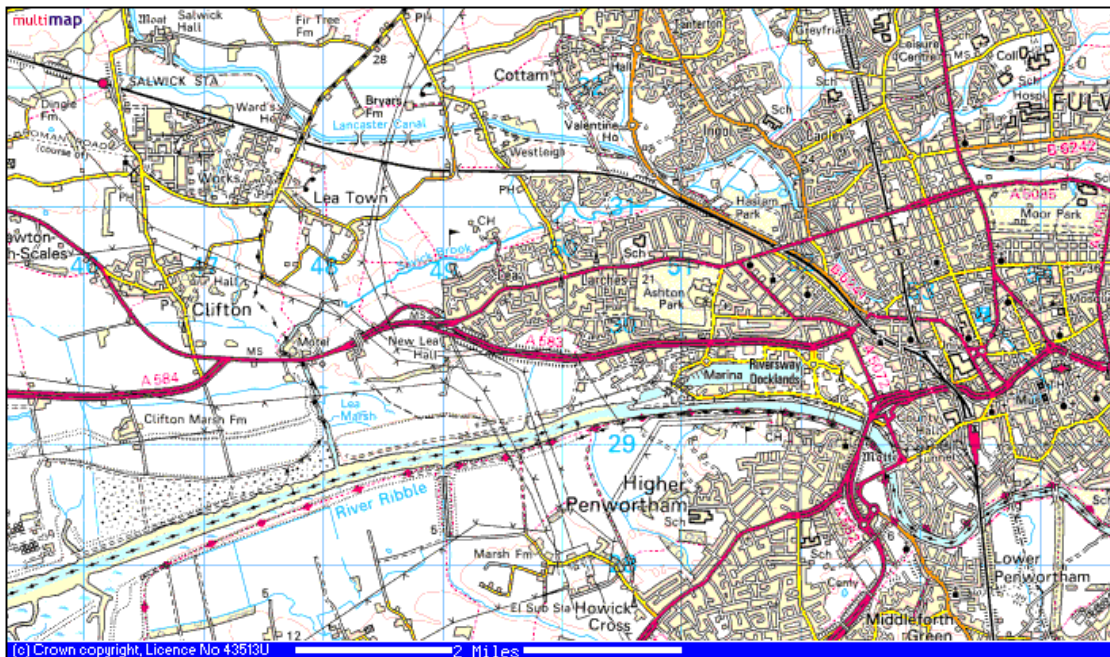
23 Springfields

23.1 Springfields

- Owner – BNFL Westinghouse

The site at Springfields produces fuel and intermediate fuel products for the nuclear industry in the UK and abroad. Uranium hexafluoride is converted on site to provide oxide fuel for use in AGR's and LWR's. It is approximately 4 miles west of Preston in the north-west of England. The site discharges liquid effluent into the River Ribble via pipeline. The riverbed in the vicinity of the discharge point is mainly muddy sand. Gaseous discharges are released via stacks at the site. The local area around Springfields is mainly arable farmland, the nearest town being Preston.

Fig 23 Map of the Springfields local area



23.2 Current liquid discharge limits for Springfields

Nuclide	Springfields Liquid discharge limit (TBq)
Alpha	4
Beta	240
Technetium-99	0.6
Thorium-230	2
Thorium-232	0.2
Neptunium-237	0.04
Uranium	0.15

23.3 Hydrographic Data

To calculate the box parameters for the Springfields area, hydrographic chart No. 1981 should be used. Using the chart, all the parameters needed to calculate the volume and depth of the box can be obtained. Sediment data can be found either from previous reports, comparison with other sites in similar areas or by contacting the site or Environment Agency. When running the WAT model, the single compartment model should be used as effluent is discharged into the River Ribble.

Parameter	Value
Model	Freshwater_master.xls
Dispersion factor: changes per day	0.33
Exchange volume, km ³	0.060
Suspended sediment load (ppm=mg l ⁻¹)	58
Sedimentation rate (kg m ⁻² y ⁻¹)	5
Mean depth (m)	1.8
Estuarine silt sedimentation rate (m y ⁻¹)	0.06

23.4 References

Allison, Grzechnik & Hunt (2002). BNFL Westinghouse Springfields – Nuclear Licensed Site Authorisation Application 2002: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL6/02.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

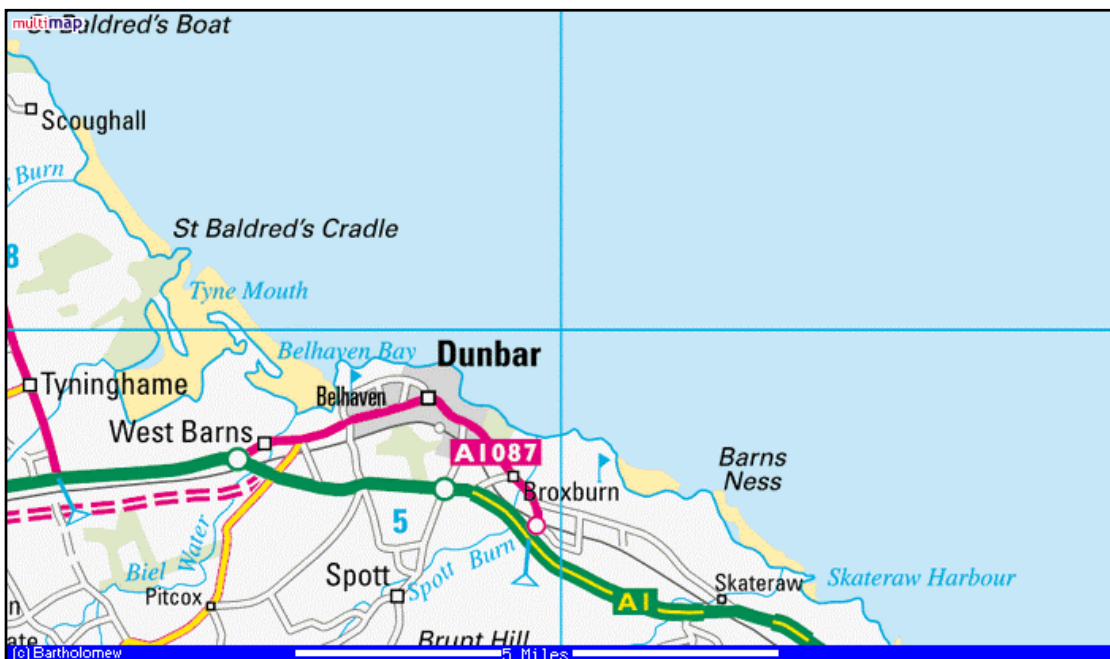
24 Torness

24.1 Torness

- Owner – British Energy Generation (UK) Ltd
- Date started production – 1988
- Capacity (mw) – 1250

Torness is situated on the eastern coast of Scotland approximately 3 miles south of Dunbar. There is one nuclear power station situated here owned by British Energy plc and powered by twin advanced gas-cooled reactors. The station discharges liquid effluent into the North Sea via an outfall on the shoreline. The seabed in the vicinity of the outfall is mainly rock with occasional sandy patches. Gaseous discharges are released via stacks at the station. The local area around Torness consists of mainly arable fields, the nearest town being Dunbar.

Fig 24 Map of the Torness local area



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24.2 Current liquid discharge limits for Torness

Nuclide	Torness Liquid discharge limit (TBq)
Alpha	0.001
Beta	0.45
Tritium	800
Sulphur-35	10
Cobalt-60	0.03

24.3 Hydrographic Data

To calculate the tidal diamond data for the Torness area, hydrographic chart No. 1192 should be used. A mean of tidal diamonds D and E would be the most appropriate to use as singly the two nearest diamonds do not fulfill the selection criteria therefore a mean of both has been taken. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.0115
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	5
Half tidal excursions (m)	2000
Initial spreading radius (m)	50
Start time for discharges: t_s	0
End time for discharges: t_e	1
Distance to critical group (m)	0 - consumption 9000 – mud external
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	10
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	5.0
Mean depth (m)	10.0
Estuarine silt sedimentation rate (m y^{-1})	0.02

24.4 References

Allison et al. (2002). British Energy plc Torness Power Station – Nuclear Licensed Site Authorisation Application 2002: Radiological Assessment of Liquid Discharges. CEFAS Environment Report RL14/02.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

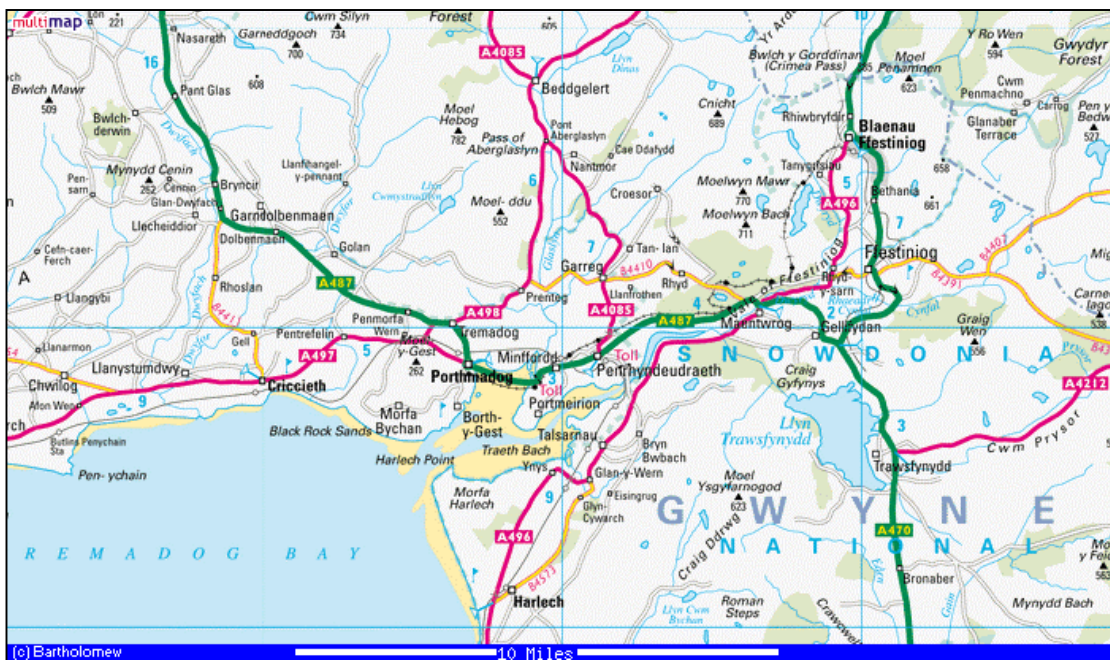
25 Trawsfynydd

25.1 Trawsfynydd

- Owner – Magnox Electric plc / BNFL
- Date started production – 1965
- Date ceased production – 1993
- Capacity (MW) – 470

Trawsfynydd is situated on Lake Trawsfynydd in Gwynedd, Wales approximately 5 miles south-west of Porthmadog. It is the only one of BNFL's reactors that is not built on the coast. There is one nuclear power station here owned by Magnox Electric plc, which ceased generating electricity in 1993 although radioactive wastes are still generated and discharged as part of the decommissioning process. The site discharges liquid effluent into Lake Trawsfynydd via a pipeline. Gaseous discharges are released via stacks at the station. The local area around Trawsfynydd is mainly arable land.

Fig 25 Map of the Trawsfynydd local area



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25.2 Current liquid discharge limits for Trawsfynydd

Nuclide	Trawsfynydd liquid discharge limit (TBq)
Total Activity	0.72
Tritium	12
Strontium-90	0.08
Caesium-137	0.05

25.3 Hydrographic Data

As the site discharges into a non-tidal inland waterway then the WAT and ADO models used to run saltwater assessments become invalid. An excel based freshwater model specifically for lake use has been developed, *lake_master.xls*, guidance on how to use this model is given in Appendix B.

Parameter	Value
Model	Lake_master.xls
Volume (m ³)	3.00E+10
Flushing rate	1.50E+11
Fish consumption data (kg/yr)	Brown Trout (adults) –1.8 15 yr olds – 0.9 10 yr olds – 0.9 1 yr olds – 0.675 Rainbow Trout (adults) - 18 15 yr olds – 9 10 yr olds – 9 1 yr olds – 6.75 Perch (adults) – 0.93 15 yrs olds – 0.465 10 yrs olds – 0.465 1 yr olds – 0.34875
Occupancy Rate (hrs/yr)	Adults– 1000 15 yr olds– 420 10 yr olds– 420 1 yr olds– 300
Modifying factor (dependent on bankside conditions i.e concrete, mud, grass)	1.0
Dry/Wet mass ratio	1.66
Mud wet density	0.6

25.4 References

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

26 Winfrith

26.1 Winfrith

- Owner – United Kingdom Atomic Energy Authority

UKAEA Winfrith is a research site operating experimental rigs, laboratories and workshops. It is also in the process of decommissioning a steam generated heavy water reactor (SGHWR) and is situated on the southern coast of England in Dorset. Winfrith is approximately 15 miles east of Weymouth and 15 miles west of Poole. The site discharges liquid effluent into Weymouth Bay via a double pipeline. The outer pipeline carries mainly trade wastes and discharges just beyond the foreshore. The inner pipeline carries the more active effluents and discharges 4km out to sea. The seabed in the vicinity of the outfall mainly consists of rock with occasional sandy patches. Gaseous discharges are released via stacks at the station. The local area around Winfrith consists of mainly arable fields, the nearest town being Wareham, which is 5 miles from the site.

Fig 26 Map of the Winfrith local area



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26.2 Current liquid discharge limits for Winfrith

<i>Nuclide</i>	<i>Winfrith (inner pipeline) Liquid discharge limit (TBq)</i>	<i>Winfrith (outer pipeline) Liquid discharge limit (TBq)</i>
Alpha	0.3	0.004
Tritium	650	1
Cobalt-60	10	N/A
Zinc-65	6	N/A
Other Radionuclides	80	0.01

26.3 Hydrographic Data

To calculate the box parameters for the Winfrith area, hydrographic chart No. 2610 should be used. Using the chart, all the parameters needed to calculate the volume and depth of the box can be obtained. Sediment data can be found either from previous reports, comparison with other sites in similar areas or by contacting the site or Environment Agency. When running the WAT model, the single compartment model should be used as effluent is discharged into Weymouth Bay.

<i>Parameter</i>	<i>Value</i>
Model	Single compartment
Dispersion factor: changes per day	0.01
Exchange volume, km ³	4
Suspended sediment load (ppm=mg l ⁻¹)	10
Sedimentation rate (kg m ⁻² y ⁻¹)	1.0
Mean depth (m)	20.0
Estuarine silt sedimentation rate (m y ⁻¹)	0.02

26.4 References

Round, 1998, 'UKAEA Winfrith Technology Centre, Authorisation Application 1999: Radiological Assessment of Liquid Discharges', CEFAS Environment Report RL10/98.

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

27 Wylfa

27.1 Wylfa

- Owner – Magnox Electric plc / BNFL
- Date started production – 1971
- Capacity (mw) – 980

Wylfa is situated on the north-western coast of Anglesey approximately 15 miles north-east of Holyhead. There is one nuclear power station situated here owned by Magnox Electric plc and powered by Magnox reactors. The station discharges liquid effluent into the Irish Sea via an offshore outfall. The seabed in the vicinity of the outfall is mainly rock with occasional sandy patches. Gaseous discharges are released via stacks at the station. The local area around Wylfa consists of mainly arable field, the nearest town being Amlwch, which is 5 miles from the site.

Fig 27 Map of the Wylfa local area



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27.2 Current liquid discharge limits for Wylfa

Nuclide	Wylfa Liquid discharge limit (TBq)
Tritium	40
Other radionuclides	0.15

27.3 Hydrographic Data

To calculate the tidal diamond data for the Wylfa area, hydrographic chart No. 1413 should be used. Tidal diamond A would be the most appropriate as it fulfils most of the selection criteria, it is not too far offshore and the coastline is very similar to that near the point of discharge. From the tidal diamond data the residual velocity and tidal excursion can be calculated using *Td.xls* as described in Appendix C. When running the WAT model, the advection-diffusion model should be used as the coastline is non-estuarine open water.

Parameter	Value
Model	Advection-diffusion
Residual Velocity (m s^{-1})	0.03
Diffusion coefficient ($\text{m}^2 \text{s}^{-1}$)	5
Half tidal excursions (m)	8000
Initial spreading radius (m)	50
Start time for discharges: t_s	0
End time for discharges: t_e	1
Distance to critical group (m)	0
Suspended sediment load ($\text{ppm}=\text{mg l}^{-1}$)	10
Sedimentation rate ($\text{kg m}^{-2} \text{y}^{-1}$)	5.0
Mean depth (m)	25.0
Estuarine silt sedimentation rate (m y^{-1})	0.02

27.4 References

Hunt, Round, 1998, 'Magnox Power Station Authorisation Applications, January 1998: Radiological Assessment of Liquid Discharges', CEFAS Environment Report RL3/98

Food Standards Agency and Scottish Environment Protection Agency (2002). Radioactivity in Food and the Environment, 2001. RIFE-7 Food Standards Agency and SEPA, London and Stirling.

Appendix A - Excel Based River Assessments Model

Freshwater_Master.xls

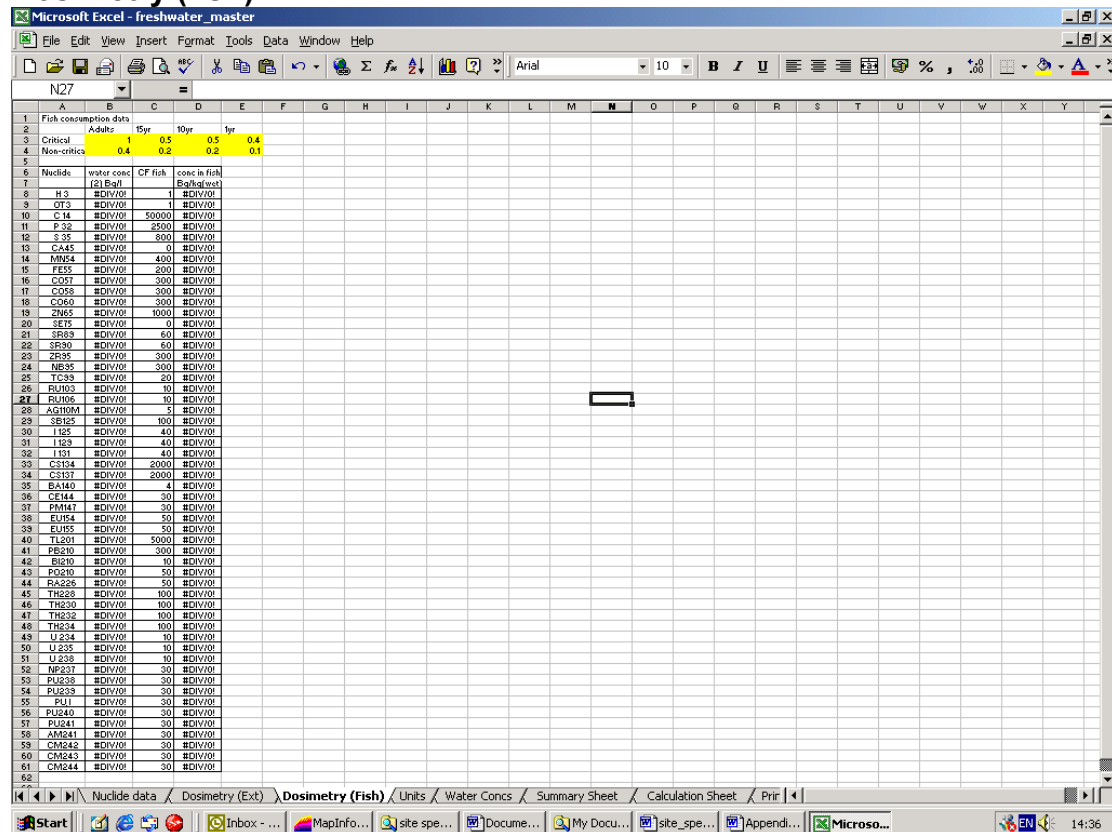
This Microsoft Excel spreadsheet performs a similar task to the WAT and ADO models for a non-marine river environment. Within the spreadsheet are individual sheets to calculate water concentrations and doses to the specified groups.

The spreadsheet has been designed so that the user enters the nuclides discharged, hydrographic data and the habits/occupancy data in the cells coloured yellow. As these are the only cells that can be changed there is no possibility of the user entering values in a part of the spreadsheet that is protected.

The data is entered on the following sheets: *Dosimetry (fish)*, *Dosimetry (ext)* and *Water concs*. The doses are then calculated and automatically transferred to the *Summary sheet* where the dose data is presented in a tabular format. The *Summary sheet* is pre-formatted so that once the relevant parameters are entered the sheet can be printed directly.

Screen captures of the three entry sheets within *Freshwater_master.xls* are shown below, the shaded areas on the sheet depicting where data is to be entered.

Dosimetry (fish)



Appendix B - Excel Based Lake Assessments Model

Lake_Master.xls

This Microsoft Excel spreadsheet performs a similar task to the WAT and ADO models for a non-marine lake environment. Within the spreadsheet are individual sheets to calculate water concentrations and doses to the specified groups. The groups are divided into age range and criticality i.e. Adult critical and non-critical, 15 yr olds critical and non-critical, etc. As with the *Freshwater_master.xls*, the areas designated for data entry are highlighted in yellow. The screen capture below shows the adult critical sheet, the area in the top left hand corner is where the doses are calculated and displayed.

Adult critical sheet

The screenshot displays the 'Adult critical' sheet in Microsoft Excel. The spreadsheet is organized into columns labeled A through V. Key sections include:

- Species List (Rows 1-15):** Lists various radionuclides and their associated parameters. For example, H-3, Co-137, Sr-90, Tc-99, Am-241, Pu-240, Pu-239, Ni-63, and Total.
- Validation Parameters (Rows 16-21):** Includes 'MAGNOX assessment - Trnsfvevdd', 'Critical Group Adult crit', 'Lake parameters: Volume', 'Flushing Rate', and 'discharge at limits: Qba'.
- Species Data (Rows 22-57):** A detailed table for each species with columns for 'Neutrons', 'Discharge Rate', '% life in days', 'Decay constant', 'Bois', 'Max. MVV', 'Gamma', 'Effective', 'DPU in (ICRP 12)', 'Ball (V)', 'Kd', 'Gen. Fish C.F.', 'Sec. Conc.', 'biokeids factor', 'Brown', 'Rainbow', 'Perch', 'Gen. Fish', 'Gen. Fish con dose', 'Gamma', 'alpha', and 'amu'.
- Total Dose (Row 58):** A summary row for the total dose, showing a value of #DIV/0!.

The status bar at the bottom of the window indicates the current sheet is 'Sheet1 Adult crit' and shows a navigation menu with options like '15 crit', '15 non crit', '10 crit', '10 non crit', '1 crit', and '1 non crit'.

Appendix C - Tidal Diamond Spreadsheet

Tidal_Diamond.xls

The spreadsheet is designed to calculate the tidal excursion, residual velocity and residual direction for use within the WAT/ADO models. Using tidal diamond data from the relevant hydrographic chart, the direction and tidal speed (in knots) is entered in the columns highlighted yellow (shaded in the screen capture below). Both the data for the spring tide and neap tide are entered. The sheet then calculates the tidal excursion and the residual velocity and direction. A graph is also produced for each state of the tidal cycle to provide a visual perspective of the shape of the tidal diamond.

Tidal (master)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2															
3															
4				Spring		cum tot N	cum tot E	Tot. Dist.		Neap			cum tot N	cum tot E	Tot. Dist.
5		Direction	Speed kn	Kn N	Kn E	0	0	0	Speed kn	Kn N	Kn E	0	0	0	0
6				0	0	0	0	0		0	0	0	0	0	0
7				0	0	0	0	0		0	0	0	0	0	0
8				0	0	0	0	0		0	0	0	0	0	0
9				0	0	0	0	0		0	0	0	0	0	0
10				0	0	0	0	0		0	0	0	0	0	0
11				0	0	0	0	0		0	0	0	0	0	0
12				0	0	0	0	0		0	0	0	0	0	0
13				0	0	0	0	0		0	0	0	0	0	0
14				0	0	0	0	0		0	0	0	0	0	0
15				0	0	0	0	0		0	0	0	0	0	0
16				0	0	0	0	0		0	0	0	0	0	0
17				0	0	0	0	0		0	0	0	0	0	0
18				0	0	0	0	0		0	0	0	0	0	0
19															
20		residual kn		0	0					0	0				
21		residual m		0	0					0	0				
22		res speed		0	0					0	0				
23															
24															
25															
26		res. vel.		0											
27		res. dir.		#DIV/0!											
28															
29		mean of spring and neap m/s		0											
30		mean of spring and neap deg.		#DIV/0!											
31															
32		Tidal excursion spring (m)		0											
33		Tidal excursion neaps (m)		0											
34		mean tidal excursion		0											
35															
36															
37															
38															



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