Berkeley & Oldbury
Site Stakeholder Group

Environmental Monitoring & Public Dose Assessment for 2010

Presented at the November 2011 Meeting

CONTENTS

1. INTRODUCTION

This report contains information on the discharge and disposal of radioactive waste at Oldbury and Berkeley Licensed Sites for 2010. The report provided details on worker doses, radioactive solid waste disposal, gaseous and liquid effluent discharges and results of the environmental monitoring programme for this period.

Oldbury and Berkeley share a joint environmental monitoring programme due to their close proximity. Oldbury and Berkeley are managed by Magnox Limited. Oldbury is a second generation Magnox station with two concrete pressure vessel reactors. The station commenced operation in 1967 and generates approximately 420 MWs of electricity when both reactors are operating. Reactor 1 operated throughout 2010 and Reactor 2 operated for most of the year except during a planned maintenance outage in September and an un-planned outage in November. Berkeley Power Station was an early Magnox station that operated between 1962 and 1989. Decommissioning activities continued throughout 2010.

Both sites are regulated under the Environmental Permitting Regulations 2010. Information on discharges and environmental measurements are sent on a regular basis to the Environment Agency. The Environment Agency is the single regulator for radiological discharges from the Oldbury and Berkeley although the Foods Standards Agency remains a consultant to the Agency. The Environment Agency carry out their own environmental programmes and issue annual reports summarising their results. Inspectors from the Environment Agency visit each site regularly to inspect the company's facilities and discuss results and any issues.

Should anyone have any comments or require any clarification regarding the content of this document please contact the Environment, Health, Safety, Security & Quality Manager, Oldbury Power Station, Oldbury Naite, Thornbury, South Gloucestershire, BS35 1RQ.

2. RADIATION DOSES TO WORKERS

Magnox Limited has responsibility under the Ionising Radiation Regulations 1999 to assess and control the radiation dose of each person working within the site's radiation controlled areas.

The whole body dose received by an individual is measured by an electronic personal dosimeter (EPD) which records the amount and type of radiation received, and provides pre-set audible and visual warnings to enable dose control. The EPD and associated software provides dose information for all individuals working inside the controlled areas.

Control of exposure is achieved by ensuring that all doses are kept As Low As Reasonably Practicable (ALARP) and well below statutory limits. All work activities within the controlled areas are pre-planned and continually assessed to ensure that the ALARP principle is applied.

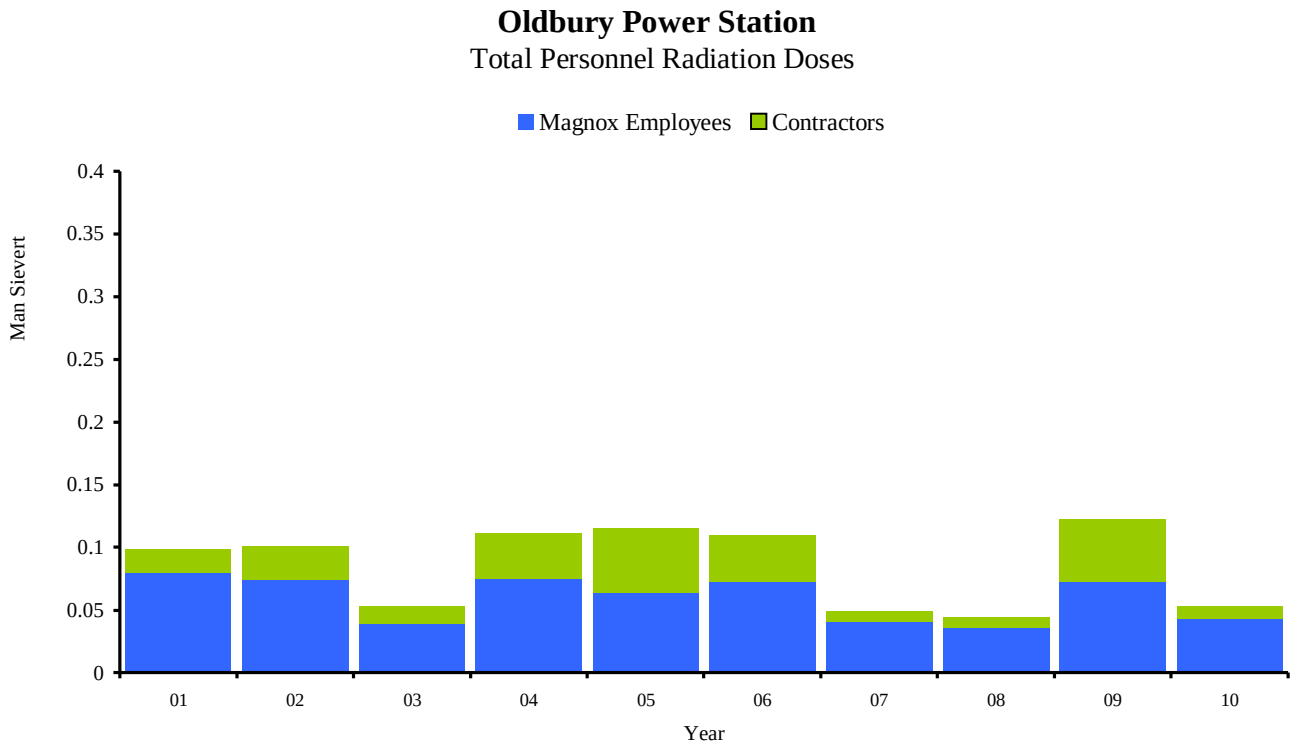


Fig 2.1 Oldbury, Total Personnel Radiation Doses

Most of the dose accumulated during outage years is due to work in the boilers, which are inside the biological shield wall. The higher site dose in 2009 was due to boiler inspections on reactors 1 and 2 and a project to empty and process the contents of a tank containing radioactive effluent plant sludge. Low doses in 2000, 2003, 2007 and 2008 were due to no boiler inspections in those years.

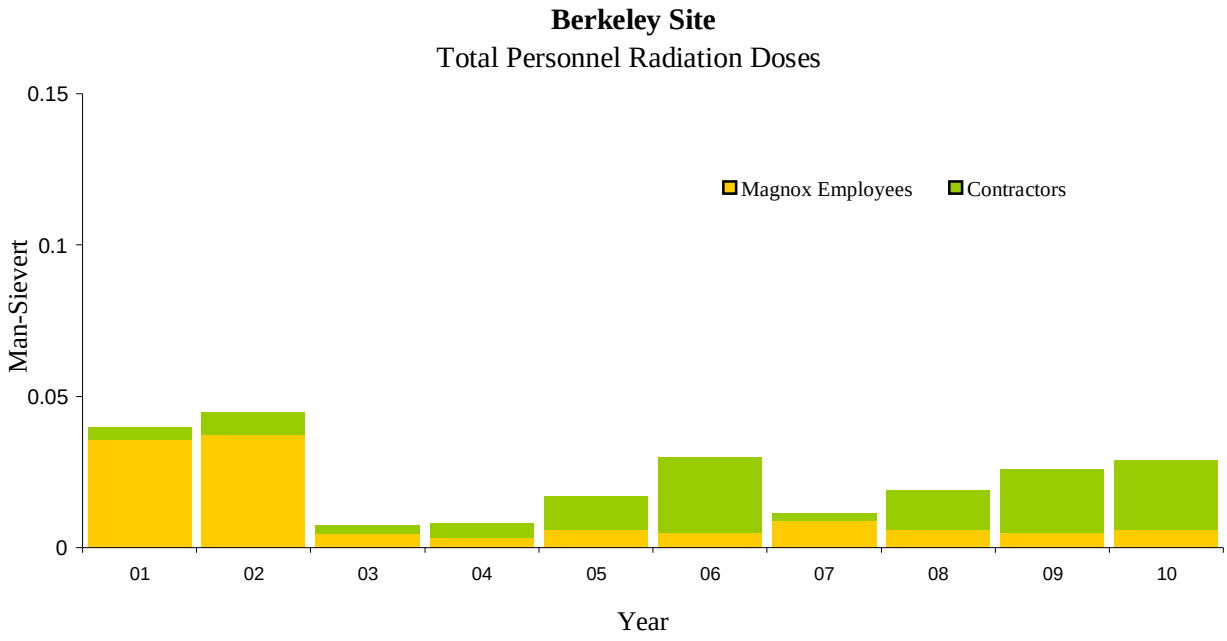


Fig 2.2 Berkeley Site, Total Personnel Radiation Doses

The doses for 2005 onwards combine those received at Berkeley Site, including Berkeley Power Station; doses before 2005 are for Berkeley Centre/Berkeley Nuclear Laboratories only.

Variations in dose received are dependant on the type of decommissioning work carried out.

3. GASEOUS EFFLUENT DISCHARGES

Site specific permits for discharging radioactive gaseous effluent to atmosphere are granted by the Environment Agency.

Authorisation limits are set after considering the actual quantities of radioactivity each site needs to discharge and the need to keep environmental risks below an acceptable level. Best Available Techniques (BAT) is used to minimise discharges and ensure doses to the public are as low as reasonably practicable (ALARP). The sites would be required to justify that any gaseous emissions greater than the Quarterly Notification Level (QNL) were discharged in accordance with BAT.

There is a very considerable safety margin between the authorised limit and the limit that could present a significant health risk to members of the public. In addition, most discharges are well below the authorised limit and any resultant doses to the public are insignificant.

Because radionuclides behave differently in the environment and influence doses to the public in varying amounts, individual authorisation limits are granted for certain radionuclides.

This section of the report presents the data for Oldbury and Berkeley from gaseous discharges from each radionuclide. The graphs presented show 2010's discharges compared to the previous discharges over a 10 year period.

In all cases there has been a slight increase in discharges at Oldbury which is due to increase generation in 2010 compared to previous years. Berkeley's discharges remain low reflecting the decommissioning stage of its lifecycle.

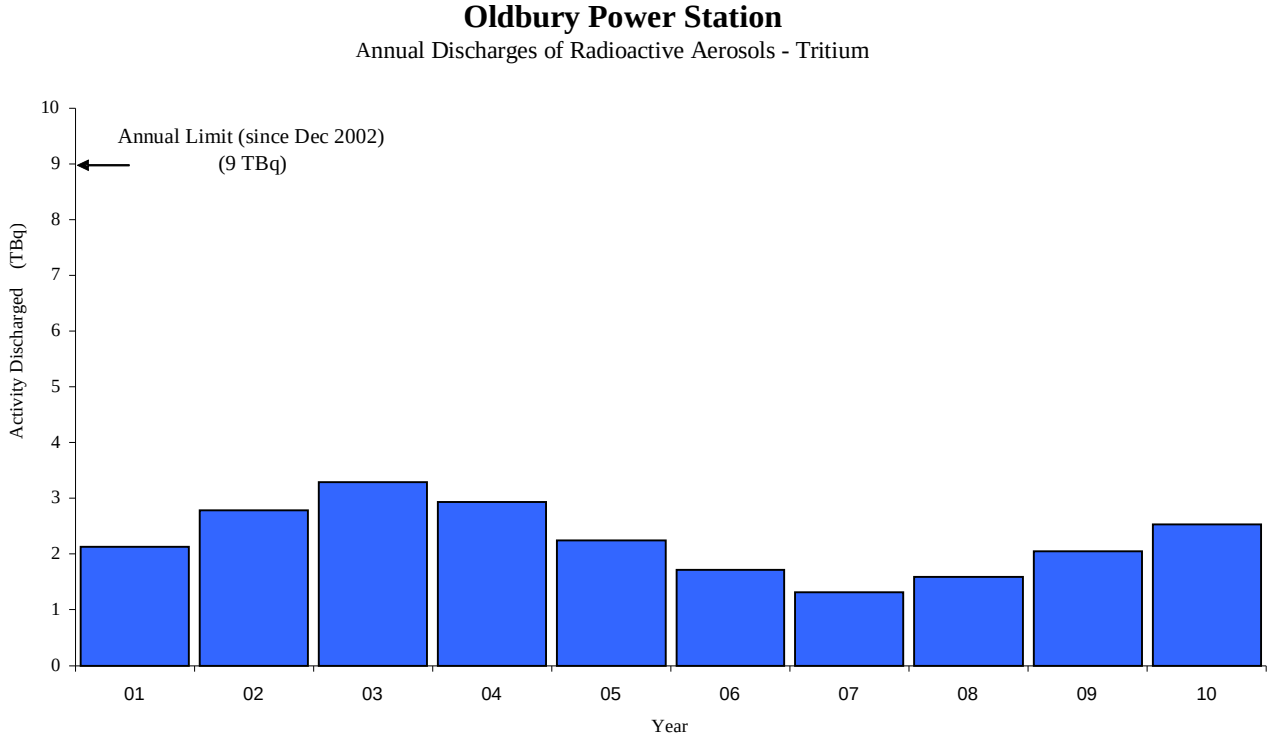


Fig. 3.1 Oldbury, Annual Discharges of Radioactive Aerosols - Tritium

Tritium (H-3) is a low energy beta emitting radionuclide with a low radiotoxicity. It is generated in the reactor by neutron activation of lithium impurities in the graphite core and also directly via the fission process.

Tritium 2010 discharges are higher than recent years due to increased electricity generation.

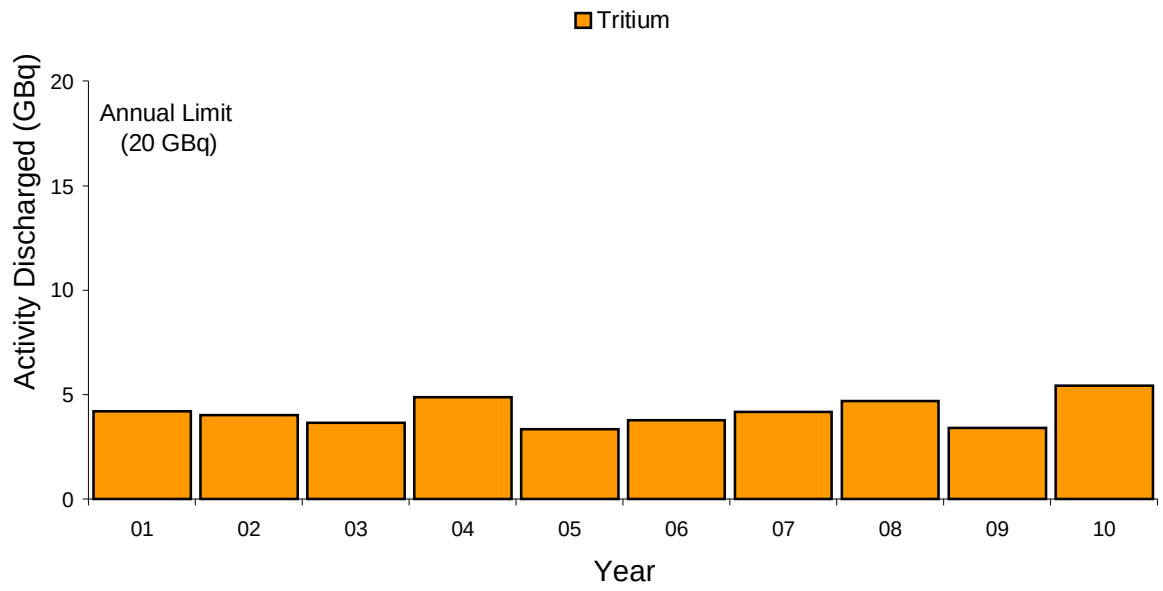


Fig 3.2 Berkeley Site, Annual Discharges of Radioactive Aerosols - Tritium

Tritium discharges from Berkeley Power Station originate from the reactors which are depressurised to atmospheric pressure and contain air.
The discharges will therefore vary with both atmospheric pressure and in the case of tritium with moisture content.

The reactors were put into safe storage in 2010 which prevents entry by personnel unless required for maintenance work. Discharges are now assessed using monitoring results over the last 5 years and current breathing rates of the reactors based on pressure and temperature. Direct monitoring of gaseous effluent discharges will be undertaken every 5 years when the reactors are opened for inspection to confirm that there are no changes in the assessment assumptions.

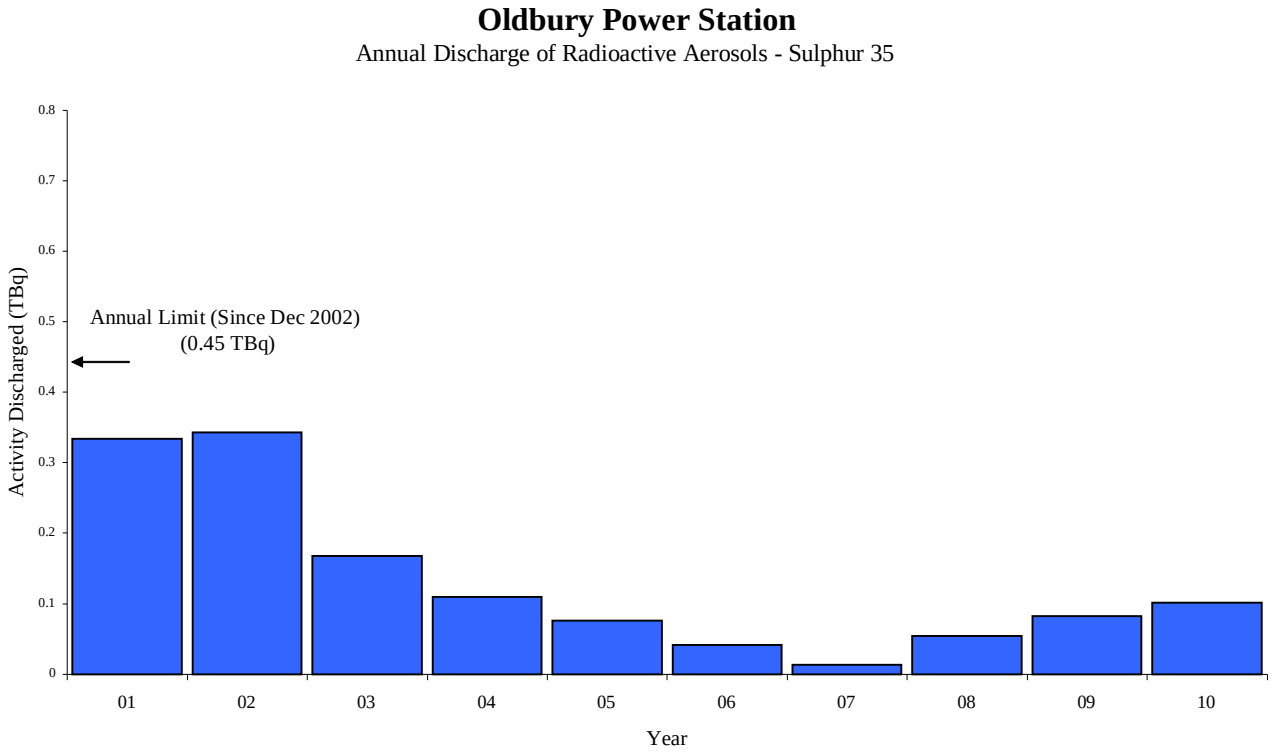


Fig 3.3 Oldbury, Annual Discharge of Radioactive Aerosols – Sulphur 35

Sulphur 35 is a low energy beta emitting radionuclide. It is generated by neutron activation of chlorine impurities in the graphite core and oils containing sulphur.

In 2010 Sulphur 35 discharges were higher than recent years due to increased electricity generation.

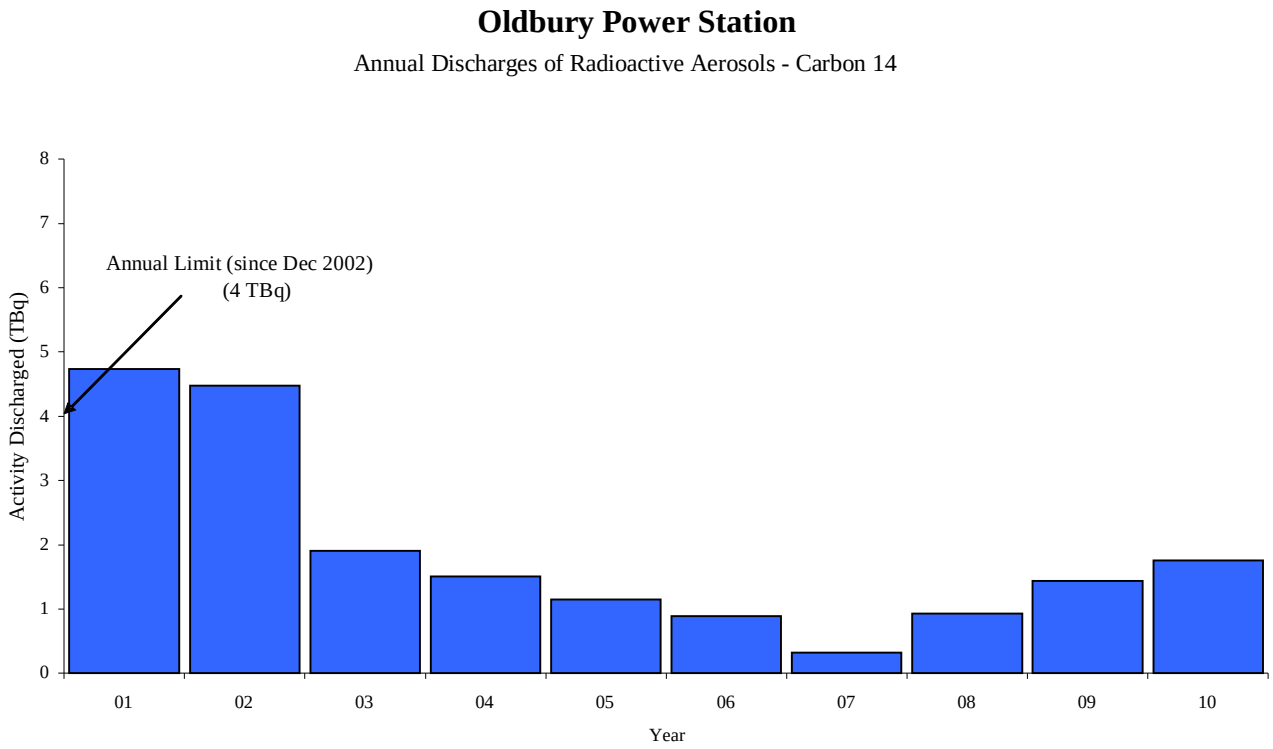


Fig 3.4 Oldbury, Annual discharges of Radioactive Aerosols – Carbon 14

Carbon 14 is a low energy beta emitting radionuclide generated in the reactor by neutron activation of stable carbon, nitrogen and oxygen.

In 2010 Carbon 14 discharges were higher than recent years due to increased electricity generation.

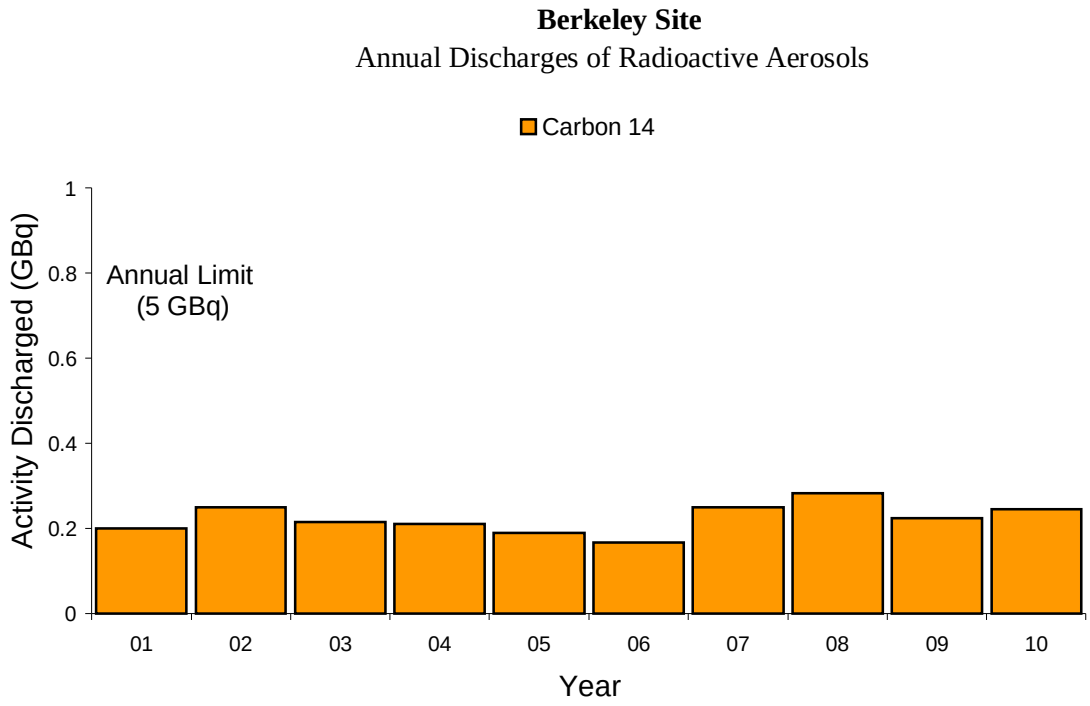


Fig 3.5 Berkeley Site, Annual Discharges of Radioactive Aerosols - Carbon 14

Carbon 14 discharges from Berkeley Power Station reactors originate from the reactors which are depressurised to atmospheric pressure and contain air.

Carbon-14 will be assessed as described in section 3.2.

Oldbury Power Station

Annual Discharges of Radioactive Aerosols - Argon 41

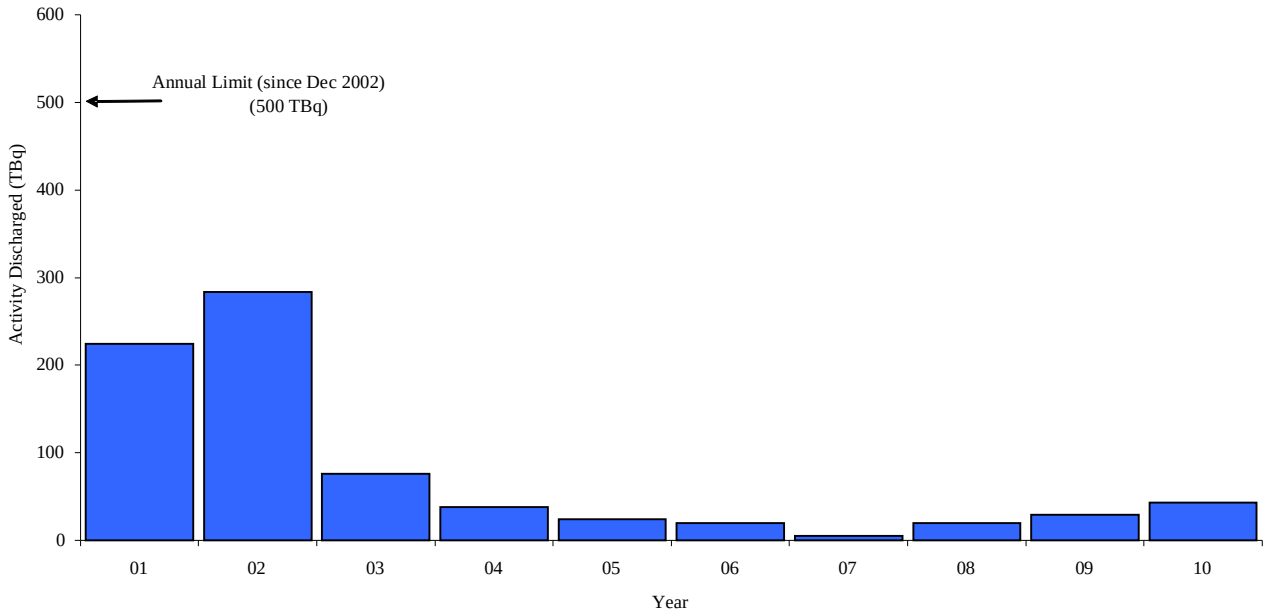


Fig 3.6 Oldbury, Annual Discharges of Radioactive Aerosols – Argon 41

Argon-41 is a beta/gamma emitting radionuclide with a very short half-life (1.83 hours) and is chemically inert. It is generated in reactor gas by neutron activation of stable argon which is a trace element in air and carbon dioxide coolant.

In 2010 Argon 41 discharges were higher than recent years due to increased electricity generation.

Oldbury Power Station

Annual Discharges of Radioactive Aerosols - Beta Particulate

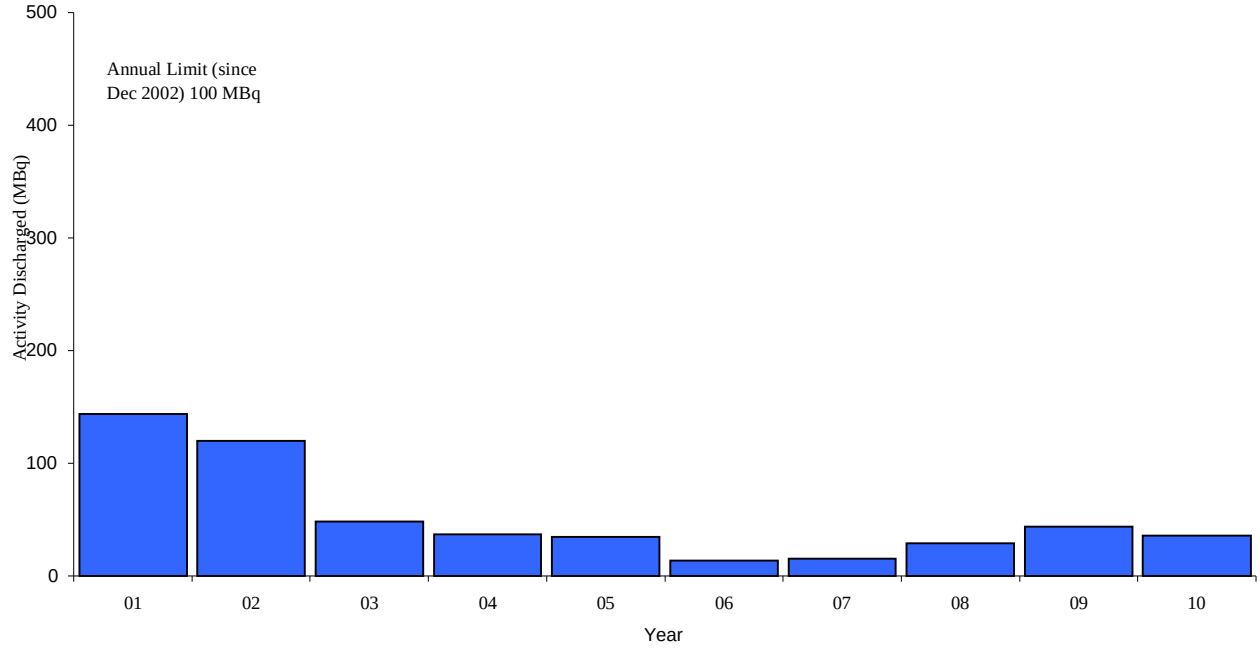


Fig 3.7 Oldbury, Annual Discharges of Radioactive Aerosols – Beta Particulate

All major gaseous discharges are passed through high-efficiency filters that remove 99.9% of all particulate prior to discharge. Particulate material is sampled and analysed for radioactivity.

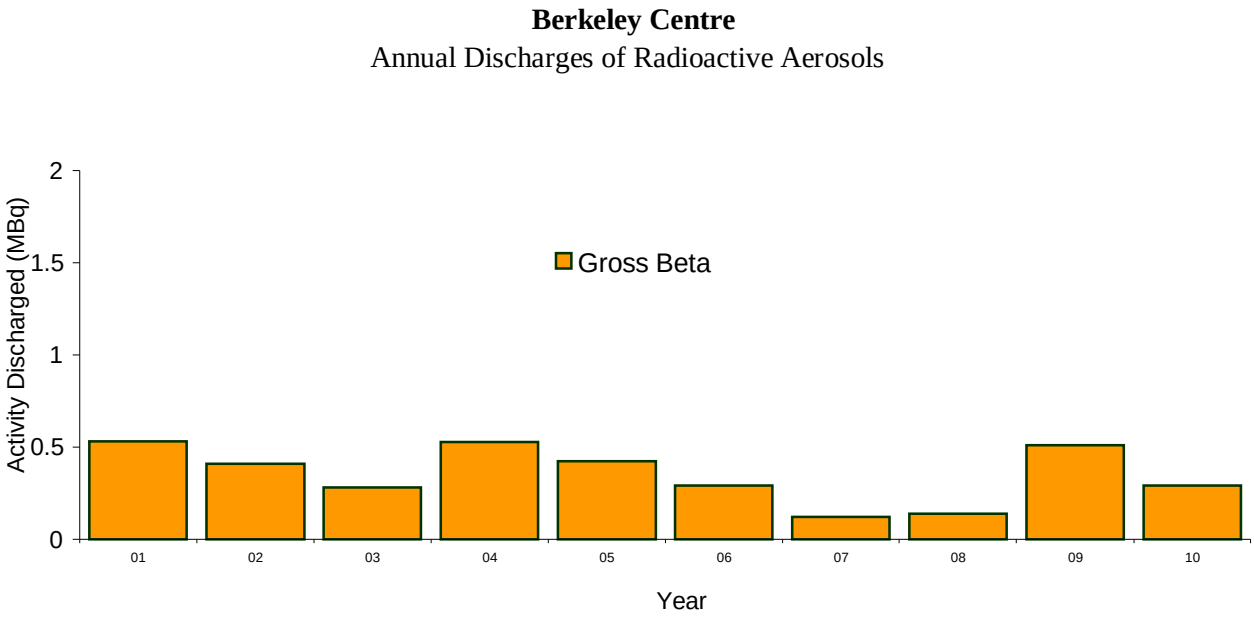


Fig 3.8 Berkeley Site, Annual Discharges of Radioactive Aerosols - Beta Particulate

All major gaseous discharges are passed through high efficiency filters before discharge. Particulate material is sampled and analysed for radioactivity.

4. LIQUID EFFLUENT DISCHARGES

Site specific permits for discharging radioactive liquid effluent to the Severn Estuary are granted by the Environment Agency. The authorisation limits are set after considering the actual quantities of radioactivity each site needs to discharge and the need to keep environmental risks below an acceptable level. Best Available Techniques (BAT) is used to minimise discharges and ensure doses to the public are As Low As Reasonably Practicable (ALARP). The sites would be required to justify that any liquid discharges greater than the Quarterly Notification Level (QNL) were discharged in-accordance with BAT.

At Oldbury the principle source of radioactive liquid effluent arises with the treatment of cooling pond water. Other smaller sources originate from change rooms, laundries and decontamination facilities. Liquid is filtered in the effluent treatment plant before passing to final hold up tanks where its radioactive content and chemical make-up are analysed prior to the effluent being authorised for discharge.

Principle sources of liquid effluent from Berkeley arise from decommissioning activities and operation of the site. However, the radioactive liquid effluent generated at Berkeley is a very small fraction of what the arisings were during generation. This is due mainly to the decommissioning of the areas that in the past would have previously generated liquid effluent.

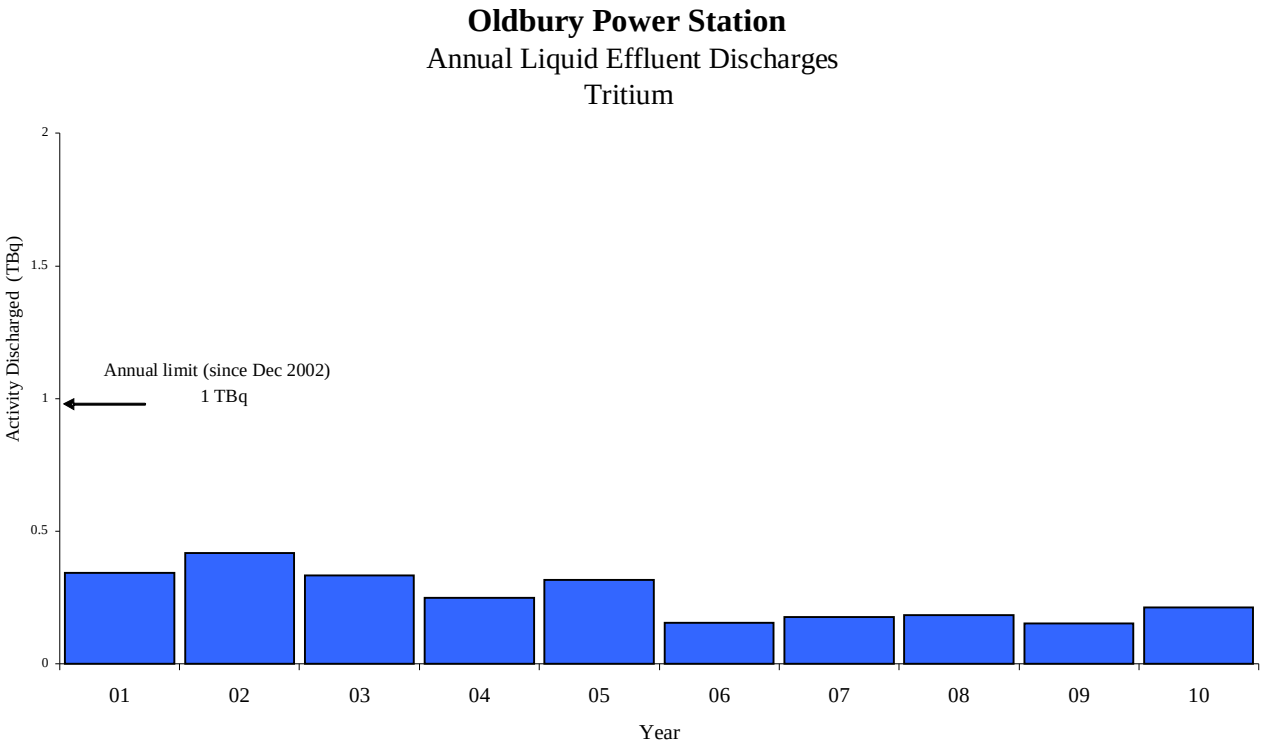


Fig 4.1 Oldbury, Annual Liquid Effluent Discharges of Tritium

Tritium (H-3) is a low energy beta emitting radionuclide with a low radiotoxicity. Limits are placed on tritium because although it has low dose implications due to its low radiotoxicity, it forms a significant fraction of the total activity discharged from Site. Tritium arises in the cooling ponds as tritiated water and is discharged via the effluent treatment plant.

Berkeley Site
Annual Liquid Effluent Discharges

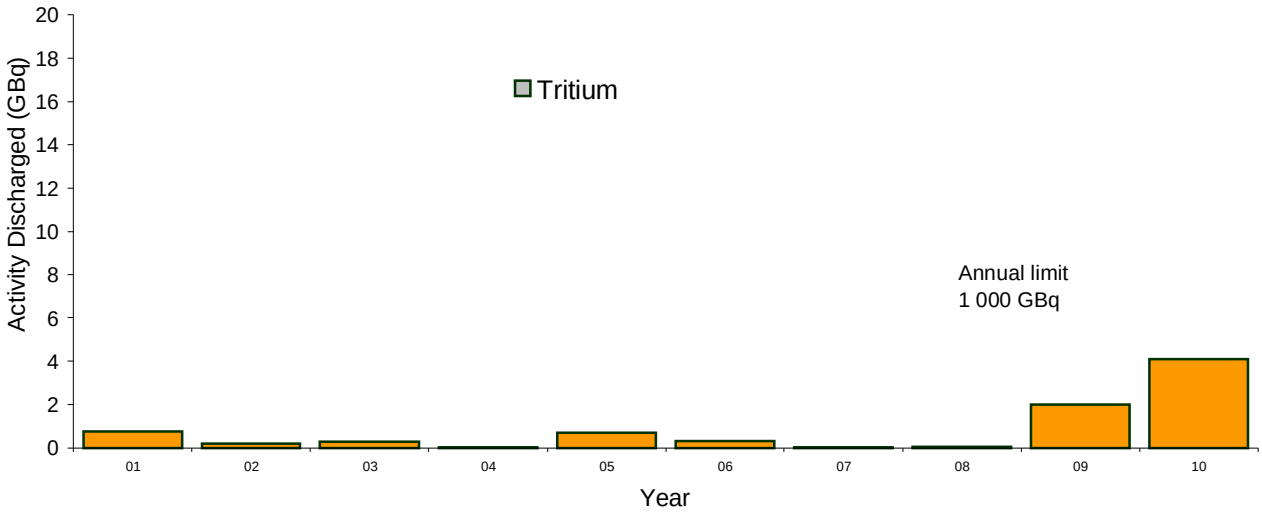


Fig 4.2 Berkeley Site, Annual Liquid Effluent Discharges of Tritium

Tritium arises in the cooling ponds as tritiated water and is discharged via the effluent treatment plant. Although Berkeley Site is a decommissioning Site, the 12 year half life of tritium will mean that traces still remain.

In 2011 it is planned to replace the active effluent treatment process with a Mobile Active Effluent Treatment Plant; this change will significantly simplify the treatment process.

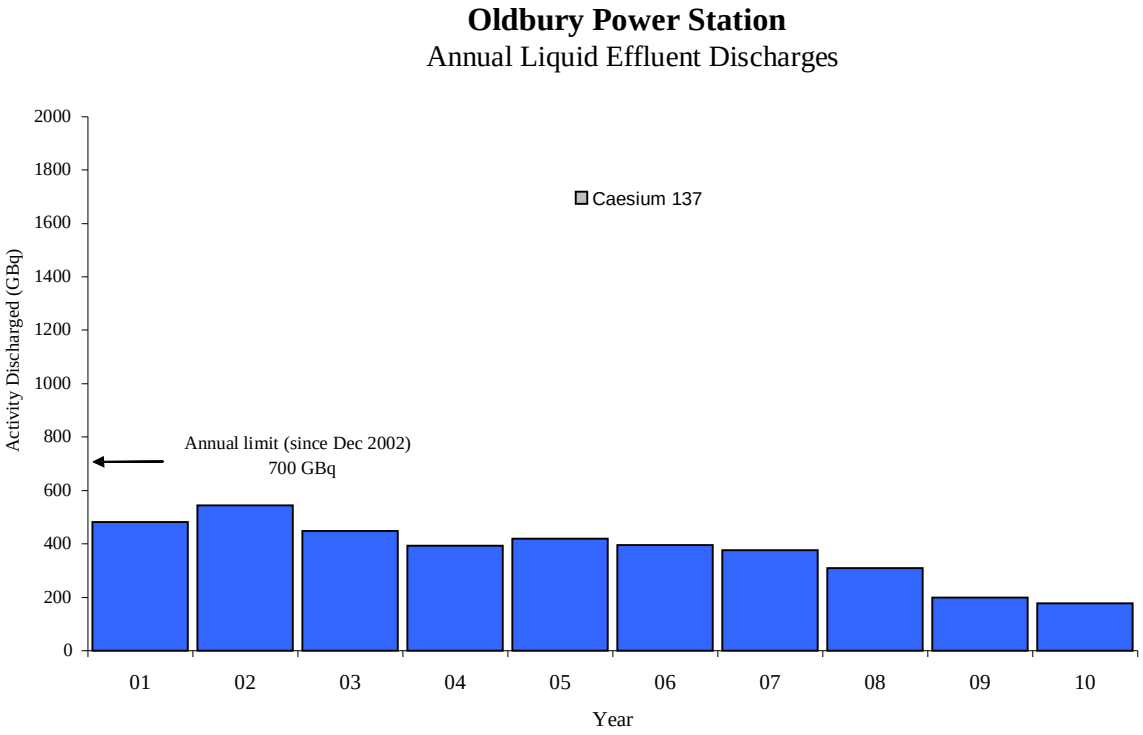


Fig 4.3 Oldbury, Annual Liquid Effluent Discharges of Caesium 137

Caesium-137 is a gamma emitting radionuclide. It is generated as a fission product and contained within the fuel can. Small quantities of highly soluble caesium-137 can be released in pond water. Good control of pond chemistry ensures that the fuel remains in good condition while it is in the ponds and significantly reduces the release of fission product into the pond water.

Discharges of caesium-137 have been higher in recent years. This is related to increases in caesium-137 levels in Sellafield's fuel handling plant, which receives fuel from stations for reprocessing and returns transport skips for re-use. Oldbury now monitor incoming skips for caesium, rejecting those that might release significant quantities of caesium-137 to the cooling ponds.

Berkeley Site
Annual Liquid Effluent Discharges

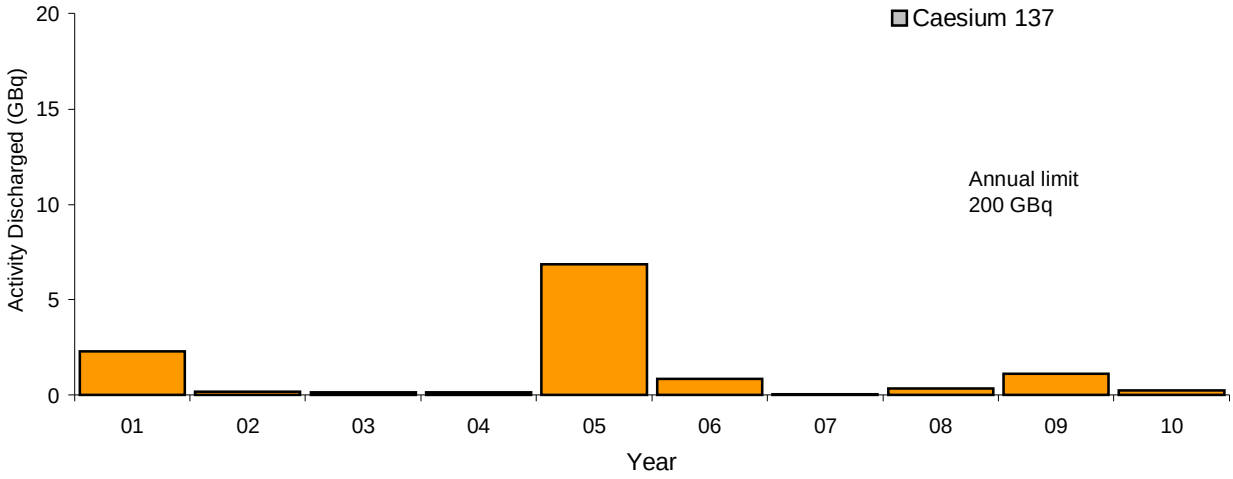


Fig 4.4 Berkeley Site, Annual Liquid Effluent Discharges of Caesium 137

Caesium-137 is a gamma emitting radionuclide. When Berkeley was operating, it would have been generated as a fission product and contained within the fuel can. Small quantities of highly soluble caesium-137 would have been released in pond water, and although fuel has been removed from Site and the fuel ponds have been decommissioned the 30 year half life of Caesium will mean that contamination will still be present and maybe discharged as a result of decommissioning activities.

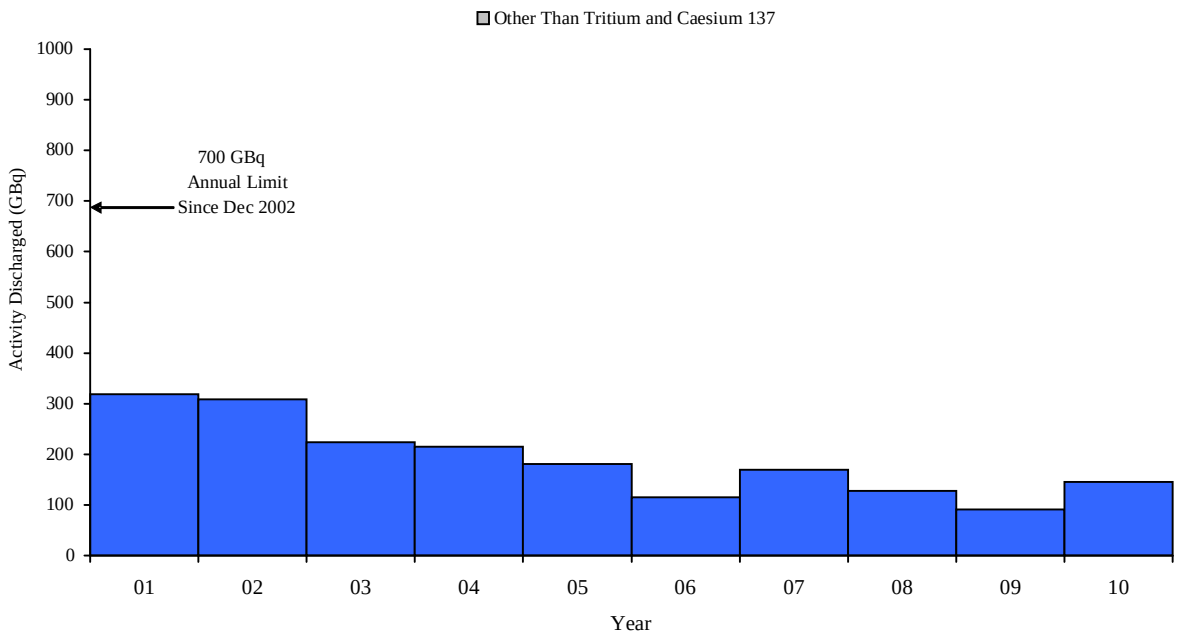


Fig 4.5 Oldbury, Annual Liquid Effluent Discharges

'Other activity' refers to all other measurable activity other than Caesium and Tritium which are regulated separately. 'Other activity' originates from:

- Fission product from the ponds; this is minimised through good chemical control of the ponds and hence good fuel condition;
- Decontamination facilities, washing and cleaning activities in a variety of areas plant areas across Site.

All radioactive liquids are filtered for particulate in the Active Effluent Treatment Plant and are measured before they are discharged.

Berkeley Site
Annual Liquid Effluent Discharges

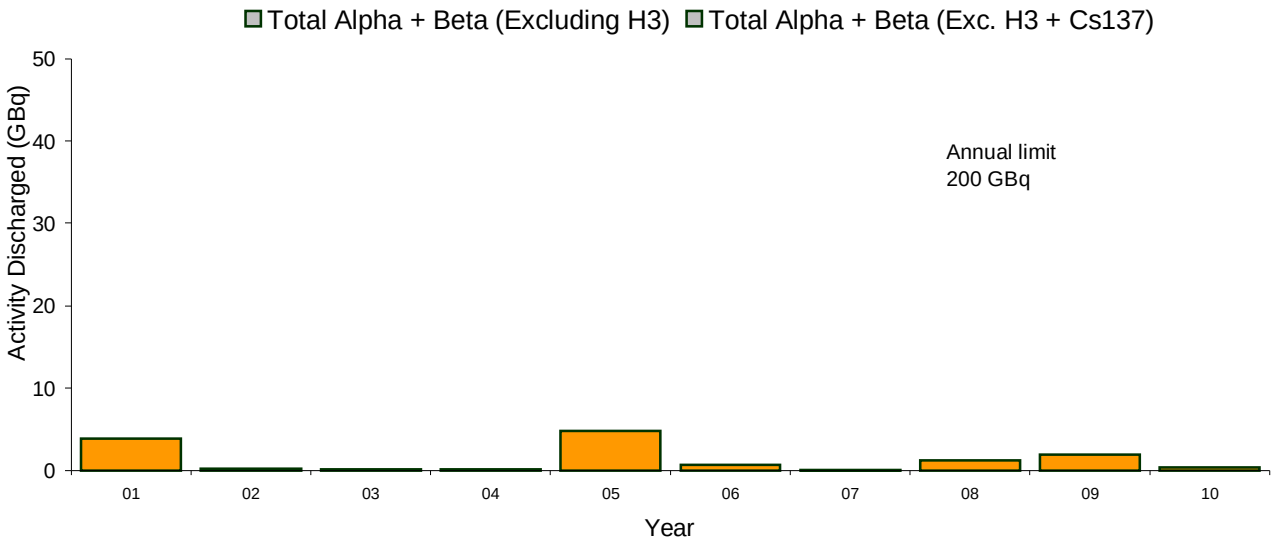


Fig 4.6 Berkeley Site, Annual Liquid Effluent Discharges

'Other activity' refers to all other measurable activity other than Caesium and Tritium which are regulated separately. The origin of 'other activity' at Berkeley Site will be contamination from the reactors and labs during the operational phase. Decommissioning activities will include cleaning, washing of personnel and decontamination of equipment or waste prior to disposal or re-use; these activities will all produce contaminated liquid effluent.

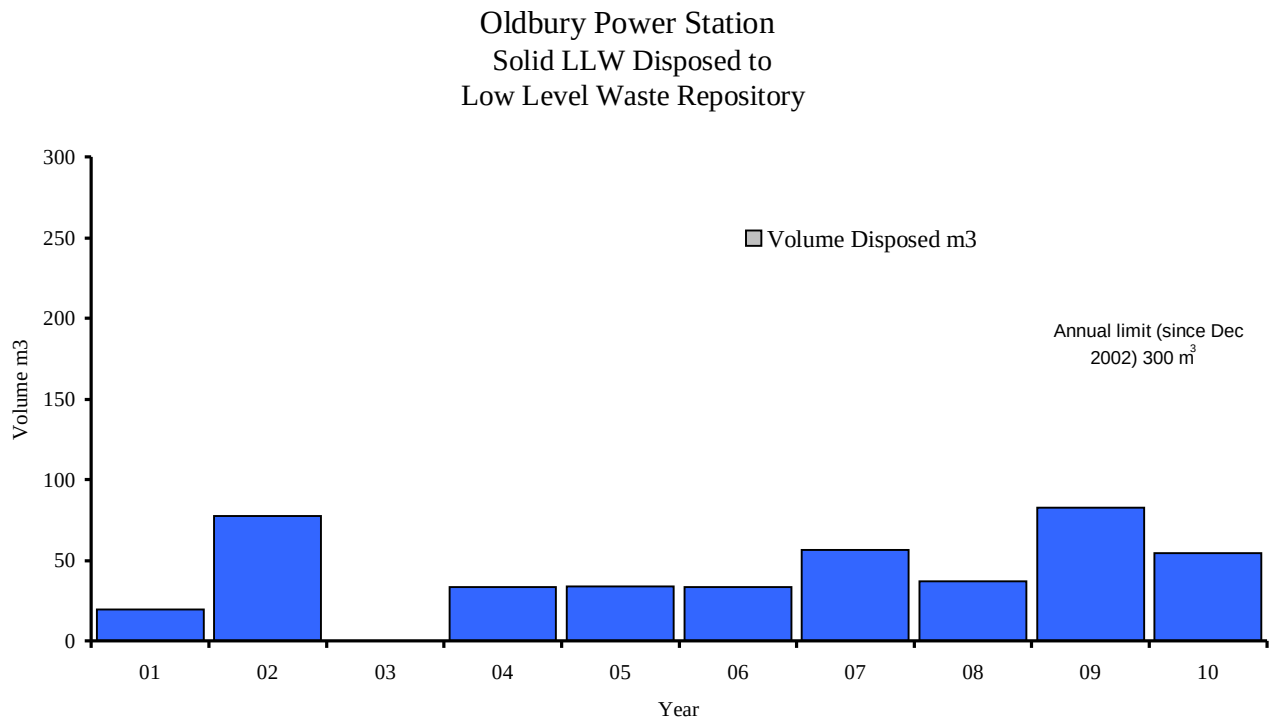


Fig 4.7 Oldbury, Annual Disposals of LLW to LLWR

Low level radioactive waste (LLW) is generated during the operation and maintenance of the power station.

Typical types of waste include filters, clothing and cleaning wipes. The waste is sent to the national low level waste repository (LLWR) in Cumbria for disposal following sorting, treating and compacting to reduce volumes. Certain types of waste are super compacted at Sellafield prior to disposal at the LLWR.

At all times the Site seeks to reduce the quantity of contaminated materials and wastes produced; where such wastes are produced the Site seeks to utilise the Waste Hierarchy to minimise the waste disposed of to the LLWR.

Berkeley Site
Annual Disposal of LLW to (LLWR)
Low Level Waste Repository

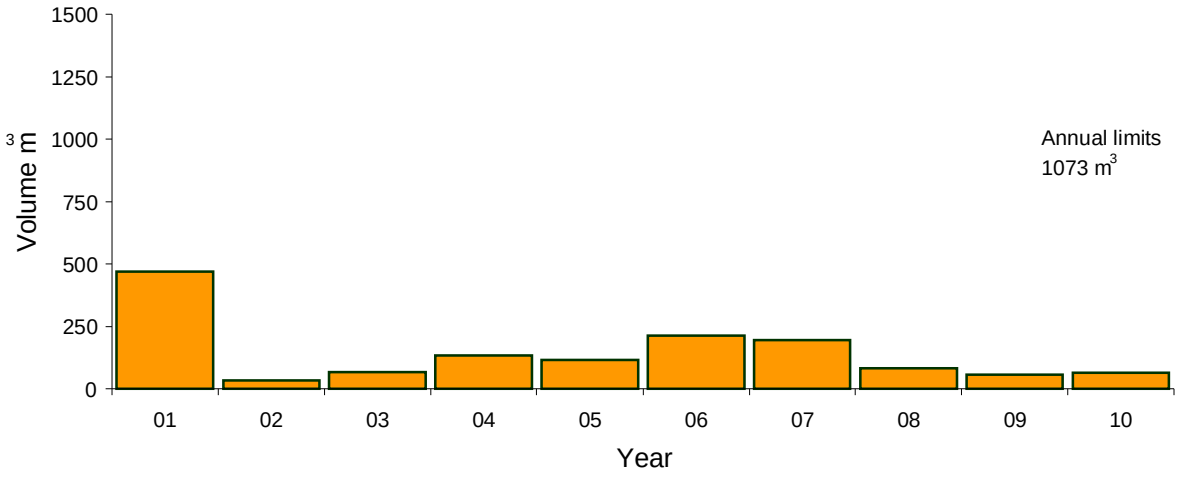


Fig 4.8 Berkeley Site, Annual Disposals of LLW to LLWR

Low level radioactive waste (LLW) is generated from decommissioning activities at the Berkeley Site.

The waste is sent to LLWR in Cumbria for disposal following sorting, treating and compaction. Certain types of waste are super compacted at Sellafield prior to disposal at the LLWR.

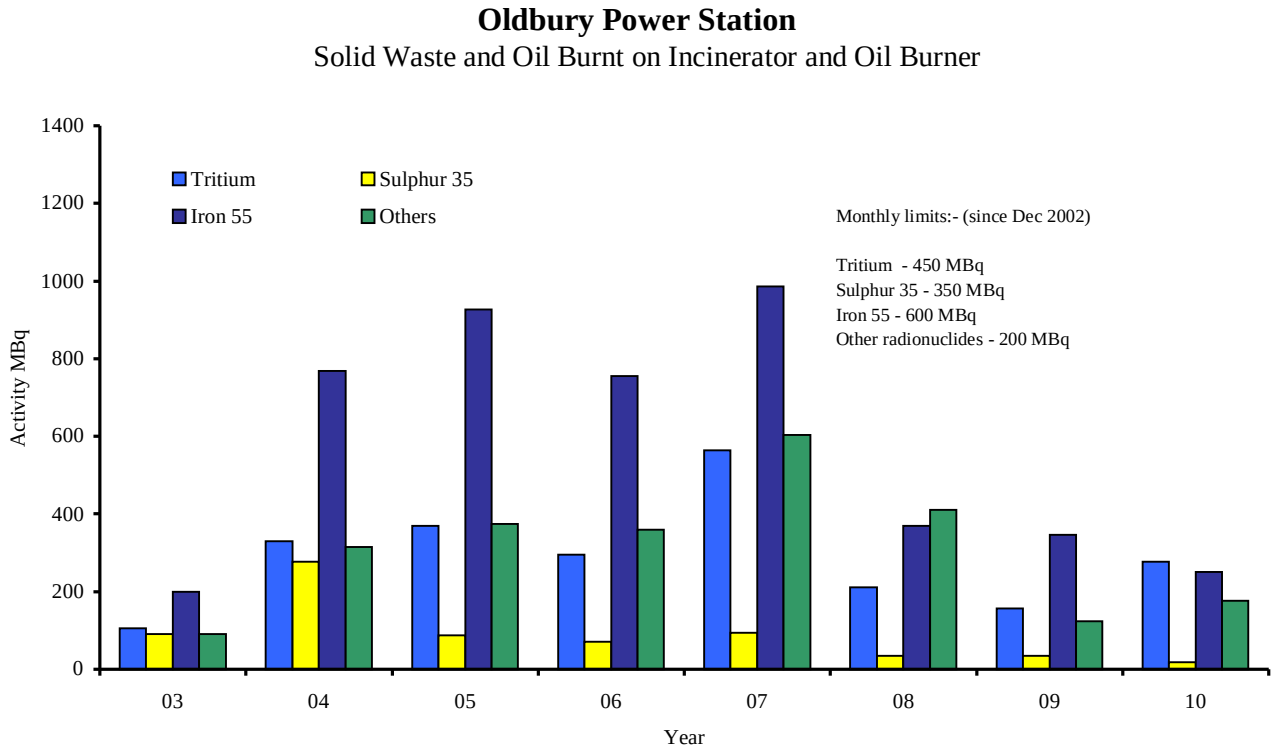


Fig 4.9 Oldbury, Solid Waste and Oil Burnt on Incinerator and Oil Burner

Combustible low level waste is produced at Oldbury and processed through the on site incinerator plant. Incineration results in a considerable volume reduction of the LLW material; the ash resulting from the incineration is sent to the LLWR for disposal.

The primary sources of combustible materials on site are:

- Lubricating oil used on in the gas circulators can become radioactive;
- Combustible materials such as paper

The graph shows the total activity discharged over the year. During this period the monthly discharges were well below the monthly discharge limits.

5. ENVIRONMENTAL MONITORING

An environmental monitoring programme is carried out by Oldbury Power Station. The purpose of the programme is several-fold but is primarily designed to provide data for the doses to members of the public to be assessed.

Samples such as grass, milk, soil, silt, seaweed, fish and tackishade dust collectors are usually collected all year round and analysed in a specially designed low level counting laboratory. Gamma radiation dose-rates are also measured in the estuary and land sites in concentric rings around the stations. During 2001, programmes were restricted due to the "foot-and-mouth" crisis, as many sampling sites were inaccessible over that period. This not only affected monitoring of milk and pasture, but also monitoring of beaches that could be accessed only via restricted areas. The restrictions on access also prevented exposure to the public over this period. A full programme was re-established by the beginning of 2002.

All results are submitted to the Environment Agency for scrutiny and comparison with their own independent monitoring programmes.

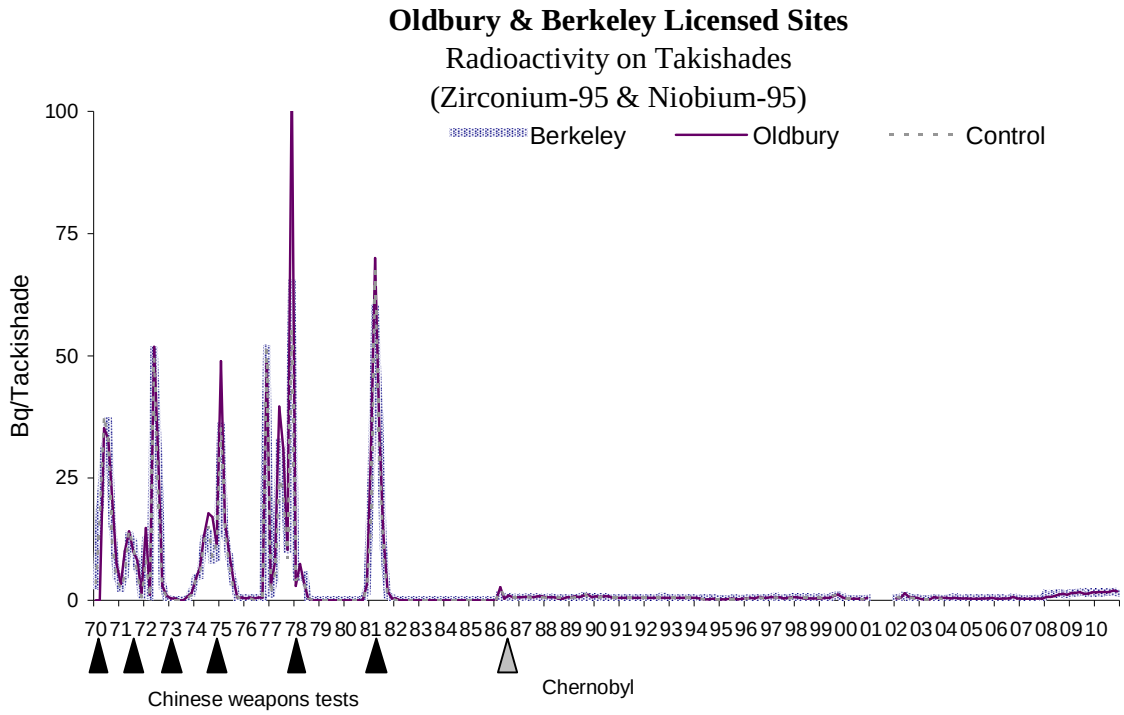


Fig 5.1 Oldbury & Berkeley Sites, Radioactivity on Tackishades (Zirconium – 95 and Niobium – 95)

Tackishades are passive dust collectors that are very sensitive indicators of airborne radioactive particulate material. The effects of the Chinese weapons testing above ground in the 1970's and the Chernobyl accident in 1986 illustrate the sensitivity of these collectors. All readings are now instrument background levels.

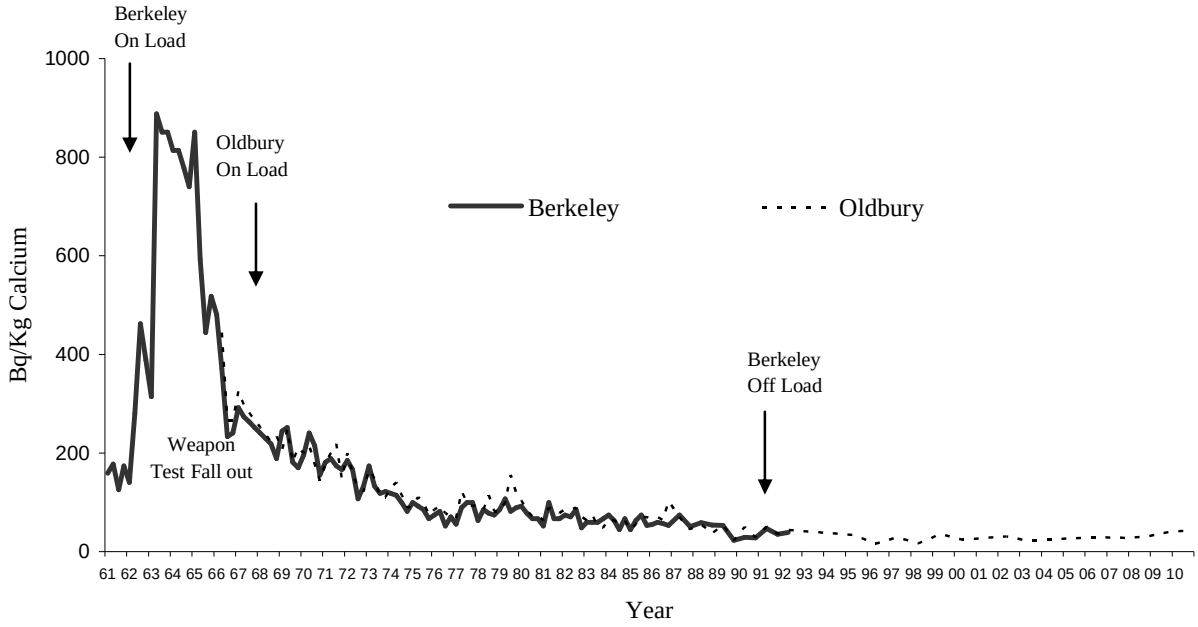


Fig 5.2 Oldbury & Berkeley Sites, Strontium 90 in Milk

Radioactive strontium is chemically similar to calcium and like calcium is concentrated in milk. Strontium-90 is a beta emitting radionuclide and is generated in the fuel as a fission product.

Since the removal of fuel and the associated fission products from Berkeley Power Station, strontium-90 in milk analysis has been confined to farms surrounding Oldbury Power Station only. The presence of strontium-90 in milk would only occur in the event of fuel element failure and a subsequent discharge of gas to the environment. All recent results of milk from Oldbury are below minimum detectable activity.

Oldbury Power Station
Radiation Dose rates at 0.5 - 1.0 km Sites

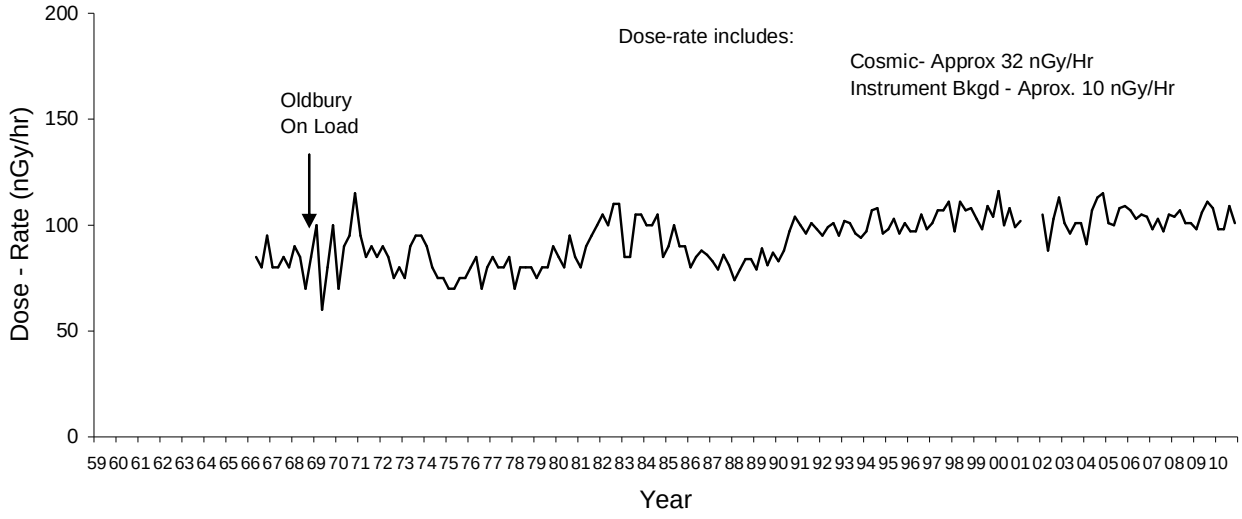


Fig 5.3 Oldbury Power Station, Radiation Dose rates at 0.5 – 1 km sites

Gamma dose-rate measurements are regularly taken in an arc around the station at a distance of between 0.5 and 1.0 Km. Gamma dose-rate measurements at greater than 3 km sites show little difference to those taken at closer sites, indicating that gamma dose-rates due to the site's operations are indistinguishable above natural background dose-rates.

Measurements are taken 1 metre above ground level. Environmental dose-rates include cosmic radiation from outer space, terrestrial radiation from naturally occurring radioactive elements in the ground and instrument background readings.

Measurements will depend on environmental conditions such as cloud cover and atmospheric pressure on the day.

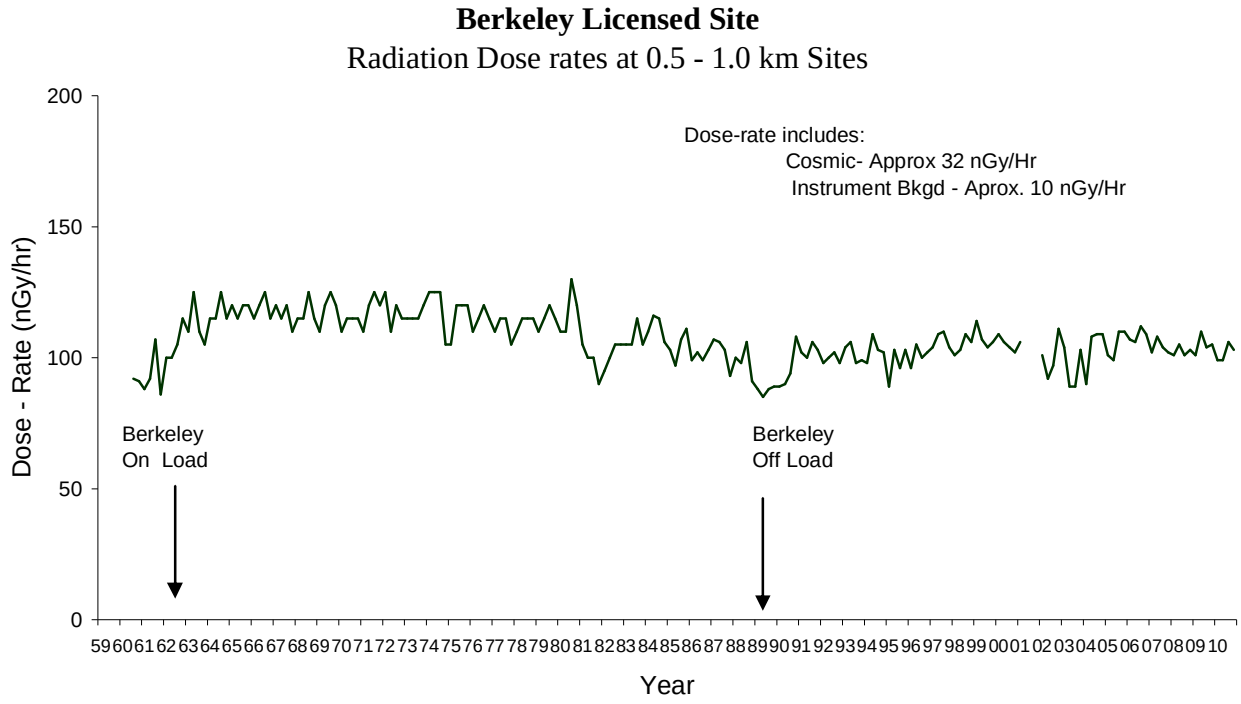


Fig 5.4 Berkeley Site, Radiation Dose rates at 0.5 – 1 km sites

Gamma dose-rate measurements at greater than 3 km sites show little difference to those taken at closer sites, indicating that gamma dose-rates due to the site's operations are indistinguishable above natural background dose-rates.

Oldbury & Berkeley Licensed Sites

Radiation Dose rate at 1 - 3 km Sites

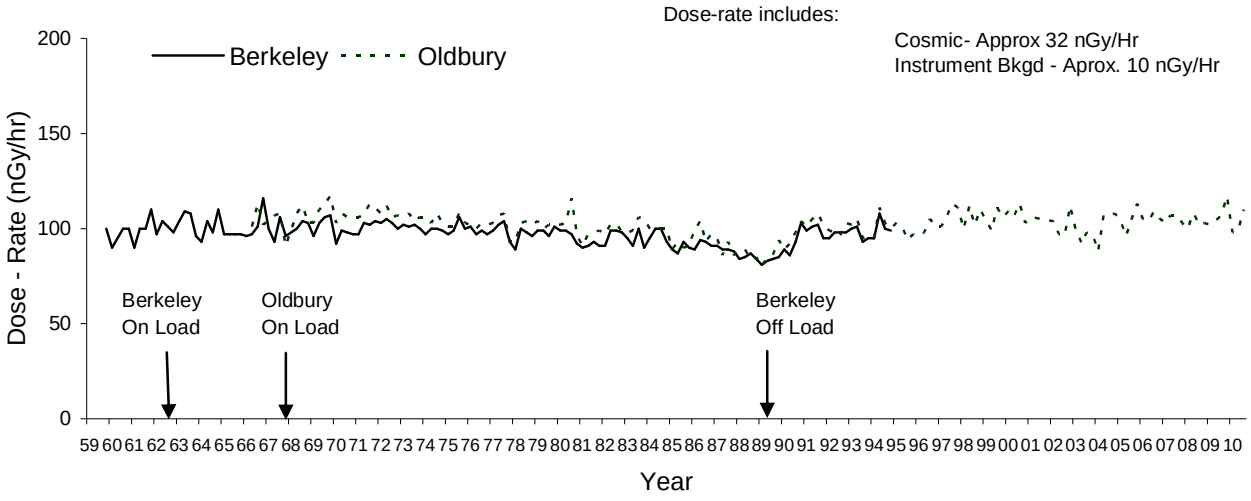


Fig 5.5 Oldbury & Berkeley Sites, Radiation Dose rates at 1 – 3 km Sites

Gamma dose-rate measurements at greater than 3 km sites show little difference to those taken at closer sites, indicating that gamma dose-rates due to the sites' operations are indistinguishable above natural background dose-rates.

Oldbury & Berkeley Licensed Sites

Radiation Dose rate >3 km Sites

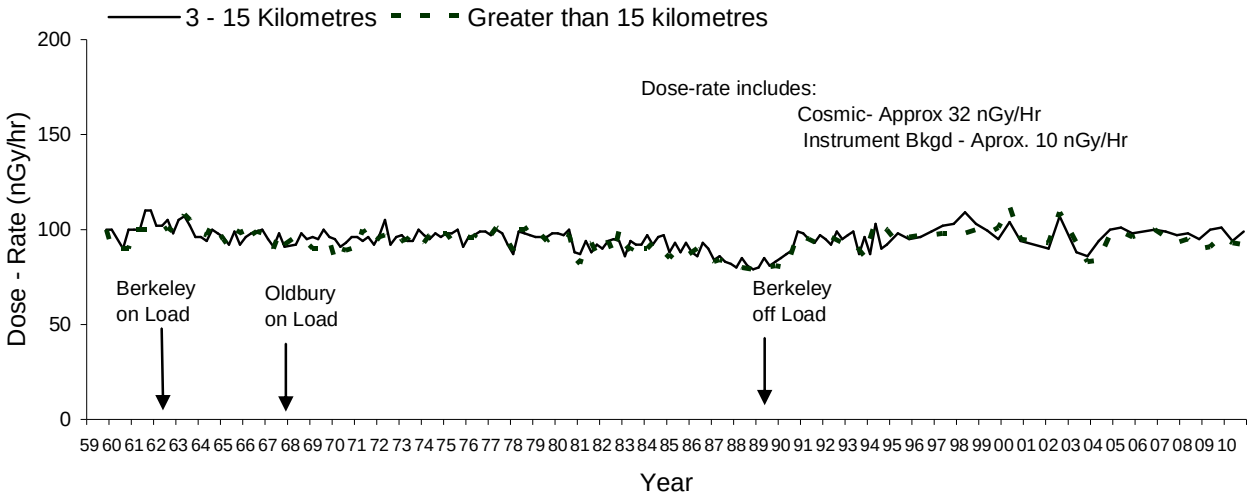


Fig 5.6 Oldbury & Berkeley Sites, Radiation Dose rates at > 3 km Sites

Gamma dose-rate measurements at greater than 3 km sites show little difference to those taken at closer sites, indicating that gamma dose-rates due to the sites' operations are indistinguishable above natural background dose-rates.

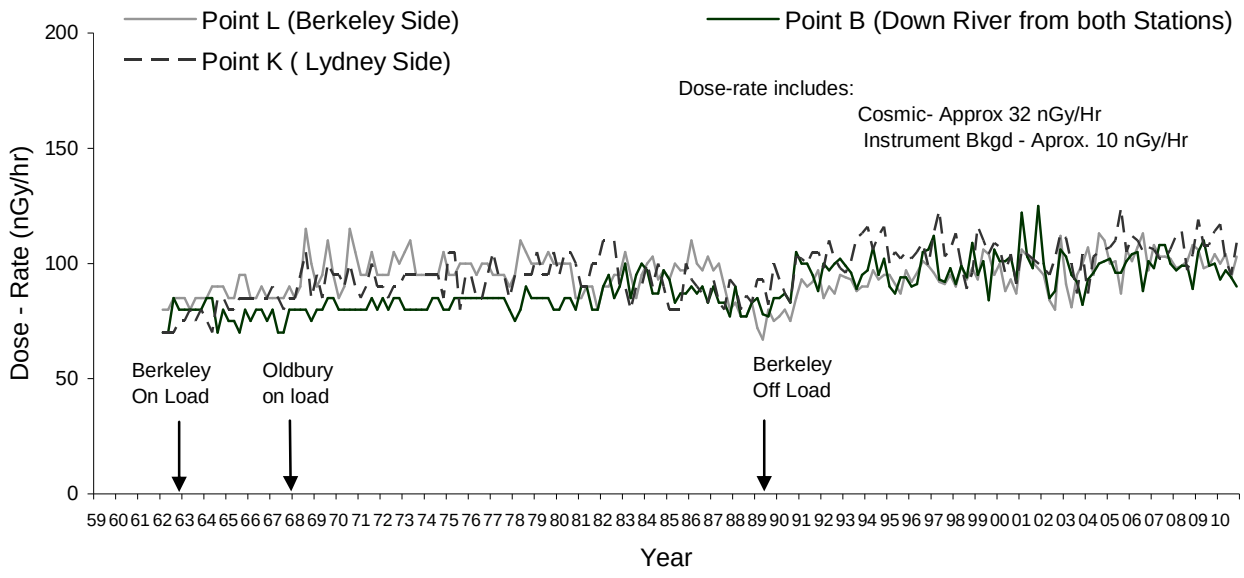


Fig 5.7 Oldbury & Berkeley Sites, Radiation Dose rates at Estuary Sites

Gamma dose-rates are measured regularly in the estuary on both sides of the channel. Measurements are taken 1 metre above silt and do vary slightly due to environmental conditions such as cloud cover and atmospheric pressure and the movement of silt and sand in the channel.

Oldbury & Berkeley Licensed Sites

Radioactivity in Seaweed - Total Beta

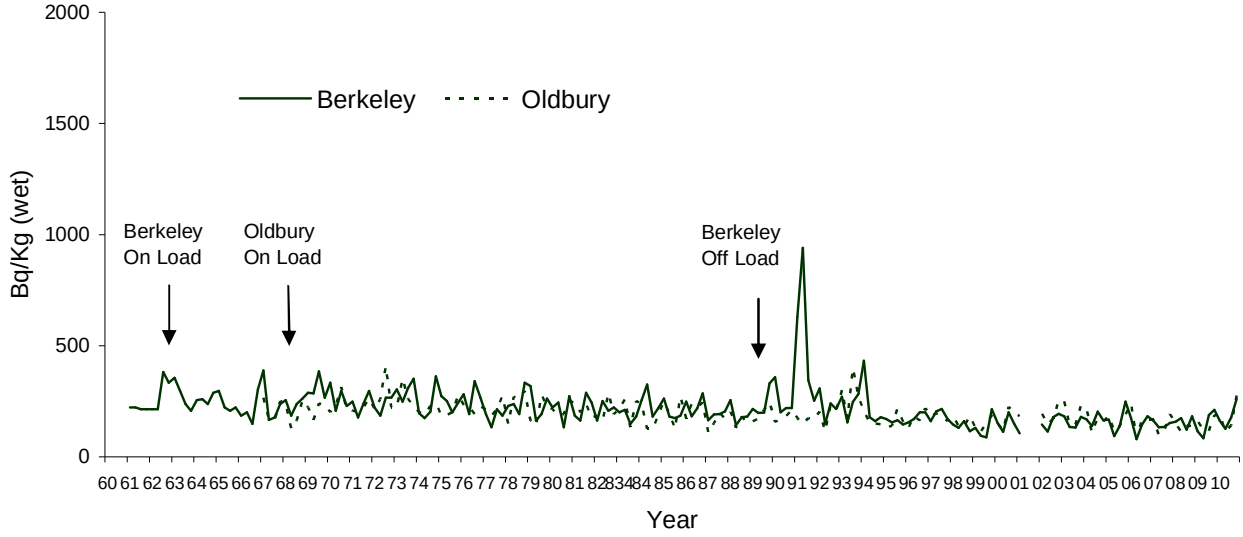


Fig 5.8 Oldbury & Berkeley Sites, Radioactivity in Seaweed (Total Beta)

Seaweed is chosen as an indicator material as it tends to concentrate radionuclides such as Caesium-137 and Iodine-131. A large proportion of the radioactivity in seaweed is naturally occurring Potassium-40. The peak in 1991 is attributable to fuel pond decommissioning activities carried out at Berkeley.

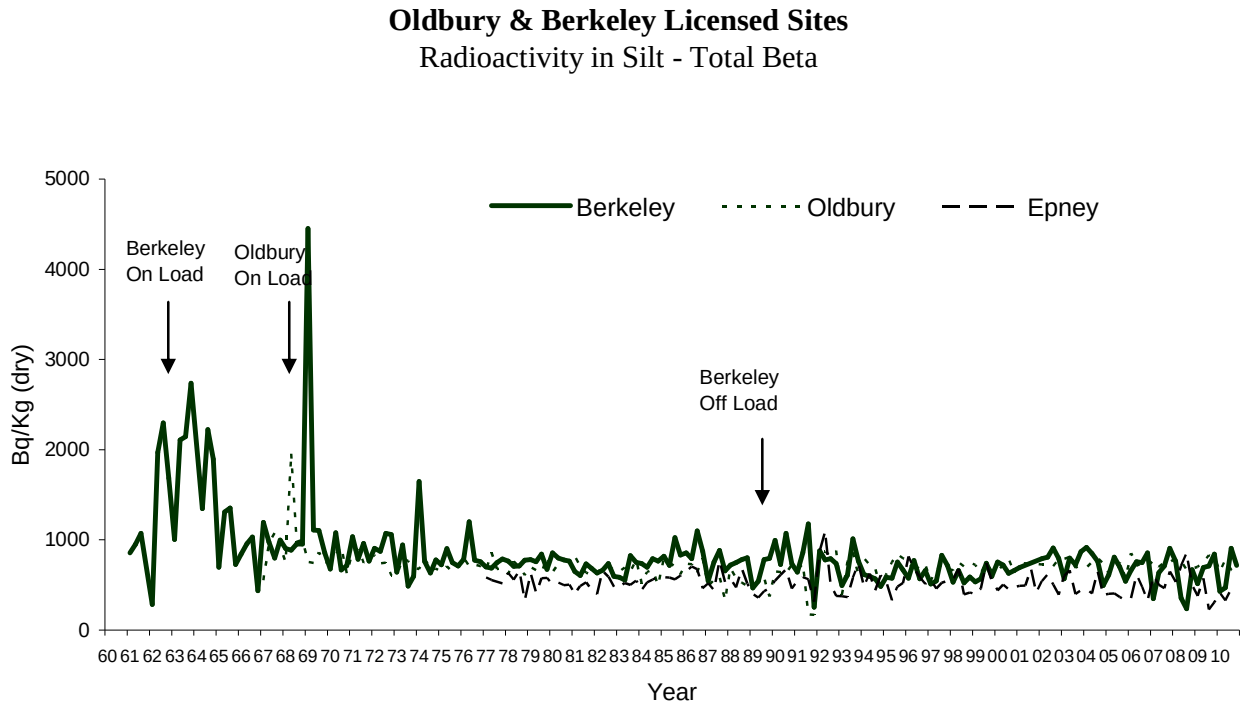


Fig 5.9 Oldbury & Berkeley Sites, Radioactivity in Silt (Total Beta)

Silt is collected from inter-tidal areas of the estuary and its radioactive content measured once it is dried. Levels of naturally occurring Potassium-40 vary depending on tidal patterns. Fission products such as Caesium-137 may be detected at very low levels due to the Chernobyl incident in 1986 and residuals from liquid effluent discharges.

Oldbury & Berkeley Licensed Sites

Radioactivity in Fish - Mean Total Beta

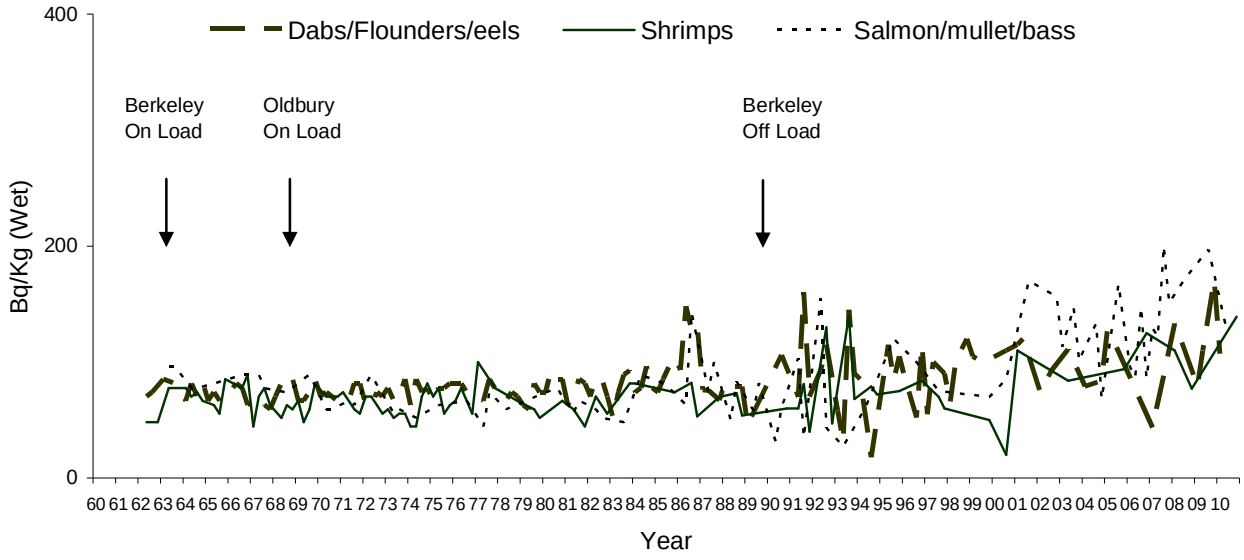


Fig 5.10 Oldbury & Berkeley Sites, Radioactivity in Fish (Total Beta)

Samples of commercially caught fish are collected from both sides of the channel and the edible portion analysed.

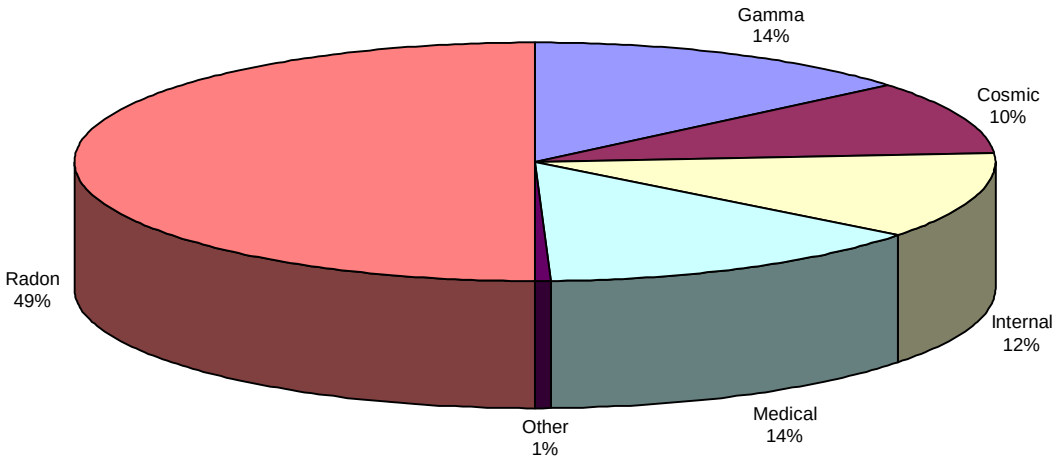
6. SUMMARY OF RADIATION DOSES TO THE PUBLIC

The annual dose in 2009 to members of a small local group of the general public (RIFE – 14) are recorded below. Note dose assessments are normally a year in arrears as information is collated and assessed.

	OLDBURY & BERKELEY
Terrestrial foodstuffs	**< 5 µSv (Same as 2008)**
Non-food discharges to air	**< 5 µSv (Same as 2008)**
Seafood	**25 µSv (29 µSv in 2008)**
External radiation from all sources	**24 µSv (41 µSv in 2008)**

The doses may be compared with the annual background dose to the UK population calculated by the Health Protection Agency (HPA) to be 2600 uSv (figure 6.1)

Figure 6.1: Average Annual Background Dose to UK Population - 2600 uSv



7. CONCLUSIONS

7.1 The aerial discharges for 2010 from Oldbury have increased slightly due to increase operation/electricity generation during this period compared to recent years.

7.2 2010 liquid discharges at Oldbury have remained similar to recent years.

7.3 Berkeley aerial and liquid discharges have remained constant compared to previous years as the site continues through decommissioning.

7.4 The environmental monitoring programme does not identify any significant increases in radiation in the environment; however a slight upward trend in has been noted in Fish which has been investigated and is due to naturally occurring potassium 40.

7.5 Total doses for 2009 are slightly lower than those received in 2008.

8. TERMS AND DEFINITIONS

1) Becquerel (Bq)

The Becquerel (Bq) is a unit of radioactivity.

1 Becquerel means one radioactive disintegration per second. The Becquerel is a very small unit.

1,000,000 Bq	=	1 Megabecquerel (MBq)
1,000,000,000 Bq	=	1 Gigabecquerel (GBq)
1,000,000,000,000 Bq	=	1 Terabecquerel (TBq)

2) Gray (Gy)

The Gray (Gy) is a unit of absorbed dose.

1 Gray is the special name given for one joule of energy from ionising radiation absorbed in one kilogram of a substance.

$\frac{1}{1{,}000{,}000{,}000} Gy = 1$ nanoGray (nGy)

3) Sievert (Sv)

1 Sievert (Sv) is a unit of effective absorbed dose.

The Sv is a measure of radiation dose equivalent, i.e. it takes into account the biological effect of the particular radiation being considered.

$\frac{1}{1{,}000} Sv = 1$ milliSievert (mSv)

$\frac{1}{1{,}000{,}000} Sv = 1$ microSievert (µSv)

4) ALARP

ALARP is the term used to ensure that the doses to staff and the public are controlled such that they are As Low As Reasonably Practicable.

5) BAT

BAT is defined as: ‘the latest stage of development of processes, facilities or methods of operation which indicate the practical suitability of a particular measure for limiting waste arisings and disposal’.