Berkeley & Oldbury
Site Stakeholder Group

Environmental Monitoring & Radioactive Discharges for 2016

Presented at the October 2017 Meeting

CONTENTS

1. INTRODUCTION

This report contains information on the discharge and disposal of radioactive waste at Oldbury and Berkeley Licensed Sites for 2016. The report provides 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. Reactor 1 was shutdown for the last time on 29 February 2012 and Reactor 2 was shutdown for the last time on 30 June 2011. Berkeley Power Station was an earlier Magnox station that operated between 1962 and 1989.

Both sites are regulated under the Environmental Permitting Regulations. 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 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 (EHSSQ Manager), Oldbury Site, Oldbury Naite, Thornbury, South Gloucestershire, BS35 1RQ. This report has been approved for issue by the EHSQ Manager.

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 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.

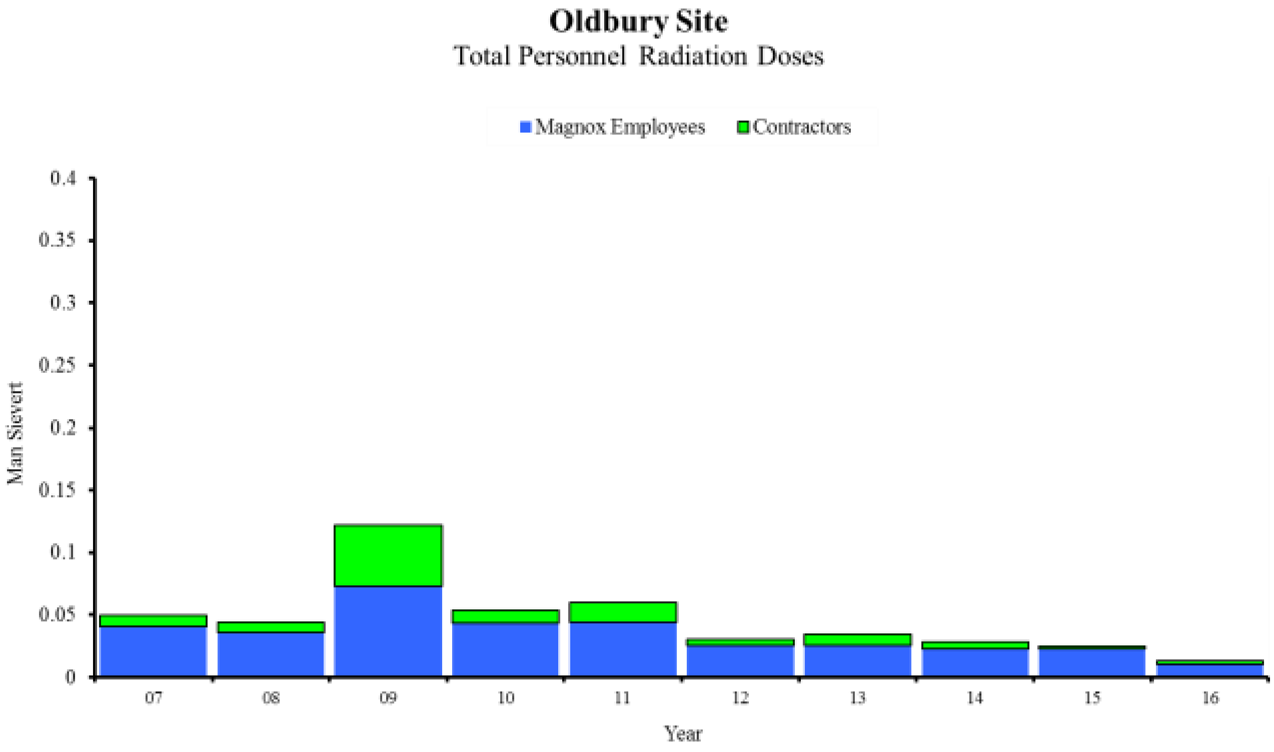


Fig 2.1 Oldbury Site, Total Personnel Radiation Doses

Most of the dose accumulated during outage years was 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.

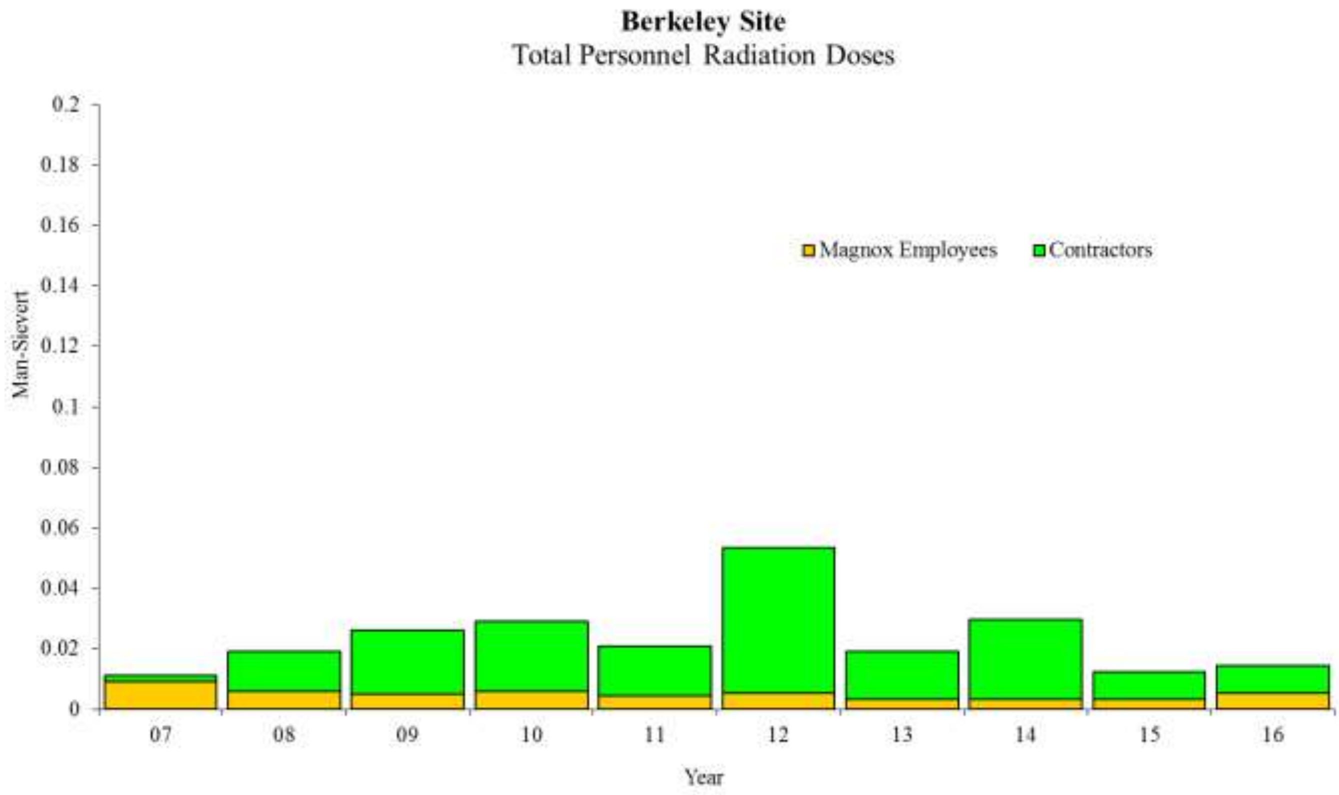


Fig 2.2 Berkeley Site, Total Personnel Radiation Doses

Variations in dose received are dependant on the type of decommissioning work carried out. Cell 1 – 10 decommissioning took place in 2012.

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) are used to minimise discharges and ensure doses to the public are as low as reasonably practicable (ALARP). Oldbury and Berkeley are 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 permit limit and the limit that could present a significant health risk to members of the public. In addition, most discharges are well below the permit 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 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 aerial discharges from Oldbury have decreased since the cessation of generation in 2012. Berkeley's discharges remain low reflecting the decommissioning stage of its lifecycle.

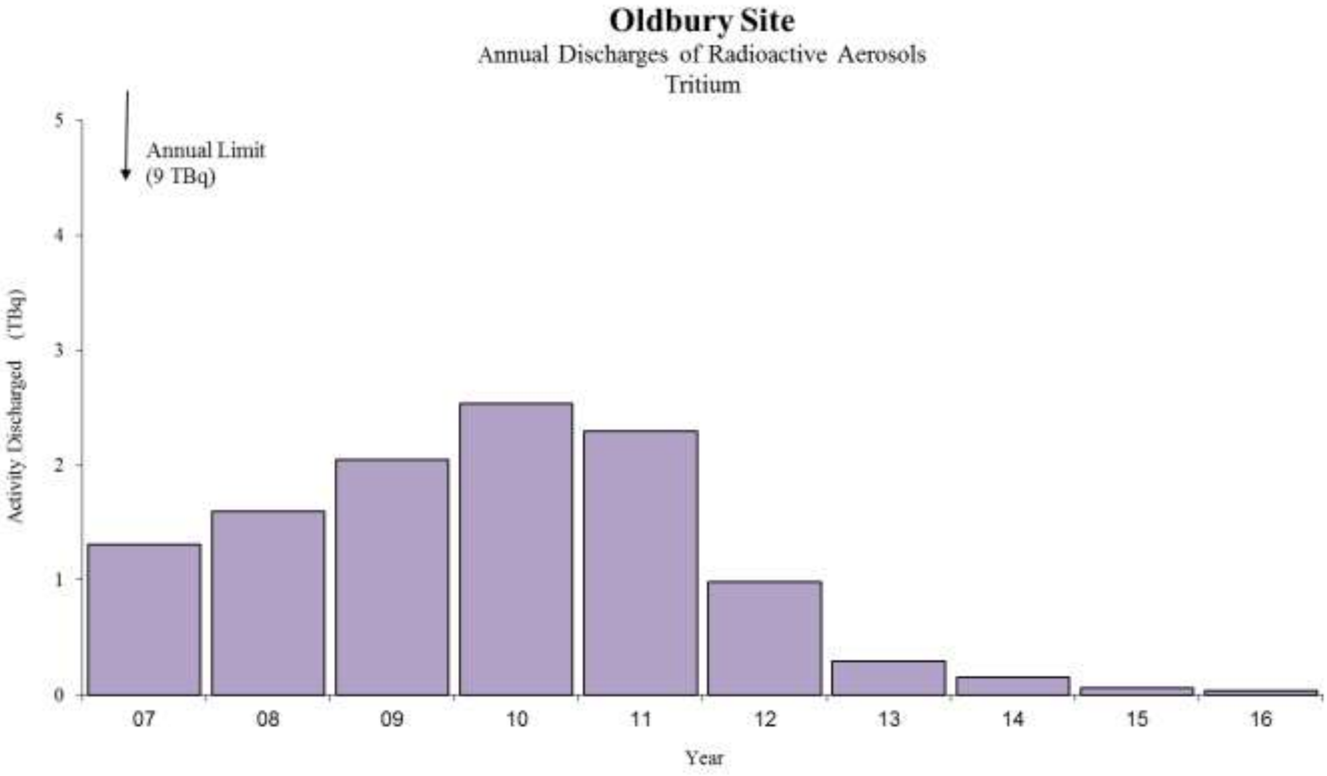


Fig 3.1 Oldbury Site, Annual Discharges of Radioactive Aerosols - Tritium

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

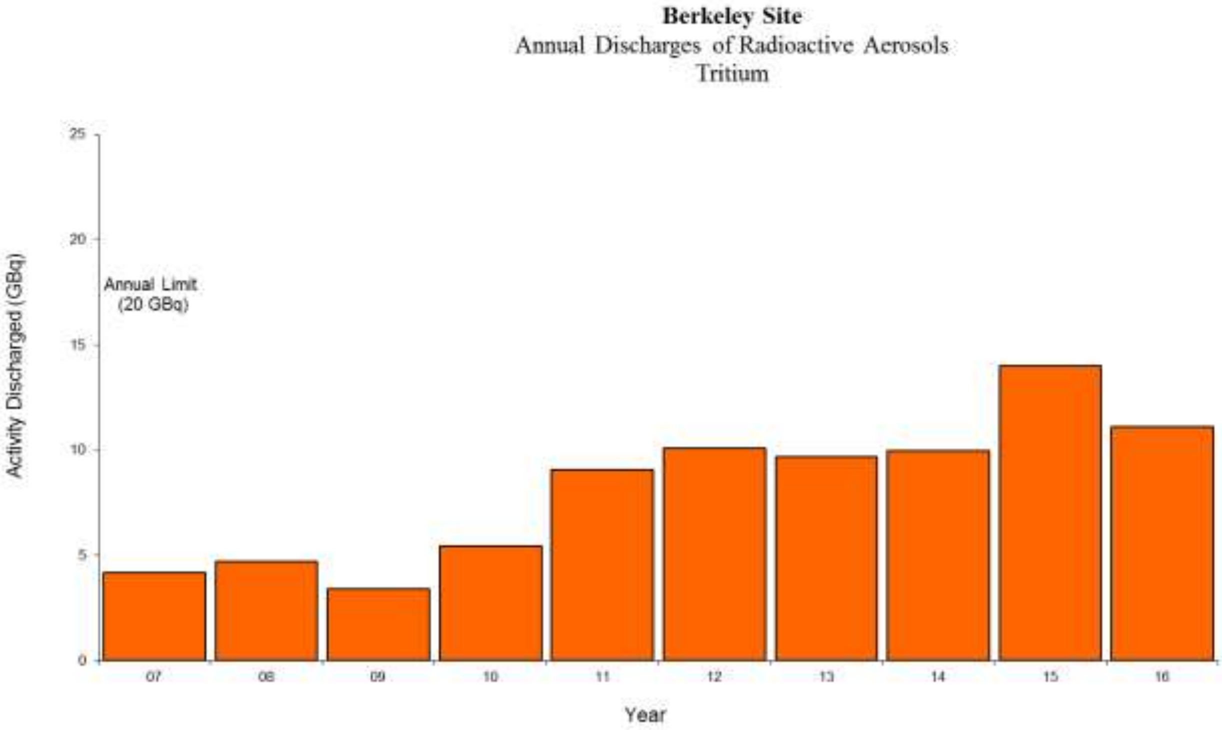


Fig 3.2 Berkeley Site, Annual Discharges of Radioactive Aerosols - Tritium

Tritium discharges from Berkeley originate from the Safestores (Reactors), the Active Waste Vault (AWV) building Intermediate Level Waste (ILW) retrieval module and the ILW Conditioning Facility.

The reactors 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. The discharges vary with atmospheric pressure and with moisture content for tritium, so an apparent change in tritium is a feature of atmospheric conditions.

Direct monitoring of gaseous effluent discharges may be undertaken whenever there is an entry into the Safestores, due to taking ad-hoc sampling over the years, Berkeley Site looked into revising how we estimate the discharges, this was amended in June 2016.

The increase in tritium discharges is due to the AWV building ILW retrieval module and the ILW conditioning facility commencing operations during the 2015.

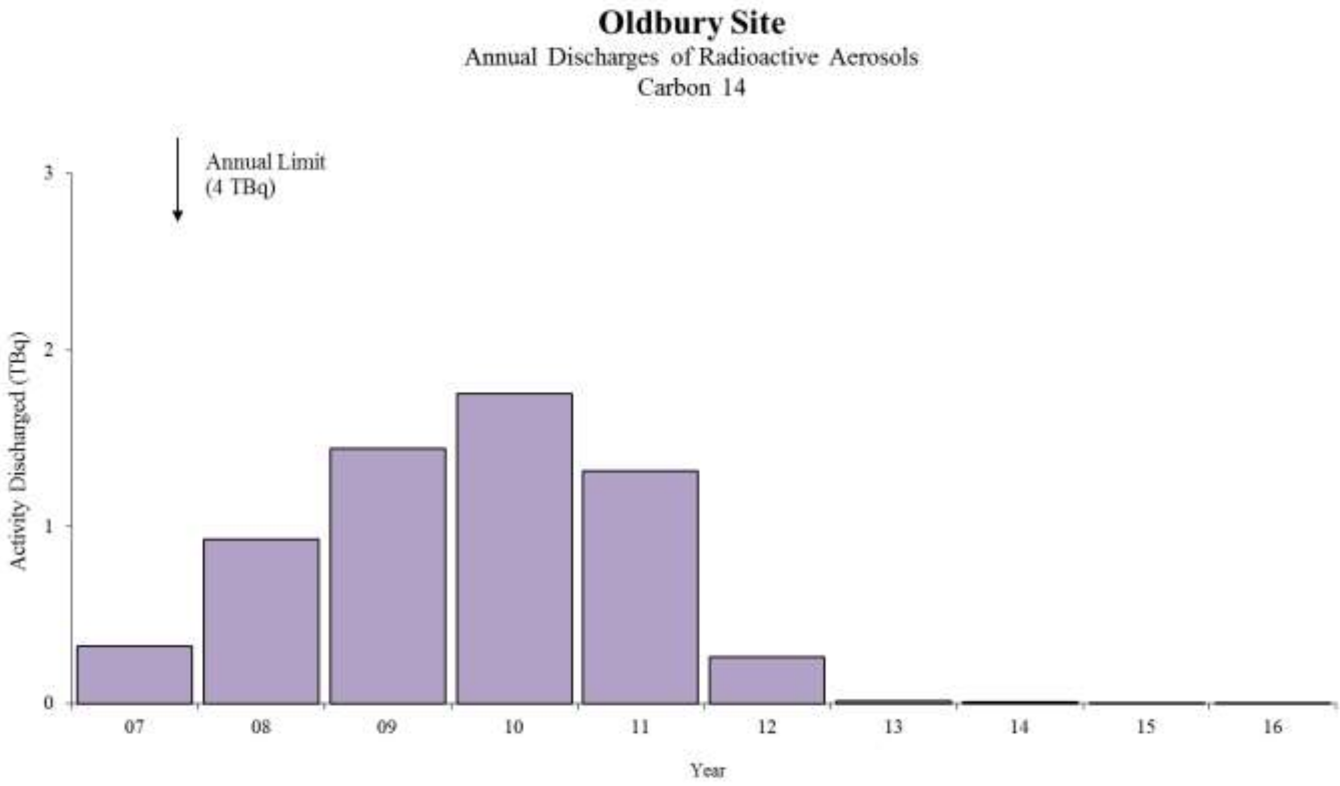


Fig 3.3 Oldbury Site, Annual discharges of Radioactive Aerosols – Carbon 14

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

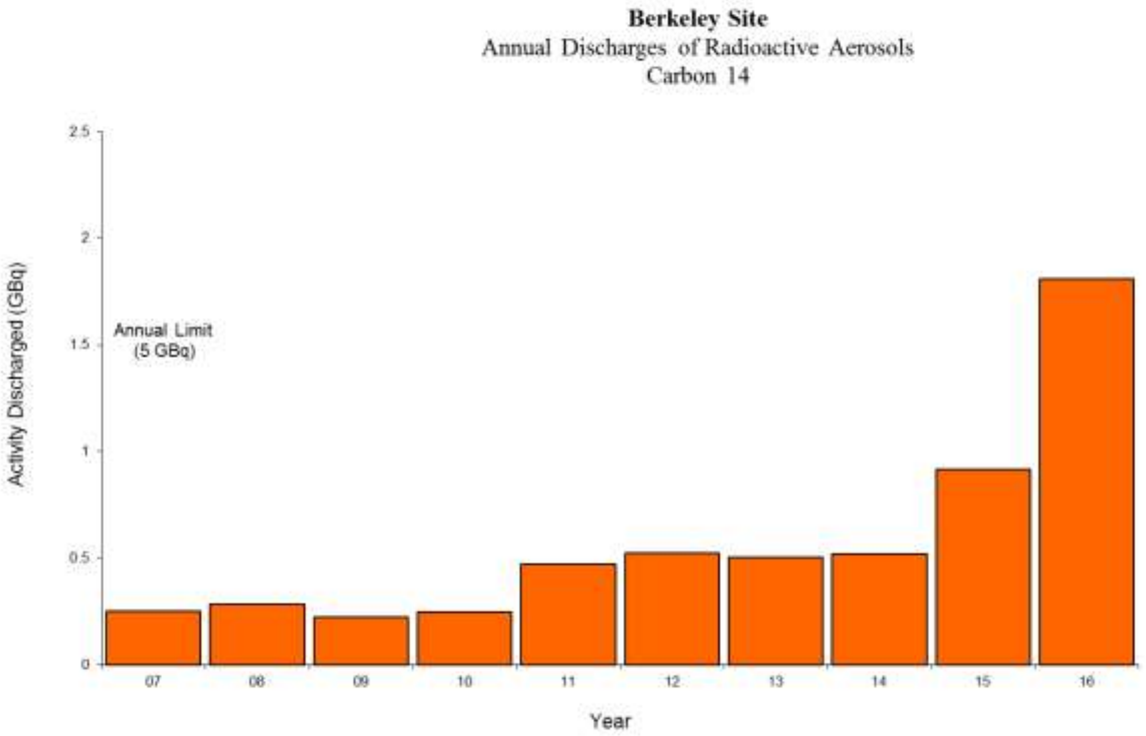


Fig 3.4 Berkeley Site, Annual Discharges of Radioactive Aerosols - Carbon 14

Carbon 14 discharges from Berkeley originate from the Safestores (Reactors), the Active Waste Vault (AWV) building Intermediate Level Waste (ILW) retrieval module and the ILW Conditioning Facility.

Carbon-14 will be assessed as described in section 3.2. The discharges vary with atmospheric pressure and with moisture content for C-14, so an apparent change in C-14 is a feature of atmospheric conditions.

Direct monitoring of gaseous effluent discharges may be undertaken whenever there is an entry into the Safestores, due to taking ad-hoc sampling over the years, Berkeley Site looked into revising how we estimate the discharges, this was amended in June 2016.

The small increase in Carbon-14 discharges is due to the AWV building ILW retrieval module and the ILW Conditioning facility commencing operations during the last year.

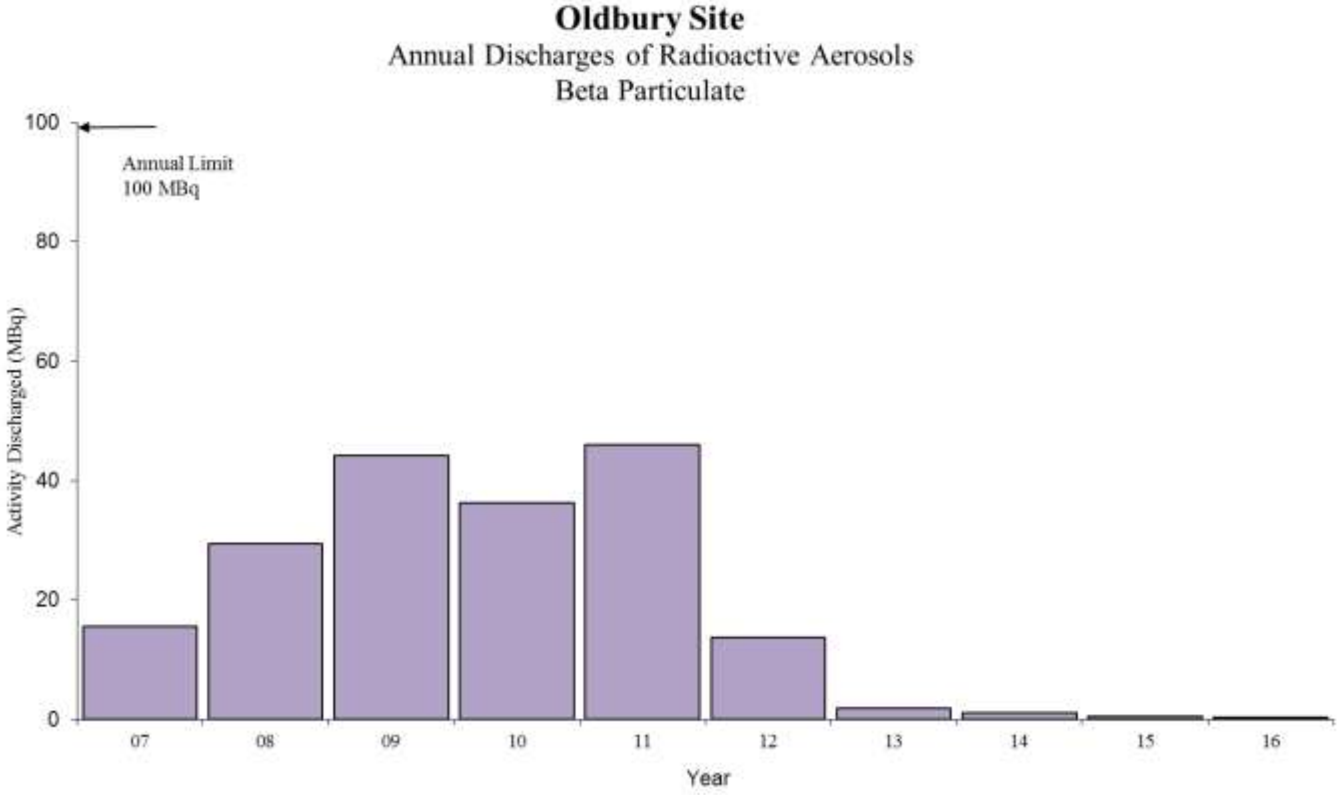


Fig 3.5 Oldbury Site, Annual Discharges of Radioactive Aerosols – Beta Particulate

Particulate material is sampled and analysed for radioactivity.

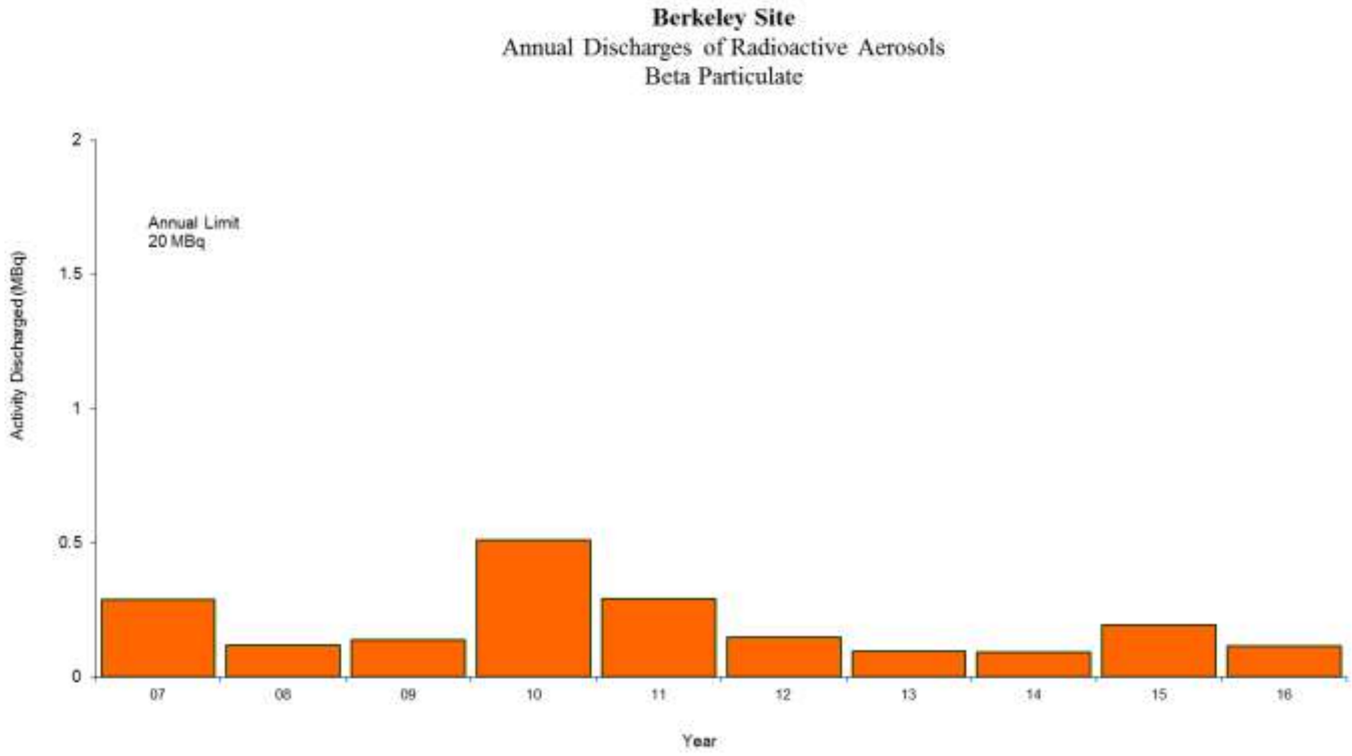


Fig 3.6 Berkeley Site, Annual Discharges of Radioactive Aerosols - Beta Particulate

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 permit 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) are 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 from 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. Liquid Effluent is transferred to the liquid effluent compliance plant (LECP) via the Site Bowser, from Intermediate Bulk Containers other suitable liquid containers and the Active Drains Reception Tank 2 in the Shielded Area.

The first discharge from the new Berkeley LECP which replaced the old active effluent treatment plant was in December 2013.

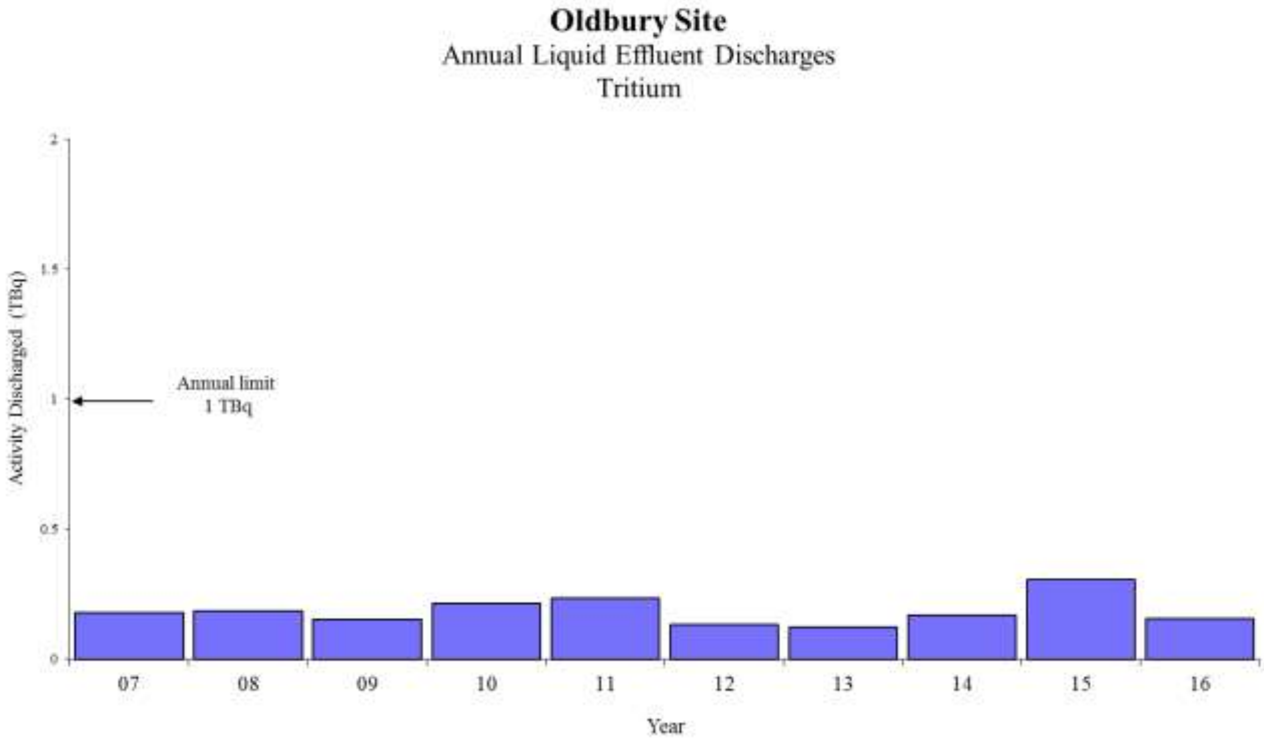


Fig 4.1 Oldbury Site, Annual Liquid Effluent Discharges of Tritium

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. The increase in 2015 tritium was due to a concentrated period of moving Magnox fuel elements from the dry reactor cores to the cooling ponds before completion of de-fuelling at the end of year.

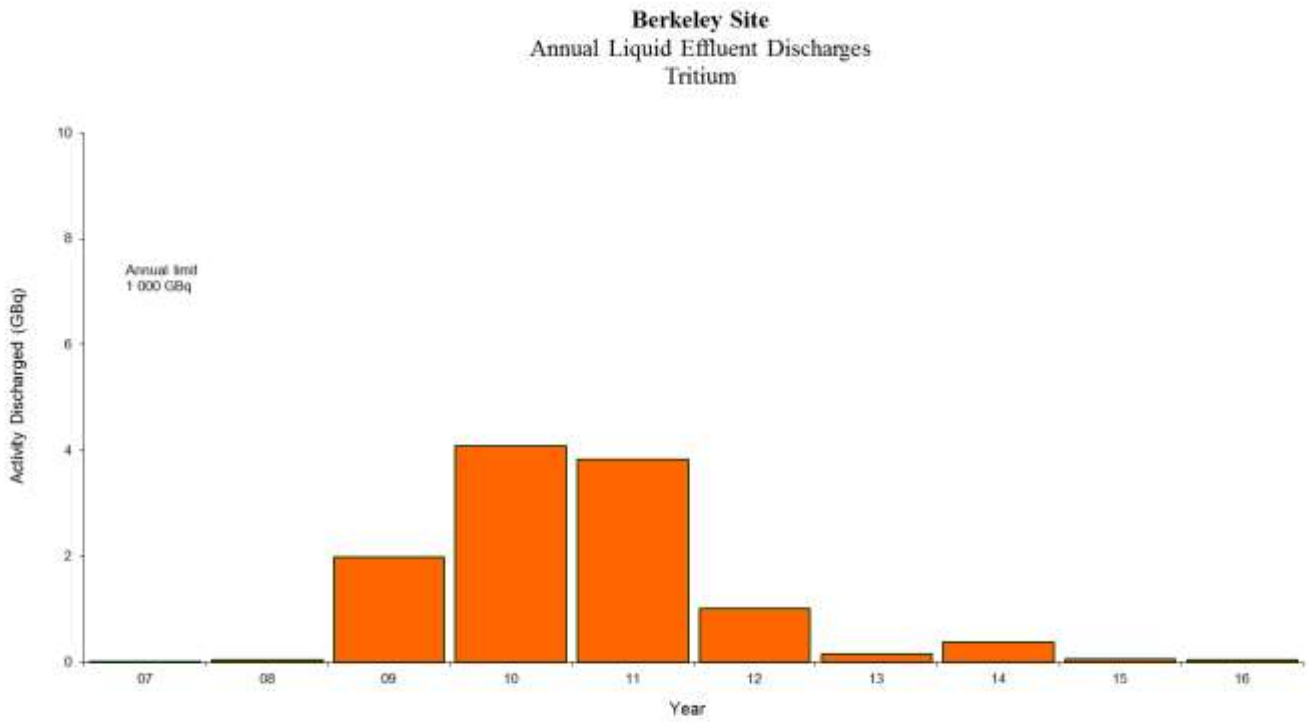


Fig 4.2 Berkeley Site, Annual Liquid Effluent Discharges of Tritium

Tritium 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.

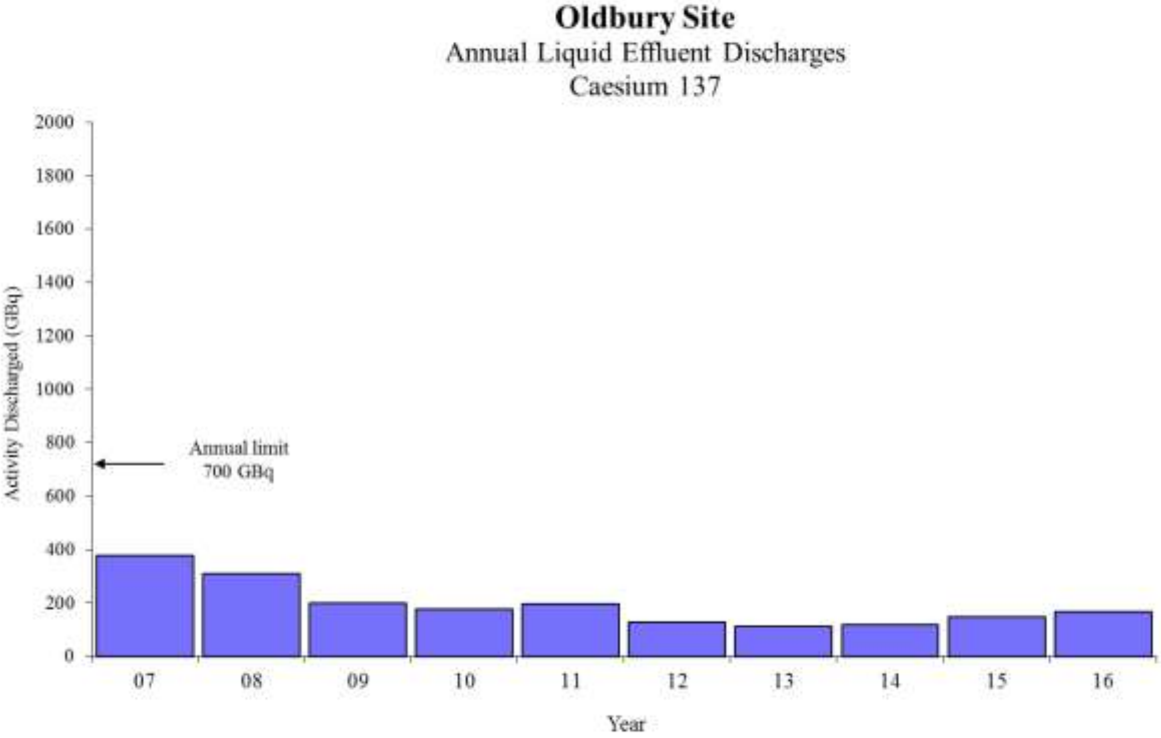


Fig 4.3 Oldbury Site, Annual Liquid Effluent Discharges of Caesium 137

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 chemistry ensured that historic fuel in the pond remained in good condition and significantly reduced the release of fission product into the pond water.

Oldbury monitored incoming fuel skips for caesium, rejecting those that might release significant quantities of caesium-137 to the cooling ponds. The movement of irradiated fuel transport flasks and skips between Sellafield and Oldbury ceased in January 2016 when the last Magnox fuel elements left site.

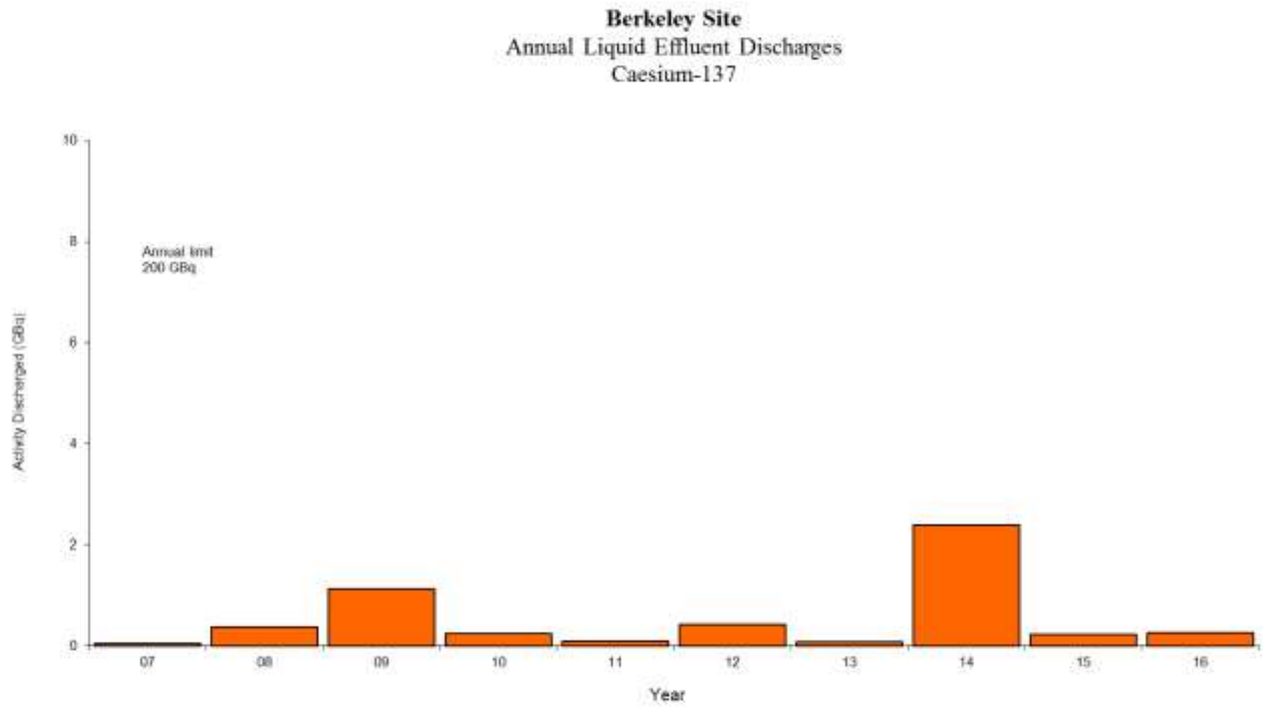


Fig 4.4 Berkeley Site, Annual Liquid Effluent Discharges of Caesium 137

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. The increase in 2014 caesium-137 discharges was due to decommissioning work on the caesium removal plant (CRP).

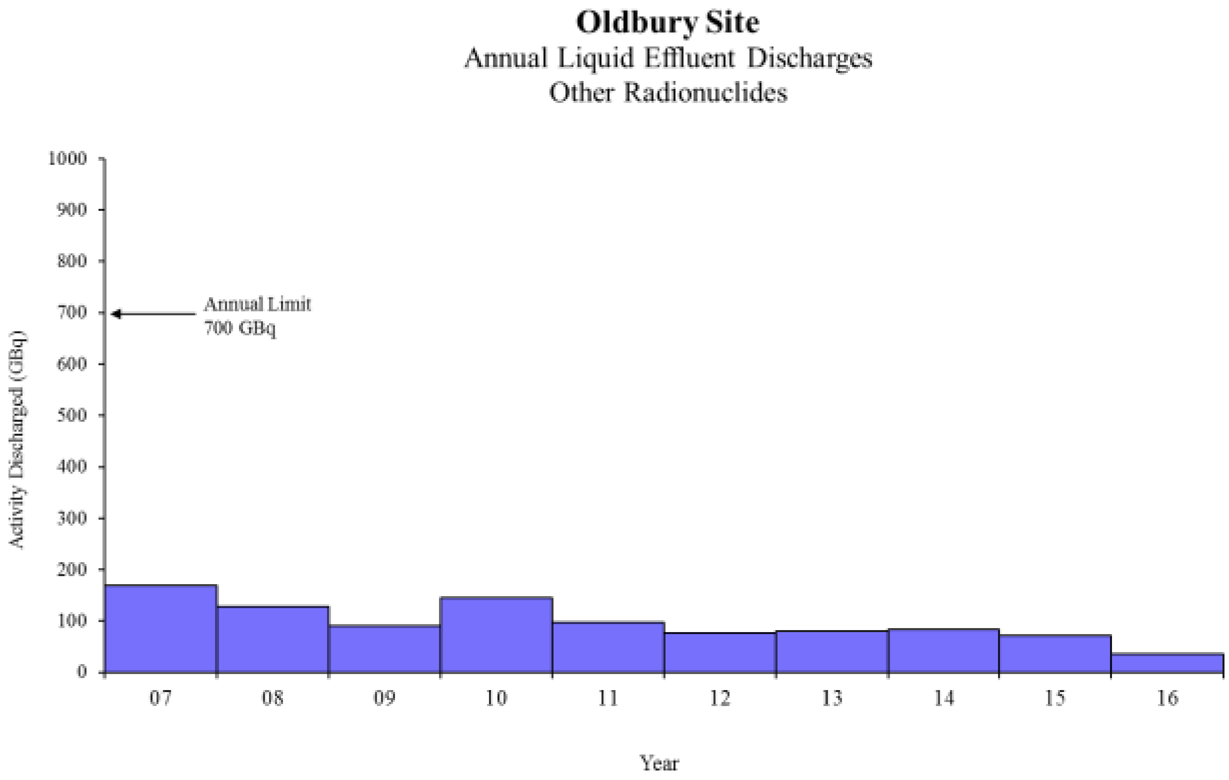


Fig 4.5 Oldbury Site, Annual Liquid Effluent Discharges

‘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.

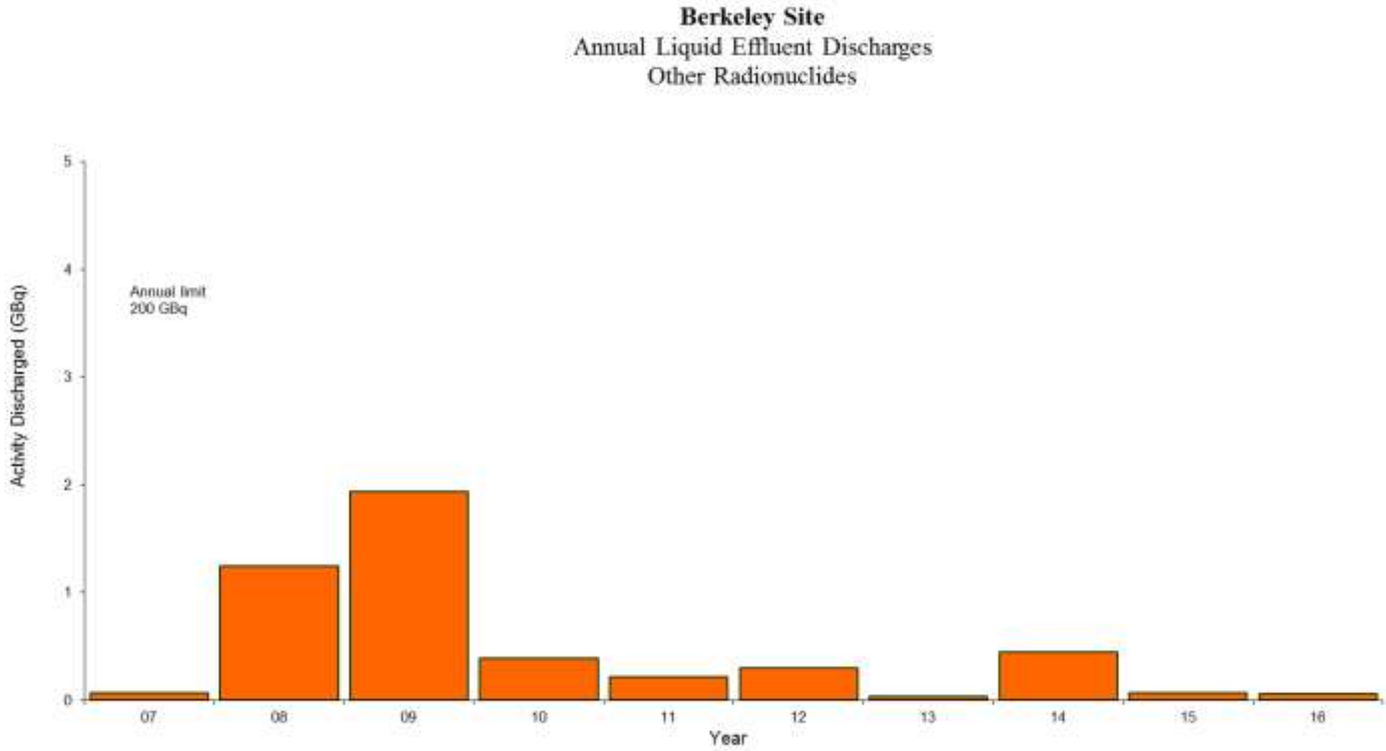


Fig 4.6 Berkeley Site, Annual Liquid Effluent Discharges

‘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.

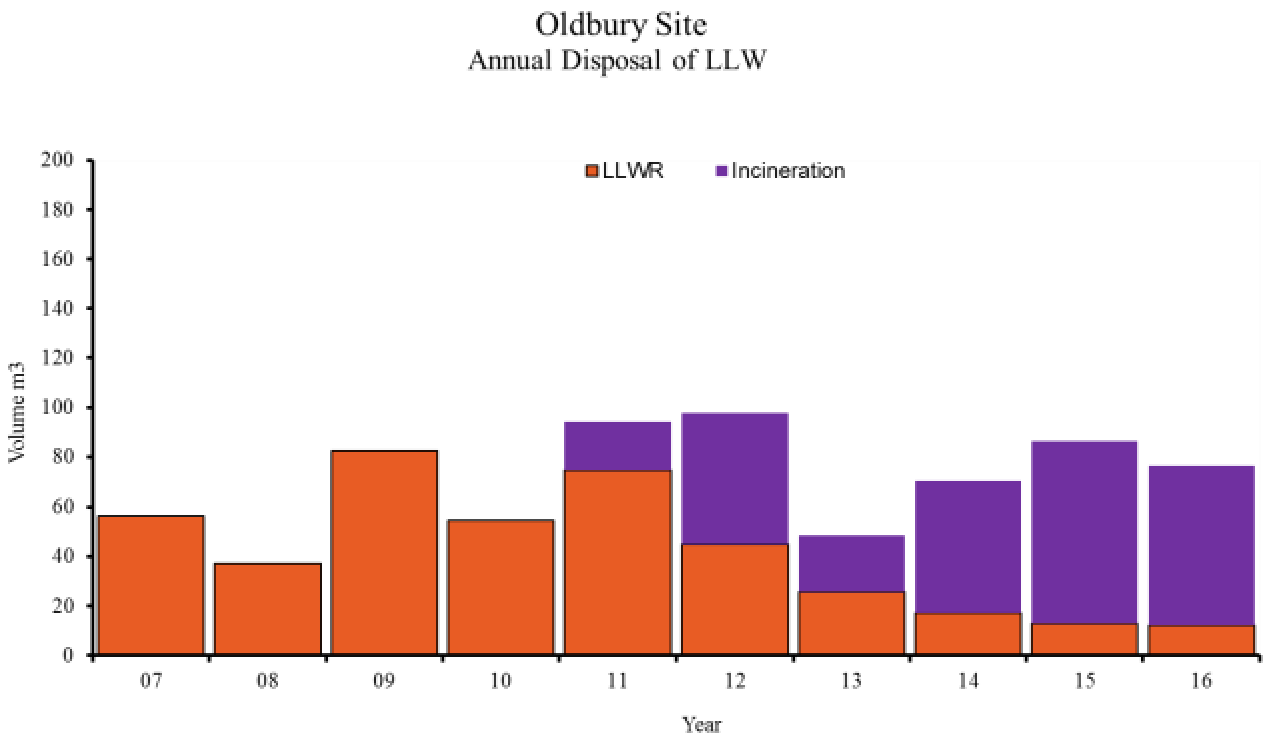


Fig 4.7 Oldbury Site, Annual Disposals of LLW to LLWR

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

Typical types of radioactive waste include redundant plant items, filters, clothing and cleaning wipes. Low level waste is processed in the on-site facilities in preparation for despatch for disposal. Oldbury works with the Low Level Waste Repository (LLWR) to deliver the National Waste Programme for low level waste and LLW is sent from Oldbury under the LLWR Framework agreement. The Waste Hierarchy is used for LLW and where possible waste is diverted from landfill by utilising the metallic treatment or incineration licenced offsite routes. Waste that is disposed of to LLWR may be supercompacted at LLWR's WAMAC facility thus reducing the landfill volumes further.

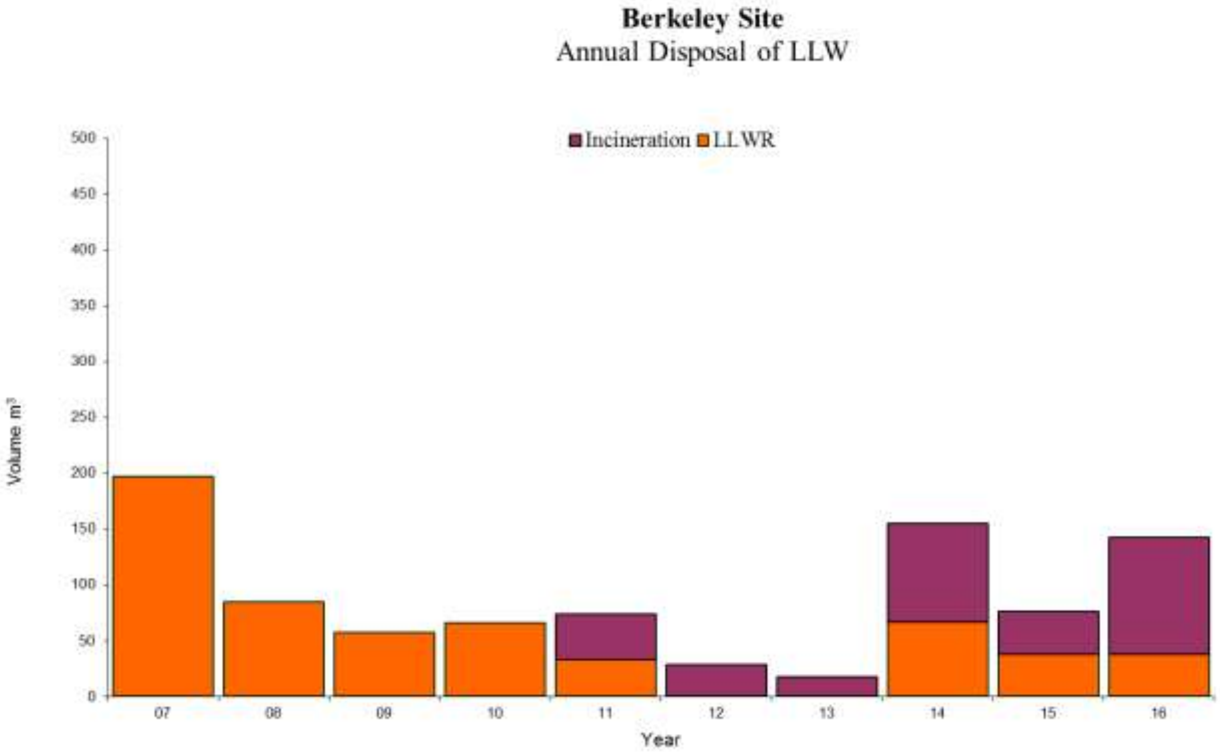


Fig 4.8 ***Berkeley Site, Annual Disposals of LLW to LLWR***

Low level radioactive waste (LLW) is generated from decommissioning activities at the Berkeley Site. The Waste Hierarchy is used for LLW and where possible waste is diverted from landfill by utilising the metallic treatment or incineration routes.

The waste is sent to LLWR in Cumbria for disposal following sorting, treating and compaction. Certain types of waste are super compacted at WAMAC prior to disposal at the LLWR. Combustible wastes are burnt offsite at a licenced incinerator.

5. ENVIRONMENTAL MONITORING

An environmental monitoring programme is carried out by Oldbury. 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.

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

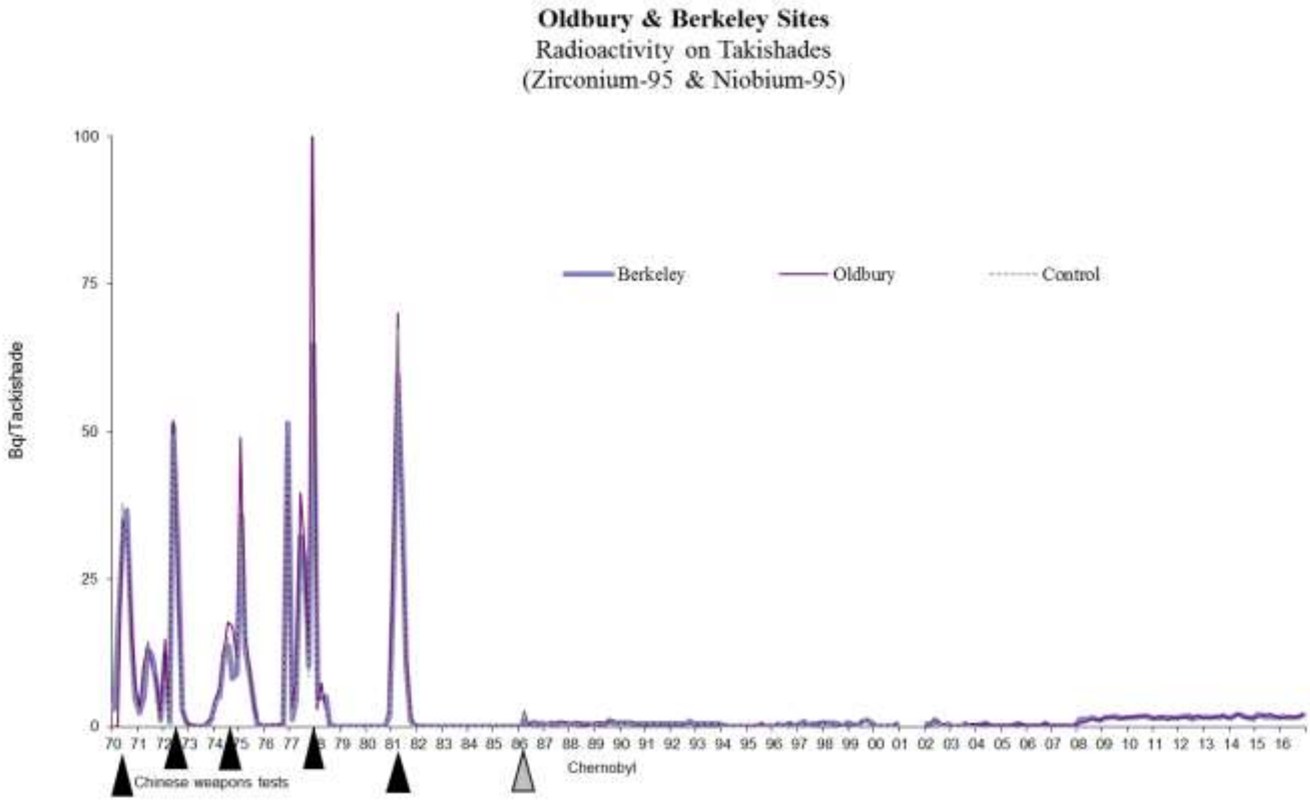


Fig 5.1 Oldbury & Berkeley Sites, Radioactivity on Tackishades (Zirconium – 95 and Niobium – 95)

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.

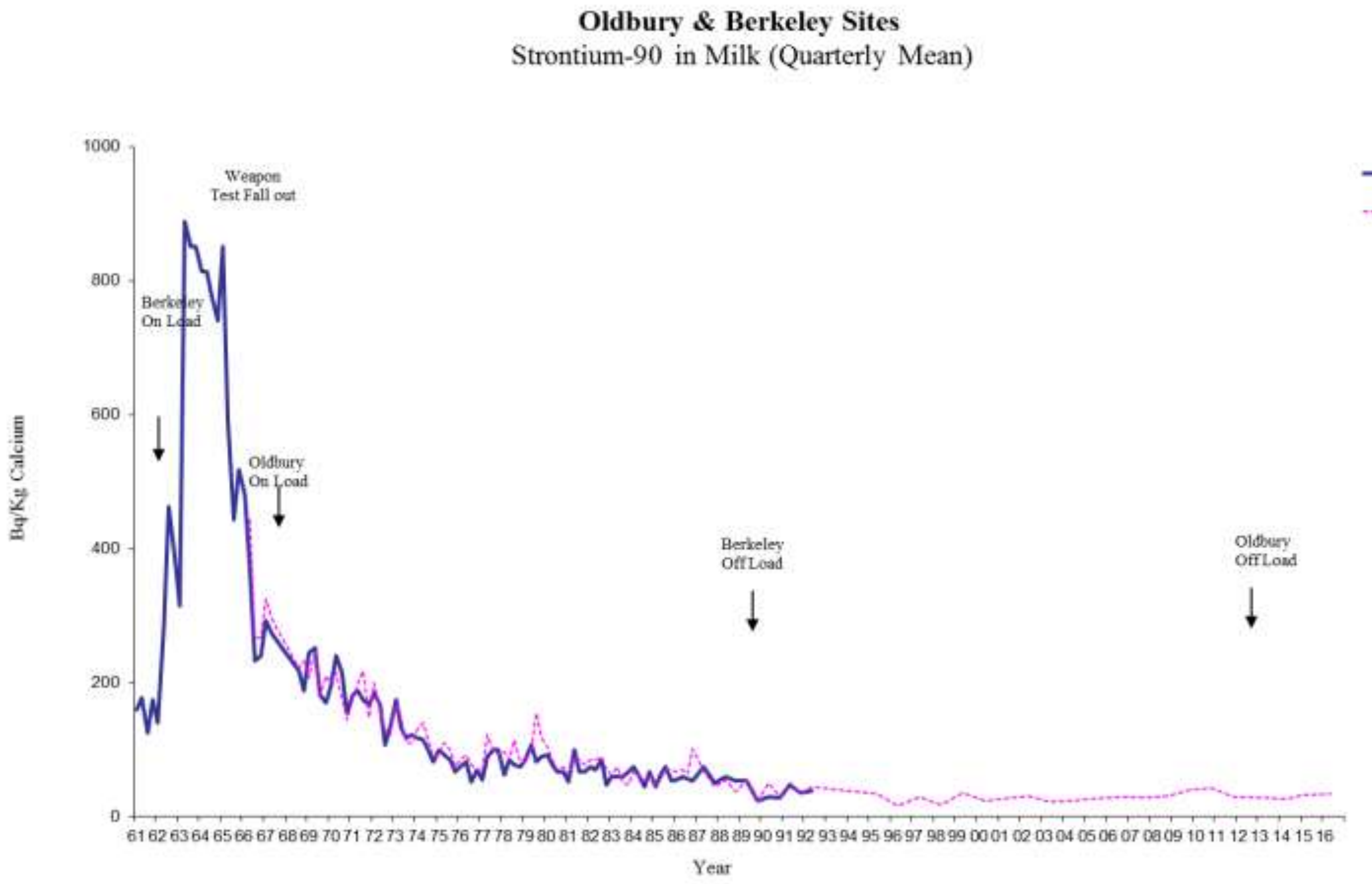


Fig 5.2 Oldbury & Berkeley Sites, Strontium 90 in Milk

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 Site, strontium-90 in milk analysis has been confined to farms surrounding Oldbury Site 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.

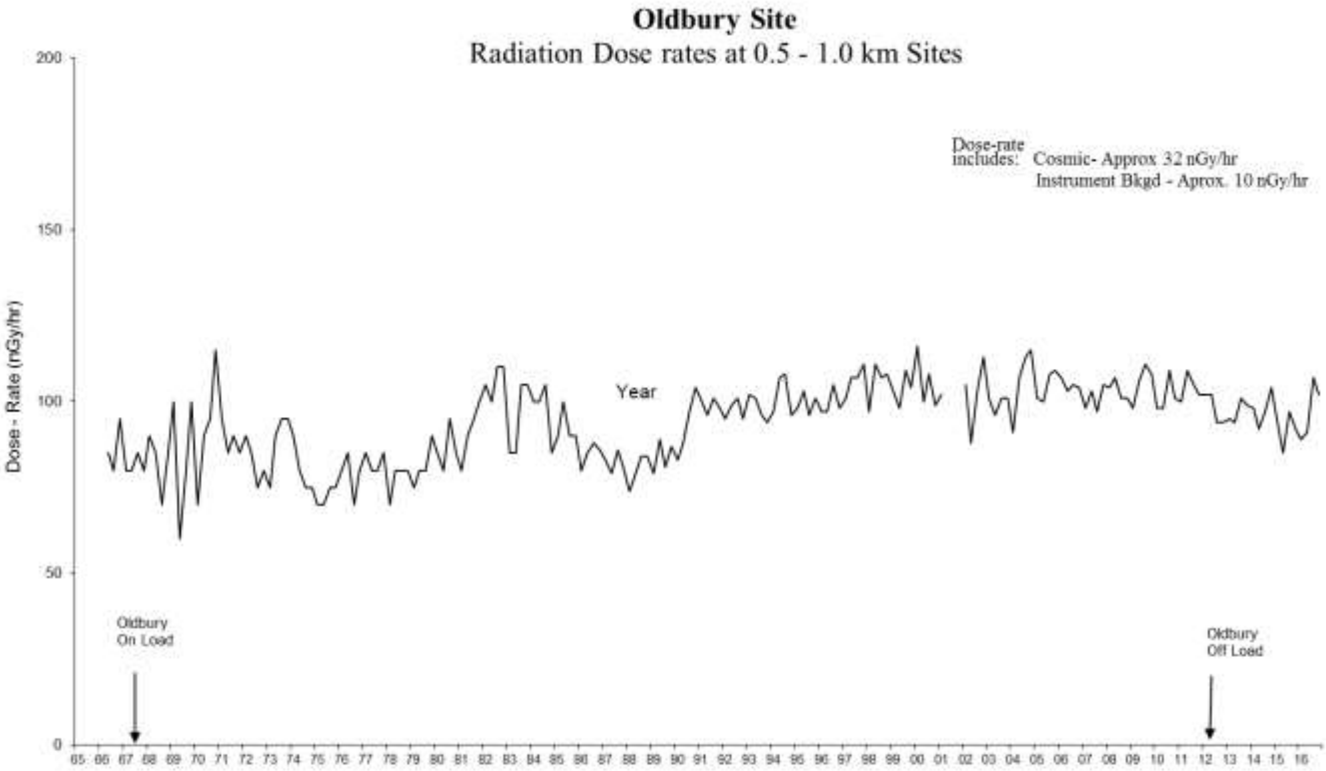


Fig 5.3 Oldbury Site, Radiation Dose rates at 0.5 – 1 km sites

Gamma dose-rate measurements are regularly taken in an arc around the station at a distance of between 0.5 and 1.0 Km.

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. Gamma dose-rates due to the site's operations are indistinguishable above natural background dose-rates.

Berkeley Site
Radiation Dose rates at 0.5 - 1.0 km Sites

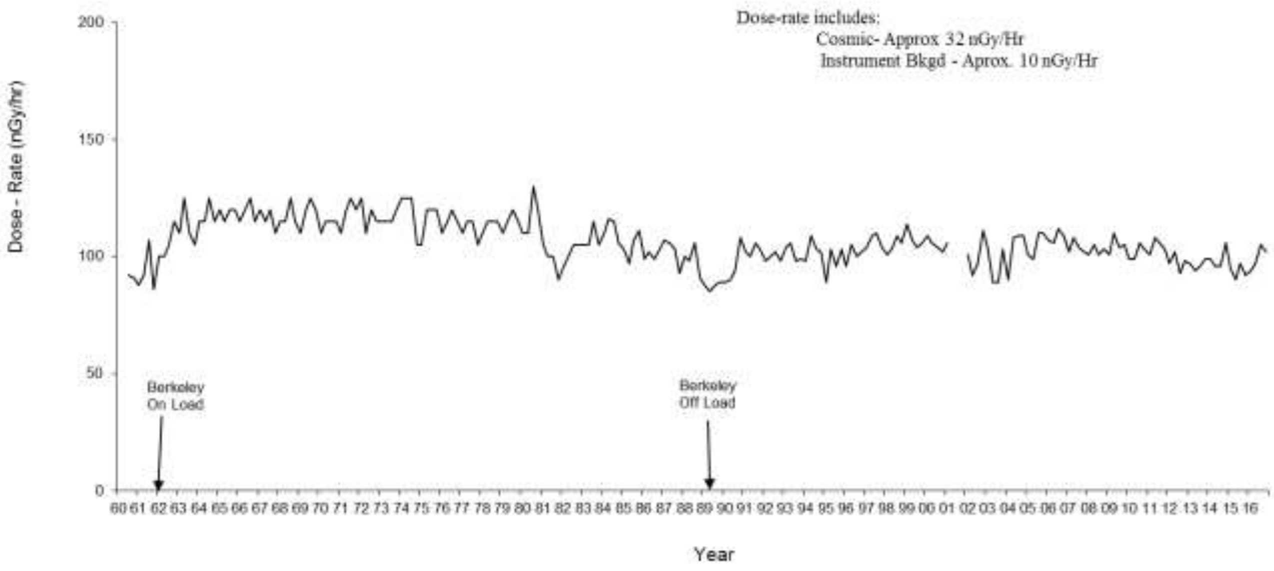


Fig 5.4 Berkeley Site, Radiation Dose rates at 0.5 – 1 km sites

Gamma dose-rates due to the site’s operations are indistinguishable above natural background dose-rates.

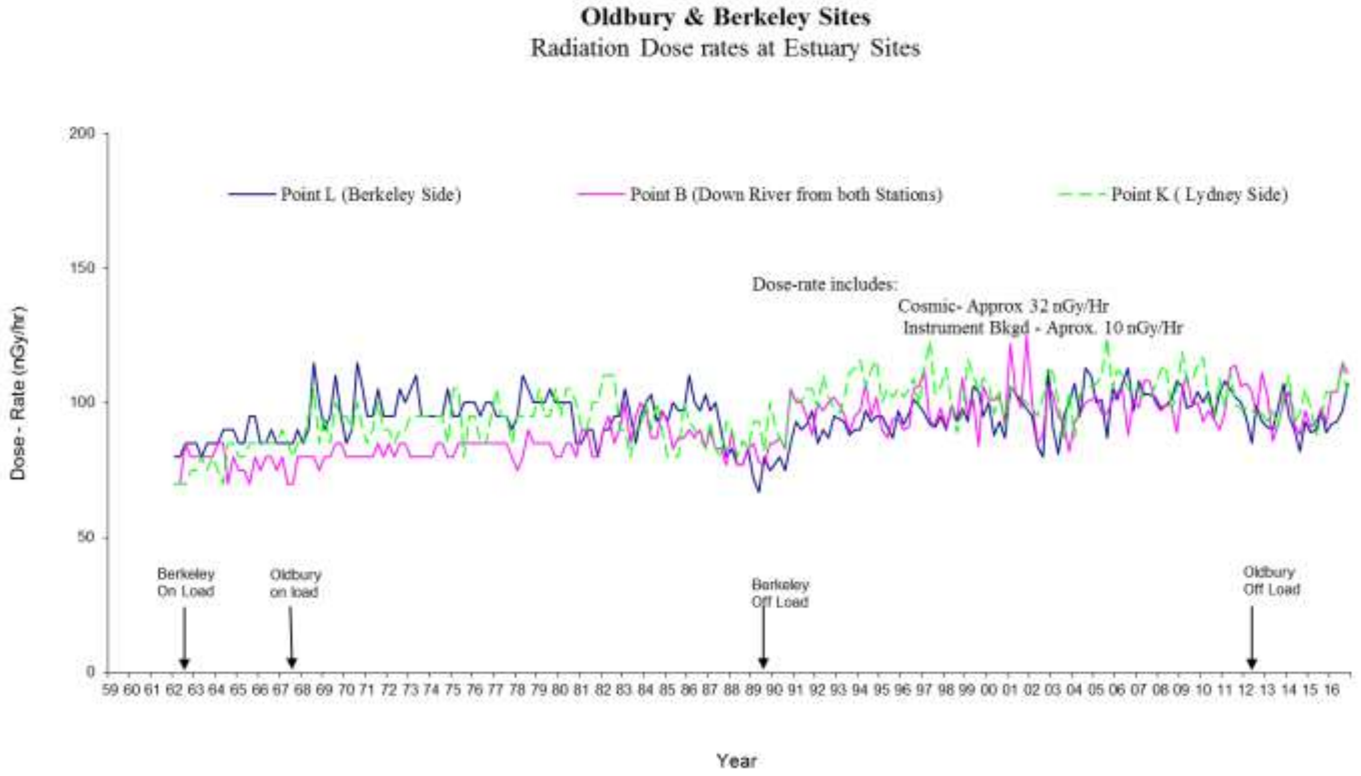


Fig 5.5 Oldbury & Berkeley Sites, Radiation Dose rates at Estuary Sites

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.

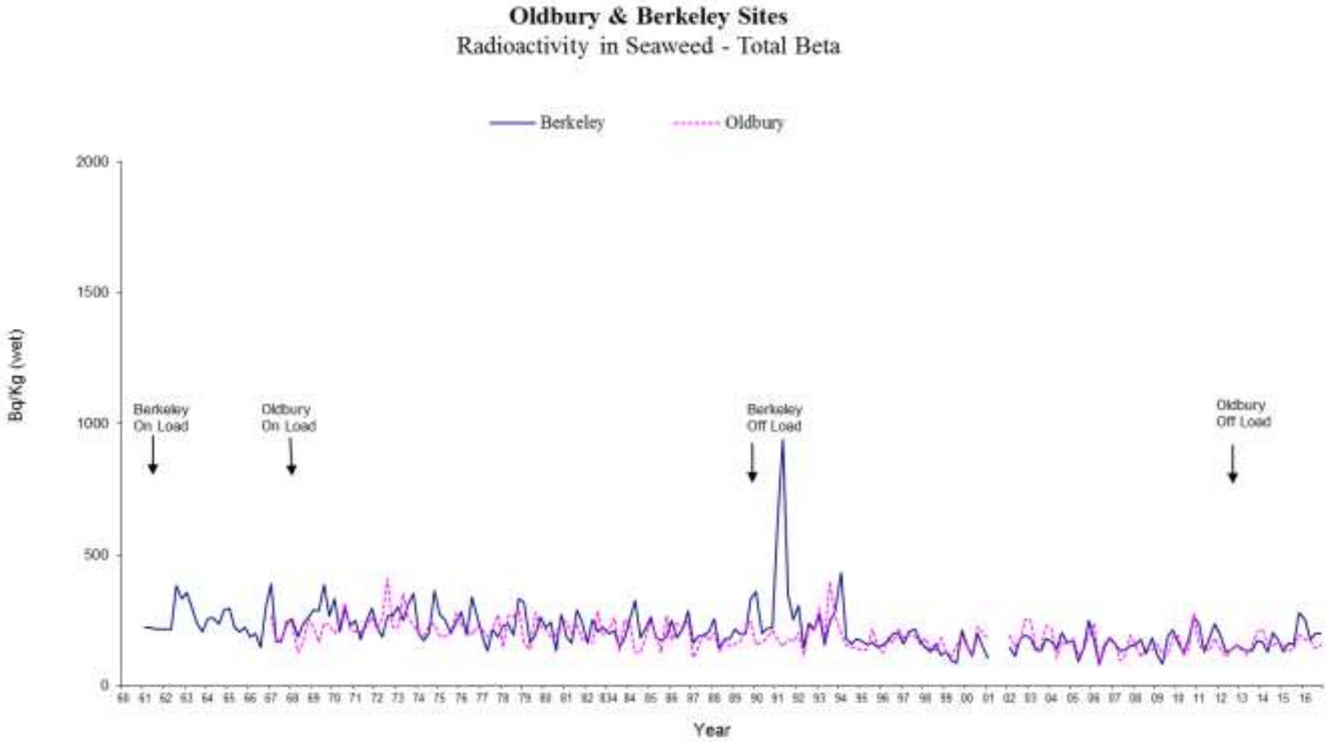


Fig 5.6 Oldbury & Berkeley Sites, Radioactivity in Seaweed (Total Beta)

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.

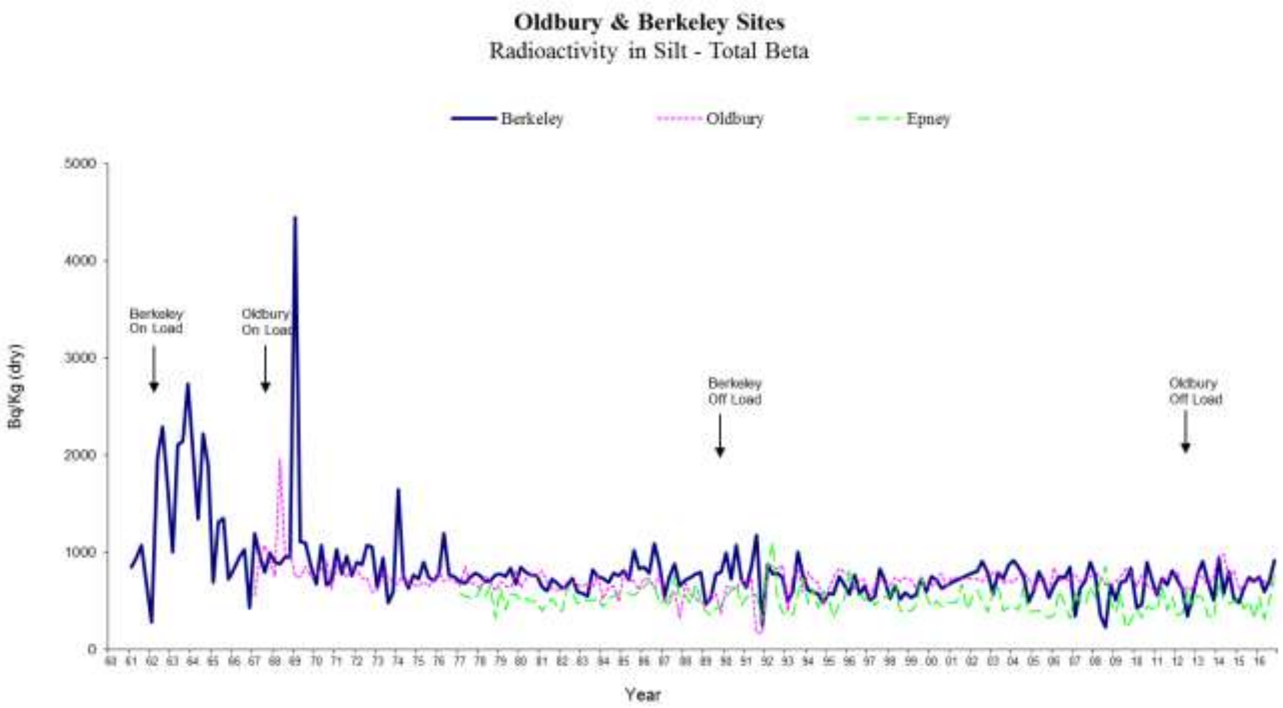


Fig 5.7 Oldbury & Berkeley Sites, Radioactivity in Silt (Total Beta)

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.

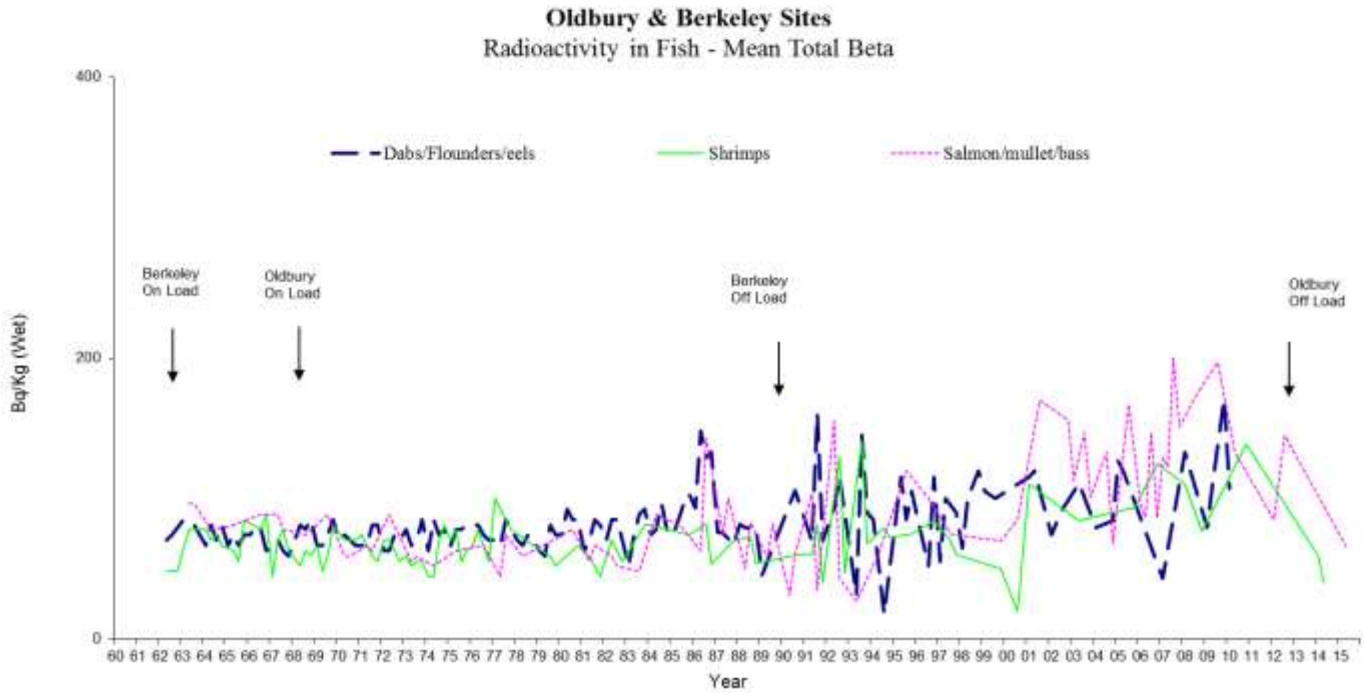


Fig 5.8 Oldbury & Berkeley Sites, Radioactivity in Fish (Total Beta)

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

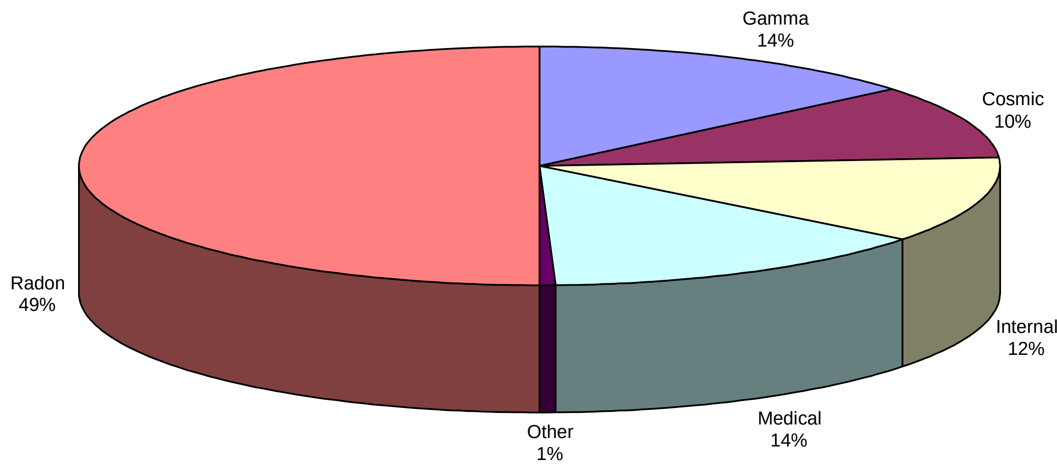
6. SUMMARY OF RADIATION DOSES TO THE PUBLIC

The annual dose in 2015 to members of a small local group of the general public (RIFE – 21) are recorded below. Note dose assessments are normally a year in arrears as information is collated and assessed.

	OLDBURY & BERKELEY
External radiation from intertidal areas:	6 µSv
Seafood consumers:	<5 µSv

The doses may be compared with the annual background dose to the UK population calculated by the Public Health England 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 from Oldbury have decreased following the cessation in electricity generation on 29 February 2012.

7.2 2016 liquid discharges at Oldbury have remained similar to recent years.

7.3 There have been no significant changes to Berkeley aerial and liquid discharges or decommissioning activities.

7.4 The environmental monitoring programme does not identify any significant increases in radiation in the environment.

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’.