

# Proposal for the Removal of Discharge Limits from the First Generation Magnox Storage Pond Stack

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### Document History

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**Glossary**

AECWP	Aerial Effluent Control Working Party
BAT	Best Available Techniques
BSRF	Bulk Sludge Retrieval Facility
CEAR	Compilation of Environment Agency Requirements
EA	Environment Agency
EDT	Effluent Distribution Tank
EPR	Environmental Permitting Regulations
FGMSP	First Generation Magnox Storage Pond
HEPA	High Efficiency Particulate Air
HVAS	High Volume Air Sampler
iCAM	Intelligent Continuous Air Monitor
LADRR	Long-term Aerial Dose Release Ratio
LAR	Liquor Activity Reduction
LOD	Limit of Detection
MBq	Mega Becquerel
MSSS	Magnox Swarf Storage Silo
MT	Magazine Transfer
PAL	Plant Action Level
RMTGN1	Radiological Monitoring Technical Guidance Note 1
RSR	Radioactive Substances Regulations
SEF	Sample Efficiency Factor
SF <sub>6</sub>	Sulphur Hexafluoride
SP	Special Purpose
SPP1	Sludge Packaging Plant 1
VTSG	Ventilation Technical Support Group

## **Introduction**

In support of its ongoing operations, Sellafield Ltd has permission to discharge prescribed radioactive substances to the environment. Those substances (and their defined discharge routes) are determined under the Environmental Permitting Regulations (EPR) (2016) Radioactive Substances Regulations (RSR) permit KP3690SX [1].

Within this permit the First Generation Magnox Storage Pond (FGMSP) & Decanning Facility outlet is categorised as an 'Individually Limited Stack' (disposal outlet ref. A1), which has rolling 12 month disposal limits for alpha, beta, and Cs137.

In order to prove compliance with the above permit, FGMSP undertakes a regime of sampling for the above radionuclides, as defined in the Techniques Document [2]. Sampling is also undertaken for Pu Alpha and Am+Cm; there is no individual plant limit for these radionuclides; however they are included in the site limit, to which FGMSP is a contributor. Discharges of Pu Alpha and Am+Cm from the FGMSP are not reported to the Environment Agency (EA), however a record of the disposals is kept by Sellafield Ltd.

Discharges from the Sellafield site as a whole have reduced massively since the 1970's, with the introduction of treatment plants and new abatement technologies. Environmental impacts have reduced to very low levels (and continue to do so) although Permitting constraints have continued to become more complicated and more extensive. When reprocessing at Sellafield comes to an end over the next few years, discharges will reduce by another step change. Sellafield's mission is increasingly focussed on site clean-up and management of future risk, and environmental remediation. In order to do this effectively a thorough review of the Permit is underway, with a view to submitting an application for a simpler Permit which encourages use of Best Available Techniques (BAT) to minimise and manage discharges with a significant impact.

As part of the above review, there is a requirement for all plants which dispose of radioactive waste to the environment to review their current and potential future discharges, with a view to removing plant limits for those radionuclides where the scale of future discharges falls below EA limit setting criteria. Removal of all plant limits for an Individually Limited Stack would prompt a change in its classification to that of 'Other Outlet'.

There is no formal requirement for the individual sampling of stacks designated as Other Outlets. Instead, these discharges contribute to the 'Open Fuel Storage Ponds & Other Approved Outlets' total, which is measured by the site-wide High Volume Air Sampler (HVAS) system.

This paper seeks to assess discharges from the FGMSP stack in order to consider the possibility of downgrading the outlet from its current designation to an 'Other Outlet', presenting a recommendation to remove permitted discharge limits and stack sampling requirements if appropriate.

## Facility and Ventilation System Description

The FGMSP was commissioned in 1959 for the purpose of receipt and storage of fuel from Magnox Reactors and the removal of cladding prior to reprocessing the irradiated uranium rods. Receipt of fuel and decanning operations formally ended in 1986 when the Fuel Handling Plant became operational, however the facility still contains a significant legacy inventory; including solid wastes, fuel, and sludge, which is now the subject of an intensive retrieval campaign.

Due to its radiological inventory, the plants that make up the FGMSP facility are provided with engineered ventilation systems, which primarily act to minimise the spread of contamination within the buildings, and reduce the activity concentrations of aerial effluents before discharging them to the environment via authorised discharge points.

The FGMSP Individually Limited Stack is comprised of three extract points, which serve the Export Facility, Wet Bays building, and Decanner building ventilation systems.

The Export Facility ventilation extract cascades from C2 areas to cells 1, 2 and 3. Along with feeds from the vent plant room and skip transfer bays, air is extracted from each of the Export Facility cells into a combined duct. The extract is drawn through primary and secondary High Efficiency Particulate Air (HEPA) filter banks, prior to discharge to the environment via a 40 m stack.

The Wet Bays ventilation extract exhausts air from various areas of the wet bays via two separate ventilation systems, namely System 730 and System 735, which combine post-filtration to discharge to the environment via a single stub stack affixed to the Annex building. System 730 provides ventilation for A, B, C and E bay ullages. System 735 provides ventilation for the D bay enclosure, the D bay ullage and withdrawal well ullage. Both the 735 and 730 systems are provided with primary and secondary HEPA filtration.

The Decanner building ventilation system draws air from various areas of plant, including; the caves (which form the centre of the depression gradient) and Cave 1 and 2 skip transfer bays, which connect to form a common duct header, and the Magazine Transfer (MT) and Special Purpose (SP) bays which connect with the common duct prior to filtration. The system also receives extract air from the Effluent Distribution Tank (EDT). Air from the system is discharged to the environment via primary and secondary HEPA filter banks.

## Stack Sampling and Monitoring Arrangements

Each extract that makes up the FGMSP Individually Limited Stack is provided with newly installed sampling and monitoring instrumentation which has been designed to meet Sellafield Ltd.'s Engineering Standard for stack and duct sampling and monitoring principles [3]. Each stack is fitted with a sampling panel containing a Lab Impex in line sampler, a Platon Vampire flowmeter/totaliser, and two electrically driven pumps. The sampling panels are used for accountancy purposes to demonstrate compliance with the Permit. The pipe-run for each panel is fitted with trace heating in order to reduce the moisture content of the air entering the sampler and therefore minimise incidences of filter paper damage. The pipe-run also features an SF<sub>6</sub> draw-off point in order to enable the

Ventilation Technical Support Group (VTSG) to SF<sub>6</sub> test the sampling equipment without causing damage to the pipe-run.

Each stack is also fitted with a monitoring panel containing a Canberra iCAM and stack flow monitor. The monitoring panels sample discharges in real time and are used to warn of elevated or escalating discharges. The installed iCAMs have three levels of associated alarm to differentiate the severity of potential elevated discharges. The alarm levels are reviewed annually to ensure they remain set at an appropriate level.

### Stack Discharges

The FGMSP stack has annual discharge limits for alpha, beta, and Cs137 particulates. These discharges are measured by obtaining a representative sample of the aerial effluents to be discharged on a filter paper using a Lab Impex in-line filter holder. The filter papers are changed daily, and bulked monthly for submission to Analytical Services. The monthly discharge is calculated using the analytical results obtained from analysis carried out on the bulk sample. The calculated monthly discharge values are reported to the EA via Sellafield Ltd.'s Discharge Records department in order to prove compliance against permitted limits.

Average discharges from the FGMSP stack are presented in Table 1, and are compared with rolling annual plant limits and site limits, along with the average total site discharge for context. The 12 month discharge values presented have been calculated using discharge data generated over a five year period between September 2012 and August 2017 (including outliers).

**Table 1. Comparison of FGMSP discharges against plant and site limits [13]**

	Alpha	Beta	Cs137	Pu Alpha	Am + Cm
FGMSP Mean 12 Month Discharge (MBq)	4.46E-01	2.01E+00	7.77E-01	2.83E-02	2.46E-01
FGMSP Plant Limit (MBq)	4.6E+00	7.3E+01	7.5E+01	N/A	N/A
FGMSP Mean 12 Month Discharge as % of Plant Limit	9.71%	2.76%	1.04%	N/A	N/A
Site Limit (MBq)	8.8E+02	4.2E+04	5.8E+03	1.9E+02	1.2E+02
FGMSP Mean 12 Month Discharge as % of Site Limit	0.051%	0.005%	0.013%	0.015%	0.205%
Mean 12 Month Site Discharge (MBq)	8.86E+01	8.37E+02	1.23E+02	1.95E+01	1.35E+01
FGMSP Mean Discharge as % of Site Mean Discharge	0.5%	0.24%	0.63%	0.145%	1.825%

It should be noted that the values listed in Table 1 do not account for the recent removal of Sample Efficiency Factors (SEFs) used in the calculation of FGMSF stack discharges. SEFs have been applied to reportable FGMSF Individually Limited Stack discharges since the initial Aerial Discharge Authorisation was introduced in the late 80s. The intent of SEFs was to compensate for potential under-sampling, and therefore avoid potential under-reporting of discharges; SEFs applied to FGMSF discharges ranged from 1 to 3. In the years since their introduction both the ventilation systems that serve FGMSF plants, and the associated sampling systems, have undergone extensive modification which has negated the need to use SEFs, hence they were removed in late 2017 following agreement with the EA [4].

Removal of SEFs was based on the following factors:

- Installation of primary and secondary HEPA filter banks: completed prior to September 2012
- Improved sampling equipment: completed early - mid 2016
- Improved sampling pipework: completed early - mid 2016
- Replacement of the Export Facility sample nozzle: completed early 2016

Not all of the above modifications were complete prior to 2012, and it would be impossible to quantify the extent to which each modification has improved the representativeness of samples taken, hence credit cannot be taken for complete removal of efficiency factors during the September 2012 – August 2017 reporting period. Due to part completion however, actual discharges would have been less than those reported and presented above. Therefore the mean annual FGMSF discharges presented in Table 1 provide conservative values against which to assess the potential removal of plant limits, and show that, in the context of both total Site discharges and Permit limits, discharges from the FGMSF are very low.

### **Removal of Plant Limits**

Sellafield Ltd. has worked closely with the EA to achieve agreement principles regarding removal of plant limits based on both the magnitude of discharges and their resulting dose impact. These take a risk-based approach, aiming to ensure that society and the environment are appropriately protected, while minimising the burden of regulation on the business.

The method defined for the purpose of assessing plant discharges to determine whether the monitoring, analysis and reporting requirements implemented are proportionate is based on the Environment Agency's Limit Setting Criteria [5] and guidance on Standardised Reporting of Radioactive Discharges from Nuclear sites [6] and has been agreed with the EA in a recent permit variation. In April 2017 Sellafield Ltd. successfully applied for a permit variation (V008) on its existing EPR/KP3690SX permit [1] (issued December 2017). This included the removal of plant discharge limits and subsequent reporting requirements on Thorp stack for the following radionuclides; strontium-90,



ruthenium-106, caesium-137, plutonium-alpha, plutonium-241, americium-241 and curium-242.

#### Assessment Methodology

1. Calculate a detection limit - i.e. an annual discharge which would result in radiological impact (dose) to the worst case critical group that would warrant enhanced monitoring, analysis and reporting requirements;
  - The detection limit is based on a maximum annual dose of 1  $\mu\text{Sv}$  to the critical group resulting from total site aerial discharges per individual radionuclides.
  - For discharges from individual stacks the dose criteria is 0.01  $\mu\text{Sv/yr}$  per stack/per nuclide; pessimistically determined by dividing 1  $\mu\text{Sv/yr}$  by 100 to account for the large number of stacks and different species discharged.
  - The detection limit is calculated using the following principle;

$$\text{Dose } (\mu\text{Sv}) = \text{Discharge (MBq)} \times \text{Dose Factor } (\mu\text{Sv/MBq})$$

Hence;

$$\text{Detection limit (or annual discharge in MBq)} = \text{Dose } (\mu\text{Sv}) / \text{Dose Factor } (\mu\text{Sv /MBq})$$

The dose factors for each radionuclide originate from SLF 2.11.109.01 [7]. The 'Sellafield Industry LADRR's' (Long-term Aerial Dose Release Ratio) dose factor have been selected, taking into account the worst case critical group (i.e. Adult, Child or Infant), and effective stack height for the FGMSF stack.

2. Determine an annual decision threshold; half the detection limit i.e. discharge which would result in a 0.005  $\mu\text{Sv}$  dose to the critical group. As discharges are typically calculated and reported on a monthly basis, the annual decision threshold must be divided by 12. This gives a maximum monthly value which would result in a 0.005  $\mu\text{Sv}$  dose if discharged for 12 consecutive months.
3. Lastly, compare monthly reported values (typically for a 1 and 5 year period) to the monthly decision threshold and determine if the below criteria are met:
  - 100% of monthly discharges in the most recent 12 months is less than the monthly decision threshold; or
  - 95% of the monthly data is less than the monthly decision threshold over a 5 year period; and
  - Justifiable operational reasoning can be provided to underpin the assumption that discharges not expected to increase in the future.

Table 2 presents the detection limits and decision thresholds calculated for radionuclides discharged from the FGMSF stack.



Table 2. FGMSP detection limits and decision thresholds [13]

Nuclide	Dose Criteria ( $\mu\text{Sv}$ )	LADRR ( $\mu\text{Sv/MBq}$ )	Detection Limit (MBq) (DC/LADRR)	Annual Decision Threshold (MBq) (DL/2)	Monthly Decision Threshold (MBq) (ADT/12)
Alpha	0.01	9.16E-03	1.09E+00	5.46E-01	4.55E-02
Beta	0.01	9.18E-05	1.09E+02	5.45E+01	4.54E+00
Cs137	0.01	9.18E-05	1.09E+02	5.45E+01	4.54E+00
Pu Alpha	0.01	9.16E-03	1.09E+00	5.46E-01	4.55E-02
Am + Cm	0.01	7.71E-03	1.30E+00	6.49E-01	5.40E-02

Table 3 presents the results of the assessment of FGMSP aerial discharges over a 5 year period (September 2012 – August 2017) and 1 year period (September 2016 - August 2017) against the decision-making criteria outlined above.

Table 3. Comparison of FGMSP Discharge Results to Monthly Decision Thresholds [13]

Nuclide	Monthly Decision Threshold (MBq)	% of results below Monthly Decision Threshold (Sept 12 – August 17)	% of results below Monthly Decision Threshold (Sept 16 – August 17)	Limit Proposal
Alpha	4.55E-02	91.67%	83.33%	Remove – conservatively reported discharge results due to application of SEFs
Beta	4.54E+00	100%	100%	Remove – below Monthly Decision Threshold
Cs137	4.54E+00	100%	100%	Remove – below Monthly Decision Threshold
Pu Alpha	4.55E-02	100%	100%	Remove – below Monthly Decision Threshold
Am + Cm	5.40E-02	100%	100%	Remove – below Monthly Decision Threshold

The assessment results presented in Table 3 confirm that the discharge of aerial particulates from the FGMSP Individually Limited Stack over recent years has resulted in a low environmental impact. It can therefore be reasoned that the limits currently applied to the stack for alpha, beta, and Cs137 discharges should be removed; prompting downgrade to an 'Other Outlet'. It is noted that the percentage of alpha results below the Monthly Decision Threshold is less than the percentage limits specified for each of the decision-making criteria, however, the vast majority of result have been reported at LOD (99.44%), and it is understood that the alpha discharge values reported over recent years have been artificially inflated due to the use of SEFs. Realistic alpha discharges values would have

been much less than those reported given that the SEFs applied to alpha discharges were 3 and 1.5 for discharges from the Export Facility and the Decanner building respectively.

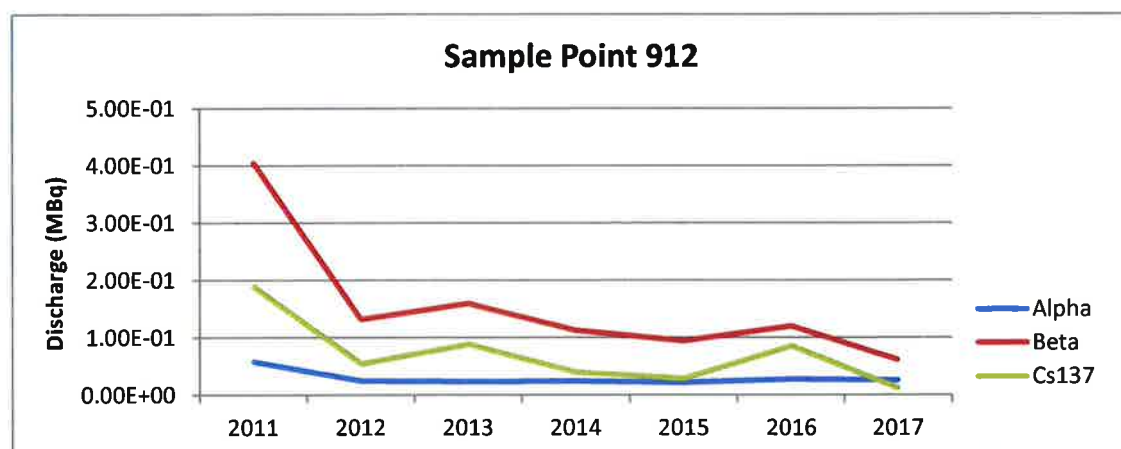
## Operational Reasoning

It is noted that many of the discharge values used for the assessment were calculated and reported while the facility was both operating under a control and surveillance regime, and undertaking preparatory work for future retrieval operations. Since 2015 the facility has largely transitioned to an operational phase to undertake inventory retrievals; the impact of this transition on future discharges should be considered in order to assess whether the proposal to remove limits remains valid despite the change in plant status.

### Review of Retrieval Operations to Date

#### *Export Facility*

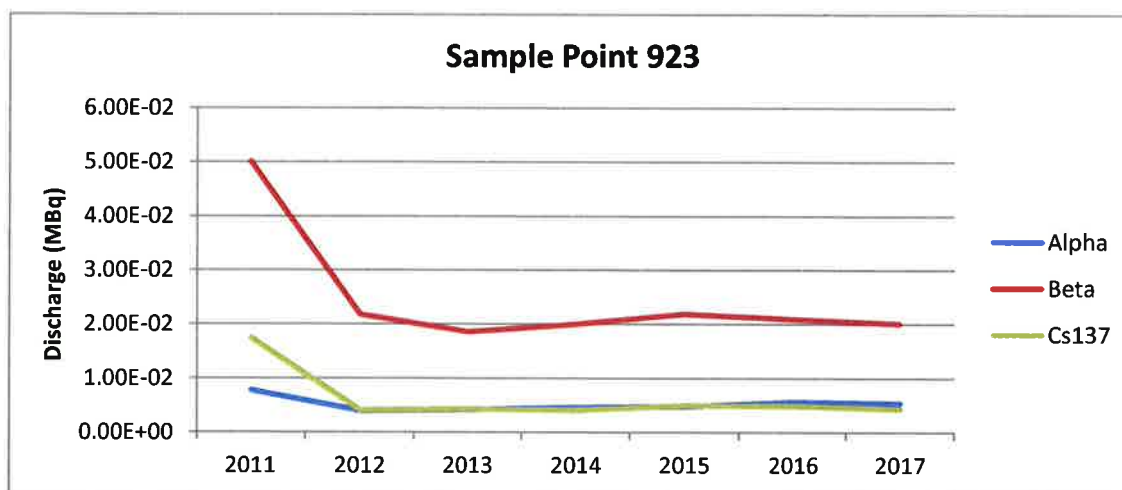
Pond solids exports via the Export Facility have been shown to have no impact on the level of activity discharged via the Export Facility stack. Discharges calculated using samples obtained at Sample Point 912 have remained consistent with those observed during control and surveillance operations (as illustrated in Figure 1), even during export of skips laden with challenging inventories i.e. un-tipped un-cemented uranium bit bins, and the Export Cell Learning Plan Trials [8]. The small peak in annual discharge observed in 2016 was due to asset improvement works undertaken on the Export Facility ventilation system post-filtration, which were understood to have dislodged historic contamination which had settled in the duct.



**Figure 1: Calendar Year Annual Average Monthly Discharge (Export Facility)**

#### *Wet Bays Building*

Ongoing manual retrieval operations i.e. physical retrieval of waste from the bays, washing of waste retrieved from the bays above the water surface etc. (and the undertaking of preparatory works for future retrievals), in the Wet Bay building have been shown to have no impact on aerial discharges from the facility, as calculated using samples obtained from Sample Point 923, and illustrated in Figure 2.



**Figure 2. Calendar Year Annual Average Monthly Discharge (Wet Bays Building)**

It is borne in mind that inventory retrievals have not yet fully commenced in D Bay. D Bay is considered to be the most challenging bay with respect to potential environmental impacts; it contains a significant radioactive inventory, including approx. 270m<sup>3</sup> of sludge, as well as various items of Intermediate Level Waste (ILW), and potentially fuel bearing material. Past operational experience has however shown that retrieval of items from the sludge bed, and consequently disturbance of bay sludge, is unlikely to impact aerial discharges from the facility.

In February 2013 and between November 2013 and January 2014 the Bay Sludge Retrieval Facility (BSRF) pumps were decontaminated and removed from D Bay. The pumps were highly contaminated <sup>[1]</sup> with sludge and fuel pieces that had embedded onto the pump surfaces. Initial decontamination in 2012 was carried out above the water using an 8 Bar hose; this was successful in removing the loose and dry compacted sludge but could not remove the fuel pieces. After this stage of decontamination the pumps were still too contaminated to remove from the Bay and were returned until November 2013 when underwater washing using a 200 Bar jet successfully removed the fuel pieces from the pump surfaces. Both pumps were then removed in January 2014. The removal and decontamination of this highly contaminated kit did not result in any breaches of the Plant Action Levels (PALs) applied to the daily stack discharges as calculated by Health Physics [9]. As no breaches in PALs occurred during the removal of the BSRF pumps using the old system it gives confidence that future bay retrievals are unlikely to increase discharge levels above those observed during both control and surveillance operations and preparatory works for future remote retrievals.

It should be noted that the retrievals equipment to be installed in the bay has been designed to minimise the spread of airborne contamination within the bay enclosure, therefore minimising the generation of aerial effluents available for discharge via the extract

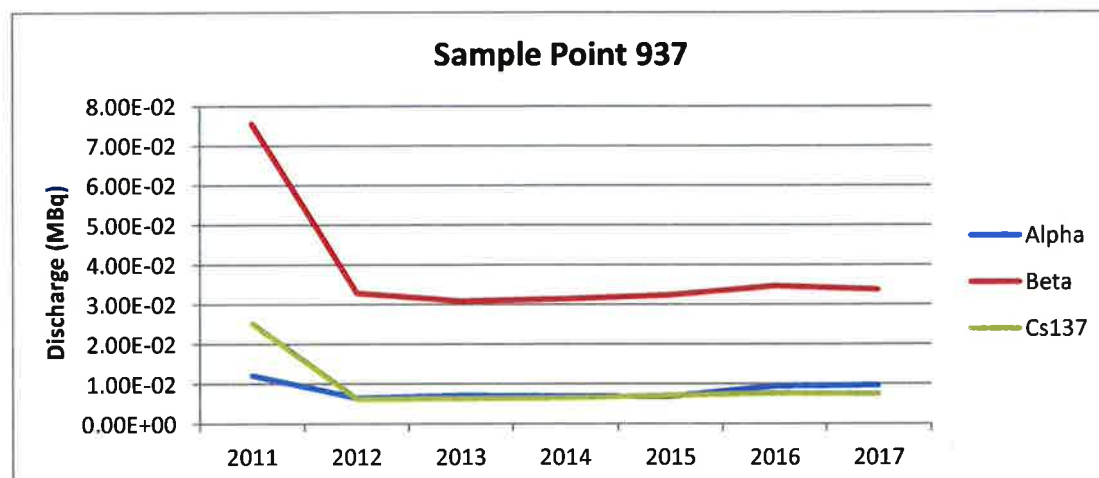
<sup>[1]</sup> Health Physics survey 22/1/2014, MOO Nos: 55769,  $\alpha$  = 4,000 cps DP6 reading,  $\beta$  = >99,000 cps DP6 reading

system. For example, exposure of the wind water line during sludge retrievals will be minimised by replacing the recovered sludge volume with clean caustic dosed demineralised water; the rate of addition is designed to match the sludge eduction rate such that a stable water level is maintained. The manipulator arm and mast will also be washed within demineralised water each time the manipulator arm is moved upward, to minimise potential for residual sludge coated on the arm to dry out and become airborne [10]. Additionally, bay liquor purging (using a caustic dosed demineralised water supply) will take place during retrievals in order to minimise dose levels in the bay enclosure. Purging the bay will remove activity entrained in the liquor such that the activity concentration of the source term for potential aerial emissions is reduced.

### *Decanner Building*

Ongoing retrieval operations undertaken in the Decanner Facility, for example MT Bay magazine size reduction, have been shown to have no impact on levels of activity discharged via the Decanner building stack, as calculated using samples obtained from Sample Point 937, and illustrated in Figure 3. Similarly, receipt of Liquor Activity Reduction (LAR) liquors from the Magnox Swarf Storage Silo (MSSS) and supernate (arising from the FGMSF sludge transfers) from the Sludge Packaging Plant 1 (SPP1) have been shown to have no impact on aerial discharges from the facility.

It is known that the radioactive inventory contained within the Decanner building, and therefore the amount of activity available for discharge, is significantly less than that contained within the Wet Bays; hence the impact of retrieval operations on aerial discharges from the Decanner building should be bound by those of retrieval operations in the Wet Bay building.



**Figure 3. Calendar Annual Average Monthly Discharge (Decanner Building)**

In view of the above considerations it can be confidently asserted that future retrieval operations are unlikely to increase stack discharges above the levels observed during control and surveillance operations, with decommissioning operations even less likely to do so given that the bulk radioactive inventory will have been removed.

### Application of BAT

It should be noted that operations carried out within FGMSF which result in the generation of environmental aspects are subject to assessment (as per the Sellafield Ltd. Environment Case process [11]), through which control measures are identified to minimise the impacts of such aspects as far as practicable, and hence demonstrate application of BAT. With respect to aerial effluents, such measures include optimisation of processes and use of equipment and procedural controls to minimise generation at source, with further controls identified to mitigate the impact of any effluents that are generated e.g. use of abatement technology. FGMSF operations will continue to be assessed in line with the Environment Case process; removal of permitted discharge limits will not affect the control measures that are implemented to demonstrate application of BAT.

In addition implementing measures to minimise aerial discharges from the facility, each of the three ventilation extract systems which make up the FGMSF Individually Limited stack are provided with a significant monitoring capability. Monitoring enables early identification of abnormal discharges such that action can be taken to minimise them and their resulting impacts are far as practicable.

The production and implementation of Environment Cases and the monitoring arrangements applied in FGMSF are considered to demonstrate application of BAT to the management of aerial effluents arising from FGMSF operations. Routine reporting of discharges to the EA will also continue via the Quarterly Report using data obtained from iCAMs installed post-filtration on each stack. The monthly analysis of aerial effluent samples and subsequent reporting of calculated discharges to the EA is not considered to better demonstrate the application of BAT to the management of FGMSF discharges and is not considered proportionate, given their low impact in terms of critical group dose.

### **Proposal**

From the assessments undertaken and arguments presented in this paper, it is recommended that the permit limits specified in [1] for alpha, beta, and Cs137 discharges currently applied to the FGMSF Individually Limit stack should be removed, and consequently the stack should be downgraded to an 'Other Outlet', removing its listing from [1] and transferring it to the Compilation of Environment Agency Requirements (CEAR) document [12]. Consequently it is recommended that stack sampling ceases, the Lab Impex sampling systems installed at each sample point are isolated, and FGMSF stops undertaking routine laboratory analysis on sample filter papers for alpha, beta, Cs137, plus Pu alpha and Am/Cm.



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