# Sellafield Ltd

## Board of Inquiry (BoI) Report

| Condition report (CR) number | Date of condition report (dd/mm/yyyy) | OU/ Directorate | Facility |
|---|---|---|---|
| BN1710A0312<br>BN1710A2447 | 03/10/2017<br>20/10/2017 | Infrastructure Services | Analytical Services |

**Investigation report title**

**Use the original condition report (CR) title if appropriate or provide a more suitable statement.**

**(BN1710A0312) Analytical Services / THF found during an Annual COSHH Audit**
This was the initiating event for this Board of Inquiry (BoI). On the 3/10/17, during a chemical storage inventory check, a quantity of Tetrahydrofuran (THF) was located in a flammable vault within Analytical Services, s.24

The chemical was subsequently identified to be unstable and, on the 20/10/17, the Site Emergency Control Centre (SECC) was stood up and the THF along with a number of other chemicals were subsequently disposed of via detonation utilising the Army's Explosive Ordinance Disposal (EOD) expertise. This disposal was captured under (BN1710A2447) Analytical Services Hazardous chemical removal / Evacuation. It is noted that an SIR has been raised against this second event, where the BoI has taken the initiating event as BN1710A0312.

Following the EOD's visit to site, a quantity of "Quickszint" with evidence of crystallisation was identified within Analytical Services and led to the EOD returning to site.

| Lead investigator/ team members | Investigation convening authority |
|---|---|
| s.40 | s.40 |

**Report Authorised by:**

| | | | |
|---|---|---|---|
| **Lead Investigator (name):** | s.40 | **Convening authority (name):** | s.40 |
| **Signature:** | s.40 | **Signature:** | s.40 |
| **Date:** | 11/12/17 | **Date:** | 11-12-17 |

## 1. Executive summary

### Condition summary

On the 3/10/17, during a chemical storage inventory check conducted by two apprentices, a part filled 500ml bottle of Tetrahydrofuran (THF) was located in a flammable vault within Analytical Services, s.24 The finding was escalated promptly through Line Management to the s.40 Analytical Services (AS).

A conscious decision was made not to sentence this initiating event as an Initial Event Report (IER) due to the consequences not being fully understood. Due to its potential to degrade, the chemical should have been disposed of one month after opening. It is believed that this chemical has been in the container in this store for some time (years).

Following the usual formal SL decision-making process, Operational Decision Making (ODM), the chemical was identified to be unstable and, on the 20/10/17, the Site Emergency Control Centre (SECC) was stood up. The THF along with a number of other chemicals were subsequently disposed of over the weekend 21/10/17 and 22/10/17 via detonation utilising the Army's Explosive Ordinance Disposal (EOD) expertise.

Commencing 23/10/17, a review of the Analytical Services facility was undertaken in order to fully understand the chemical inventory held against the standard industry list of peroxide forming chemicals ("Guidelines for Explosive and Potentially Explosive Chemicals Safe Storage and Handling", R J Kelly 1996) and check if there was any evidence of crystallisation. This identified 2,400 vials (each 10g in 10ml Quickszint) in s.24 under s.24 s.24 which is labelled as post operational with no radiological inventory and 13 x bottles of Quickszint in s.24 under s.24 which has signage dated June 2017 stating no radiological inventory and has not been operational since 2003. Quickszint has peroxide generation potential. The Quickszint bottles were found to have degraded with evidence of crystallisation identified. This led to the EOD returning to site to undertake a number of further disposals via detonation.

A site wide review was initiated on the 23/10/17 that identified a number of chemicals defined in the R. J. Kelly list. A "Chemical Recovery Project Team" has been set up by the company with the mandate to validate, categorise and safely dispose of this "Amber" list of chemicals.

The significance of the event has been recognised, and, in order to understand the causes and gain the learning, a Board of Inquiry (BoI) was initiated. The BoI team have identified two Root Causes and eleven Contributory Causes that need to be addressed in order to realise our key business objectives. Leading up to the initiating event, there were a number of missed opportunities, strong and weak cues over several years where we could have identified and holistically assessed the issues associated with long-term storage of chemicals within Analytical Services and wider chemical management across the site.

The necessity to meet our legal obligations through enabling a more effective way of working is key. Although this BoI has essentially been bounded to chemical safety, the findings and wider learning are applicable to all areas of the business.

**Summary conclusions**

1. Changes in the Analytical Services management team over the last five years have driven a healthy nuclear safety culture, including a questioning attitude. The fact that the THF 'out-of-date' status was questioned by two relatively new apprentices and reported through the line management chain, is evidence for this healthy culture and strong focus on safety. The BoI team considered that this culture change has been instrumental in the recent recognition of the potential risk posed by these chemicals. In addition to this positive step change in safety culture, it is important to note that there has been a strong focus and good progress on fissile hazard and risk reduction within the facility within this same period. The BoI team identified additional positive findings during the investigation; there are noted in Section 9 of this report.

2. Analytical Services inventory included THF and Quickszint, so these chemicals were not 'unknown' or 'lost'. Therefore, the issue has been one of 'risk awareness and recognition' rather than 'chemical awareness and recognition'. What was unknown until this event was the some of the potential risk posed by them; i.e. there was a poor *risk perception* regarding degradation of redundant chemicals stored long term. Everyone spoken to as part of the inquiry confirmed this finding.

3. Analytical Services store many hundreds of chemicals in various states as well as many hundreds of samples. For example, in s.24 and s.24 alone there are nearly 1000 different types of redundant chemicals; across all of the Analytical Services facility, there are in the region of 2000 different types. The analysis equipment is complex and ageing, there are hundreds of different analysis techniques, and quality assured methods. Furthermore, the over-riding priority in Analytical Services is to provide high quality analysis and to 'keep the site going' as timely results fundamentally support the hazard reduction operations. In the context of this highly complex and time-pressured environment, Analytical Services employees over many years have unconsciously developed mental strategies for reducing complexity. Employees have inadvertently reduced the vast and complex array of chemicals and samples into four broad categories to allow them to focus on the materials that they use in their regular daily tasks. The four categories described within this report are: chemicals in use, samples, redundant chemicals and orphan wastes.

4. Over the years, disposal of redundant chemicals has waxed and waned. Despite this, over a thousand bottles of radiologically clean chemicals have been disposed. In addition, there is positive evidence for the segregation of incompatible redundant chemicals.

5. One of these categories, redundant chemicals, does not form part of the Analytical Services daily analysis and as a result, has remained in the unconscious i.e. 'out-of-sight, out-of-mind'. This has meant that chemicals within this category have had very low visibility and, in general, are not considered or thought about. THF and Quickszint were both in the 'redundant chemicals' category. The BoI team consider this a root cause of the event.

6. DSEAR is the relevant legislative instrument for identifying the hazards posed by flammable and explosive substances, including THF and Quickszint, under certain circumstances. DSEAR assessments have been conducted in Analytical Services since 2009 by an external supplier, s.43 However, both THF and Quickszint have been missed from both the DSEAR assessments. This assessment, had it included these two chemicals, was an opportunity to have recognised the potential risk associated with their long-term storage. This is a result of the very low visibility – both in sight and in mind – of redundant chemicals, including THF and Quickszint; the poor understanding of DSEAR in the facility; and the vast quantity of chemical substances stored in the facility.

7. As a site, the full appreciation of chemical legislation has been inadequate, including DSEAR. COSHH has been the primary legislation used on site for chemical hazards. Chemical risks are assessed based on the exposure route and duration of exposure (task-specific). For some stored redundant chemicals, since there is no exposure risk, they have been assessed and recorded as 'Trivial risk'. This trivial risk label provides a false impression of the totality of risks posed by the chemicals. The BoI considers that, as a site, there is a focus on the hazardous to health aspect of COSHH, but we have missed the control of dangerous substances elements of the legislation with regards to cradle to grave storage. There is no DSEAR 'intelligent customer' capability within Analytical Services to translate the chemical safety legislative requirements against the Analytical Services chemical inventory. During DSEAR assessments undertaken by s.43 since 2009, assessors were taken to rooms where chemicals were subsequently disposed of via EOD. The potential risk posed by these chemicals was not identified. It is considered that, due to high complexity (2000 different chemicals in Analytical Services) and the lack of an internal intelligent DSEAR-competent customer within the Analytical Services facility, the opportunity to identify the potential risk associated with these redundant chemicals was missed.

8. In 2015, a MUMCHI chemical inventory for COMAH did include THF and Quickszint, but they were only considered under the flammable chemical category and not under peroxide forming. The focus of the COMAH assessment is on identifying bulk volumes of hazardous chemicals against a number of hazards. There is a site requirement for the MUMCHI to be communicated to a number of persons, including a DSEAR facilitator within the facility. Again, due to lack of a DSEAR facilitator within Analytical Services, an opportunity was missed to identify the potential risks associated with their long-term storage.

9. The competency to support DSEAR assessment in Analytical Services was inadequate, despite holding many hundreds of different chemicals in the facility. The safety advisors available to the Analytical Services facility were generalists and neither had the capability or capacity (they were supporting Analytical Services and Flask Maintenance) to advise on chemical legislation. However, there was an expectation that they would provide DSEAR advice. Furthermore, there is limited DSEAR competency on the site, none of which was available to Analytical Services. The BoI considers a root cause that the organisational resource and capability is not tailored to the specific risks and hazards of different facilities.

10. Compartmentalisation in a number of areas relating to chemical hazard management has meant that the organisation has not had a holistic perspective on this issue. For example, each of the different legislative instruments that control chemical hazards are treated separately – in time, ownership and execution. Compartmentalisation, in addition to a lack of time dedicated to self-evaluation, has meant that, as an organisation, we have not self-evaluated on the multiple weak and strong cues that have indicated weaknesses with chemical hazard management.

**Sentencing Comments:**

At the time of initial sentencing of BN1710A2447 "Analytical Services Hazardous Chemical Removal / Evacuation" raised on the 20th October 2017, the full understanding of the circumstances and the wider scenario was still emerging.

In particular, evidence of crystallisation within the Quickszint was noticed on the 23rd October 2017, three days after the event (BN1710A2447) to which the SIR had been attached and on which, the INF1 process had been initiated.

In light of the findings of this Board of Inquiry, the following internal site sentencing classifications have been confirmed (source document SLSP 3.09.100.02 Issue 3):

**N5f** - Events of management concern, which indicate a deficiency in standards expected for disciplined conduct of operations of a nuclear facility and which should be reported.
**I4** - Events where no or only minor injury occurred but where there is judged to have been a credible risk of a death or major injury from a work related hazard.
**E6b** - Other events associated with environmental protection which should be recorded but do not fit other categories.
**M4a** - Condition Reports thought likely to attract (national) media or public interest

## Summary of root cause

The BoI considers that there are two Root Causes of the event, both of which are necessary for it to have occurred.

1. The organisational resource and capability to support the duty holder in conventional safety is not tailored in recognition of the risks and hazards of individual facilities.
   *(Throughout, the 'Duty holder' in this context is taken as the internally accountable person within the facility i.e. the* s.40 *)*

2. There was a lack of priority given to the disposal of redundant chemicals due to them not being visible and out of conscious awareness to the majority of people within Analytical Services.

If THF and Quickszint had been in conscious sight *and* if there had been available DSEAR competency, then the opportunity to recognise the potential risk associated with these chemicals would not have been missed; i.e. there would have been a different *risk perception* about THF and Quickszint and other peroxide forming chemicals.

It wasn't until the 20th October 2017 when strong and specific advice was received via Sellafield Fire and Rescue that there was a step change in risk perception.

## Summary of contributory causes

Eleven Contributory Causes have been identified:

- THF and Quickszint were not assessed for the risks associated with their long-term storage.
- In general, the organisation focusses on COSHH and there is a misperception that this assesses all chemical hazards.
- Ineffective implementation of DSEAR process across the Site, including available competent resource.
- There is no common language or scale for risk assessing radiological and non-radiological hazards on an equal basis.
- There is no 'intelligent customer' for making the translation between legislative requirements and the chemical inventory.
- The knowledge that THF can degrade over time to form potentially explosive compounds is not widely held, either within the organisation or externally.
- The high numbers of redundant chemicals in storage in Analytical Services.
- With regards to the chemical safety arrangements in the SL management system, SLP reviewers are unclear about their role in implementation.
- There has been no deliberate involvement of people, teams and departments with the right level of capability on chemical hazard management and knowledge of the chemical inventory in Analytical Services in scanning, sharing and interpreting weak cues; or the coordination of collective attention to reduce fragmentation and confusion on this issue.
- Compartmentalisation in a number of areas relating to chemical hazard management has meant that the organisation has not taken a holistic perspective on this issue. As a result, there was no holistic risk assessment of chemical hazards.
- There was no perception of the potential risk associated with a very small number of the hundreds of redundant chemicals. The assumption was that they were adequately risk assessed as they were on the Trivial Risk Register for COSHH.

## Summary of actions

See Section 7.5 of this report

## 2. Terms of reference

The following **minimum** terms of reference (ToR) apply for each board of inquiry (BOI)

1. Investigate the circumstances leading up to and surrounding the condition.
2. Use root cause analysis techniques to identify the root and contributing causes.
3. Review any previous incidents across the organisation with similar root causes, including systematic failures and assess the effectiveness of any actions placed and the adequacy of the company's response.
4. Engage with the convening authority during the investigation process to ensure they understand the event and causal factors chart (ECFC), causal factors, and are involved in the development of corrective actions.
5. Develop SMART corrective action(s) that address the causes.
6. Develop an effectiveness review plan to verify that (1) the actions have been effectively implemented and (2) the identified cause(s) have been effectively removed.
7. Identify any required changes to the company classification, and flag to the site sentencing authority.
8. Using template SLF 3.09.101.06 Board of inquiry (BOI) report, provide a level of detail such that a third party reader can understand the results, and how the results were derived. Include completed analysis tools used as an attachment to this report.
9. Prepare appropriate learning material to capture generic wider lessons learnt.
10. Compile the folder of evidence with the information required to obtain a complete picture of the investigation, its conclusions and corrective actions, and how these were identified.
11. Ensure the final BOI report is placed against the associated CR in ATLAS.

All BOI investigation teams aim to submit their final report to the convening authority **within 45 days** of the sentencing of the CR. The target date can be extended by agreement from convening authority.

## Additional terms of reference / sentencing comments

Record any additional terms of reference assigned by the convening authority.

The **additional** Terms of Reference were agreed with the Convening Authority, s.40 s.40. The text in *italics* provides the additional context from which the lines of inquiry for this investigation were established.

1. Following the crystallisation event in October 2017 assess the response of the facility to answer the why, what, how, who and when, decisions were made, work initiated, handling of emerging understanding, escalation and review, including use of Organisational Decision Making (ODM), and independent challenge.

2. Understand how the facility arrived at the position of requiring outside assistance from a plant, people and procedural aspect, with regards to inventory control.

3. Consider the wider learning for the Remediation of Sellafield Site.

*Additional context:*

- *Consider any benchmarking with other High Hazard industries as a recommendation.*
- *Endorsed to contact independent representative from Sellafield Limited Nuclear Safety Committee (SLNSC) Human Factor and Organisational Expert. This is seen as BoI 'due process' and good practice.*
- *The scope of this BoI does not cover Sellafield Emergency Control Centre (SECC) timeline and decision making. However, in order to capture the learning from the SECC response, it would be beneficial to undertake a review on the handover from the facility to the SECC on the 20/11/17, the actions / decisions made by the SECC, how the chemicals were disposed of and any learning following communications / external media interest. Any learning should be incorporated into relevant procedures / practices for any similar future events and made visible.*

| Terms of reference met? | | |
|---|---|---|
| Have the terms of reference for this BOI been met including any additional terms of reference/ sentencing comments raised by the convening authority? | ☒ **Yes** | ☐ **No** (if no, provide justification below) |
| For further details see Appendix 6 | | |

## 3. Problem statement/ condition

The story of what happened, expand the detail in the original CR if required, this section does not describe your findings. A good problem statement describes the difference between what should be happening, what is actually happening and the consequences of this.

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A conscious decision was made not to sentence this initiating event as an Initial Event Report (IER) due to the consequences not being fully understood. Due to its potential to degrade, the chemical should have been disposed of one month after opening. It is believed that this chemical has been in the container in this store for some time (years).

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A site wide review was initiated on the 23/10/17 that identified a number of chemicals defined in the R. J. Kelly list. A "Chemical Recovery Project Team" has been set up by the company with the mandate to validate, categorise and safely dispose of this "Amber" list of chemicals.

**Investigation Context:**

The conclusions and recommendations from this investigation have been developed through conducting two pieces of analysis:

1. Based on interviews and documents, a horizontal analysis was produced looking at the timeline leading up to the initiating event and onwards through the escalation period and subsequent disposals. This provided the context of chemical management both within the Analytical Services facility and across site since the mid 1980's. Although the timeline in this case is not absolutely crucial in establishing root cause, it has helped describe the context of 'what happened' and 'when it happened'. Twenty Missed Opportunities, seven Strong Cues and sixteen Weak Cues have been identified over the last fourteen years.

   Appendix One presents a schematic of the timeline.
   Appendix Two presents a narrative around the event timeline.

2. A vertical analysis looking at the causal factors of this event and 'why it happened'. Findings from this analysis identified a number of 'inappropriate actions', twelve contributory causes and two root causes.

   An organisational framework for "Attention to Weak Cues" around organisational visibility, accountability and self-evaluation was used to structure the vertical analysis of this event.

   Appendix Three presents the Event & Causal Factors Charts (ECFCs) developed.
   Section 7 presents a discussion on the findings from this causal analysis, along with proposed recommendations.

## 4. Extent of condition

Outline here if the condition could be present elsewhere in the area under investigation, and confirm if it has been checked. NOTE: If this could be a site wide condition, consider issuing an OPEX brief for wider awareness or direct action (SLP 3.09.200 refers).

Within Analytical Services, extent of condition was established by undertaking a thorough search of the facility and further peroxidable chemicals were identified. In addition ODM Sessions 1 and 2 placed actions to determine whether THF was present in THORP laboratories and to share learning with s.43

A site wide search was conducted through Fleet Call to establish an inventory across all facilities of peroxide forming chemicals, as identified within 'Kelly's List 1996' (attached to BN1710A2447). This identified additional chemicals and is discussed further within Appendix 2 Time Line Discussion.

Whilst no interviews were conducted in other facilities, a review of the DSEAR assessment process within Thorp has highlighted that the same root and contributory causes are also present within this facility.

Following the site Fleetcall action, two substances were identified in laboratories within Thorp. These bottles were historic and no long-term assessment for storage was in place (although one was on the COSHH Trivial Risk Register). The potential degradation risk was not understood. Whilst the scale of redundant chemicals within Thorp (44 listed in laboratories within the facility) was smaller, the redundant chemicals were not visible.

## 5. Investigation tools and techniques used

Record the investigation tools and techniques used (as a minimum, an Event and Causal Factors Chart); include the completed analysis tools in the evidence folder.

The investigation team used the following methodology:

1. Interviews included a wide selection of individuals who were either incumbent within Analytical Services / Infrastructure Services, or had previously held positions. In addition, the key persons across the EH&S organisation were interviewed, both those supporting the facility and those in the central organisation.

2. Selections of documents were assessed. These included;
   - Management of Changes (MOC)
   - SLP / SLSP relating to Chemical Safety Topics within the SLMS
   - Facility Logs
   - Facility Improvement Plans
   - Previous Condition Reports across the facility and Site wide
   - Chemical Data Sheets
   - MUMCHI reports
   - DSEAR reports
   - COSHH assessments
   - Chemical Inventories
   - Current Chemical Legislation
   - MSC minutes 2104-2017
   - Operational Decision Making (ODM ) and supporting decision making sheets

3. As described previously, a horizontal timeline analysis and a vertical causal factors analysis were conducted.

4. Formal peer reviews of both the causal factor thinking and the proposed recommendations were undertaken during the investigation by a wider audience independent to the team and the event.

5. In addition to these peer reviews, an external review of the draft findings was conducted by the SL Nuclear Safety Committee independent, s.40 who is an expert in Human and Organisational Factors.

## 6. Operating Experience (OE)

Review OE to determine if existing available OE would have prevented the event (same/ similar type events with same/ similar causes). If so, then determine why it was not effective in preventing this event.

What OE was used in the preparation for this task? If none say why.

The task was to undertake an annual COSHH audit / stocktake of the chemical inventory, no OE was used in the preparation of this audit. It is not common practice to use OE prior to carrying out an audit.

What OE is available that could have been used? (e.g.: on the ATLAS Learning Module / Qlikview).

There are several Condition Reports and findings from audits / peer reviews which have indicated gaps within chemical storage and compatibility. These have been identified and described as part of the event timelines.

Have similar previous CRs been identified? If Yes – have corrective actions been completed and effective?

Previous CRs (trawls completed against key words (Chemical / DSEAR & COSHH)) have been identified, where loss of control on storage of chemicals, including one previous BoI, BN1410A2156. Although the effectiveness of the actions placed against the ToR were deemed adequate at the time, it is concluded there was a missed opportunity to identify the risk of the chemicals which were stored. This is further discussed in Section 7 Findings.

In addition, previous CRs have been raised regarding effective implementation of other Conventional Safety requirements and the recommendations from this BoI do recognise shortfalls in effectively demonstrating organisational excellence in conventional safety requirements.

Conclusion(s) of above OE review:

Note that no evidence of Analytical Services undertaking benchmarking was identified.

Conclusions from previous OE have been discussed in Section 7 Findings.

Has the investigation identified any wider learning, if so please detail and identify suitable means of communication:

Yes, this is detailed within the Conclusions and Recommendations.

## 7. Findings and actions to be taken

This section describes how the vertical causal analysis was conducted and how the root and contributory causes led to the event. The supporting Event & Causal Factor Charts are provided in Appendix Three.

There are five main sections in the Findings:

- The first section describes a framework around organisational attention and an organisational 'sense making' model against which the causal factor analysis was undertaken.
- The second section describes the causal factor analysis undertaken.
- The third section presents a summary and conclusion of the decision making undertaken by the facility post the initiating event against the specific Term of Reference set.
- The fourth section presents recommendations to address the root and contributory causes identified.
- The fifth section presents the agreed actions.

### 7.1 Frameworks for Organising and Making Sense of the Evidence

Two models have been used to aid our understanding of the evidence. This section describes the organisational attention framework and organisational sense-making model used during the analysis.

#### 7.1.1 A Framework for Organisational Attention to Weak Cues

Organisations experience rare events when they fail to notice and act on weak cues that could have predicted a future event. Weak cues are internal or external signals that can alert an organisation of potential future events when viewed in totality. Strong cues are signals that are difficult to ignore and independently give direct information about a problem. Organisations do not attend to weak cues either because they do not recognize the cues as indicators of potential problems or because they lack the resources to do so. Another possibility is that weak cues are noticed, but only by those who are close to where the cues manifest. These individuals may recognise the meaning of weak cues, but they do not have the power, resources or understanding of their wider significance for the organisation to speak up or to act on them.

During the evidence-gathering phase of the investigation, it became clear that, over fourteen years prior to the event, there had been a large number of 'weak cues' and some 'strong cues' that indicated problems with the management of chemical hazards. Therefore, we sought to understand how the organisation had missed the significance of these cues and therefore, had not taken earlier action on this issue. Organisations attend to weak cues by making the cues visible using sufficiently fine-grained measures that detect change; by sharing and interpreting information across different groups; and by maintaining a stable focus on the issue over time. By doing so, the organisation has an opportunity to gain a holistic picture and understand the significance of weak cues. These ideas were considered in the context of Sellafield Ltd and adapted to provide a useful frame for making sense of the evidence gathered during the inquiry.

The adapted framework provided three topic areas:

1. **Visibility**: how are weak cues made visible?
    a. Does the organisation have sufficiently fine-grained categories so that potentially significant changes in any one category are not lost?
    b. Are safety performance measures appropriate and are measures sufficiently fine-grained to indicate potential problems?
    c. How does the organisation make use of legislation as an alerting device for identifying potential problems?

2. **Accountability**: how does the organisation maintain a coherent picture over time?
    a. How do accountabilities ensure that one person or group maintains a stable, focussed and coherent picture over time?

3. **Self-evaluation**: how are different people, groups and experts brought together to gain a holistic picture?
    a. How are resources (time, people) allocated to self-evaluation?
    b. How does the organisation self-provoke (assurance) to create its own 'weak cues' and indicators of potential problems?

The evidence has been organised around these three topic areas and is presented in the event and causal factors (ECFC) charts. It is considered that this analysis meets the intent of the Term of Reference set and replaces the "people, plant, procedure" aspect with a more detailed analysis of the circumstances leading up to the initiating event. A fourth ECFC was produced for an additional route by which the event could have been prevented – i.e. had the redundant chemicals been disposed in the past, they would not have been present in Analytical Services to have created the current event.

### 7.1.2 The Social Construction of Organisational Understanding

Social construction is a way of understanding how humans in organisations jointly create understandings of their organisational 'life' and make sense of their experience at work by creating mental models. These mental models form the basis for their shared assumptions about their work and organisation, including the tools, systems and objects that they use. The models are *reified* (assumed by the group to be concrete entities and 'real', even though they are only mental models). In that respect, a social construct as an idea would be widely accepted as normal and 'taken for granted' by the local group, but may or may not represent a reality shared by those outside. The 'taken for granted' nature means that the people and groups who construe them, are barely aware of their existence. At the same time, they influence how people act with respect to the tools, systems and objects that form the basis of their mental models.

During the interviews, people from Analytical Services regularly used terms to refer to different categories of chemicals and samples in their building. The same terms were frequently used by the Analytical Services staff, both those who currently worked in the facility and those who had worked there in the past. The BoI team explored the terms with a long-standing member of the Analytical Services team to understand what categories existed, what objects (chemicals) formed the items within each category, what assumptions had been construed for each category, and how they informed people about how they should interact with the chemicals in their building.

In order to do this, the team used a psychological tool (G Kelly's repertory grid) to elicit the categories. The exercise revealed that there are four broad categories for considering chemicals and samples in Analytical Services. The exercise revealed the basic concepts that people use to make sense of these different categories. The basic concepts include what people assume to be important or significant about these categories.

The categories and concepts are described in the table below: (Fig 1)

| | | | *Categories* | | |
|---|---|---|---|---|---|
| Concepts | *Chemicals in use* | *Samples* | *Redundant chemicals* | *Orphan waste* | *Legacy waste (this is a sub-set of orphan wastes)* |
| What are they? | Pure chemicals in bottles or taken from the bottle. Fully known and confident in their history | Radiological or trace radiological samples associated with daily work | Chemicals that are no longer used or past expiry date | Things that are difficult to get rid of due to no identified disposal route | These were once orphan wastes, but now there's a way to get rid of them |
| What do people assume to be the risk associated with this category | Chemo-toxicity associated with using them | Radiological | Considered LOW risk as they're not used for doing analysis | Radiological | Radiological |
| How is the assumed risk managed? | Task-based COSHH | Adherence with IRR's | Keep in cupboard, control access, keep on inventory list | Store until find a disposal route | Disposal |
| What is seen as significant about this category | Their quality for doing high quality analysis; making sure there's enough left and its in-date. Risk of use in labs. | Managing the rad risk through IRR | Storage and inventory list. BUT – they are 'out-of-sight', not in use or radiological. | Finding a disposal route | Reducing rad inventory |
| How visible are they to the wider Analytical Services population | Medium-high<br><br>In use every day | Medium-high<br><br>In use every day | VERY LOW, not really considered or thought about | Low | Very high for small number of people who deal with them daily |

The categories were shared with other long-standing members of Analytical Services; this confirmed these findings. Furthermore, people said that, whilst they had not been aware of them beforehand, the categories and their respective assumptions were correct and intuitive.

Analytical Services people were asked to identify which concept for making sense of the categories was the most important in terms of how they thought about them. Visibility was confirmed as the most important concept. They said that this drove the extent to which they considered the items at all. Finally, we asked people to identify to which category the THF and Quickszint belonged; both the THF and Quickszint bottles were in the Redundant Chemicals category. The Quickszint samples (vials) were in the Orphan Waste category.

### 7.2 Event and Causal Factors Analysis

The event and causal factors analysis have been developed around the question: in what ways could this event have been avoided? In answer to this question, broadly, there were two ways of avoiding this event:

- Either the weak and strong cues that indicated problems with the management of chemical hazards could have been used to recognise the potential risk associated with storage of chemicals long term chemicals; or,

- The THF and Quickszint (or any of the other peroxide-forming chemicals found) could have been disposed of in the past, hence avoiding the initiating event.

The event and causal factor analysis has been developed for both of these ways of avoiding, and hence, generating the event. The questions that have framed the analysis are:

***ECFC Part One***
How did the organisation seek out and use information (weak and strong cues, missed opportunities) that could have indicated the potential hazard posed by long term storage of redundant chemicals in Analytical Services? (see the previous section for an explanation of 'redundant chemicals').

a. Did the organisation have systems or processes for making the hazard *visible* to the wider organisation e.g. through application of legislation?
b. Did the organisation allocate managerial *accountability* for maintaining a coherent focus on the management of chemical hazards over time?

c. Did the organisation *self-evaluate* to gain a holistic view of the weak and strong cues relating to chemical hazard management in order to understand their significance?

***ECFC Part Two***
What factors influenced the failure of chemical disposal efforts in Analytical Services to identify and dispose of the chemicals that were the focus of the event?

***ECFC Part One***
**7.2.1 The visibility of the potential risk posed by the storage of THF / Quickszint long term. Did the organisation have systems or processes for making the hazard visible to the wider organisation e.g. through application of legislation?**

There are several hundreds of different chemicals in Analytical Services, some of which are used regularly as part of analysis tasks, in use chemicals, and others that are no longer used, but have not been disposed of and are currently stored, redundant chemicals. The opportunity for making chemicals visible in Analytical Services exists through inventory lists. In turn, inventory lists provide an opportunity for chemical hazards to be risk assessed. Legislation provides the provocation for this risk assessment; three specific chemicals legislation areas (COSHH, DSEAR, COMAH) consider different types and levels of harm that could be caused by chemicals i.e. respectively, harm to people due to chemical toxicity; harm to people due to gases, fumes, fires or explosions; and, harm to people and the environment due to major accidents. The COMAH regulations, since they consider major accidents, examine the total volumes of flammable, environmentally hazardous or toxic substances and, therefore, is a poor indicator of hazards posed by relatively small volumes of individual chemicals. COSHH, as applied by the organisation, considers the potential harm to people exposed to the chemicals during tasks; hence, if the chemicals are not being used during tasks, their risk is considered low, some have been COSHH assessed and placed on the Trivial Risk Register. The DSEAR regulations provide an opportunity for making visible the potential risk posed by flammable and explosive substances and would have been the most appropriate legislative tool for making visible the potential risk posed by the THF/Quickszint or any of the peroxide forming chemicals.

Analytical Services prepared inventory lists in 2010 and 2015. The 2010 list identifies redundant chemicals allowing them to be corralled, segregated and where possible disposed of was used to assess the potential risk of chemical incompatibility in storage. The 2015 list was produced for the purposes of gaining an understanding of what chemicals were present in Analytical Services. Thus, the purpose was taking stock rather than identifying risks. Therefore, neither of these lists provided an opportunity to make visible the potential risk due to degradation during the storage of THF/Quickszint or any of the peroxide forming chemicals long term.

In 2015, a MUMCHI was produced for Analytical Services by the Analytical Services chemical co-ordinator who was in training at the time. This is an inventory for the purposes of the COMAH legislation. THF and Quickszint were listed on the Analytical Services 2015 MUMCHI, but, since this risk assessment examined the total volume of hazardous chemicals, rather than individual chemical risks, this did not provide an opportunity to recognise the specific risk of degradation during long-term storage of the small volumes.

***Contributory Cause 1: THF and Quickszint were not assessed for the risks associated with their long-term storage.***

The organisation's SLP process requires that the MUMCHI list be shared with four groups of people: the safety case manager, the DSEAR facilitator, the accident response group and the COMAH manager. In practice, the Analytical Services 2015 MUMCHI was only shared with the COMAH manager. The BoI team considered that, whilst there was no strong evidence that this was an influential factor, it could have contributed to the lack of appropriate sharing of the MUMCHI.

The COMAH manager would only have examined the potential risks posed by the total volume of stored chemicals to assess the potential for them to cause a major accident. Hence, the specific risk posed by individual chemicals would not have been assessed.

The MUMCHI was signed off by the s.40 in Analytical Services, but the level of scrutiny for risks posed by individual chemical is tenuous. The site governance for chemical safety, such as management safety committee, is not at the same level as for nuclear safety.

There was no DSEAR facilitator in Analytical Services in 2015 and, hence the MUMCHI was not shared with anyone holding this responsibility. In 2015, there was a site requirement (SLP) for facilities to appoint DSEAR

facilitators, but this requirement was not fulfilled in Analytical Services. In fact, there were only three trained DSEAR facilitators across the site: two in the central team and one in Thorp. There was a perception that the DSEAR facilitator role was onerous, and, since 2015, the requirement for facilities to appoint a DSEAR facilitator has been removed from the SLP. Due to poor implementation of the DSEAR SLP from the central team to facilities, facilities had a poor understanding of DSEAR requirements, in particular, the requirement to have a DSEAR facilitator. This was recognised by the central team, and hence, through the safety advisor competency scheme, they envisaged that safety advisors would be able to provide DSEAR advice to facilities. In Analytical Services, this has been ineffective. There are currently only two safety advisors available to Analytical Services, but they also cover Flask Maintenance, a considerably diverse task from the Analytical Services tasks and some distance away from Analytical Services. Hence, the role carries significant workload demands.

Across the site, there are eighteen safety advisors with basic competency in DSEAR; none of these allocated to Analytical Services, and only one allocated to Infrastructure. The two safety advisors available to Analytical Services are safety generalists, rather than specialists in chemicals and chemical legislation requirements. Therefore, the central team's allocation of competent safety advisors is poorly matched to the potential risks associated with storing and using chemicals in Analytical Services.

Allocation of support to duty holders does not recognise the specific risks and hazards of individual facilities. The BoI team consider this a root cause as it resulted in the Analytical Services facility having no DSEAR competent person available to advise on DSEAR requirements or to assess the MUMCHI list to identify and assess DSEAR chemicals. However, even *had* a DSEAR facilitator been available, the fact that redundant chemicals had very low visibility, both in sight and consciousness, meant that, when the s.43 assessor conducted Analytical Services DSEAR assessments in 2016 and previously, THF and Quickszint were both overlooked due to them being 'out-of-sight, out-of-mind' and due to the large numbers of chemicals.

Therefore, the BoI considers that both these are root causes as both are necessary and sufficient for the event to have occurred. Had Analytical Services had THF and Quickszint in their sight *and* had available DSEAR competency, then they would have had the opportunity to recognise the potential DSEAR risk associated with these chemicals; i.e. they would have a different *risk perception* about THF and Quickszint.

***Root Cause 1: The organisational resource and capability to support the duty holder in conventional safety is not tailored in recognition of the risks and hazards of individual facilities. As a consequence, Analytical Services did not have sufficient access to a fully competent DSEAR facilitator to assess the MUMCHI.***

***Root Cause 2: There was a lack of priority given to the disposal of redundant chemicals due to them not being visible and out of conscious awareness to the majority of people within Analytical Services. As a result, the s.43 assessments did not include THF and Quickszint.***

Note that Root cause 1 was identified during the 2016 leadership and management for safety review conducted jointly between ONR and SL.

In 2016, a DSEAR assessment was carried out by an external organisation, s.43 . The s.43 assessor was guided in Analytical Services by Analytical Services employees. However, they did not take the assessor to view the areas where Quickszint was stored. Therefore, this opportunity to make visible the potential risks posed by long-term storage of these chemicals was missed.

In discussion with Analytical Services employees, it is evident that, over many years and due to the high complexity of the Analytical Services environment (hundreds of chemicals, samples and techniques, within the context of working safely in a nuclear environment) people have unconsciously developed mental 'categories' for samples and chemicals. This is one way that humans use to make sense of high complexity: the complexity is reduced by constructing the mental categories; hence several hundreds of separate chemicals and samples are reduced to a small and mentally manageable number of discrete categories. Four categories were evident during discussions: Samples, chemical-in-use, redundant chemicals and orphan wastes. The first two categories were visible and in people's conscious awareness. The last two categories were not visible to the majority of people in Analytical Services, except for a sub-category of the orphan wastes, which was the focus of disposal efforts for a small number of people in the department. The category, redundant chemicals, was not visible to the majority of people in Analytical Services; this category remained in the organisation's unconscious – people generally said in interviews that they "just didn't think about them". They were 'out-of-sight, out-of-mind'. THF and Quickszint bottles were both in the redundant chemicals category, neither were being used and both had been in storage for a long time. The Quickszint vials were in the Orphan Wastes category – there had been samples which were stored under a glovebox with no identified waste route.

It is the BoI's conclusion that the 'out-of-sight, out-of-mind' nature of chemicals, and the vast numbers of these chemicals that were considered redundant, meant that the Analytical Services employee who directed the s.43 assessor during the 2016 DSEAR assessment, missed the risk associated with these chemicals. As a result, an opportunity was missed to potentially highlight the risks posed by degradation of these chemicals in storage. The BoI team consider this unconscious 'out-of-sight, out-of-mind' nature of redundant chemicals to be a root cause (2) of the event.

The s.43 assessor, however, was taken to rooms where chemicals were subsequently disposed of via EOD. The potential risk posed by these chemicals was not identified during the 2016 DSEAR assessment. It is considered that, due to high complexity, of the order of 2000 different chemicals in Analytical Services; the short timescale afforded to the assessor to conduct the assessment across all of Analytical Services; and the lack of access to internal intelligent DSEAR-competent customer within the Analytical Services facility, the opportunity to identify the potential risk associated with these chemicals was missed.

***Root Cause 2: There was a lack of priority given to the disposal of redundant chemicals due to them not being visible and out of conscious awareness to the majority of people within Analytical Services.***

As a consequence of this, essential chemicals were unconsciously overlooked during the 2016 DSEAR assessment and an opportunity to make visible the potential risk was missed. Up until the 20/10/17, when there was a step change in risk perception about THF following correspondence with an external organisation, s.43 the risks due to degradation associated with these chemicals were not recognised.

Some of the redundant chemicals in Analytical Services have been risk assessed under COSHH and placed on a Trivial Risk Register. Others have only been placed on an inventory list. During interviews, it was evident that 'being on a list' conferred a sense of 'it's someone else's responsibility', 'I don't have a worry about it' and that they could put it 'to the back of their minds' and get on with their day-job. Thus, being on the Trivial Risk Register meant that Analytical Services employees had a perception that they didn't have to think about these type of chemicals. The Trivial Risk Register further supported people to 'forget' about these chemicals. Furthermore, it gave a sense that all the risks associated with these chemicals had been considered and that they presented a low risk in general. To some extent, this was also due to a gap in knowledge in respect of certain elements of chemical legislation by Analytical Services. In general, there is a focus on COSHH and a misperception that this assesses all chemical hazards. The Trivial Risk Register provided a comfort blanket. The BoI team consider this a contributory cause as this misperception and poor understanding contributed to a lack of consideration of DSEAR.

***Contributory Cause 2: In general, the organisation focusses on COSHH and there is a misperception that this assesses all chemical hazards.***

Had the risk assessment conducted for COSHH also included DSEAR and COMAH assessments, then the potential risks posed by long-term storage may have been identified. This was not done, since the three different requirements are assessed separately. The BoI consider that not assessing all chemical requirements in one holistic risk assessment of chemical hazards contributed to the event, since this could have identified the risk posed by long term storage.

***ECFC Part One***

**7.2.2 The allocation of accountability for chemical safety. Did the organisation allocate managerial accountability for maintaining a coherent focus on the management of chemical hazards over time?**

The s.40 is accountable for everything within the facility; this responsibility can be discharged within the line and outside, through the central team.

Within the line, the s.40 discharged this responsibility through the operations support team. One of the operations support team members had responsibility for chemical safety as one of their responsibilities, i.e. no-one had chemical safety responsibility as their sole role. The individual had not yet gained the full SQEP status for this role. Their main focus was on review of the large numbers of COSHH assessments in Analytical Services.

Analytical Services fulfil a critical role in 'keeping the site going', because the analysis is required for multiple plants in support of high hazard reduction operations. Therefore, analysis tasks are a key focus for the facility.

COSHH assessments were conducted during the overall assessment of analysis tasks and therefore, concentrated on the hazards due to handling the chemicals. No consideration was given to assessing dangerous substances, including chemicals in storage, as is required for the DSEAR regulations due to the perception that COSHH covers all hazards posed by chemicals.

***Contributory Cause 2: In general, the organisation focusses on COSHH and there is a misperception that this assesses all chemical hazards.***

In addition to discharging the responsibility through the line, the responsibility for chemical safety was discharged through the central conventional safety team. The central team saw their role primarily as providing guidance and standards SLPs for complying with conventional safety legislation. The overarching SLP for chemical safety legislation recognises the need to assess the risks from dangerous substances, as required by DSEAR. However, the assessment of explosive atmospheres has been the focus of DSEAR assessments on the site, rather than the dangerous substances.

***Contributory Cause 3: Ineffective implementation of DSEAR regulations across the Site, including competent resource.***

There is a lack of capability to do DSEAR assessments, both within the central team and across the business. DSEAR has not been prioritised, possibly due to a focus on radiological risks. There is no common language or scale for risk assessing radiological and non-radiological hazards on an equal basis. Hence, the radiological risks are given priority. Furthermore, there is no 'intelligent customer' for making the translation between legislative requirements and the chemical inventory. However, even had this intelligence been available to Analytical Services, the BoI team in discussion with chemical experts, view that the knowledge that THF can degrade over time to form potentially explosive compounds is not widely held, either within the organisation or outside. Thus, both these factors are considered contributory to the event as had knowledge about the degradation of THF been available to Analytical Services and had someone with the knowledge of the Analytical Services inventory been able to translate this knowledge into the legislative requirements, then the risks associated with the degradation of THF / Quickszint over time may have been identified. The high numbers of redundant chemicals in storage in Analytical Services, however, added to the difficulty in achieving this and therefore, this is also a contributory factor in the event.

***Contributory Cause 4: There is no common language or scale for risk assessing radiological and non-radiological hazards on an equal basis.***

***Contributory Cause 5: There is no 'intelligent customer' for making the translation between legislative requirements and the chemical inventory.***

There is a relatively recent case of an uncontrolled explosion of THF in an academic setting, where the academic staff were unaware of the potential risks.

***Contributory Cause 6: The knowledge that THF can degrade over time to form potentially explosive compounds is not widely held, either within the organisation or externally.***

***Contributory Cause 7: The high numbers of redundant chemicals in storage in Analytical Services.***

As described above, there has been poor implementation of the DSEAR SLP across the site, resulting in confusion about the DSEAR requirements. The selection of SLP 'Reviewers' across the site is ad-hoc and does not take account of the need for reviewers to also implement the SLP. Reviewers adequately fulfil the reviewing aspect of their role, but are not clear that they also need to implement the SLP within their area. Thus, there is a lack of clarity about this aspect of their task. Furthermore, the selection of reviewers is, in some cases, inappropriate; whilst they are able to review the SLP, their relatively junior position in the organisation means that they are unable to fully implement them.

***Contributory Cause 8: With regards to the chemical safety arrangements in the SL management system, SLP reviewers are unclear about their role in implementation.***

It is suggested that the ongoing work within the Transformation team, tasked with reviewing / simplifying the SL management system, fully incorporates the learning from this BoI. This should not be bounded to chemical safety as the learning is applicable to all areas of the business. In order to fully gain the benefits of the learning from this BoI, as part of this management system review, it is suggested that the organisation benchmarks other high hazard industries where the safety focus has changed over a number of years; for example, Magnox, where the focus is changing from nuclear safety / radiological protection to more of the remediation and decommissioning of conventional safety hazards. It would be beneficial to understand how this mind-set change has been managed / communicated and made visible; furthermore, understand how the supporting arrangements and management system compensate and evolve.

***ECFC Part One***

**7.2.3 The organisational self-evaluation on chemical safety. Did the organisation self-evaluate to gain an holistic view of the weak and strong cues relating to chemical hazard management in order to understand their significance?**

Due to multiple competing demands and priorities, people within Analytical Services gave little time or priority to self-evaluation on chemical safety. The major foci for Analytical Services were the quality of analysis, including UKAS accreditation; the constant demand to provide timely, high quality analysis results against the backdrop of difficulties with degraded analysis equipment; the forthcoming move to another building; and the strong focus on the special nuclear material returns over the last few years.

The priority given to conventional safety has not been as high as for nuclear / radiological safety. The organisation does not provide the same level of self-provocation, internal assurance or governance activities on conventional as on nuclear safety. This is evidenced in both capability and capacity for providing advice on chemical safety; in limited assurance processes such as Tier 1, 2 or 3 audits on chemical safety; and in a lack of a sustained and holistic perspective on the external and internal cues that have indicated weaknesses in chemical hazard management. Safety advisors provide advice on a broad scope of work and, as already discussed above, capability is not tailored to the specific risks and hazards of facilities. Furthermore, their involvement in safety issues is reactive and in response to concerns raised by facilities. They provide little provocation on chemical safety issues. It is suggested that the existing plant modification process (PMP) and management of change process (MoCRA) are reviewed in light of these findings to ensure that conventional safety is given the right level of focus.

Conventional safety dashboards have been initiated, but have not yet reached a level of maturity to provide a sufficiently fine-grained view of chemical safety. Nevertheless, the conventional safety dashboard for Analytical Services had rated COSHH and DSEAR in Analytical Services as 'amber', meaning that concerns in these areas were noted.

The BoI identified that, in the last fourteen years, there were twenty missed opportunities, seven strong cues and sixteen weak cues that indicated issues with chemical hazard management leading up to the event and two missed opportunities during the escalation after the initiating event. Many of these cues related to the accumulation of high numbers of chemicals in Analytical Services, to segregation in storage and to gaining an understanding of the inventory. However, taken together with the 'amber' ratings on the dashboard, the holistic picture indicates weakness in chemical hazard management. Until this BoI, in reaction to the current event, no sustained attempt has been made to gain a holistic picture of the whole of chemical safety in Analytical Services, including DSEAR, COSHH and COMAH. Instead, action to address external and internal concerns on chemical safety has been reactive and isolated. Therefore, discrete efforts have been taken to address only the specific concern raised by the external or internal agent without consideration of the totality of concerns in the context of chemical hazard management.

***Contributory Cause 9: There has been no deliberate involvement of people, teams and departments with the right level of capability on chemical hazard management and knowledge of the chemical inventory in Analytical Services in scanning, sharing and interpreting weak cues; or the coordination of collective attention to reduce fragmentation and confusion on this issue.***

The BoI team consider that this is due to the compartmentalisation of ownership and efforts to comply with different regulatory instruments (e.g. DSEAR, COSHH, COMAH, REACH); of the consideration of hazards (e.g. nuclear vs chemical); and of the different types of chemicals in Analytical Services (e.g. redundant, in-use, samples containing chemicals and orphan wastes).

***Contributory Cause 10: Compartmentalisation in a number of areas relating to chemical hazard management has meant that the organisation has not taken a holistic perspective on this issue. As a result, there was no holistic risk assessment of chemical hazards.***

In order to fully gain the benefits of this BoI, the effectiveness of existing LFE networks for conventional safety areas should be reviewed. Furthermore, consideration should be given to raising the conventional safety profiles of facilities on site by displaying the major conventional safety hazards and risks alongside those for nuclear safety at the entrances to each facility.

***ECFC Part Two***
**7.2.4 Disposal**

The BoI team considered that, had the material been disposed of, then it would not have been present in Analytical Services to create the current event. The label on the THF container recommended disposal one month after opening or one year after manufacture due to its potential to become chemically unstable. Therefore, given that the chemicals were old, it is likely that, had Analytical Services attempted to dispose of them prior to this event then they would likely have required disposal via the EOD route.

Prior to 1992, the BoI team found no evidence of focussed efforts to dispose of waste chemicals. There was a strong focus on developing new analysis methods and disposal was not considered or thought about. There was possibly no conception that they could become unsafe during long term storage. Knowledge was not retained for these stored chemicals and hence, it has historically been difficult to show that they are non-radioactive without assessment. This has led to a delay in disposal.

Since 1992, efforts to dispose of chemicals have 'waxed and waned'. WANO peer reviews since 2010 have provided strong cues for disposal efforts. However, even despite these cues, the efforts have not been sustained over time. A number of reasons were identified which meant that disposal has stopped once initiated, including environmental reasons for halting disposal routes; being unable to identify obvious disposal routes; the difficulty in proving non-active; and a site ban on certain chemicals. Efforts have therefore focussed on the easier to dispose chemicals in an attempt to reduce the number rather than the potential risk posed by the long term storage of chemicals. As a result, hundreds of chemicals have not been disposed and were still held within Analytical Services.

***Contributory Cause 11: There was no perception of the potential risk associated with a very small number of the hundreds of redundant chemicals. The assumption was that they were adequately risk assessed as they were on the 'Trivial Risk Register' for COSHH.***

Historically, there has been a strong customer focus in Analytical Services, resulting in, for example, accepting samples with no identified disposal route. However, in the last few years, changes in the management team have driven a healthy nuclear safety culture, including a questioning attitude. The fact that the THF was noticed and picked up by two relatively new apprentices, reported to their team leader, and taken seriously by the team leader in reporting it to a higher management level, is evidence for this healthy culture and strong focus on safety. The BoI team considered that this culture change has been instrumental in the recent recognition of the potential risk posed by these chemicals.

During 2014, disposal efforts were halted when a previously considered 'clean' chemical triggered the gate monitor on exit from the site. This resulted in a requirement to assess every chemical prior to disposal. The radiological analysis for redundant chemicals has historically been of low priority as the focus was on performing analysis of plant samples. The BoI team consider that this was a missed opportunity.

The Innovation team, who were involved in redundant chemical disposal, were disbanded and staff were given different priorities in 2013. The BoI team consider that the conscious decision to not prioritise disposal of redundant chemicals at this point was a missed opportunity.

Chemicals that had no obvious disposal route were stored and some were assessed under COSHH as 'trivial risk'. This assessment may have further supported a perception that the chemicals were of 'no or low risk' in general; further risk assessment was not considered. This further supported the low consideration and unawareness of redundant chemicals for the majority of Analytical Services staff.

### 7.3 Summary and Conclusion of the decision-making undertaken by the facility post the initiating event

*Term of Reference:*
*Following the crystallisation event in October 2017 assess the response of the facility to answer the why, what, how, who and when, decisions were made, work initiated, handling of emerging understanding, escalation and review, including use of Organisational Decision Making (ODM), and independent challenge.*

Upon locating the bottle of Tetrahydrofuran (THF) in s.24 during an Annual COSHH audit/ chemical inventory undertaken by two apprentices, it was apparent that a good questioning attitude had been deployed. Subsequent escalation through the apprentices Line Management also indicated a cultural change in Analytical Services, where issues could be raised and dealt with in a timely manner. It was recognised that the re-questioning of THF was due to delivery against the facility improvement programme, where shortfalls in chemical management were identified following a 2014 Board of Inquiry (BoI) gate post monitor event.

The investigation noted that there was a slight delay (6 days) in convening an Operational Decision Making (ODM) from event initiation on 3rd October 2017. There was also a missed opportunity to raise the profile of the event to an IER, however at the time the consequence was not fully understood. In addition, further fact finding was required in order to formulate an ODM problem statement.

The first ODM was held on 9th October 2017, was quorate and followed due process in line with SLSP 1.05.05.04 (Conservative and Operational Decision Making Supporting Information) as substantiated by the Internal Regulator acting as independent. The ODM utilised the FORDEC (Facts, Options, Risks, Decision, Execute and Closeout) model to establish a way forward to safely dispose of the THF. The ODM also recognised other chemicals of concern which may require similar scrutiny. There was a conscious decision to concentrate on THF and revisit the other chemicals in the near future through the ODM process.

There was a missed opportunity to have Sellafield Fire & Rescue (SF&R) and a chemical expert in attendance, however the s.40 Analytical Services (AS) did engage correctly with the Infrastructure Safety Manager in order to obtain their support. The ODM organisers were able to secure individuals from within Infrastructure and Occupational Hygiene in lieu of SF&R and a chemical expert.

A second ODM was convened on 12th October 2017 in order to assess progress from the actions. The Internal Regulator (Independent) again observed good decision-making, adequate challenge and the committee following due process. Due to SF&R not being in attendance a decision was made for the Operations Manager AS to contact SF&R to obtain advice on THF and understand more fully the potential consequences.

An ODM Sub Group meeting (ODM-001-2017-AS) was held on 17th October 2017 to establish a method potential disposal of the chemical.

In conjunction with the facility investigations, SF&R made contact with s.43 for advice on THF. The feedback received from s.43 was that THF could change state to TATP, which is a potentially explosive. This information prompted SF&R to immediately contact North West Fire for Explosive Ordinance Department (EOD) advice. SF&R documented the advice, including control measures in an e-mail dated 20th October 2017 at 11:30 which was issued to relevant personnel within Analytical Services and the Site Shift Manager (SSM). In essence, the information received was that THF was more unstable than first thought and in extreme circumstances could be explosive.

The Operations Manager (Instrumental Laboratories) who was deputising for the s.40 AS received information with respect to EOD attending Site through a direct telephone call from the Civil Nuclear Constabulary (CNC), out with the communications protocol, and promptly made contact with the Programme Manager AS to escalate the information received from CNC and SF&R.

The Programme Manager AS used the opportunity to utilise the Site Emergency Control Centre (SECC) duty team at FRIDEX to appraise the SECC of the situation and establish viable options. In addition, an independent peer check was received from the Innovation Strategy Manager and an experienced POCO (Post Operations Clean Out) Thorp Operations Support member with extensive chemical knowledge and experience.

The decision was made to formally establish SECC and control was formally handed over from AS to SECC in the afternoon of 20th October 2017. The Site Emergency Controller (SEC) who was the SSM made the decision to declare Operational Alert status. The SECC requested support from EOD who arrived at the Sellafield Site at 23:00hrs to view the chemicals and debrief the SECC of the way forward. Over the weekend of the 21st / 22nd October 2017 the EOD successfully detonated nine chemicals with two controlled explosions.

A Site wide review was initiated by Fleet Call through plan of the week on 23rd October 2017. Following Fleet Call, representatives from AS held a teleconference with the Office of Nuclear Regulation (ONR) which initiated a full root and branch review of Analytical Services. The subsequent inspections identified 2,400 vials of Quickszint and 13 x bottles of Quickszint in s.24 under s.24 Note that the s.24 were post operational and did not have a radiological inventory. It was identified that Quickszint has peroxide generation potential and may form explosive peroxides. However, the adjoining s.24 did have signage in place stating radiation levels of 45 micro Sieverts Beta / Gamma. This is from bottles of filtrate washings, which is not accountable inventory.

A further ODM (Meeting No.3) was convened on 24th October 2017 in two parts to establish a way forward. The meeting was quorate, followed due process and good challenge was observed throughout by the Internal Regulator (Independent). It was concluded by the ODM that the Quickszint bottles have unstable crystals and that Analytical Services do not have the required storage arrangements. The ODM Decision Maker contacted key stakeholders, including the s.40 and Security & Resilience to appraise them of the situation and the Crisis Management Team (CMT) were engaged. A controlled evacuation of Analytical Services commenced at 16:00hrs. The SECC duty team were requested to attend SECC on Wednesday 25th October 2017.

In tandem with the ODM, through the daily Fleet Call meeting, all facilities were provided with a deadline of 16:00hrs on Thursday 26th October 2017 to respond to the R J Kelly list which contained a list of chemicals containing peroxide.

On 25th October 2017 an additional Fleet Call at 15:00hrs reiterated to all facilities that they were required to conduct a trawl of their respective facilities as an immediate priority. A list of the findings from the facility Site trawl were recorded in SECC on an excel spreadsheet which became known as the 'Amber List'. This is being managed to date by a chemical recovery team which was assembled by the Head of Profession for Operations on behalf of the Head of Remediation.

During the period of 26th October to 1st November 2017 the EOD removed several chemicals (as identified on the event timeline) from Analytical Services and successfully detonated them in a safe location on the Sellafield Site.

The inspection team concluded that adequate decision making was enacted throughout, from event initiation to handover with the SECC on 20th October 2017. The ODM meetings captured factual information and sought prompt action to assess and understand the situation in order to make an informed decision.

However, a further observation was noted whilst investigating who within Infrastructure Services had received formal ODM training (SO845E). It was confirmed through OPMS that only four had been trained, which included the ODM facilitator in attendance at the first ODM on 9th October 2017. Note that the latest iteration of SLSP 1.05.05.04 (Conservative and Operational Decision Making Supporting Information) dated 09/2017, Issue 1 does not require any formal ODM training. Although this did not detract from the overall decision making, it would have been beneficial to have additional sufficiently trained personnel in the ODM to aid decision making. Therefore, it would be beneficial to conduct a review of the company's capability to conduct ODM and specifically, the application of ranking and rating systems in light of this event. It is suggested that this should identify any areas for improvement regarding corporate knowledge and training of ODM principles for non-radiological events / scenarios.

The handover from AS to SECC was also deemed as adequate, with sufficient dialogue between AS and the SECC observed by individuals from AS who were interviewed during the inquiry.

SF&R obtained advice from an external source s.43 and acted immediately, utilising the SECC duty team to co-ordinate a facility site wide response based on the information they were in possession of. This was augmented by Fleet Call who assisted in co-ordinating a measured response capturing factual information.

In order to capture the learning from the SECC response to this event, it would be beneficial to undertake a review on the handover from the facility to the SECC on the 20/11/17, the actions /decisions made by the SECC, how the chemicals were disposed of and any learning following communications / external media interest. Any learning should be incorporated into relevant procedures / practices for any similar future events and made visible.

### 7.4 Recommendations

The learning from this event has a direct relevance to the forward direction of the company.

This BoI has identified causes and contributory factors that need to be addressed through sustained corrective action in order to realise our key business objectives. The necessity to meet our legal obligations through enabling a more effective way of working is key. Although this BoI has essentially been bounded to chemical safety, the findings and wider learning are applicable to all areas of the business.

This BoI should be seen as the 'sign post' for all learning following the initiating event and subsequent actions the company took during October and November 2017. As such, an additional recommendation has been made out-with the terms of reference to assess current improvement plans and activities in SL and ascertain any further enhancement action against opportunities, enhancements and suggestions for improvement indicated by this BoI.

In addition, appropriate communications to share the learning from this investigation across the site will be undertaken by the investigation team.

***Improvement Recommendations***

1. This BoI (and learning) should be formally linked to the "Chemical Recovery Project Team" set up by the company with the mandate to validate, categorise and safely dispose via a risk-based approach, those chemicals placed on the site's existing Amber list. Clarify accountability for the Amber chemicals with the facility duty holders and clarify legal duties and responsibilities for contractors. Clarify and implement a new set of norms / processes and methods for onward chemical disposal including governance and route for escalation.

2. Undertake external benchmarking for the management of complex chemical inventories throughout their lifecycle of storage, use and disposal in order to understand best practice in meeting chemical safety legislative requirements. This work is a precursor for subsequent recommendations and should consider the chemical inventory on site now and likely inventories through the years of Transformation, end of reprocessing and POCO, recognising different / new analysis may be required.

3. Review existing contracts with external chemical expertise (ie) s.43 or the s.43 s.43 in order to secure specialist chemical advice and ongoing site support and extend contracts if required. Publicise these routes accordingly and make visible to all facility duty holders.

4. Establish a "Chemical Safety Module" that provides a process / database for oversight and control / configuration management of site wide chemical inventories against legislative requirements. Define the governance, ownership and competent support network. Consider how to expand the "format / principle" to other areas of conventional safety (eg) asbestos.

5. Establish a "Chemical Safety Competency" baseline that can be used as a foundation to support the "Chemical Safety Module" and support network, (facility Intelligent Customers) and wider organisational structure. This should provide a consistent understanding of all chemical safety legislation, including DSEAR and the requirement for a holistic cradle to grave chemical risk assessment. Competent individuals should understand the site and wider LFE in respect to the site's chemical inventory. Ensure clear protocols on knowledge management and retention around chemical safety. Develop and communicate across the wider business targeted "engagement" material that will foster the understanding that a Remediation mind-set needs to cover the chemical legacy. In particular, produce and communicate to key persons, such as facility duty holders, a chemical safety 'Ladybird' guide that promotes understand and improves technical competency.

6. Undertake a holistic review within the site EHS&Q organisation with respect to Executive direction and goal deployment, structure, arrangements and support to the facility duty holders around conventional safety legislation. Ensure the correct tailoring of competent resources to effectively address the conventional safety risk profiles and hazards of the different facilities on the site. Ensure the effective implementation and ongoing control / governance of conventional safety legislation within the facilities is given the right priority and allocation of capacity.

7. Review the current approach, focus, priority and visibility given to the conventional safety dashboards. Link to the necessity of tailoring the right capability to different facilities and discriminate that they have different risks profiles and hazards.

   Determine the important KPIs (conventional safety plant configuration) per facility rather than a generic approach that are rolled up to fleet call and executive monthly reports. Create a true and flexible picture of the conventional safety legacy profile for each facility. Consider how to build in the self-provocation and make recommendations for routine business / agenda items at facility MSCs.

8. In addition to liaising with the "Chemical Recovery Project Team", Analytical Services as a priority, should take the learning from this BoI and undertake both a full chemical inventory check and subsequent holistic risk assessment against chemical safety legislation. This approach should then be undertaken across all facilities with the appropriate competent resources and supporting site framework. Where it is considered not ALARP to undertake a full chemical inventory check, the risk(s) and argument should be clearly described and presented at facility MSC.

***Enhancement Recommendations***

9. In order to drive excellence in all areas of EHS&Q, undertake an enterprise-wide review regarding the site's organisational arrangements for best practice "Self-Evaluation" against conventional safety areas. Re-enforce the link between conventional safety and nuclear safety whilst ensuring a more equal footing regarding the self-evaluation of conventional safety. Challenge the current governance structure and supporting functional organisations to be more effective in self-provoking conventional safety shortfalls through identifying cues / triggers. Establish a different mind-set in the company's approach to organisational sense making and the ability to truly self-evaluate. Consider formally convening at least two "Board of Inquiry" depth self-evaluations / investigations per year on conventional safety topics.

10. For the EHS&Q s.40 to review this BoI and understand the broader benefits, opportunities and enhancements indicated by the findings. Conduct a gap analysis against the ongoing improvement plans and identify additional enhancement actions. Present the output to the Delivery Committee and establish the Enterprise position on taking them forward.

***Corrective Action Effectiveness Review***

11. Undertake an interim review every four months and present action progress to the Convening Authority and Delivery Committee. Furthermore, undertake a final Corrective Action Effectiveness Review (CAER) six months after the last action is closed out.

**7.5 Actions**

| Action Owner | Actionee | Target Date | Action |
|---|---|---|---|
| s.40 | s.40 | 31/5/18 | Improvement 1 "Chemical Recovery Project Team"<br>Action Description:<br>The 'Chemical Recovery Project Team" is to facilitate a risk based disposal of all chemicals on the existing "Amber" list across Sellafield site. The recovery team should take into account within its Terms of Reference, the context of Recommendation 1. Review external benchmarking of chemical disposal methods to incorporate best practice.<br>*Note: This action should be completed within six months from the date the "Amber" list was finalised, as co-ordinated through the SECC.* |

| Action Owner | Actionee | Target Date | Action |
|---|---|---|---|
| s.40 | s.40 | 31/5/18 | Improvement 2 "Chemical Recovery Project Team"<br>Action Description:<br>The "Chemical Recovery Project Team" is to define a new set of norms, implement processes / tools to facilitate disposal of chemical waste, and communicate to all facility duty holders. |

| Action Owner | Actionee | Target Date | Action |
|---|---|---|---|
| s.40 | s.40 | 31/5/18 | Improvement 3 External benchmarking and chemical safety learning<br>Action Description:<br>To establish best practice in chemical inventory management including the requirement for holistic risk assessment. Undertake external benchmarking with regards to handling of complex chemical inventories and the lifecycle of storage, use and disposal versus chemical safety legislative requirements. Take into account the context described in Recommendation 2. |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/5/18 | Improvement | 4 | External benchmarking and chemical safety learning |
| | | | Action Description:<br><br>Ensure the scope of future analytical requirements, in particular the Replacement Analytical Project, includes assessment of the impact of new chemicals, their storage, use and disposal by incorporating this requirement into any project scope question sets. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/5/18 | Improvement | 5 | External benchmarking and chemical safety learning |
| | | | Action Description:<br><br>With reference to Recommendation 3, review existing contracts and determine the escalation process for gaining further specialist chemical safety advice from external contract holders (eg) s.43 s.43 . This process must be made visible to all facility duty holders throughout the organisation. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/5/18 | Improvement | 6 | Chemical Safety Module |
| | | | Action Description:<br><br>Establish a "Chemical Safety Module" that provides a process / database for oversight and control / configuration management of site wide chemical inventories against legislative requirements. Define the governance, ownership and competent support network. This should be undertaken referencing the context in Recommendation 4. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/8/18 | Improvement | 7 | Chemical Safety Competency |
| | | | Action Description:<br><br>Establish a "Chemical Safety Competency" baseline that can be used as a foundation to support the "Chemical Safety Module" and support network (facility Intelligent Customers) and wider organisational structure. Develop and communicate across the wider business. Take cognisance of the context and address the specific deliverables described in Recommendation 5. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 30/11/18 | Improvement | 8 | EHS&Q organisational review |
| | | | Action Description:<br><br>Undertake a holistic review within the site EHS&Q organisation with respect to Executive direction and goal deployment, structure, arrangements and support to the facility duty holders around conventional safety legislation. Take cognisance of the context and address the targeted areas in Recommendation 6. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/5/18 | Improvement | 9 | Conventional safety dashboards |
| | | | Action Description:<br><br>To enable oversight of the conventional safety risks, revise the current conventional safety dashboards to enhance focus, priority and visibility, addressing the context in Recommendation 7. Determine the important KPI's per facility to create a true (and flexible) picture of the conventional safety profile within each facility. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | Facility Duty Holders | See note | Improvement | **10** | Facility chemical inventory checks |
| | | | Action Description:<br><br>In order to fully understand the potential risk posed by chemicals in their facility, each area must undertake a full chemical inventory check and subsequent holistic risk assessment against chemical safety legislation. For areas where access presents significant risk, an ALARP justification can be made however, this must be endorsed by local Management Safety Committee (MSC).<br><br>*Note: Analytical Services to complete this as a priority (31/3/18). Other facilities are to complete the action as the supporting site framework is established (by 30/11/18).* | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/8/18 | Enhancement | **11** | Enterprise wide self-evaluation review |
| | | | Action Description:<br><br>Undertake an enterprise wide review regarding the site's organisational arrangements for best practice "Self-Evaluation" against conventional safety areas. This review should be cognisant of the context of and address the specific deliverables in Recommendation 9. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/8/18 | Enhancement | **12** | Further enhancement action |
| | | | Action Description:<br><br>Review this BoI and understand the broader benefits, opportunities and enhancements indicated by the findings. Conduct a gap analysis against the ongoing improvement plans and identify additional enhancement actions. Present the output to the Delivery Committee and establish the Enterprise position on taking them forward. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | Interim reviews by: 31/3/18 31/7/18 30/11/18 | Improvement | 13 | Interim Corrective Action Effectiveness Reviews |
| | | | Action Description: Undertake an interim Corrective Action Effectiveness Review (CAER) every four months and present action progress to the Convening Authority and Delivery Committee. | | |

| Action Owner | Actionee | Target Date | Action | | |
|---|---|---|---|---|---|
| s.40 | s.40 | 31/3/19 | Improvement | 14 | Final Corrective Action Effectiveness Review |
| | | | Action Description: Undertake a final Corrective Action Effectiveness Review (CAER) six months after the last action is closed out and present output to the Convening Authority and Delivery Committee. | | |

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## 8. Actions already taken

List here actions that have already been completed, and note the evidence to underpin these actions.

1. Site Wide Action for extent of Condition, via Fleet Call and SECC. This has resulted in the site "Amber" list of peroxide forming chemicals and the "Chemical Recovery Project Team" being established.

2. A 24 hour chemical help line agreement has been set up with the s.43 s.43

3. A "Chemical Recovery Project Team" has been established and is tasked with the recovery of the site position regarding redundant chemicals identified in the collated inventory (Amber) list.
   The team are working on several different work-streams which will ultimately enable the site to understand the scale of the remaining redundant chemicals and then to start to optimise our disposal routes on a prioritised basis – with the aspiration of defining and implementing a new set of norms that will enable us to improve the methods we use for chemical disposal going forward.

   As a basic overview, this teams initial remit was the following:

   - Validation of the list of 'Amber' Chemicals (firstly in Analytical Services, then s.24 then the rest of the site)
   - Characterising the 'Amber' chemicals within Analytical Services – then arranging disposal.
   - Characterising the 'Amber' chemicals with s.24 – then arranging disposal.
   - Transferring the learning from 'Amber' chemical characterisation/disposal across the rest of the organisation to optimise progress on disposal.
   - Establishing/optimising disposal routes (working closely with the Effluent Discharge SME and the Environmental assessment leads)
   - Readying the supply chain.
   - Preparing the transport / consignment departments
   - Validating the existing lists of 'Redundant chemicals (Analytical Services, then the rest of site – in a similar method to the Amber list)
   - Simplifying the assessment/analysis process required for chemical disposal.

   The BoI team has made a recommendation that this initial remit is reviewed in light of the findings from this investigation.

4. Following the initiating event, escalation and subsequent actions through SECC, prompt communications were delivered to relevant stakeholders, including Regulators.

## 9. Additional findings/ observations

Outline any additional findings your investigation has revealed that have not caused/ contributed to the condition but have revealed other areas of weakness or concern.

A number of positive findings were identified during the investigation, including the following improvements identified below:

**Leadership within the facility**:

- Safety Stand down was undertaken following the s.24 Dispensary contamination event which demonstrates a positive change in behavioural culture. Previous focus was providing a service to the site facilities (keeping the labs operational). This demonstrates a change in the Managerial mindset to recognise off normal conditions and take appropriate action.

- The conditions for acceptance were modified to ensure disposal routes were agreed before samples were accepted into the facility. Previously the facility accepted samples to support continued operations without consideration of the legacy. This represented a positive change in culture where risk reduction was appropriately prioritised over analysis. This prevented further accumulation of orphan wastes aiding the risk reduction programme for the facility.

- Prioritisation within the facility focussed appropriately on fissile risk reduction whilst the disposal routes existed. 1464 bottles of fissile residues and 621 litres of active solvent disposed of from the facility. Senior Management also consciously took the decision to focus on a small number of key priorities to manage the broad spectrum of deliverables required by the facility.

- s.40 requested facility trend report to be carried out quarterly instead of annually to have the visibility of the efforts being put in with work on the improvement plan to see if this was positively affecting the trends.

- The initiating event, where the two apprentices were able to question the chemical and raise it to their team leader demonstrates the change in culture within the facility.

- The appointment of a Business change Manager initiated improvements in Human Performance and Nuclear Professionalism in the facility.

- During the first half of 2012 there were a number of cues such as the WANO Peer Review Follow Up, the Tier 3 audit, the s.24 sludge sample spillage and also some senior management changes within Analytical Services. The culmination of these events were perceived by many interviewed as the start of some positive cultural changes within the facility with a real focus on nuclear safety and an operational mind-set.

- The Event Time Line Diagram Section 10 Appendix 4, shows the missed opportunities, the waxing and waning for disposal efforts within the facility and progress against fissle risk reduction.

## 10. List Of Appendices

| | |
|---|---|
| Appendix 1 | Event Timeline |
| Appendix 2 | Event Timeline Discussion |
| Appendix 3 | Event and Causal Factors (Part 1 & 2) |
| Appendix 4 | Event Time Line Diagram |
| Appendix 5 | Photographs of THF / Quickszint |
| Appendix 6 | Terms of Reference Review |
| Appendix 7 | Glossary of Terms |

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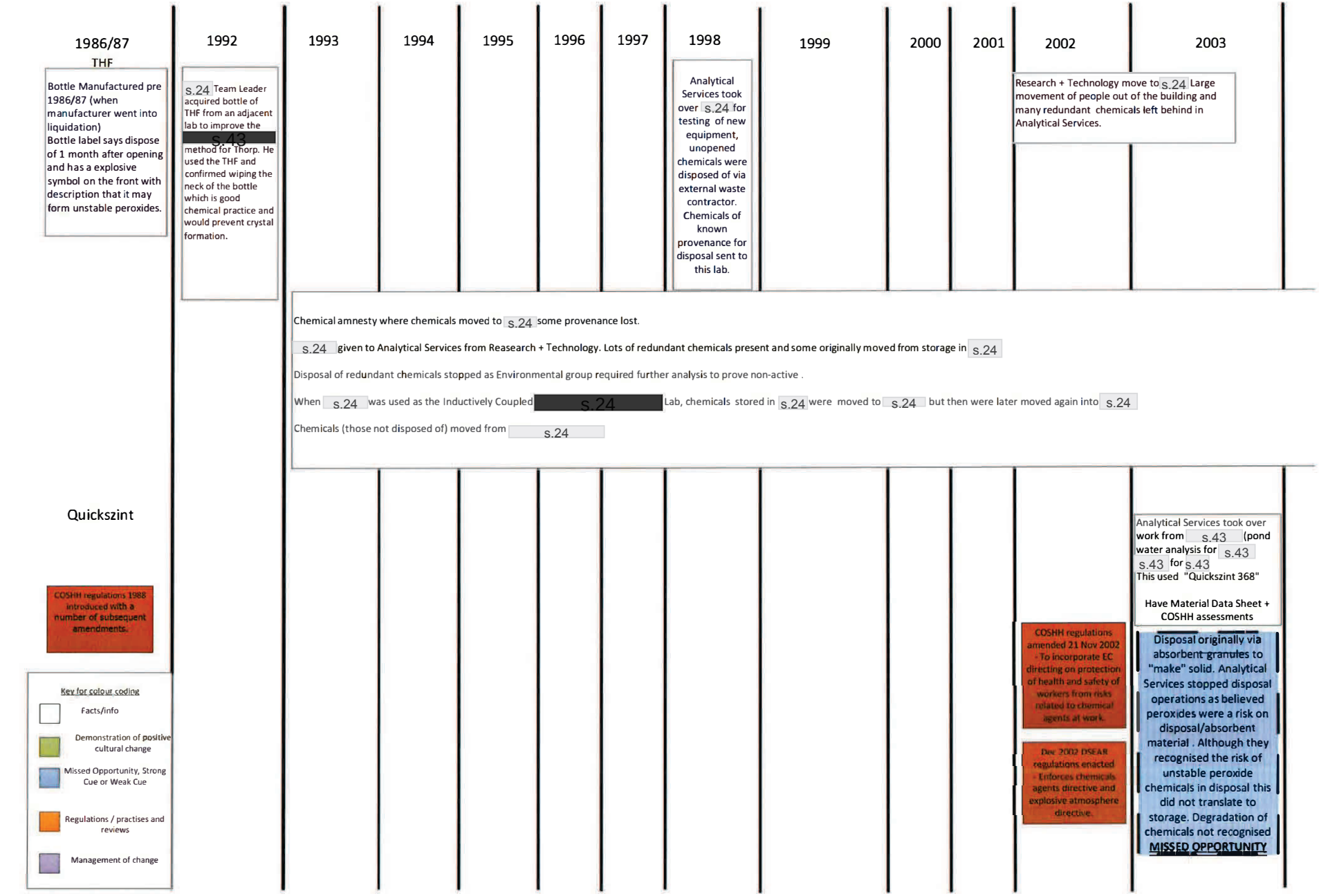
## 10. Appendix 1. Event Time Line



2004 2005 2006 2007 2008 2009 2010

THF bottle opened and sampled. Sample analysed for Alpha + Beta (08/05/2007). Results demonstrated it was non-active 500ml of liqour noted.
**MISSED OPPORTUNITY**

15/12/09
BN0912A1076- "Minor spillage of Lithium Nitrate Solution. Local sentencing comments: Analytical Services management needs to re-evaluate and improve as necessary storage arrangements for waste materials in Analytical Services to ensure they are stored correctly & safely (in compliance with all relevant regulations i.e. COSHH). Site sentencing agreed."

Two actions placed:
"1. Check existing risk assessment for the storage of chemicals in connection with BN0912A1076 the existing risk assessment/ instruction for the task (storage of chemicals prior to disposal) is to be checked and rewritten to ensure the following are considered:
1) The transport of the materials
2) Degradation of the ageing chemical containment
3) Make the task a 2 man job with operators fully aware of each chemicals hazards
4) The contingency arrangements in the event of spillage"
**ACT050514**
**Close out statement:"** Inappropriate action placed. Superseded by action 2

2. Review building wide, handling, storage and disposal of redundant chemicals."
**ACT053850**
**Close out statement:"** As part of Analytical Services ORSE2 review a new management work stream to deal with wastes is being set up. This will have a part of its priorities a building wide review and strategy for handling and disposal of redundant equipment."
**MISSED OPPORTUNITY & STRONG CUE**

2010 WANO peer review Infrastructure identified "chemical control" as an issue.
Area For Improvement (AFI)
**Chemical storage arrangements across the plants do not effectively control operational and legacy waste chemicals and contaminated oils, solvents and samples.** Incompatible chemicals including oxidising agents, reducing agents, organic compounds and unknowns are stored together with the potential for uncontrolled chemical reactions. Storage within the laboratory facilities is not underpinned by adequate risk assessments. Disposal routes have not been established for all wastes which is resulting in the accumulation of orphan wastes.

One of the facts against this Area For Improvement: Radio chem s.24 found large metal cabinet full of redundant waste chemicals. Some inven ears old.
**MISSED OPPORTUNITY & STRONG CUE**

Thorp Hydrozoic Event - BN1011A1232- November 2010 51 actions placed across site following the event . 1 of the actions placed on Analytical Services:

**ACT056806** Undertake a review of COSHH assessments with a view to establish the robustness of the information contained within the assessments. COSHH assessments for chemicals or chemical mixes that do not have a MSDS (Material Safety Data Sheet) should be reviewed as a matter of priority. Specifically:-

a) Confirm appropriate assessment and controls are evident for any decomposition chemicals that may be produced.

b) Clarity of PPE and RPE exists within the assessment with clear guidance on quantises that may change the PPE/RPE requirements. For example if a change in PPE/RPE is required for a 'significant' spillage, clear quantification should be given in the COSHH assessment of what 'significant' actually means

c) Ensure appropriate SME (Subject Matter experts) have been used in generation, reviewing and authorising the COSHH assessments

Close out – target date extended. The reviews requested have been carried out since the Head of Facility left the department. For details see new Head of department.

This close out statement was inadequate

**MISSED OPPORTUNITY**

Pond water analysis stopped. No use for "Quickszint 368"
Vials on Orphan Waste List. Unused scintillate on redundant chemicals list (13 bottles)

April 2005 Manufacturing and storage of explosive Regs 2005

September 2006 Chemo toxic Assessment Rev 0 -Hazardous area classification paper for Analytical Services -COSC-Internal Hazards assessment NOT FULLY IMPLEMENTED

March 2008 Chemo toxic Assessment Rev 1 NEVER IMPLEMENTED

November 2008 Chemo toxic implementation strategy

March 2009 Analytical Services DSEAR Assessment s.43 NEVER IMPLEMENTED

March 2009 DSEAR and Hazardous area classification implementation options.

October 2009 Summary of DSEAR Compliance measures Analytical Services

Innovation managers were in position

2011

THF accounted for in s.24 flammable cupboard. Solvent identified for disposal

2012

2012 WANO Follow-up
**WEAK CUE & MISSED OPPORTUNITY**

Assurance activity AU001076 19-01-2012-31-03-2012
Tier 3 COSHH Audit
Concerns:
- Out of review date COSHH assessments, not all assessments were activity based as required by SLP 2.04.403 Action Placed.
**WEAK CUE FOR CHEMICAL MANAGEMENT**

Following 2010 Peer Review the Innovation team were working on the redundant chemicals, pulling together inventories and disposing of chemicals where possible. 1027 chemicals with provenance (not opened) were disposed of.

**July 2012 - BN**
Analytical Services s.24 trolley carrying s.24 sludge sample tipped over and the sample bottle c containment b t was retained. 9 actions placed following the event. 1 action regarding suitable storage of decommissioning samples. To ensure that post analysis and prior to disposal that samples are stored in a suitable location with suitable ventilation.

Close out -"The storage of future decommissioning samples will be subject to more significant levels of scrutiny, and work is being put in place to ensure that compliance with the Analytical Services safety case is more likely to be considered before sample receipt.

Samples currently stored are assessed for risk, and will be managed accordingly. Advice from the Safety Case manager will now be a routine feature of storage of non-routine samples."

**MISSED OPPORTUNITY**

The Cue's experienced during first part of 2012 are perceived to be the start of positive cultural change within Analytical Services.

Feb 2011
Head of Analytical Services #1

January 2011
Chemo toxic Assessment Rev 2 Updated, but not implemented

May 2011
SLP 2.04.403
COSHH- 1st Issue

June 2011
SLP 2.04.503 #1
Major Chemical Inventory Issue 1

July 2011
SLP 2.04.501 #1
Controls the Quantities and safe use of chemicals 1st Issue

February 2011-November 2011
Head of Analytical Services #2

2011
Delivery Manager #1

Facility Manager #1

November 2011-July 2012
Head of Analytical Services #3

April 2012 SLP .04.504 #1 REACH

May 2012
SLP.2.04.403
COSHH
-Amalgamate SLSP 2.04.403.01 include trending reg for new assessors.

Oct 2012
DSEAR- SLF reference changed (DSEAR register, DSEAR Assessment)

July 2012- March 2014
Head of Analytical Services 4
The appointment of the Head of Analytical Services (4) introduced a new focus on nuclear safety culture

October 2012
SLP 2.04.503
Major chemical inventory
-Requirement for chemical coordinator added
Wording amended to reinforce accountabilities.

December 2012
SLP 2.04.504 #2 REACH
-Requirement for chemical coordinator added
- Working change to reinforce accountabilities.

Legacy Waste and Safety Case Manager 1

2013

Site wide review on competency and resource for conventional safety prompted site inspectors visit. The resulting site inspectors report outlines concerns about 62% overdue COSHH assessments.
**WEAK CUE FOR CHEMICAL MANAGEMENT**

- Disbanding of Innovation team and cessation of work
Team disbanded due to focus changing to higher priorities within Analytical Services
**MISSED OPPORTUNITY**

April 2013
Analytical Services issue first MUMCHI
No reference to THF or Quickszint

2014

January 2014
Paper prepared by [redacted] identification of disposal routes for redundant chemicals in Analytical Services Resulting from WANO 2010 Peer Review.

April 2014
Analytical Services issue second MUMCHI No reference to THF to Quickszint

March 2014
Delivery Manager #2 (Temporary)
Ops Support Manager #1 (Temporary)

March 2014
Head of Analytical Services #5
Delivery Manager #3
Analytical Services Ops Support Manager #2

August 2014
Safety Case + LTPR Manager #2
Legacy Waste Manager #1
Delivery Manager #4
Residues & Waste Manager #1

January 2014
SLP 2.04.504 #3
REACH
-Ref top SLP 2.04.501 title amended

January 2014
SLP 2.04.503 #3
Major Chemicals Inventory
- Ref to SLP 2.04.501 title amended

SLP 2.04.501 #3
Quant/use of chemicals
-Typing errors

April 2014
SLP 2.04.502 Issue 3
-Doc re-written to provide clarity on requirements of role holders
- Revised training requirements
- New roles- DSEAR facilitator
DSEAR Assessor
- Local DSEAR register requirement removed
**MISSED OPPORTUNITY**

SLP 2.04.501 #4 Aug
Quant/use of chemicals
-Waste Management hierarchy clarity
-PPC (ENV) incorporated
-SQEP role of chemical co-ordination added
- Template change

SLP 2.04.504 #4
REACH
- Chemical co-ordinator SQEP role added

SLP 2.04.503 '4
Major Chemical Inventory
- Chemical Co-ordinator to forward MUMCHI to relevant depts. (DSEAR, PSC, Emergency Response)
- SQEP Role for chemical Co-ordinator.

September
Safety Case Manager commented at MSC that Chemo toxic assessment is not high on the safety case priority list, that the chemo toxic assessment is not included in the Nuclear Safety Case anymore and that we are dealing with issues as they arise. The safety case manager added that transferring the issues to Building Services is not the best way forward, it is a very technical document that is hard to unpick to find the usable detail. The committee agreed to close the current action and raise a new action on the safety case manager to deliver a talk on the strategy of how we are going to prioritise and implement the requirements identified in the chemotoxic assessment. To be delivered at March MSC.

July 2014 MSC Action 469
September 2014 MSC Action 495
ATLAnalytical Services Act137358

**WEAK CUE FOR CHEMOTOXIC MANAGEMENT**

## 2014

### October

15/10/2014- BN1410A2156
Waste chemicals from Analytical Services are being disposed of.
Gate post monitors alarm as vehicle leaves site.
28 Actions placed following BOI investigation. One of the actions ACT138198 related to chemical inventory in Analytical Services. For all Analytical Services labs and rooms containing stocks of chemicals carry out the following:
- Identify an owner responsible for chemical inventory of each lab.
- An inventory stock take of all chemicals.
- Assess the provenance of chemicals and characterise any that are unlabelled
- Put in place COSHH assessments for all chemicals.
- Put in place management systems to ensure inventories of chemicals and associated COSHH assessments are maintained.
- Confirmation of completion of improvements to chemical inventories and associated COSHH assessments through the Analytical Services MSC
Note this action applies to stored chemicals and does not apply to analytical work in progress.
Corrective Action Effective Review (CAER) at 6 months and 12 months and a further action was placed. CAER carried out for this further action ACT159504.

Closeout Statement demonstrates re-initiation of chemical inventory for all chemicals, COSHH assessments, annual COSHH audits and possible disposals of redundant chemicals (new version of analytical services guideline 08-Analytical Services08.)
**STRONG CUE**

### November

Letter of concern from Internal Regulator. COSHH assessments out of date. Lack of risk assessment for all chemicals and the tasks/ areas. Lack of full inventory (BN1411A4306)
**WEAK CUE FOR CHEMICAL MANAGEMENT**

2014
Explosive Reg's introduced, the majority in force October 2014.

## 2015

### January

Following BOI in 2014 BN1410A2156 Ops Support team produced a full inventory of Analytical Services labs. THF + Quickszint are both on this list. In the region of 2000 different types of chemicals identified on this inventory. List is not live- Line in the sand.

### February

Internal regulator revisit.
Lack of progress against the improvement plan. Difficulty in getting Lab leaders to complete annual audits from Analytical ServicesG08
Corrective Action placed.
Compelling advice threatened.
**WEAK CUE**

BN1502A0727- Volum[illegible]x released externally to s.24 which resulted in Inci[illegible] Control Centre being set up.
This was a significant COMAH event shared throughout Thorp (the area) not throughout site.
**MISSED OPPORTUNITY FOR THE SITE**

### March

MSC- 229 Solid Waste report 2014 New action set 506 Atlas 141599.
s.40 discuss with s.40 ho will be re[illegible]he disposal of chemicals.
Close out statement demonstrates discussion and requests further update meeting to be held in June but no evidence that this meeting was ever held.
**WEAK CUE**

### April

BN1504A0115-Analytical Services: Failure to meet Manufacturing Unit Major Chemical Hazard Inventory (MUMCHI). Analytical Services have not produced a MUMCHI and so have missed the deadline for submission 31/03/2015.
Action placed to: Identify an appropriate individual to carry out the work of a chemical co-ordinator and inform the relevant parties.
**WEAK CUE**

Ops support team member identified to start training as chemical co-ordinator for Analytical Services (never SQEP). Individual prepared MUMCHI which identified THF + Quickszint as flammable. 119 entries for flammable substances identified on this MUMCHI.

Internal regulator follow up visit.
Satisfied with progress to enable close out of Letter of concern.
BN1411A4306
**MISSED OPPORTUNITY**

2015

May | June | August | September | November | December

02/06/2015 BN1506A0257- Find of new inventory items not previously declared. During review of redundant chemical inventory in s.24 it was identifi chemical storage cabinet contained several items that should be declared Special Nuclear Material **WEAK CUE**

BN1508A0754- Unknown HF discovered in fume hoods.24 s.24Partially used bottles o HF were found behind a microwave used for sample dissolution. The laboratory personnel were unaware of its presence in the fume hood. **WEAK CUE FOR CHEMICAL MANAGEMENT**

BN1506A0131 Analytical Services/ s.24 dispensary s.24 amination ctions placed. Safety stand down in Analytical Services in July. **Positive demonstration of cultural change.**

Thorp COMAH HSE inspection prompted by NOx event in February 2015. HSE noted that chemical safety not given the same priority as nuclear safety.
- Prompted chemical safety improvements in Thorp
**MISSED OPPORTUNITY FOR THE SITE**

August 2015
Change in responsibilities for Manufacturing Support Manager #3 to include:
- Safety Case
- Operations Support
- Legacy Waste Ops Support & Technical
- Building Ops Support

DSEAR Regulations amended in 2015

COMAH Regs 2015 in force

SLP 02.04.503 #5 June 2015
Major chemical inventory
- Update to account for COMAH regulations 2015
- Simplified and clarity on accountabilities
- Requirements for MUMCHI to go to doc control.

Joint SL/ONR Leadership & Culture Review
- Initiates changes to SLP's
**STRONG CUE FOR THE SITE**

SLP 02.04.502 #4 DSEAR
- Template change
- 7.5% Methane Discounted

Joint ONR/SL Conventional Health and Safety Intervention. Concerns raised about conventional safety on the site. This was the prompt for conventional safety dashboards.
**STRONG CUE FOR THE SITE**

**2016**

January

February

Ops support manager presented paper at Analytical Services MSC
The management of waste chemicals and their disposal within Analytical Services
Included copy of improvement plan

March

Thorp HA Labs managed by Analytical Services

07/03/2016
BN1603A2173- Periodic COSHH Audit completed in Thorp Labs by Team Leader and COSHH Assessor identified a few areas for improvement/non-compliances:
- Some COSHH assessments out of date
- A number of bottles require OB references
- Too much of some chemicals are being stored
- Chemicals are labelled for disposal, but have been that way for several years.
Actions are being tracked locally via COSHH folder and not on ATLAnalytical Services database.
**WEAK CUE**

30/03/2016
BN1603A3547- Periodic COSHH Audit for s.24 & s.24 l ances.
1. Number of bottles require correct labelling as per Analytical ServicesG08.
2. Redundant chemicals to be disposed off. Audit action sheet completed and actions assigned.
RAISED FOR TRENDING. Actions are tracked locally and not on ATLAnalytical Services database.
**WEAK CUE**

April

Infrastructure WANO Peer Review
**AFI**
Practices concerning inappropriate containment, incompatible storage and unsuitable volumes of chemicals are evident. Incompatible storage increases the potential for interaction between chemicals leading to violent reactions or explosion, fire, personal injury and plant equipment damage.
**STRONG CUE**

May

BN1605A1372- Analytical Services s.24 Operator Inhaled n analyst working at Fume hood 9 performing part of QAAM 334 (Phosphate Analysis) felt tightness in the throat/chest area and saw white fumes outside of the fume hood containment.
BCI Carried out
**WEAK CUE FOR CHEMICAL MANAGEMENT**

January 2016
Conventional Safety Dashboard
1st issue
Phase 1
Legionella, Asbestos, Confined Space, Transport safety
**MISSED OPPORTUNITY**

March 2016
Conventional Safety Improvements plan to exec committee
**STRONG CUE FOR THE SITE**

April 2016
Conventional Safety Dashboard phase 2 specifying
- DSEAR, noise, power, COSHH, Fire Safety

May 2016
Joint ONR/SL conventional safety intervention report issued.

2016

June July August September October November

12/09/2016
BN1609A1217- Incorrect inventory of chemicals for disposal via s.43 out of 60 chemicals only 10 were correct.
**WEAK CUE FOR CHEMICAL MANAGEMENT**

BN1611A1728- DSEAR checklist findings for small scale chemical storage. It was identified that areas within Analytical Services were not compliant with the checklist.
3 actions placed:
- Review progress of the implemented COSHH Improvement Plan for Analytical Services and determine any required recommendations, placed on Safety Case & Safety Dept.
Create & Implement an Improvement Plan for all COSHH storage within Analytical Services. Closed out Jan 2017: Action plan added to the Analytical Services master Improvement Plan. Monitored on a monthly basis at Lead Team ops monthly meeting.
**MISSED OPPORTUNITY**

July 2016
Building Ops Manager #1
Nuclear Safety Performance Manager #1

Conventional Safety dashboard phase 3 specifying
- Work at height, manual handling, lifting operations and hand arm vibration.

2016

December

2017

January

Head of Analytical Services requested trend report to be carried out quarterly instead of annually, to have visibility of the efforts being put in with work on the improvement plan to see if this was positively affecting the trends.
**DEMONSTRATION OF POSITIVE CULTURAL CHANGE**

From January 2017 with respect to the quarterly trend report reviewed no trends were identified for chemical storage. 40 CRs raised associated with chemical management in the last 36 months.
**MISSED OPPORTUNITY**

April

Latest MUMCHI identifies THF (2.5L) a able, present in s.24 Quickszin s.24

May

BN1705A1975- Poor storage of chemicals in Radio chemistry labs Analytical Services. As part of a manager in field incompatible chemicals were stored together in bunds eg. Nitric acid (2m) and acetone and ammonium sulphate and nitric acid. Trend only. Found but nothing done to address
**MISSED OPPORTUNITY & WEAK CUE**

June

20/06/2017
Analytical Services Safety Inspection Improvements required: flammable cabinet requires contents updated (faded) unknown chemical (labelled unknown)
No signage on containers. Poor closeout statement for action (BNA06A2015)
**MISSED OPPORTUNITY & WEAK CUE**

August

BN1708A3418- Safety Inspection Analytical Services Instrumental. Areas for improvement for instrumental to be monitored. There are no formal actions required. Lab operations manager is tracking these improvements through these instrumental safety committee.

September

BN1709A0585 Conventional Safety Dashboard COSHH. Condition report raised in order to track actions. No formal actions placed on atlas.

Demonstration that chemical safety inspections are being undertaken in Analytical Services and condition reports are being raised to highlight the improvements needed .
**DEMONSTRATION OF POSITIVE CULTURAL CHANGE**

January 2017
Operation Support Manager #4

June 2017
New roles appointed:
Head of Programme Delivery #1
Strategy and Technical Manager #1
Program Manager #1

SLP 2.04.502 #5 DSEAR
- Removal of DSEAR facilitator role & safety advisor competency
- Work place assessment Ref's and responsibilities added migration to Chemical Labelling Packaging.

Scope mmenced with s.43 on DSEAR Assessment for Analytical Services.
DSEAR SWARM Team supported.
**MISSED OPPORTUNITY**

s.43 DSEAR re . Not yet implemented. Does not identify risk associated with storing chemicals that may degrade to form peroxide crystals.
**MISSED OPPORTUNITY**

2017

October

03.10.2017

**INITIATING EVENT- BN1710A0312**

THF part filled bottle (in 500ml) located in s.24 Flam Vault (active are active DURING A CHEMICAL INVENTORY by two apprentices (3rd year). Raised as a concern.

**DEMONSTATION OF POSITIVE CULTRAL CHANGE.**

Initial Findings
- THF should be disposed of one month after opening.
- Explosive sticker was prominent on the bottle
- No visible crystals
- Cannot see inside bottle
- bottle locked away

s.40 Analytical

Conscious decision not to sentence the CR as an IER due to the consequence not being fully understood and not perceived as a significant issue. Note the CR had not been locally sentenced as of 31/10/2017

Sentencing of the CR as an IER to raise profile of the event.

**MISSED OPPORTUNITY**

s.40 Analytical

Reasons for chemical inventory take was delivery against the facility improvement plan. Recognise shortfall in chemical control. Trying to standardise storage of chemicals across the facility

**POSITIVE**

Programme Manager Analytical Services New Business change manager appointed, culture change commenced. Event escalated promptly through to the duty holder.

**POSITIVE**

04.10.2017

s.40 initiated fact findings following CR (BN1710A0312) raised on decision to gather facts prior to convening ODM. Not perceived as a significant issue

Internet searches conducted not much that said THF was explosive only one 1 piece of LFE from USA (Berkeley event.)

09/10/2017- ODM 1

9:00-10:30
THF ODM held Part 1 for THF chemical

Internal Regulator attended as independent. Considered to be a good ODM, well run, identified risks, good 'output' i.e (action list). Team represents specialist areas (as far as able) facilitator kept to process, all contributed and in agreement.

- THF not believed to be on chemical inventory. Peroxide crystals MAY have formed. Belief peroxide crystals required external energy to become unstable. Risk to people/plant perceived as months as opposed to days, hours.
- Can't find COSHH Risk Assessment/ Material Safety Data Sheet
- obtain MSDS from elsewhere

Limited info on material and risk.
-ODM recognised THF located in area with no Nuclear Inventory

s.40 Analytical Services Safety Manager for chemical expert to support ODM. Representative sent from site occupational hygiene team (responsible for signing off COSHH assessor)

s.24 team leader requested ld Fire and Rescue to be in attendance at ODM no 1, however ODM committee were satisfied to proceed without Sellafield Fire and Rescue as individual was in attendance who had previous fire/ EOD experience.

**Sellafield Fire and Rescue and Chemical Expert not in attendance at the ODM**

**MISSED OPPORTUNITY**

12/10/2017 ODM 2

17/10/17

20/10/2017

Discussion held to conduct ODM again in the future for different chemicals i.e. 2,4 Dinitrophenyl hydrazine. NO timescale set though

ODM number 1 determines
- Make facility safe
- ODM triggered trawl of COSHH lists
- Concern re extent of condition (i.e. other chemicals)
- Preferred option to open bottle of THF and dispose of via the LA (low active) Drain. Method statement required prior to commencing disposal.

13:00-14:00
THF ODM reconvenes (No 2)
- Recognises some information missing re-knowledge.
- ODM identified possible disposal route, as in liquid form, THF was compatible with trace active drain.

Internal Regulator attended as independent.
ODM quorate, good challenge observed throughout.

Head of Operations Analytical Services
- Sellafield Fire and Rescue not available to attend. Action from ODM to contact Sellafield Fire and Rescue to investigate THF
- No one from technical i.e. expert chemist

ODM No 2 determines
- Complete identified actions in ODM decision making record sheet (DMRS)
- To arrange for ODM sub group to establise method for opening bottle and discharging to trace active drain.

ODM Sub Meeting
ODM-001-2017-Analytical Services
THF in solvent cupboard follow up meeting 1 convened (meeting minutes produced)
Two Key elements discussed:
1. Method for opening bottle
2. Discharge to trace active (TA) drain.

Analytical Services had arranged a further meeting with Sellafield Fire and Rescue for 25/10/17, however meeting did not proceed due to event escalation in SECC.

Operations Manager (Instrumental Labs) (Deputising for head of operations Analytical Services) Receives call from CNC that EOD are looking to be dispatched.

11:30-Site Shift Manager contacted by Sellafield Fire and Rescue who receives information that THF is more unstable than thought from s.43 In extreme circumstances can be explosive

STEP CHANGE IN RISK UNDERSTANDING
Programme manager Analytical Services utilises SECC team at FRIDEX to discuss options. Risk assessment reviewed in SECC with FRIDEX team and Duty Holder

Independent peer check requested from Programme Manager Analytical Services from Head of technical and capability and POCO THORP team member. It was confirmed nothing else could be done other than follow s.43 advice.
Cross check conducted of s.43 advise verses government fact sheet concluded that it is credible but unlikely.

Handover to SECC
OPERATIONAL ALERT decision made by SSSM at 16:00. Full SECC team attended s.24 EOD arrive at 23:00hrs on Friday 20.10.17. View bottles in the laboratory, debrief SECC and reduce exclusion zone.

Condition report raised BN1710A2447_Analytical Services/Hazardous chemical removal/Evacuation BOI being carried out.

Sellafield Fire and Rescue Response 13/10-19/10/2017

Sellafield Fire and Rescue were requested through ODM (meeting no.1 ) to obtain information for THF

Sellafield Fire and Rescue contacted s.43 s.43 for advice on THF. Response [prompted Sellafield Fire and Rescue to contact north west fire for EOD contact). EOD engaged. Sellafield Fire and Rescue stated that s.43 feedback was that THF could change state to TATP

Sellafield Fire and Rescue receive further request from lab technician founding ODM Sub meeting dated 17/10/2017 for information regarding bottle opening and where best to do so.

Sellafield Fire and Rescue observed good decision making throughout by EOD. Good pre job briefs observed for each detonation activity

Sellafield Fire and Rescue do not have equipment to determine if a chemical has peroxide forming properties i.e. HAPSITE or PID (Photo Ionic Detector.)

SL have a contract with s.43 for 2x training course per annum at s.43

21/10/17

SECC Team stood down at 02:00 hrs

08:00 hours SECC re-established

EOD carry out 2x controlled explosions . THF disposed of along with another 8 chemicals identified from ODM 1.

22/10/2017

The majority of the chemicals disposed of were stored in flamvaults/cupboards safely and were captioned on the redundant chemical list.

Monday 23/10/2017

FLEET CALL 12:00
Initiate site review through plan of the week, where hot feedback was given from the weekend and the Head of EHS&Q received a action to produce a brief.

ONR Telecom Discussion with s.40
Programme Manager and Operations Manager all Analytical Services at 13:30.
Following the meeting head of operations initiated full root and branch review to understand chemical inventory
.

Full facility walkdown commences to check all areas against lists to compare against peroxide list and check if any evidence of crystals.

The inspection identified the following chemicals:
2400 Vials (each 10g in 10ml quickszint) in s.24 under s.24 (post operational).
13 bottles quickszint in s.24 s.24 (not operational since 2003)
Which have peroxide generation potential.
MSDS identifies they may form explosive peroxides.
Handling and storage do not specify a use before/dispose of after opening requirement.

Tuesday 24/10/2017 ODM 3

10:30-12:00
Quickszint ODM 3 (Part 1)

ODM identified following facts:
- Visible crystals in bottles
- In an active s.24 under s.24 s.24
- didn't know % proportion of peroxide forming chemical in Quickszint
- Scintillate originally missed as a proprietary name (i.e. didn't look at chemical components in first instance.)
- Can't see vial contents

Further discussions held about:
- Routine COSHH
- Redundant chemical list
- Orphan waste list
- Chemicals NOT on a list e.g. THF
- 2015 inventory list
ODM pauses to allow further fact finding.

Internal Regulator attended as independent.
ODM quorate, good challenge observed throughout.

Tuesday 24/10/2017 ODM 3

11:50 Brief sent to all facilities and details discussed at 12:00 fleet call.
Thursday 16:00 deadline for response against RJ Kelly list.

ODM Part 2
15:00-15:45
Analytical Services confirmed that Quickszint contains 70-80% peroxide-able chemicals. On observation, crystals were observed in the bottom of the bottles.
Conclusion:
-Have unstable crystals
- We do not have the storage arrangements required
(against problem statement)

Decision maker (Programme Manager Analytical Services) takes information to Chief operating officer
> Forward plan made.

Further discussions held with Security and Resilience.

Crisis Management team (CMT) engaged.
Analytical Services controlled evacuation commenced at 16:00 hrs
SECC team told to attend Wednesday (25/10/17)
Site Technical contributed to expertise on Quickszint.

Site technical commenced a contract with the s.43 s.43 or peroxide knowledge.

Wednesday 25/10/17

Fleet call informed that SECC were being stood up from 12:00 to co-ordinate responses.

An additional fleet call at 15:00 reiterated that all facilities were to conduct a trawl as an immediate priority.

Thursday 26/10/2017

EOD attends site
- 13x quickszint bottles moved from s.24

Lists of findings recorded in SECC on excel sheet (Amber List)

13 bottles (500ml per bottle) of Quickszint DISPOSED of from s.24 s.24

Saturday 28/10/2017

2400 vials of Quickszint DISPOSED of from s.24

| Monday 30/10/2017 | Tuesday 31/10/2017 | Wednesday 01/11/17 | Monday 06/11/2017 |
|---|---|---|---|
| Over the period Mon 30/10/17 to Wed 01/11/17 two further chemicals were disposed of from Analytical Services s.24 and some Quickszint waste was disposed of from another storage location on site. | | | SFM Nuclear Independent Oversight (NIO) monthly report- Oct 17 issued. Analytical Services received rating of red (unacceptable). Issued to key stakeholders. |

## 10. Appendix 2. Event Time Line Discussion

In summary, the investigation team identified that leading up to the initiating event on the 3rd October 2017, over the last 14 years (when the BoI identified the first missed opportunity to dispose of these chemicals), there have been 20 missed opportunities, 7 strong cues and 16 weak cues to identify the issues associated with long term storage and holistic risk assessment of chemicals within Analytical Services and wider chemical management across the Site.

A missed opportunity within this report is defined as an opportunity presenting itself to either the Analytical Services management team or the Site and could have identified the deficiency and addressed the problem.

A strong cue within this report is where a concern has been raised to such a level where the specific deficiency has been highlighted.

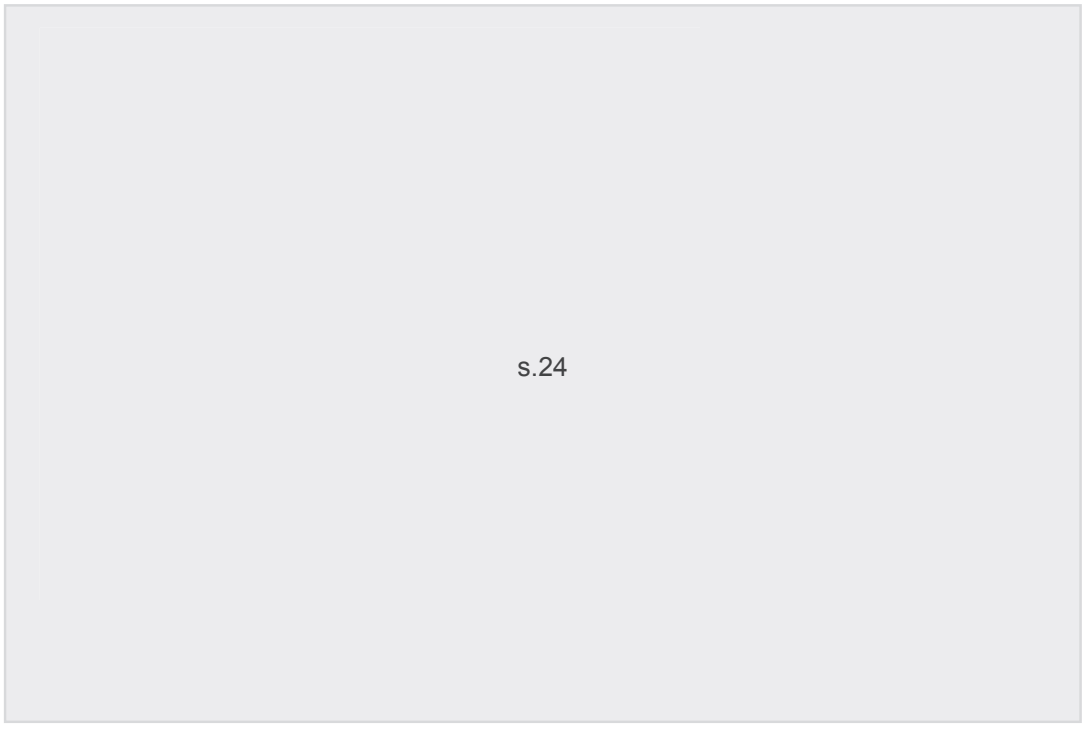
A weak cue within this report is where a concern has been raised relating to chemical management or chemical storage, but not to the specific issue connected with the initiating event and therefore, represents a weaker signal.

These terms have been used throughout the timeline.

**(Timeline 1986 – October 2017)**

**Pre 2002**

Tetrahydrofuran (THF) was purchased prior to 1986 /87. The manufacturer of this chemical is known to have gone into liquidation in 1986 / 87. The bottle has a label on it that has an explosive symbol and a clear warning of peroxide hazard. It states "The contents of this bottle are liable to form unstable peroxides during prolonged storage. We recommend the material be destroyed a) one year after receipt or b) one month after opening." The label also has blank fields to record the date purchased and date opened but these were blank.




The bottle is known to have been present in s.24 uring 1992. In 1992, the s.24 Team Leader acquired the bottle from s.24 to use it to improve the [redacted] s.24 method of analysis for THORP. This proved unsuccessful and the bottle was returned to s.24 The Team Leader confirmed wiping the neck of the bottle which is good chemical practice and prevents crystals forming on the neck.

In 1988 the first set of COSHH (Control of Substances Hazardous to Health) regulations were introduced.

Over the next few years Analytical Services saw some build-up of redundant chemical inventory and movement of these chemicals throughout the facility with some provenance of the chemicals history being lost. There was a chemical amnesty where some redundant chemicals were moved to s.24 was also given to Analytical Services from the Research and Technology Department. Lots of redundant chemicals were already present in s.24 and some were transferred here from s.24 At a later date s.24 was identified as a suitable lab for the s.24 analysis and the redundant chemicals stored there were moved to s.24 then at a later date these were all moved to s.24 was taken over by Analytical Services in 1998 for testing of new equipment. At this time any unopened chemicals present in s.24 s.24 were disposed of via an external waste contractor. Chemicals of known provenance were also sent to s.24 for disposal. Chemicals present in s.24 which had not been disposed of were also moved to s.24 At some point during this time the disposal of redundant chemicals stopped as an environmental group challenged whether they could be classed as non-active as many had been opened and stored within the active area. s.24 is an active area laboratory and has since this time, been used as a storage area for redundant chemicals.

**2002**

Research and Technology Department vacated Analytical Services and moved to s.24. A large number of personnel transferred to the new facility resulting in a loss of corporate knowledge and a significant number of redundant chemicals being left behind.

COSHH regulations were replaced in 2002 as well as the DSEAR (Dangerous Substances and Explosive Atmosphere Regulations) 2002 coming into force.

**2003**

Analytical Services took over work from the s.43 analysing pond water for s.43 . This analysis utilised the scintillation material "Quickszint 368". The material was assessed at the time and the Material Safety Data sheets and COSHH assessments are available. The analysis continued until 2008 / 9 when there was no further use for Quickszint 368. The unused scintillate (13 bottles x 500mls) were registered on the redundant chemicals list and were stored with the remaining samples (2400 vials on the orphan waste list) in s.43

**Missed opportunity 1:** Disposal of scintillation solvents was originally via solidification on absorbent granules. Analytical Services stopped disposal via this method due to concerns of unstable peroxide formation. Although the risk of unstable peroxide formation was identified on disposal methods this was not considered for long term storage.

**2006 - 2009**

Analytical Services were undergoing the Continued Operations Safety Review (COSR) and as part of this process produced a suite of assessments. These included a Chemotoxic Assessment (Rev 0), Internal Hazards Assessment and a Hazardous Area Classification Paper. These assessments were not fully implemented.

During 2009, the Chemotoxic Assessment was revised and an Implementation Strategy produced but the assessment has never been implemented. This in part was due to ownership of Chemotoxic hazard as it moved from within the bounds of Safety Case and prioritisation was lost.

Also, during 2009 the first DSEAR assessment was undertaken within the Analytical Services facility by external contractor s.43 This assessment has never been implemented for similar reasons to the Chemotoxic assessments.

**Missed opportunity 2:** In 2007 the used bottle of THF (500 mls) was opened and sampled. It was analysed for alpha and beta possibly preparing for its disposal. It was not disposed of at this time.

**Missed opportunity 3:** In December 2009 there was a significant event in Analytical Services where there was a minor spillage in Analytical Services. The Local Sentencing comments for this event which were agreed by Site Sentencing Authority were: "Analytical Services management needs to re-evaluate and improve as necessary storage arrangements of waste materials in Analytical Services to ensure they are stored correctly and safely (in compliance with all relevant regulations ie. COSHH)".

If a risk assessment for storage of chemicals had been carried out against all relevant regulations, not just COSHH, the risk of peroxide formation during long term storage may have been identified.

Two actions were set following this event. One specifically requests "Review building wide handling, storage and disposal of redundant chemicals". This was closed out with a statement saying that a new management work stream to deal with wastes was to be set up. This was a promissory statement and there is no evidence that this was carried out hence a missed opportunity.

**Strong cue 1:** The spillage event in Analytical Services was a strong cue that Chemical Management within the Analytical Services facility, specifically with waste and redundant chemicals, was deficient.

**2010**

**Missed opportunity 4:** The Infrastructure WANO Peer Review in 2010 identified an issue with chemical control. The following Area for Improvement (AFI) was raised: "Chemical storage arrangements across the plants do not effectively control operational and legacy waste chemicals and contaminated oils, solvents and samples. Incompatible chemicals including oxidising agents, reducing agents, organic compounds and unknowns are stored together with the potential for uncontrolled chemical reactions. Storage within the laboratory facilities is not underpinned by adequate risk assessments. Disposal routes have not been established for all wastes which is resulting in the accumulation of orphan wastes."

One of the facts supporting this AFI was the identification of a large metal cabinet full of redundant waste chemicals within s.24 Analytical Services. Some inventory was 20 years old.

Although the AFI did identify the risk of uncontrolled chemical reactions the responses and resulting actions focussed on compatibility issues associated with chemical storage.

**Strong cue 2:** It was clearly identified in the 2010 WANO Peer Review report that there were issues and concerns associated with the storage of redundant chemicals and issues with risk assessments associated with chemical management and there was a risk of uncontrolled chemical reactions / compatibility.

Following the 2010 WANO Peer Review the Analytical Services Innovation Team began to focus on redundant chemicals. Their work stream consisted of corralling chemicals into s.24 producing an inventory for redundant chemicals and disposing of chemicals of known provenance (unopened) where possible. 1027 chemicals were disposed of during this time until the team was disbanded in 2013. Anecdotally, the focus for disposal of redundant chemicals was based on number reduction as opposed to reducing the level of risk.

**Missed opportunity 5:** During November 2010 the THORP facility experienced an event involving Hydrozoic acid. Following the investigation into this event, 51 actions were placed across the Sellafield Site. One of the actions was placed on Analytical Services to undertake a review of COSHH assessments with a view to establish the robustness of the information contained within the assessments. Specifically the wording within the action requested that confirmation be gained that appropriate assessments and controls were evident for any decomposition chemicals that may be produced.

This action was closed out with the statement "The reviews requested have been carried out since the Head of Department left the department. For details see the incoming Head of Department". If these reviews had been robustly completed and evidence provided this could have highlighted that some peroxide forming chemicals degrade over time forming peroxides over time.

**2011**

During 2011, the Analytical Services facility saw some changes in personnel, with the Head of Department changing twice. The Delivery and Facility Managers were also introduced. During this time, the Analytical Services Chemotoxic assessment was also revised but was not implemented.

The Site also saw some relevant changes, with respect to new Sellafield Limited Practices (SLP's) being introduced. These were the first issues of SLP's associated with COSHH, Major Chemical Inventory and the Controls of Quantities and Safe Use of Chemicals.

It is documented that in 2011 the bottle of THF was stored in s.24 flammable cupboard and was identified as a solvent for disposal.

**2012**

**Missed opportunity 6:** The Infrastructure WANO Peer Review Follow Up was undertaken in 2012. The revisit identified that progress against the Chemistry AFI CY.5-1 from 2010 was graded as a category B (On track (Level B) – Evidence shows that performance has begun to improve but some performance gaps remain. Initial corrective actions have been implemented, and remaining planned corrective actions are expected to fully resolve the AFI.).

It is reported anecdotally that the feedback recognised a great deal of improvement work had been ongoing, but categorisation noted there were still gaps to address and although the facility was on track to close the gaps the risk of storing redundant chemicals long term has not been identified and hence presents a missed opportunity with respect to this event.

**Weak cue 1:** The category B grading received in the 2012 Infrastructure WANO Peer Review Follow Up flagged up that some progress had been made, although not to a satisfactory standard with respect to chemical management.

**Weak cue 2:** During the first quarter of the 2012 calendar year, a Tier 3 assurance audit was undertaken in Analytical Services looking specifically at COSHH. Concerns were raised regarding the then out-of-date COSHH assessments and that not all assessments were activity based as required by the SLP. An action was placed to capture concerns. This audit is a weak cue to the Analytical Services management that there were deficiencies with chemical management within the facility.

**Missed opportunity 7:** In July 2012, there was an event in Analytical Services where a sample was dropped in s.24 9 Actions were placed with one specifically regarding suitable storage of decommissioning samples. It requests that following analysis and prior to disposal that samples are stored in a suitable location with suitable ventilation. The close out of this action suggests that a higher level of scrutiny will be given to storage of future decommissioning samples and that samples will not be received into the labs until compliance with the safety case has been considered. The work to consider risks associated with storing these decommissioning samples did not extend to the post analysed Quickszint samples stored in s.24

**Demonstration of positive cultural change:** During the first half of 2012 there were a number of cues such as the WANO Peer Review Follow Up, the Tier 3 audit, the sample spillage and also some senior management changes within Analytical Services. The culmination of these events were perceived by many interviewed as the start of some positive cultural changes within the facility with a real focus on nuclear safety and an operational mind-set. Improvements were developed in the facility such as introducing Conditions for Acceptance (CFA) and therefore not accepting samples or chemicals unless an approved disposal route existed.

During 2012 the Sellafield Limited Practices associated with chemical management introduced some changes. There was a new SLP introduced for REACH. The role of Chemical Co-ordinator was introduced to comply with REACH and Major Chemical Inventory. Analytical Services did not identify any individuals to fulfil this role at this time although it was not classed as a formal SQEP Role until a later date.

**2013**

**Weak cue 3:** There was a Site wide review on competency and resource for conventional safety which prompted a visit into Analytical Services by the Internal Regulator. The resulting Internal Regulators report outlines concerns around certain COSHH assessments being overdue. This was a weak cue for Analytical Services management that there were deficiencies associated with chemical management. This was a distraction from redundant chemicals.

**Missed opportunity 8:** As mentioned earlier the decision to disband the Analytical Services Innovation Team was made in 2013. This was due to a change in priorities onto high hazard Plutonium and Fissile risk reduction and the focus moved away from management of redundant chemicals.

2013 also saw the first production of the Manufacturing Unit Major Chemical Hazard Inventory (MUMCHI) for Analytical Services. There was no reference to either Quickszint or THF on this inventory. A second MUMCHI was submitted in April 2014 but again THF nor Quickszint were identified. It was only from April 2015 onwards where THF and Quickszint were identified on the Analytical Services MUMCHI as flammable substances.

**2014**

Early in 2014 a Technical Scientific Trainee who had previously been part of the Analytical Services Innovation Team produced a report titled Identification of Disposal Routes for Redundant Chemicals in Analytical Services. This was as a result of the 2010 WANO Peer Review. It demonstrates that redundant chemical disposal is still a focus for the facility.

In 2014 there were several changes to SLPs associated with chemical management, REACH, Major Chemical Inventory, Controls of Quantities and Safe Use of Chemicals and DSEAR. This also saw the formation of the chemical coordinator SQEP role.

**Missed opportunity 9:** The changes to the DSEAR SLP (SLP 2.04.502 issue 3) saw the introduction of the new roles of DSEAR Facilitator and DSEAR Assessor. Across the Site, this was slow and to date two individuals are trained as DSEAR assessors and three trained as DSEAR Facilitators. Analytical Services did not have individuals appointed to these roles, therefore the knowledge of DSEAR regulations and the requirements associated with Dangerous Substances was missed.

**Weak cue 4:** During the September 2014 Analytical Services Management Safety Committee (MSC) the Safety Case Manager raised concerns associated with the implementation of the Analytical Services Chemotoxic assessment. They outlined it was a technical document that needed some level of expertise to understand it and felt that as it was no longer included within the bounds of the Nuclear Safety Case its implementation was no longer a high priority. A new MSC action was placed on the Analysing, Trending, Learning And Safety Reporting (ATLAS) database for the Safety Case Manager (SCM) to present back at the March 2015 MSC. The SCM did present back to the MSC but no prioritisation was ever given to implement the Analytical Services Chemotoxic assessment and it still requires implementation at the time of this event. This was a weak cue associated with chemotoxic management.

**Strong cue 4:** During October 2014 redundant chemicals were corralled into s.24 on the non-active side of Analytical Services in preparation for disposal. A contract firm collected a number of chemicals and were transferring the chemicals to an offsite location for disposal. As the vehicle was leaving Site the gate post monitor alarm was triggered which resulted in a Board of Inquiry being convened. This investigation placed 28 actions across the Site, one action specifically set on Analytical Services relating to chemical inventory:

"ACT138198 – For all Analytical Services labs and rooms containing stocks of chemicals carry out the following:
- Identify an owner responsible for chemical inventory of each lab.
- An inventory stocktake of all chemicals.
- Assess the provenance of chemicals and characterise any that are unlabelled
- Put in place COSHH assessments for all chemicals.
- Put in place management systems to ensure inventories of chemicals and associated COSHH assessments are maintained.
- Confirmation of completion of improvements to chemical inventories and associated COSHH assessments through the Analytical Services MSC.
  Note: This action applies to stored chemicals and does not apply to analytical work in progress."

This action close out demonstrates re-initiation of chemical inventory for all chemicals, COSHH assessments, annual COSHH audits and possible disposals of redundant chemicals in Analytical Services.

The Analytical Services Operations Support Team focus on the work required associated with chemicals following this Board of Inquiry. A facility improvement plan was formulated which the Operations Support work associated with chemical management fed into. The Operations Support improvement work included updating of Analytical Services local documentation including Analytical Services Guideline 08 (ASG08) - Labelling, Storage and Handling of Chemicals within Analytical Services. This document includes the requirement of an annual COSHH audit by the Analytical Services teams which was being undertaken when the THF was re-questioned initiating this event on 3rd October 2017.

**Missed opportunity 10:** A point to note is that this document (ASG 08) does discuss storage and disposal of chemicals and recommends segregation whilst awaiting disposal but it does not identify the risk of degradation of chemicals over time to form potentially unstable substances.

The Operations Support team also produced a full chemical inventory list for all chemicals held within Analytical Services. This included revisiting the redundant chemical lists produced by the Innovation Team between 2010 and 2013. The full inventory list is comprehensive and identifies THF in s.24 and Quickszint in s.24 It is worthy of note that there are in the region of 2000 different types of chemicals identified on this inventory. This paints a complex picture of the chemicals stored within Analytical Services. This inventory was not a live list and was just a line in the sand of what the labs held at this point in time and did not consider the hazards or risks posed by these chemicals.

**Weak cue 5:** Due to concerns identified during the Internal Regulators visit to Analytical Services in 2013 as part of the Site wide review on competency and resource for conventional safety a revisit was undertaken in November 2014 and a formal Letter of Concern was issued to the facility. It highlighted that COSHH assessments were out of date, there was a lack of risk assessment for all chemicals and the tasks / areas where they were used and a lack of a full inventory. Although this was a catalyst to drive the Operations Support Team to produce a full inventory of chemicals held within the facility there was no consideration given to the risks associated with storage of chemicals long term. Much focus was given to producing the inventory list and also completion of the outstanding COSHH assessments which were being monitored via a burndown curve. This letter was a weak cue to the Analytical Services management that there were deficiencies associated with chemical management within the facility.

**2015**

**Weak cue 6:** Following the Internal Regulators Letter of Concern in November 2014 a revisit by the Site Internal Regulator was undertaken in February 2015. A lack of progress against the Analytical Services improvement plan was observed. A further corrective action was placed which was logged on the ATLAS database and the Internal Regulator threatened Compelling Advice unless a step change in progress against the improvement plan was delivered.

**Missed opportunity 11:** The Internal Regulator revisited again in April 2015 where good progress against the Analytical Services improvement plan was observed and therefore the letter of concern was closed out. Although good progress had been made the improvements required on the plan were not progressed to completion and by closing out the letter of concern some priority and focus on redundant chemical management was lost.

**Missed opportunity 12:** During February 2015, there was a chemical event in the Thorp facility on Site. A volume of NOx was released from primary containment. This was a COMAH (Control of Major Accident Hazards) relevant event. This prompted an HSE inspection in Thorp in June 2015. This resulted in a number of chemical improvement actions within Thorp, but these did not filter out across the Site and therefore it was a missed opportunity for the Site.

**Weak cue 7:** Following presentation of the Analytical Services Solid waste report for 2014 at the Analytical Services MSC an action was raised on ATLAS requiring the Analytical Services Waste Manager to discuss with the Head of Analytical Services who will be responsible for the disposal of chemicals. The action was closed out demonstrating that a discussion had taken place but a further update meeting was to be held in June. There was no evidence that this meeting was ever held and the close out was promissory. This was a weak cue that the ownership for the disposal of redundant chemicals was not evident.

**Weak cue 8:** In April 2015, a Condition Report was raised in Analytical Services as the annual MUMCHI had not been submitted by the required deadline. An action was placed to identify an appropriate individual to be appointed as a Chemical Co-ordinator for Analytical Services. In response to this action, a member of the Analytical Services Operations Support Team was identified to start training as a Chemical Co-ordinator for Analytical Services but they never achieved Suitably Qualified and Experienced Person (SQEP) status. The individual prepared the annual Analytical Services MUMCHI for 2015, which was comprehensive and identified both THF and Quickszint as flammable substances (not potentially peroxide forming). There were 119 entries for flammable substances identified on this MUMCHI, again, painting a picture of the complexity of the number of types of chemicals held within the Analytical Services laboratories. The annual 2015 MUMCHI was submitted after the deadline date.

**Weak cue 9**: In June 2015, a Condition Report was raised on ATLAS for an event whereby some Material was incorrectly located within the redundant chemical store in s.24 in Analytical Services. This was a weak cue that redundant chemical management was deficient within the facility.

**Positive Demonstration of Cultural Change:** A safety stand down was held in Analytical Services in July 2015 following a contamination incident in the s.24 Dispensary Lab. This demonstrates that safety deficiencies were

being treated seriously and the Analytical Services management were prepared to put a hold on operations until safety concerns were addressed.

**Weak cue 10:** Some partially used bottles of acid were found at the back of an operational fumehood. The laboratory personnel were unaware of the presence of the bottles in the fumehood. This was a weak cue that chemical management within Analytical Services was deficient.

**Strong cue 5:** In September 2015 there was a joint Sellafield Limited and Office of Nuclear Regulation (ONR) Leadership and Culture Review. This reported that interviewees indicated a poor perception of Sellafield Limited central processes and arrangements which hampers site-wide conformance and learning. This was a strong cue that the central processes and arrangements, such as DSEAR requirements, were not being implemented effectively.

**Strong cue 6:** In November 2015, there was a joint Sellafield Limited and Office of Nuclear Regulation (ONR) Conventional Health and Safety (CHS) Intervention. This was the prompt for the company's Conventional Safety Dashboards that are visible in forums such as Fleet Call. Although the report commended the Organisation for "seeking to act without the backdrop of a recent serious conventional health and safety incident to catalyse action" there were two conclusions that were strong cues. One of these conclusions stated "As with previous regulatory interventions, a number of priority actions were identified during the inspection, such that compliance with legislative requirements was not being met. Whilst Sellafield Limited has already taken action to address the issues identified, it is evident from this and previous CHS interventions, there are instances where Site Safety personnel are falling short in identifying and controlling these risks". A second conclusion stated "Alternatively, sometimes Site CHS subject matter experts are alerting plant personnel to potential breaches of Health and Safety Legislation, yet sufficient company action is not always being taken to address the issues. Sellafield Limited needs to establish and address why it sometimes takes sustained regulatory focus before action is taken by plants, even when the need for action has previously been highlighted by EHS&Q subject matter experts."

**2016**

**Missed opportunity 13:** As mentioned, the company introduced a suite of Conventional Safety Dashboards which are visible in forums such as Fleet Call. These dashboards were managed by the Site EHS&Q (Environment, Health, Safety and Quality) Safety Managers on behalf of the facility Duty Holders (the Heads of Operations). The first phase of Conventional Safety Dashboards focussed on Legionella, Asbestos, Confined Space and Transport Safety. This was a missed opportunity with respect to this event as DSEAR was vitally important. DSEAR and COSHH were part of the second phase of the Conventional Safety Dashboards. A point to note was that the Analytical Services Conventional Safety Dashboard still shows amber for both COSHH and DSEAR.

**Strong cue 7:** The Conventional Safety Improvement Plan was presented to the Executive Committee in March 2016. This identified in its problem statement "The ability of safety teams and overall EHS&Q resource to influence safety in facilities has been met with mixed success; in some cases EHS&Q have not effectively got across the importance of a safety issue, nor has that safety challenge always been accepted." There were a number of actions placed. One of the actions outlined in the improvement plan was "Implement EHS&Q enterprise approach to enable direct control and mobilisation of competent safety resource to facilities; prioritising the right type of resource to areas with specific conventional safety risks – risk profile eg. DSEAR assessors to areas with DSEAR gaps and Legionella support to areas with Legionella risks." Another action was to "Realign role and day-to-day accountabilities of Safety Teams to focus on assuring standards and helping to resolve safety issues in facilities." A further action was to "Track appointment of key safety role holders to completion, through conventional safety dashboards for each facility." A number of gaps were listed in the improvement plan, one specifically related to this event which was "Reliance on waiting for Regulators to identify issues and sometimes to go to potential enforcement action before progress is made on a safety issue." One of the positive findings listed was that "New dashboards have already begun to show improvement in visibility of performance."

In February 2016 the Operations Support Manager presented a paper at the Analytical Services MSC titled "The Management of Waste Chemicals and their Disposal within Analytical Services." This included a copy of the Analytical Services Improvement Plan which incorporated all the chemical management improvements for the facility as well as the burndown curve for overdue COSHH assessments.

**Weak cue 11:** A condition report was raised on ATLAS following a periodic COSHH audit which identified a number of areas for improvement. These were that some COSHH assessments were out of date, a number of bottles required an 'OB' reference (the OB reference specifies it's an Open Bench chemical and the number refers

to what Personal Protective Equipment (PPE) is required for its use), too many chemicals were being stored and some chemicals had been labelled for disposal, but disposal had not progressed. Actions were not recorded formally on the ATLAS database as they were being tracked locally via the COSHH folder. This was a weak cue for Analytical Services management as it demonstrates deficiencies in storage of redundant chemicals. Although there was a weak cue it is positively noted that it is evident that the annual COSHH audits as required by ASG08 are being undertaken.

**Weak cue 12**: A condition report was raised on ATLAS following a periodic COSHH audit which identified a number of areas for improvement. These were that a number of bottles required correct labelling as per ASG08 and redundant chemicals were to be disposed of. Actions were not recorded formally on ATLAS as they were being tracked locally. This was a weak cue for Analytical Services management as it demonstrates deficiencies in management of redundant chemicals. Although there was a weak cue it is positively noted that it is evident that the annual COSHH audits as required by ASG08 are being undertaken.

**Strong cue 8:** In April 2016 there was an Infrastructure WANO Peer Review. This identified an Area for Improvement (AFI) associated with Chemical Management. "Practices concerning inappropriate containment, incompatible storage and unsuitable volumes of chemicals are evident. Incompatible storage increases the potential for interaction between chemicals leading to violent reactions or explosion, fire, personal injury and plant equipment damage." This was a strong cue that storage of chemicals within Analytical Services was deficient although the focus was on chemical compatibility.

**Weak cue 13:** A Condition Report was raised on ATLAS following an event concerning fumes whilst working in a fumehood. This was a weak cue to Analytical Services management that chemical management within the laboratories was deficient.

**Weak cue 14:** A Condition Report was raised on ATLAS in September 2016 when an inventory of chemicals for disposal via a contract firm was identified as incorrect. Only ~10 out of ~60 chemicals were listed correctly. The Condition Report raiser specified that immediate actions taken were to segregate the incorrectly listed chemicals and return them to s.24 This was sentenced as 'trend only' and no actions were placed. This was a weak cue to Analytical Services management that chemical management within the laboratories was deficient.

**Missed opportunity 14:** A Condition Report was raised on ATLAS in November 2016 associated with DSEAR checklist findings for small scale chemical storage. It was identified that areas within Analytical Services were not compliant with the checklist. 3 actions were placed but all associated with COSHH improvements. It was declared that these were built into the Analytical Services Improvement Plan and monitored on a monthly basis at the Lead Team Operations Monthly Meeting. The fact that the Condition report was raised from a DSEAR perspective, but the actions are all COSHH related is a missed opportunity to identify any storage deficiencies.

**Missed opportunity 15:** The Analytical Services DSEAR assessment was overdue for review and a scope of work was developed by a SQEP DSEAR Facilitator from the central team in conjunction with personnel from Analytical Services to provide a bounded scope for the external contractor s.43 to deliver against.

The Analytical Services personnel requested all lab team leaders to review all analytical methods and identify chemicals that can generate hydrogen, reactive chemicals that could be exothermic and other types of reactive chemicals such as oxidants or can lead to pressurisation. The purpose was to get an idea of how many substances were present and at what quantities.

This is an unusual question set as it does not prompt the lab leaders to look for all substances that would fall under the DSEAR definition of Dangerous Substances (i.e. flammables, highly flammables, explosives and oxidisers). A team leader queried whether the scope should include all redundant chemicals and it was implied that it should but is not clear if this was shared with all team leaders and is not evident in the information supplied to underpin the scope.

The s.43 assessor is seen as an industry expert. The assessor had 4 days to complete the site visit and was escorted by Analytical Services personnel. The local personnel had no perception of the risk of unstable chemical degradation associated with chemicals over a long period of time and had limited knowledge of DSEAR regulations. The labs containing redundant chemicals were identified within the scope document and the

s.43 contractor did enter s.24 (where the THF was stored) however the report identified no risks within s.24 The Quickszint was stored in s.24 and this was included in the scope but the assessor did not enter this lab during his walkdown.

Although the Assessor did identify some issues regarding chemical storage (specifically s.24 and s.24 these were more concerned with total volumes and general waste accumulation concerns than with issues with specific substances. It should be noted that some of these labs (such as s.24 hold just under 700 different substances and the individual risks associated with these substances was not considered.

The DSEAR assessment produced by s.43 states it consists of three principal parts based on DSEAR, including: "Where a dangerous substance is or is liable to be present at the workplace, the employer shall make a suitable and sufficient assessment of the risks to his employees which arise from that substance. (Carry out a DSEAR Risk Assessment)." The Analytical Services DSEAR Assessment did not identify any risks associated with degradation of the chemicals which were subsequently disposed of by EOD and so even if this DSEAR assessment had been implemented, which it has not, it would not have identified the risks associated with these individual chemicals hence is a missed opportunity.

**2017**

**Demonstration of positive cultural change:** In January 2017 the Head of Analytical Services requested the trend report to be carried out quarterly instead of annually, to have visibility of the efforts being put in with work on the improvement plan to see if this was positively affecting the trends.

**Missed opportunity 16:** The trend reports have been produced quarterly since January 2017 and the reports reviewed but no trends have been identified associated with chemical storage. The fact that no trends were identified suggests that there was an insufficient number of Condition Reports raised regarding chemical storage and no actions were raised, therefore this is a missed opportunity.

**Missed opportunity 17:** A Condition Report was raised on ATLAS in May 2017 following a Manager in the Field observation. This highlighted that there were incompatible chemicals being stored together in bunds. This Condition Report was sentenced as 'Trend Only' and no further actions placed on the ATLAS system. This was a missed opportunity for Analytical Services to identify and address redundant chemical storage issues within the facility.

**Weak cue 15:** The above Condition Report raised for poor storage of chemicals within Analytical Services was a weak cue for Analytical Services that there were deficiencies regarding redundant chemical storage within the facility.

**Missed opportunity 18:** A Condition Report was raised on ATLAS in June 2017 following a Analytical Services safety inspection. This highlighted that there were improvements required associated with the storage of chemicals stored within a flammable cupboard. An action was raised on the ATLAS system but the close out of this action was poor. This was a missed opportunity for Analytical Services to identify and address redundant chemical storage issues within the facility.

**Weak cue 16:** The above Condition Report raised for poor storage of chemicals within Analytical Services was a weak cue for Analytical Services that there were deficiencies regarding redundant chemical storage within the facility.

**Demonstration of positive cultural change:** The Condition Reports raised in May, June and a further one in August 2017 associated with chemical management, demonstrate that there is a drive within Analytical Services to undertake safety inspections and report where deficiencies exist. A further Condition report was raised in September to capture and track actions raised following the introduction of the Analytical Services Conventional Safety Dashboard for COSHH.

**Missed opportunity 19:** During September 2017 the new SLP for DSEAR (issue 5) removed the requirements of the Facility DSEAR Facilitator and DSEAR Assessor SQEP roles. Although previously the requirements of the DSEAR Facilitator had not been fulfilled by the majority of Facilities across the Site, the removal of the role requirements in this latest SLP means that in Analytical Services the DSEAR expertise required to recognise the risks associated with long term storage of redundant chemicals was missed.

**Missed opportunity 20:** The new version of the s.43 DSEAR report 2016 for Analytical Services was issued in May 2017. It is now in the process of going through an ALARP review and as such is not yet implemented. Although this latest revision of the assessment is much more comprehensive than the 2009 assessment it does not identify the risks associated with individual dangerous substances and those associated with storing peroxide forming chemicals long term.

This takes us to the point in the timeline where two apprentices were undertaking an annual COSHH audit on the 3rd October 2017. They observed the bottle of THF in the flammable cupboard in s.24 and questioned what was seen on the label of the bottle. **This being the investigation's initiating event.**

**(Timeline 3rd October - 6th November 2017)**

**3rd to 8th October**

During an annual COSHH audit on 3rd October 2017, which was conducted by two apprentices (3rd Year) in s.24 of Analytical Services, a part filled 500ml bottle of Tetrahydrofuran (THF) with an explosive sticker with a note stating that it is potentially peroxide forming, was located and was subsequently raised to their Team Leader. The finding was escalated promptly through Line Management to the s.40 Analytical Services (AS).

The s.40 AS made a conscious decision not to sentence the Condition Report (CR) as an Initial Event Report (IER) due to the consequences not being fully understood.

**Missed Opportunity 1:** Sentencing of the CR as an IER.

The reason for the annual COSHH audit was delivery against ASG08 which was revised following the 2014 Board of Inquiry (BoI) gate post monitor event. The audit was designed to standardise storage of chemicals across the Analytical Services facility.

s.40 initiated fact finding in order to gather facts prior to convening an Operational Decision Making (ODM) meeting on the 9th of October. In conjunction, internet searches were conducted, however there was only one piece of Learning From Experience (LFE) stating that THF was potentially explosive from an event at Berkeley in the USA, where a peroxide explosion injured a Campus Researcher. It was established that hazardous peroxide contaminants formed in old solvent and exploded after concentration.

**9th October 2017**

ODM Meeting No.1 was held to determine a way forward. THF was believed not to be on a chemical inventory at this juncture and there was a belief that peroxide crystals may have formed. There was an initial perception that peroxide crystals required external energy to become unstable. The committee recognised that the THF was located in an area of the facility with no nuclear inventory.

The Decision Maker s.40 AS) asked the Infrastructure Safety Manager to obtain chemical expertise from the Sellafield Site. This resulted in a representative being sent from the Site Occupational Hygiene department who was responsible for signing off COSHH (Control of Substances Hazardous to Health) Assessors. SF&R were also requested to be in attendance, however they were unavailable. In lieu of this an individual working in Infrastructure who had fire safety / Explosive Ordinance Disposal (EOD) experience was identified to provide support.

**Missed Opportunity 2:** SF&R and chemical expert were not in attendance at the ODM.

Discussions were held around conducting future ODM's for other chemicals of concern, however no timescales were set for the next ODM meeting.

At the conclusion of ODM Meeting No.1 it was determined to ensure the facility was safe, initiate a trawl of COSHH lists and further investigate the option of opening the bottle of THF and producing a method statement to dispose of via the Low Active (LA) drain. Also, a requirement to liaise with SF&R for support in understanding the potential consequences of THF was recognised. At this point no formal decision was made.

Discussions with the Internal Regulator (Independent) concluded that the ODM followed due process, as outlined in SLSP 1.05.05.04 (Conservative and Operational Decision Making Supporting Information), and information was recorded on the Decision making Record Sheet (DMRS). The risks were clearly identified, the ODM Facilitator kept to process and all attendees contributed to the decision, challenging where appropriate.

**12th October 2017**

The THF ODM (Meeting No.2) reconvened in possession of additional facts from actions placed in ODM Meeting No.1. The committee identified a possible disposal route, as in liquid form, as THF was compatible with the Trace Active (TA) drain as opposed to using the LA drain. As with ODM Meeting No.1, SF&R were not in attendance due to other commitments and the Site Occupational Hygiene department provided the chemical advice, in lieu of a chemical expert. In addition, the Internal Regulator (Independent) confirmed that due process was adhered to, as outlined in SLSP 1.05.05.04. At the conclusion of the ODM it was determined that an ODM Sub Group would be convened to establish potential disposal of the chemical.

**17th October 2017**

An ODM Sub Group meeting (ODM-001-2017-AS) was held. Meeting minutes were produced, along with underpinning actions.

**13th October to 19th October 2017**

During this period the facility engaged with SF&R for advice on THF to understand more fully the potential consequences. SF&R made contact with s.43 for advice on THF. The feedback received from s.43 was that THF could change state to TATP, which is potentially explosive. This information prompted SF&R to immediately contact North West Fire for an EOD contact.

**20th October to 22nd October 2017**

Following the information received from s.43 SF&R documented the advice, including control measures in an e-mail dated 20th October 2017 at 11:30, which was sent to relevant personnel in Analytical Services and the Site Shift Manager (SSM). In essence, the information received was that THF was more unstable than first thought and in extreme circumstances could be explosive. The Operations Manager (Instrumental Laboratories) who was deputising for the s.40 AS received information with respect to EOD attending Site through a direct telephone call from the Civil Nuclear Constabulary (CNC), out with the communications protocol, and promptly made contact with the Programme Manager AS to escalate the information received from CNC and SF&R.

The Programme Manager AS decided to utilise the Site Emergency Control Centre (SECC) on call duty team who were located in s.24 for their FRIDEX. The options and risk assessment were discussed with the duty team and the s.40 AS in order to ascertain viable options. An independent peer check was received from the Innovation Strategy Manager and an experienced POCO (Post Operations Clean Out) Thorp Operations Support member with extensive chemical knowledge and experience. Following a cross check between s.43 advice versus a government fact sheet it was concluded that the best course of action would be to follow the advice received from s.43

During the afternoon of the 20th October 2017, control was handed over to the SECC. At 16:00hrs, the SSM made the decision to declare Operational Alert status and the full emergency duty team were requested to attend SECC. The EOD arrived at the Sellafield Site at 23:00hrs, where they viewed the chemicals in s.24 and debriefed SECC. The SECC duty team were formally stood down at 02:00hrs on 21st October 2017. At 08:00hrs on 21st October 2017 the SECC team were re-established to provide emergency support.

Over the weekend of 21st / 22nd October 2017 the EOD carried out two controlled explosions, disposing of nine chemicals in total, including THF. The additional eight chemicals had been identified in ODM Meeting No.1 as a concern. Therefore, the s.40 AS asked EOD to look at these also whilst they were in the Analytical Services facility. The EOD determined that they would also detonate these chemicals at the same time. It was noted that the majority of the nine chemicals identified were stored appropriately in Analytical Services within flamvaults / cupboards.

**23rd October 2017**

At 12:00hrs during Fleet Call, a Site wide review was initiated through plan of the week. Following Fleet Call at 13:30hrs a teleconference was held between the Office of Nuclear Regulation (ONR) and the s.40 Programme Manager and Operations Manager for AS. Following the discussions the s.40 AS

initiated a review of Analytical Services in order to fully understand the chemical inventory against the "R J Kelly list" (which contained a list of chemicals containing peroxide) and check if there is any evidence of crystals.

The inspection of Analytical Services identified 2,400 vials (each 10g in 10ml Quickszint) in s.24 under s.24 which is labelled as post operational with no radiological inventory and 13 x bottles of Quickszint in s.24 under s.24 which has signage dated June 2017 stating no radiological inventory and has not been operational since 2003. **Note** that the adjoining s.24 has signage to state radiological levels of 45 micro Sieverts Beta / Gamma, which is from bottles of filtrate washings. This material is not accountable inventory.

It was identified that Quickszint has peroxide generation potential and the associated Material Safety Data Sheet (MSDS) identified that they may form explosive peroxides.

**24th October 2017**

An ODM (Meeting No.3 (Part 1)) was convened at 10:30hrs following the discovery of Quickszint. The ODM identified that there were visible crystals in the bottles and they were located in s.24 under s.24 s.24 There were a number of unknowns discussed, namely, the % proportion of peroxide forming chemical in Quickszint and the correct number of chemical lists, as there were several, including a redundant list, orphan waste list and a 2015 inventory list. It was also recognised that Quickszint was originally missed due to its proprietary name. At this point the ODM was paused by the Decision Maker (Programme Manager AS) in order to answer the unknown issues.

At 11:50hrs a brief was issued to all facilities with the specific details discussed at the 12:00hrs daily Fleet Call meeting. All facilities on site were provided with a deadline of 16:00hrs on Thursday 26th October 2017 to respond using the R J Kelly list that contained a list of chemicals containing peroxide.

The ODM (Meeting No.3 (Part 2)) reconvened at 15:00hrs where further information was presented to clarify understanding of the unknown issues. It was concluded by the ODM that the Quickszint bottles have unstable crystals and that Analytical Services do not have the required storage arrangements. The ODM created a forward plan and the Decision Maker informed key stakeholders, such as the Chief Operating Officer (COO) and Security & Resilience of the ODM outcome. The Internal Regulator (Independent) confirmed that due process was adhered to, as outlined in SLSP 1.05.05.04.

The Crisis Management Team (CMT) was engaged following the ODM and a controlled evacuation of Analytical Services commenced at 16:00hrs. The SECC duty team were requested to attend SECC on Wednesday 25th October 2017. The Site Technical team also contributed, providing expertise on Quickszint. In addition, Site Technical commenced discussions with the s.43 for peroxide knowledge, including initiating a contract, which includes a 24/7 helpline for chemical advice. The contact details for s.43 are held with SF&R.

**25th October 2017**

At the daily Fleet Call meeting they were informed that SECC was being established at 12:00hrs in order to co-ordinate responses. An additional Fleet Call held at 15:00hrs reiterated to all facilities that they were required to conduct a trawl of their respective facilities as an immediate priority.

**26th October 2017**

The EOD attends the Sellafield Site and moves the 13 x Quickszint bottles (500ml per bottle) from s.24 in Analytical Services and subsequently detonates the bottles in a safe location. A list of the findings from the facility Site trawl were recorded in SECC on an excel spreadsheet which became known as the 'Amber List'.

**28th October 2017**

The EOD removes the 2,400 vials of Quickszint from s.24 in Analytical Services and subsequently detonates in a safe location.

**30th October 2017**

The EOD removes chemical from s.24 in Analytical Services and subsequently detonates in a safe location.

**31st October 2017**

The EOD removes chemical from s.24 in Analytical Services and subsequently detonates in a safe location.

**1st November 2017**

The EOD removes Quickszint waste, which was identified in a chemical s.43 store and subsequently detonates in a safe location.

**6th November 2017**

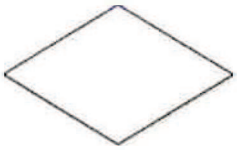
The Spent Fuel Management (SFM) Nuclear Independent Oversight (NIO) Monthly Report for October 2017 was issued. Analytical Services received a rating of Red (unacceptable). The report was issued to key stakeholders.

## 10. Appendix 3. Event and Causal Factors (Part 1 and 2)

### Summary page of the key

Initiating Event

Action/Event (i.e.) what happened



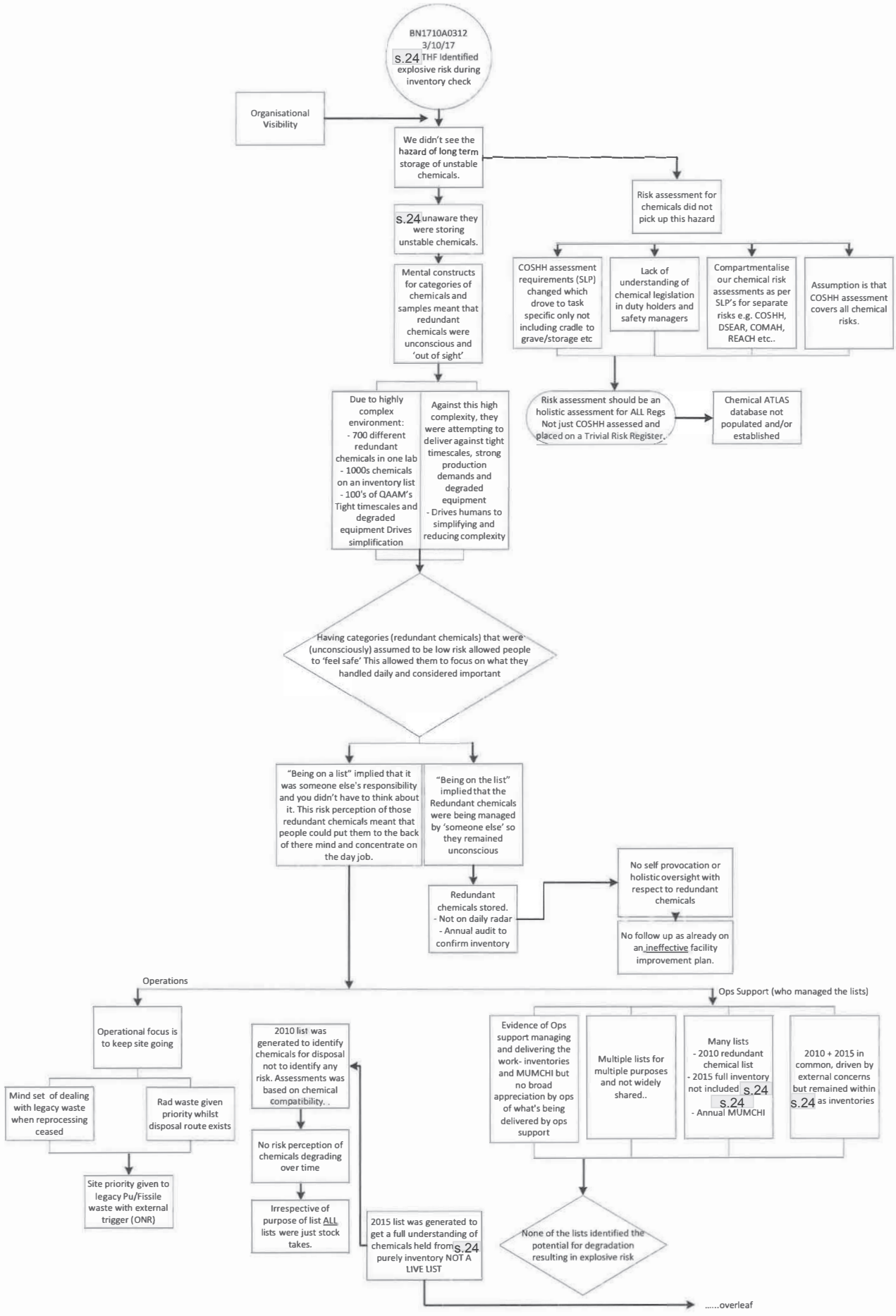
Inappropriate action or undesirable event (i.e.) where it started to go wrong

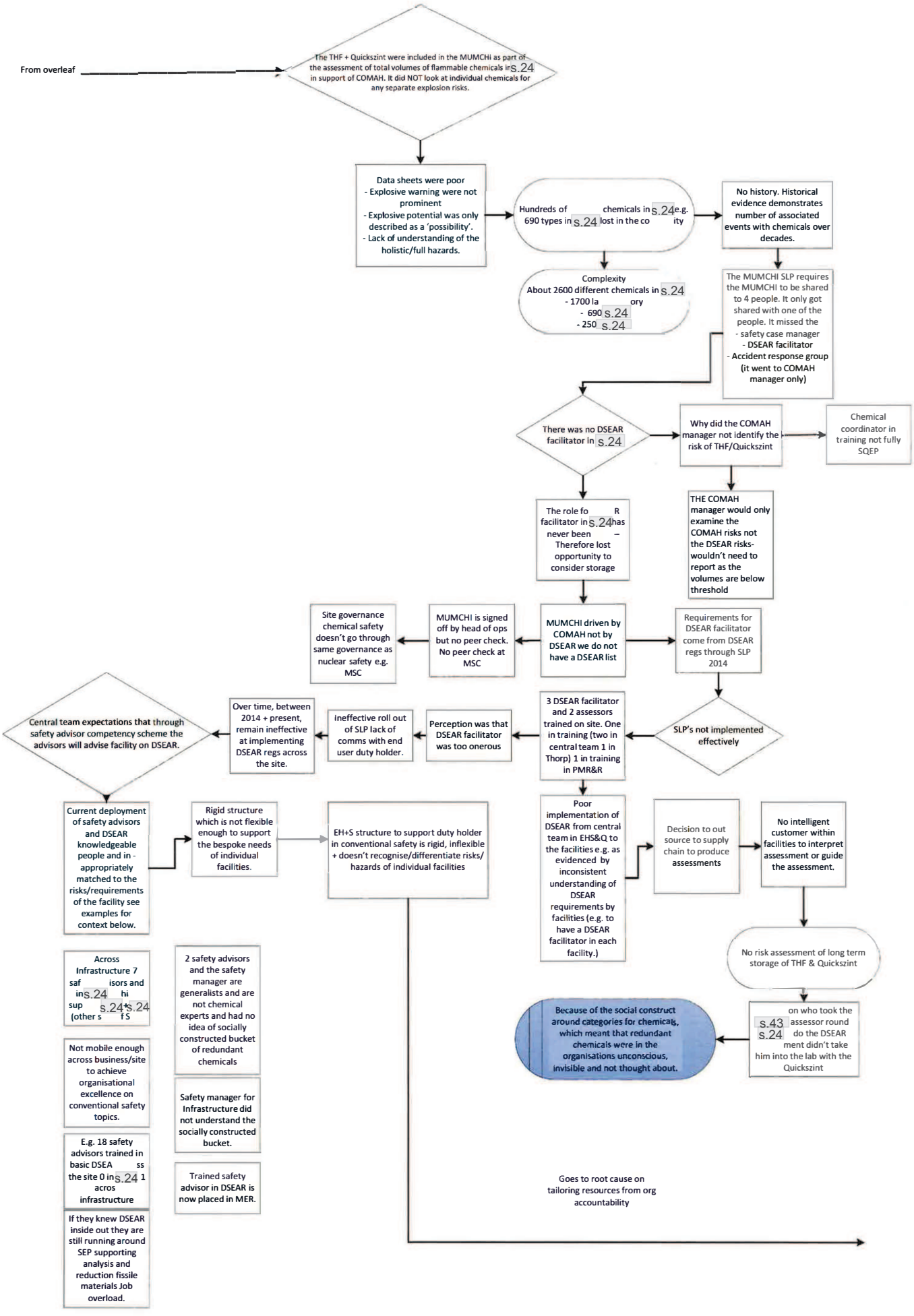
Contributory causes, conditions, behaviours

Root cause (s)

## PART 1

## ECFC "Cues"


BN1710A0312 3/10/17 s.24 THF Identified explosive risk during inventory check
Organisational Visibility
We didn't see the hazard of long term storage of unstable chemicals.
Risk assessment for chemicals did not pick up this hazard
s.24 unaware they were storing unstable chemicals.
COSHH assessment requirements (SLP) changed which drove to task specific only not including cradle to grave/storage etc
Lack of understanding of chemical legislation in duty holders and safety managers
Compartmentalise our chemical risk assessments as per SLP's for separate risks e.g. COSHH, DSEAR, COMAH, REACH etc..
Assumption is that COSHH assessment covers all chemical risks.
Mental constructs for categories of chemicals and samples meant that redundant chemicals were unconscious and 'out of sight'
Due to highly complex environment: - 700 different redundant chemicals in one lab - 1000s chemicals on an inventory list - 100's of QAAM's Tight timescales and degraded equipment Drives simplification
Against this high complexity, they were attempting to deliver against tight timescales, strong production demands and degraded equipment - Drives humans to simplifying and reducing complexity
Risk assessment should be an holistic assessment for ALL Regs Not just COSHH assessed and placed on a Trivial Risk Register.
Chemical ATLAS database not populated and/or established
Having categories (redundant chemicals) that were (unconsciously) assumed to be low risk allowed people to 'feel safe' This allowed them to focus on what they handled daily and considered important
"Being on a list" implied that it was someone else's responsibility and you didn't have to think about it. This risk perception of those redundant chemicals meant that people could put them to the back of there mind and concentrate on the day job.
"Being on the list" implied that the Redundant chemicals were being managed by 'someone else' so they remained unconscious
Redundant chemicals stored. - Not on daily radar - Annual audit to confirm inventory
No self provocation or holistic oversight with respect to redundant chemicals
No follow up as already on an ineffective facility improvement plan.
Operations
Ops Support (who managed the lists)
Operational focus is to keep site going
Mind set of dealing with legacy waste when reprocessing ceased
Rad waste given priority whilst disposal route exists
Site priority given to legacy Pu/Fissile waste with external trigger (ONR)
2010 list was generated to identify chemicals for disposal not to identify any risk. Assessments was based on chemical compatibility. .
No risk perception of chemicals degrading over time
Irrespective of purpose of list ALL lists were just stock takes.
2015 list was generated to get a full understanding of chemicals held from s.24 purely inventory NOT A LIVE LIST
Evidence of Ops support managing and delivering the work- inventories and MUMCHI but no broad appreciation by ops of what's being delivered by ops support
Multiple lists for multiple purposes and not widely shared..
Many lists - 2010 redundant chemical list - 2015 full inventory not included s.24 s.24 - Annual MUMCHI
2010 + 2015 in common, driven by external concerns but remained within s.24 as inventories
None of the lists identified the potential for degradation resulting in explosive risk
.....overleaf


From overleaf
The THF + Quickszint were included in the MUMCHI as part of the assessment of total volumes of flammable chemicals in s.24 in support of COMAH. It did NOT look at individual chemicals for any separate explosion risks.
Data sheets were poor
- Explosive warning were not prominent
- Explosive potential was only described as a 'possibility'.
- Lack of understanding of the holistic/full hazards.
Hundreds of chemicals in s.24 e.g. 690 types in s.24 lost in the co ity
No history. Historical evidence demonstrates number of associated events with chemicals over decades.
Complexity
About 2600 different chemicals in s.24
- 1700 la ory
- 690 s.24
- 250 s.24
The MUMCHI SLP requires the MUMCHI to be shared to 4 people. It only got shared with one of the people. It missed the
- safety case manager
- DSEAR facilitator
- Accident response group (it went to COMAH manager only)
There was no DSEAR facilitator in s.24
Why did the COMAH manager not identify the risk of THF/Quickszint
Chemical coordinator in training not fully SQEP
The role fo R facilitator in s.24 has never been – Therefore lost opportunity to consider storage
THE COMAH manager would only examine the COMAH risks not the DSEAR risks- wouldn't need to report as the volumes are below threshold
Site governance chemical safety doesn't go through same governance as nuclear safety e.g. MSC
MUMCHI is signed off by head of ops but no peer check. No peer check at MSC
MUMCHI driven by COMAH not by DSEAR we do not have a DSEAR list
Requirements for DSEAR facilitator come from DSEAR regs through SLP 2014
Central team expectations that through safety advisor competency scheme the advisors will advise facility on DSEAR.
Over time, between 2014 + present, remain ineffective at implementing DSEAR regs across the site.
Ineffective roll out of SLP lack of comms with end user duty holder.
Perception was that DSEAR facilitator was too onerous
3 DSEAR facilitator and 2 assessors trained on site. One in training (two in central team 1 in Thorp) 1 in training in PMR&R
SLP's not implemented effectively
Current deployment of safety advisors and DSEAR knowledgeable people and in - appropriately matched to the risks/requirements of the facility see examples for context below.
Rigid structure which is not flexible enough to support the bespoke needs of individual facilities.
EH+S structure to support duty holder in conventional safety is rigid, inflexible + doesn't recognise/differentiate risks/ hazards of individual facilities
Poor implementation of DSEAR from central team in EHS&Q to the facilities e.g. as evidenced by inconsistent understanding of DSEAR requirements by facilities (e.g. to have a DSEAR facilitator in each facility.)
Decision to out source to supply chain to produce assessments
No intelligent customer within facilities to interpret assessment or guide the assessment.
No risk assessment of long term storage of THF & Quickszint
on who took the s.43 assessor round s.24 do the DSEAR ment didn't take him into the lab with the Quickszint
Because of the social construct around categories for chemicals, which meant that redundant chemicals were in the organisations unconscious, invisible and not thought about.
Goes to root cause on tailoring resources from org accountability
Across Infrastructure 7 saf isors and in s.24 hi sup s.24 s.24 (other s fS
Not mobile enough across business/site to achieve organisational excellence on conventional safety topics.
E.g. 18 safety advisors trained in basic DSEA ss the site 0 in s.24 1 acros infrastructure
If they knew DSEAR inside out they are still running around SEP supporting analysis and reduction fissile materials Job overload.
2 safety advisors and the safety manager are generalists and are not chemical experts and had no idea of socially constructed bucket of redundant chemicals
Safety manager for Infrastructure did not understand the socially constructed bucket.
Trained safety advisor in DSEAR is now placed in MER.

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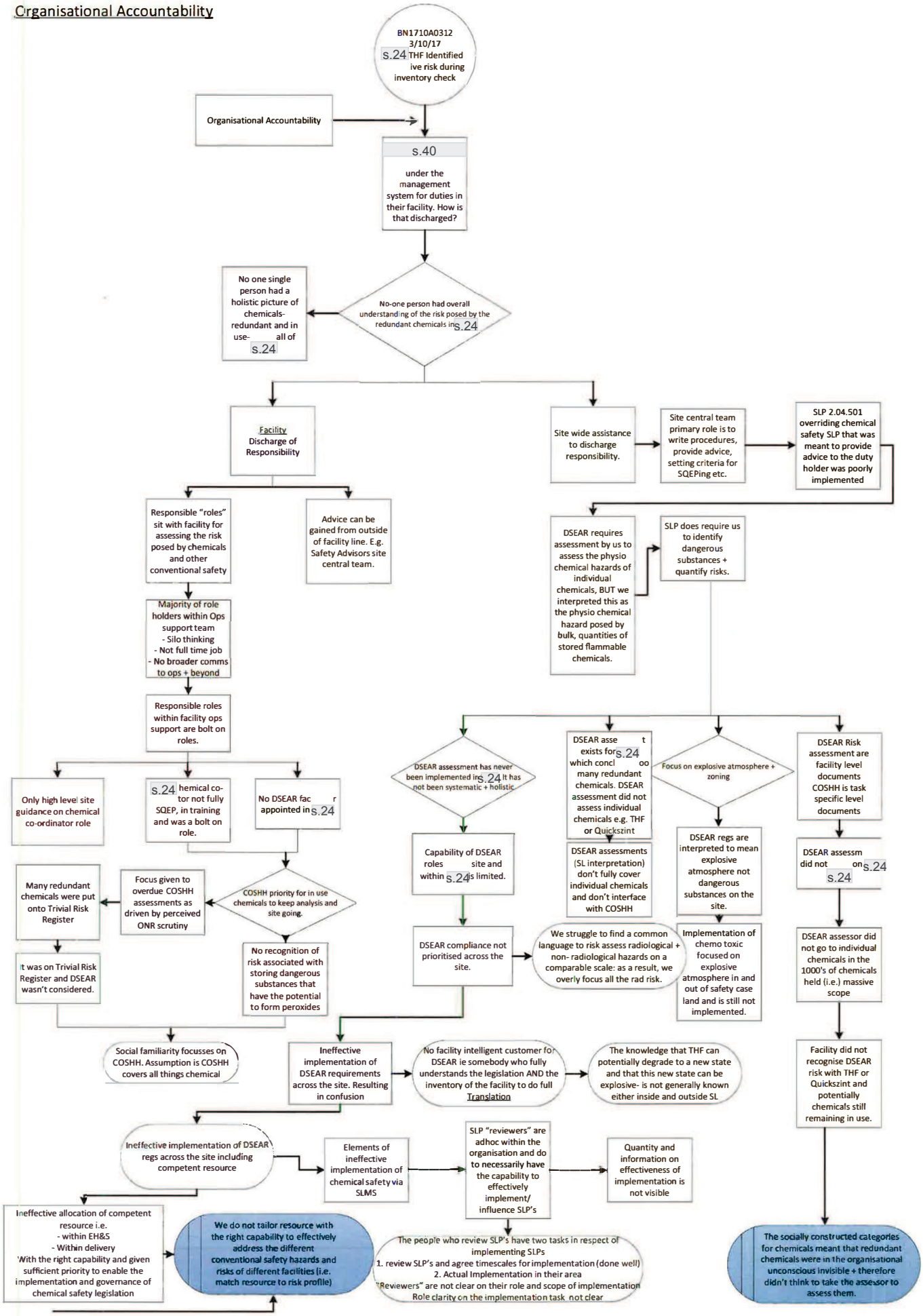
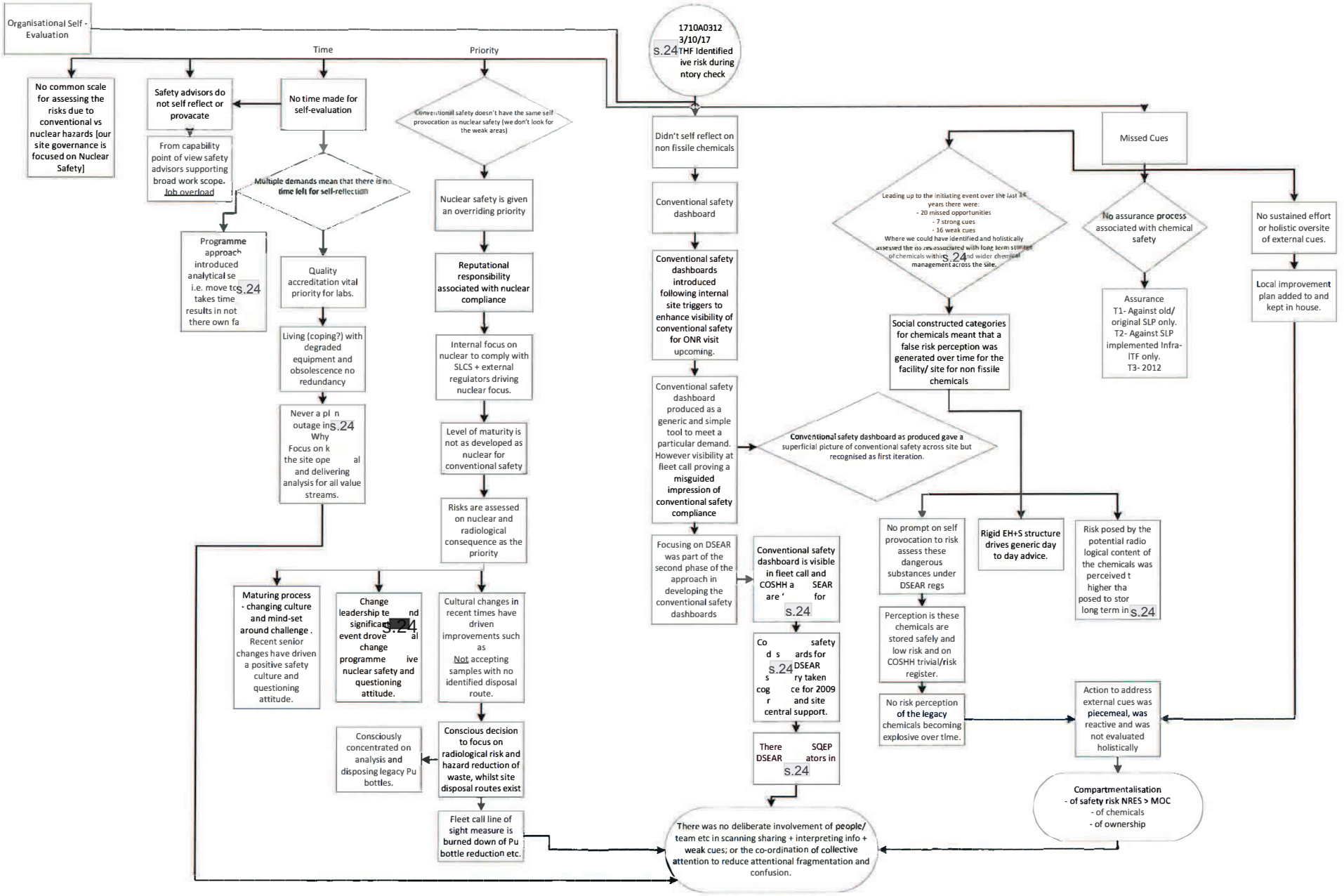
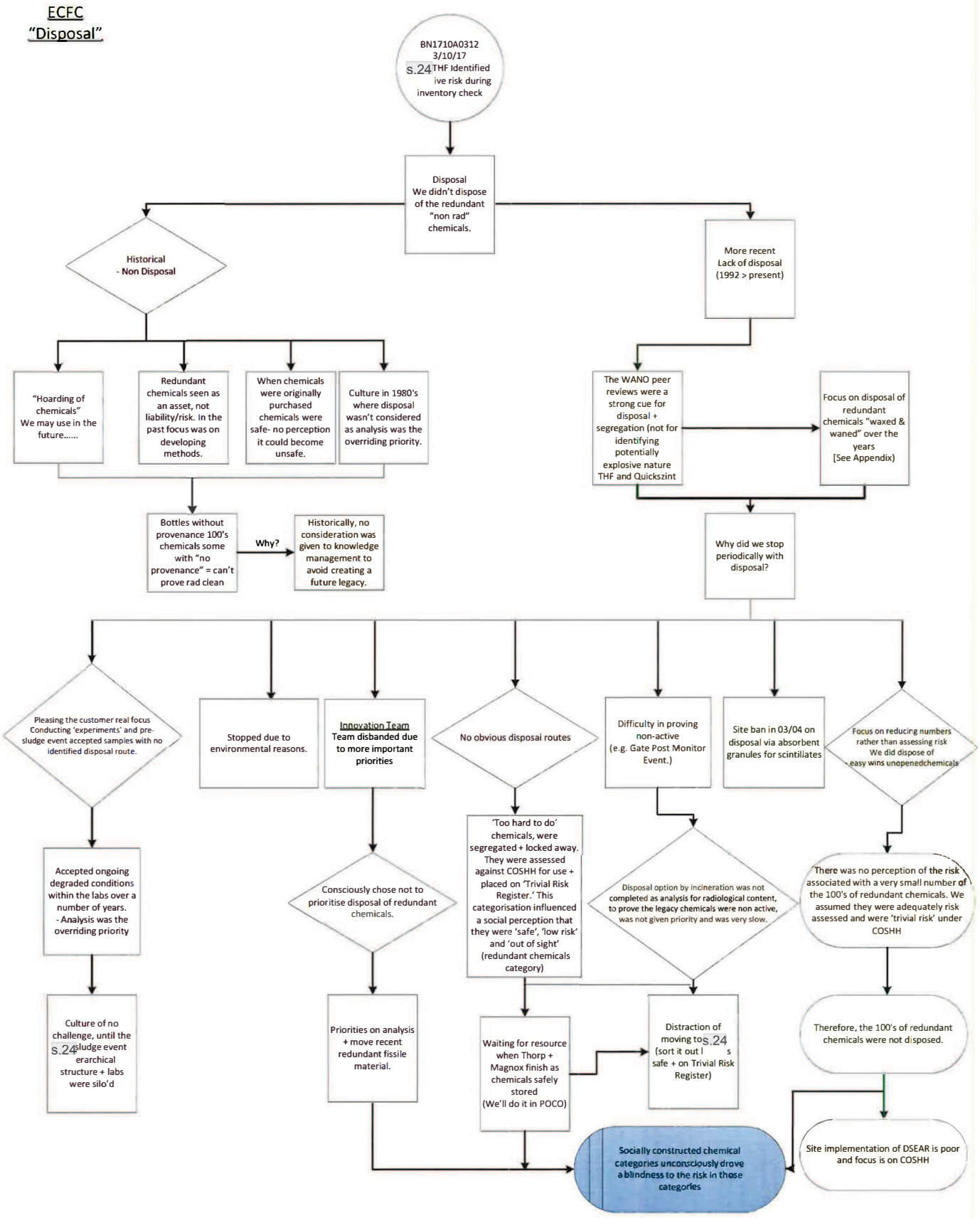
## Organisational Accountability



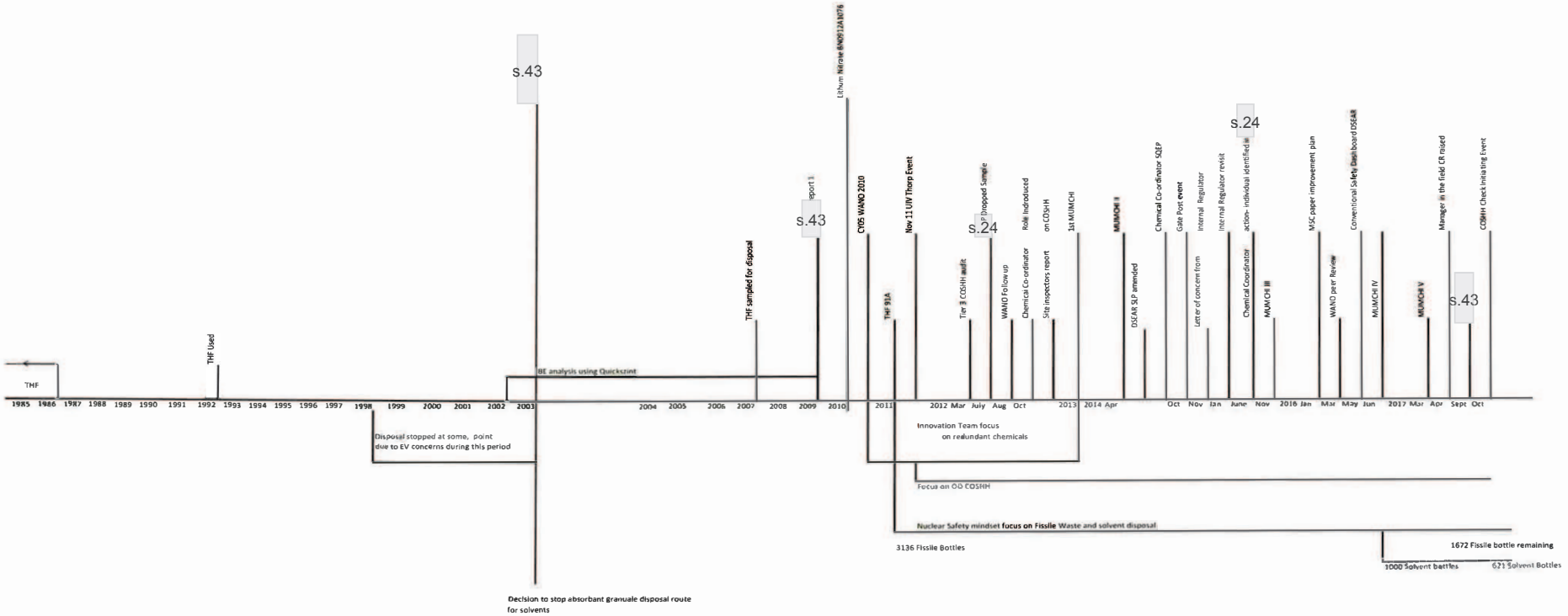

Organisational Self - Evaluation
Time
Priority
No common scale for assessing the risks due to conventional vs nuclear hazards [our site governance is focused on Nuclear Safety]
Safety advisors do not self reflect or provacate
From capability point of view safety advisors supporting broad work scope. Job overload
Programme approach introduced analytical se i.e. move to takes time results in not there own fa
No time made for self-evaluation
Multiple demands mean that there is no time left for self-reflection
Quality accreditation vital priority for labs.
Living (coping?) with degraded equipment and obsolescence no redundancy
Never a pl n outage in Why Focus on k the site ope al and delivering analysis for all value streams.
Conventional safety doesn't have the same self provocation as nuclear safety (we don't look for the weak areas)
Nuclear safety is given an overriding priority
Reputational responsibility associated with nuclear compliance
Internal focus on nuclear to comply with SLCS + external regulators driving nuclear focus.
Level of maturity is not as developed as nuclear for conventional safety
Risks are assessed on nuclear and radiological consequence as the priority
Maturing process - changing culture and mind-set around challenge . Recent senior changes have driven a positive safety culture and questioning attitude.
Change leadership te nd significa al event drove change programme ive nuclear safety and questioning attitude.
Cultural changes in recent times have driven improvements such as Not accepting samples with no identified disposal route.
Consciously concentrated on analysis and disposing legacy Pu bottles.
Conscious decision to focus on radiological risk and hazard reduction of waste, whilst site disposal routes exist
Fleet call line of sight measure is burned down of Pu bottle reduction etc.
1710A0312 3/10/17 THF Identified ive risk during ntory check
Didn't self reflect on non fissile chemicals
Conventional safety dashboard
Conventional safety dashboards introduced following internal site triggers to enhance visibility of conventional safety for ONR visit upcoming.
Conventional safety dashboard produced as a generic and simple tool to meet a particular demand. However visibility at fleet call proving a misguided impression of conventional safety compliance
Focusing on DSEAR was part of the second phase of the approach in developing the conventional safety dashboards
Conventional safety dashboard is visible in fleet call and COSHH a SEAR are ' for
Co safety d s ards for s DSEAR cog r ce for 2009 and site central support.
There SQEP DSEAR ators in
Conventional safety dashboard as produced gave a superficial picture of conventional safety across site but recognised as first iteration.
Leading up to the initiating event over the last 16 years there were: - 20 missed opportunities - 7 strong cues - 16 weak cues Where we could have identified and holistically assessed the risks associated with long term storage of chemicals within and wider chemical management across the site.
Social constructed categories for chemicals meant that a false risk perception was generated over time for the facility/ site for non fissile chemicals
No prompt on self provocation to risk assess these dangerous substances under DSEAR regs
Rigid EH+S structure drives generic day to day advice.
Risk posed by the potential radio logical content of the chemicals was perceived t higher tha posed to stor long term in
Perception is these chemicals are stored safely and low risk and on COSHH trivial/risk register.
No risk perception of the legacy chemicals becoming explosive over time.
Missed Cues
No assurance process associated with chemical safety
Assurance T1- Against old/ original SLP only. T2- Against SLP implemented Infra-ITF only. T3- 2012
No sustained effort or holistic oversite of external cues.
Local improvement plan added to and kept in house.
Action to address external cues was piecemeal, was reactive and was not evaluated holistically
Compartmentalisation - of safety risk NRES > MOC - of chemicals - of ownership
There was no deliberate involvement of people/ team etc in scanning sharing + interpreting info + weak cues; or the co-ordination of collective attention to reduce attentional fragmentation and confusion.

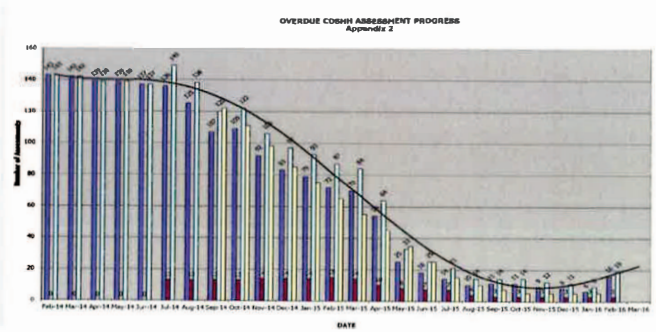
**PART 2**

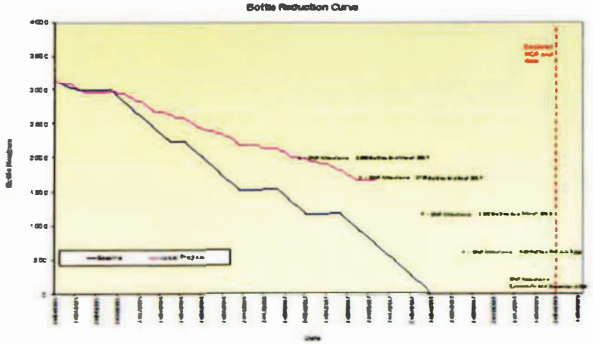

ECFC
"Disposal"
BN1710A0312
3/10/17
s.24 THF Identified ive risk during inventory check
Disposal
We didn't dispose of the redundant "non rad" chemicals.
Historical
- Non Disposal
More recent
Lack of disposal
(1992 > present)
"Hoarding of chemicals"
We may use in the future.....
Redundant chemicals seen as an asset, not liability/risk. In the past focus was on developing methods.
When chemicals were originally purchased chemicals were safe- no perception it could become unsafe.
Culture in 1980's where disposal wasn't considered as analysis was the overriding priority.
The WANO peer reviews were a strong cue for disposal + segregation (not for identifying potentially explosive nature THF and Quickszint
Focus on disposal of redundant chemicals "waxed & waned" over the years
[See Appendix)
Bottles without provenance 100's chemicals some with "no provenance" = can't prove rad clean
Why?
Historically, no consideration was given to knowledge management to avoid creating a future legacy.
Why did we stop periodically with disposal?
Pleasing the customer real focus Conducting 'experiments' and pre-sludge event accepted samples with no identified disposal route.
Stopped due to environmental reasons.
Innovation Team
Team disbanded due to more important priorities
No obvious disposal routes
Difficulty in proving non-active
(e.g. Gate Post Monitor Event.)
Site ban in 03/04 on disposal via absorbent granules for scintillates
Focus on reducing numbers rather than assessing risk
We did dispose of
- easy wins unopenedchemicals
Accepted ongoing degraded conditions within the labs over a number of years.
- Analysis was the overriding priority
Consciously chose not to prioritise disposal of redundant chemicals.
'Too hard to do' chemicals, were segregated + locked away. They were assessed against COSHH for use + placed on 'Trivial Risk Register.' This categorisation influenced a social perception that they were 'safe', 'low risk' and 'out of sight' (redundant chemicals category)
Disposal option by incineration was not completed as analysis for radiological content, to prove the legacy chemicals were non active, was not given priority and was very slow.
There was no perception of the risk associated with a very small number of the 100's of redundant chemicals. We assumed they were adequately risk assessed and were 'trivial risk' under COSHH
Culture of no challenge, until the s.24 sludge event erarchical structure + labs were silo'd
Priorities on analysis + move recent redundant fissile material.
Waiting for resource when Thorp + Magnox finish as chemicals safely stored
(We'll do it in POCO)
Distraction of moving to s.24 (sort it out l s safe + on Trivial Risk Register)
Therefore, the 100's of redundant chemicals were not disposed.
Site implementation of DSEAR is poor and focus is on COSHH
Socially constructed chemical categories unconsciously drove a blindness to the risk in those categories

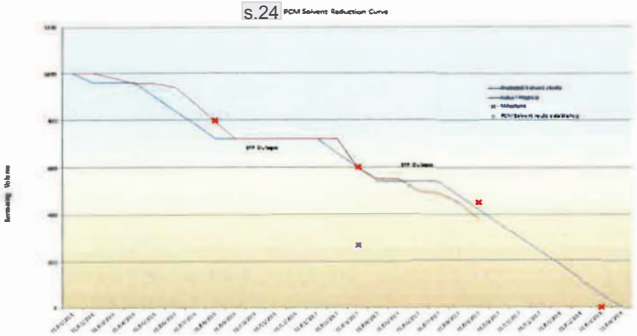
## 10. Appendix 4. Event Time Line Diagram

The diagram below shows the missed oportunities, the waxing and waning for disposal efforts within the facility and progress against fissle risk reduction.
Below the time line indicated the periods of waxing and waning of chemical disposal, above the line indicated the dates which influenced the waxing and waning and missed opportunities.



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## 10. Appendix 5 Photographs of THF and Quickszint

### THF (Stored in a Flammable Vault in s.24

**Quickszint (Stored under** s.24

s.24

s.24

s.24

s.24

## 11. Appendix 6 Terms of Reference Review

**Standard Terms of Reference**

| | |
|---|---|
| 1. To investigate the circumstances leading up to and surrounding the condition | Board of Inquiry report |
| 2. Use root cause analysis techniques to identify the root and contributing causes. | The event and causal charts are provided in Appendix 3. |
| 3. Review any previous incidents across the organisation with similar root causes, including systematic failures and assess the effectiveness of any actions placed and adequacy of the company's response. | Evidence presented in the report details a review of previous conditions / investigations around chemical safety across the site. The conclusions and recommendations capture that this is equally applicable across all aspects of conventional safety. |
| 4. Engage with the Convening Authority during the investigation process to ensure they understand the Event & Causal Factors Chart (ECFC), causal factors and are involved in the development of corrective actions. | Reviews conducted during the course of the investigation. |
| 5. Develop SMART corrective action(s) that addresses the causes. | See section 7.5 in the report. Actions have been agreed with the convening authority. |
| 6. Develop a Corrective Action Effectiveness Review Plan to verify that (1) the actions have been effectively implemented and (2) the identified causes have been effectively removed. | Included as a recommendation and action detailed in Section 7.5 |
| 7. Identify any required changes to the company classification and flag to the Site Sentencing Authority. Confirm the Classifications are appropriate. | At the time of initial sentencing of BN1710A2447 "Analytical Services Hazardous Chemical Removal / Evacuation" raised on the 20th October 2017, the full understanding of the circumstances and the wider scenario was still emerging.<br><br>In particular, evidence of crystallisation within the Quickszint was noticed on the 23rd October 2017, three days after the event (BN1710A2447) to which the SIR had been attached and on which, the INF1 process had been initiated.<br><br>There is no further condition report for the Quickszint<br><br>In light of the findings of this Board of Inquiry, the following internal site sentencing classifications have been confirmed (source document SLSP 3.09.100.02 Issue 3):<br><br>**N5f** - Events of management concern, which indicate a deficiency in standards expected for disciplined conduct of operations of a nuclear facility and which should be reported.<br><br>**I4** - Events where no or only minor injury occurred but where there is judged to have been a credible risk of a death or major injury from a work related hazard. |

| | |
|---|---|
| | **E6b** - Other events associated with environmental protection which should be recorded but do not fit other categories.<br><br>**M4a** - Condition Reports thought likely to attract (national) media or public interest |
| 8. Using template SLF 3.09.101.06 Board of Inquiry (BOI) report, provide a level of detail such that a third party reader can understand the results, how the results were derived. Include completed analysis tools used as an attachment to this report. | Report produced against template. |
| 9. Prepare appropriate learning material to capture generic wider lessons learnt. | Complete |
| 10. Compile the folder of evidence with the information required to obtain a picture of the investigation, its conclusions and corrective actions and how these were identified. | Complete |
| 11. Ensure the final BOI report is placed against the associated CR in ATLAS. | Complete |

**Additional Terms of Reference**

| | |
|---|---|
| 12. Following the crystallisation event in October 2017 assess the response of the facility to answer the why, what, how, who and when, decisions were made, work initiated, handling of emerging understanding, escalation and review, including use of Organisational Decision Making (ODM), and independent challenge. | Described in the timeline and Section 7 |
| 13. Understand how the facility arrived at the position of requiring outside assistance from a plant, people and procedural aspect, with regards to inventory control. | Described in the timeline, Section 7 and Event and Causal Factor Charts |
| 14. Consider the wider learning for the Remediation of Sellafield Site. | Captured in the conclusions and recommendations and will be captured in the wider learning pack. |

## 10. Appendix 7 Glossary of Terms

| | |
|---|---|
| AFI | Area For Improvement |
| ALARP | As Low As Reasonably Practical |
| AS | Analytical Services |
| ASG | Analytical Services Guideline |
| ATLAS | Analysing Trending Learning and Safety (Reporting) Database |
| BoI | Board of Inquiry |
| s.43 | |
| CHS | Conventional Health & Safety |
| CMT | Crisis Management Team |
| CNC | Civil Nuclear Constabulary |
| COMAH | Control of Major Accident Hazards |
| COSHH | Control of Substances Hazardous to Health |
| CoSR | Continued Operations Safety Review |
| CR | Condition Report |
| DSEAR | Dangerous Substances and Explosive Atmosphere Regulations |
| EA | Environment Agency |
| ECFC | Event & Causal Factors Chart |
| EHS&Q | Environmental, Health, Safety & Quality |
| EOD | Explosive Ordnance Disposal |
| s.43 | |
| HSE | Health and Safety Executive |
| ICP | Inductively Coupled Plasma Mass Spectrometer |
| IER | Initial Event Report |
| MoCRA | Management of Change Risk Assessment |
| MSC | Management Safety Committee |
| MSDS | Material Safety Data Sheet |
| MUMCHI | Manufacturing Unit Major Chemical Hazard Inventory |
| s.43 | |
| NIO | Nuclear Independent Oversight |
| OB | Open Bench Reference |
| ODM | Operational Decision Making |
| ONR | Office of Nuclear Regulation |
| OPEX | Operating Experience |
| PMP | Plant Modification Proposal |
| POCC | Plant Operations Control Centre |
| POCO | Post Operational Clean Out |
| PPE | Personal Protective Equipment |
| RAP | Replacement Analytical Project |
| REACH | Registration, Evaluation, Authorisation & Restriction of Chemicals |
| SECC | Site Emergency Control Centre |
| SL | Sellafield Limited |
| SLNSC | SL Nuclear Safety Committee |
| SLP | Sellafield Limited Practices |
| SOER | Significant operating experience report |
| SQEP | Suitably Qualified and Experienced Person |
| SSM | Site Shift Manager |
| THF | Tetrahydrofuran |
| THORP | Thermal Oxide Reprocessing Plant |
| ToR | Terms Of Reference |
| UKAS | United Kingdom Accreditation Services |
| WANO | World Association Of Nuclear Operators |