

**FIRST INTERNATIONAL FORUM ON THE DECOMMISSIONING OF THE
FUKUSHIMA DAIICHI NUCLEAR POWER PLANT**

April 2016, Fukushima Japan

**The Regulation of Decommissioning
and Associated Waste Management**

By

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Reflections

Looking back from 5 years on:

- A Devastating Time
- Resilience and Fortitude
- Amazing Progress
- Learning, Looking Around, Looking Forward
- Crisis to Calm Determined Progress in Harmony



Lessons, Castles and Values

Fundamental Lesson from TEPCO Fukushima Daiichi:

Need a **robust strong institutional nuclear safety** system to ensure that national/international standards and best practices are fully and rigorously implemented.

Use **Strength in Depth** Principles:

- Involve All

Strong Deep Foundations:

- **Values and a Vibrant Safety Culture**

Strong Protecting Roof:

- **Humble Leadership**

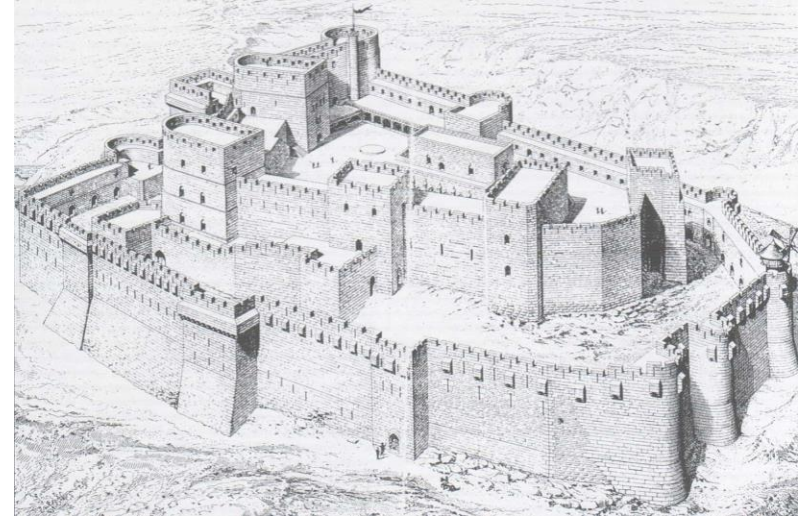
Castles – Built on Strength in Depth

Principles:

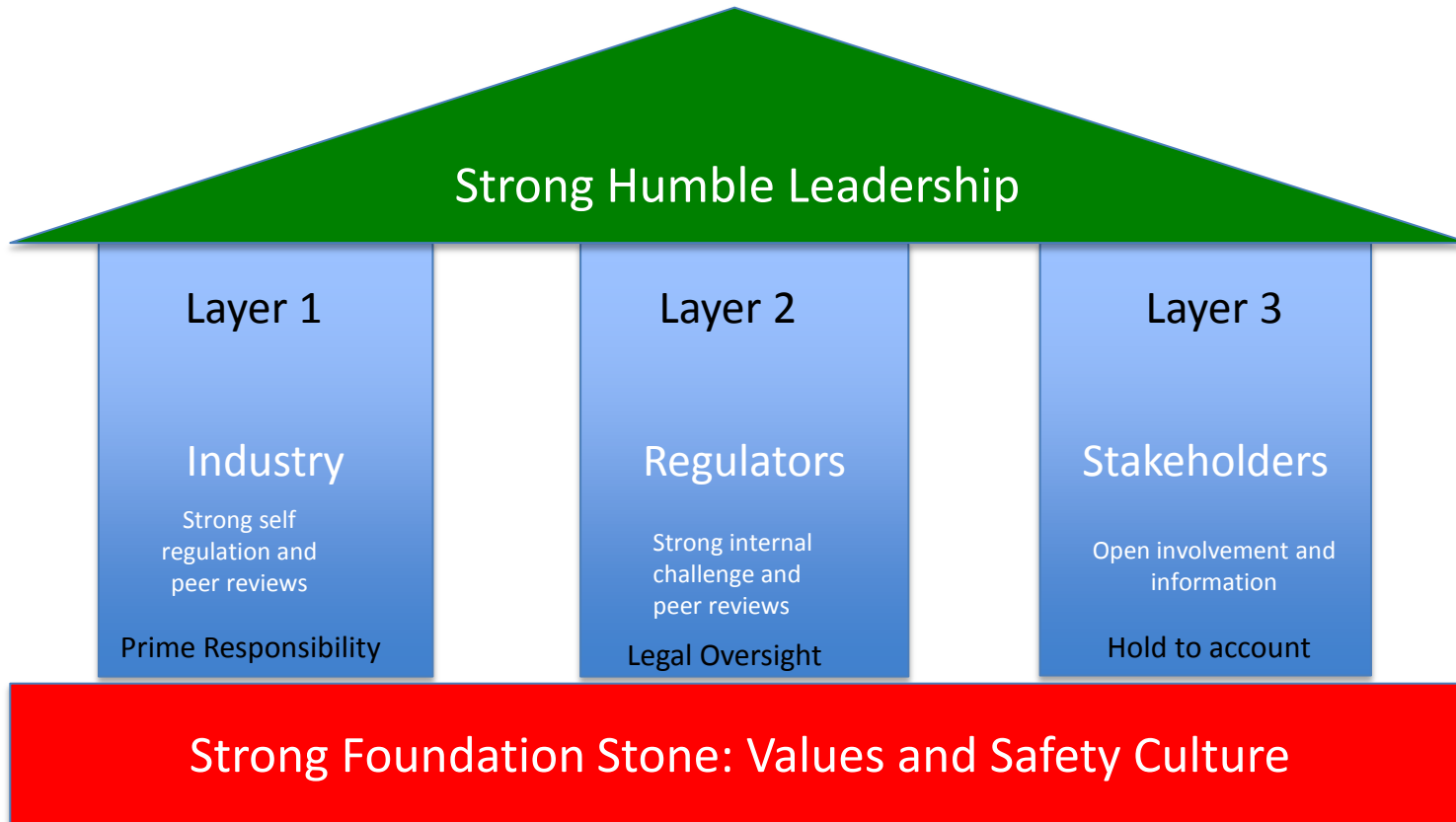
- Independent strong layers
- Within each several diverse weapons of strength
 - Bow and arrows
 - Spears
 - Clubs
 - Swords
 - Stones
 - Boiling oil
- No single point/Common mode failure

But success depends on the **people**:

- Their culture
- Their organisation
- Their **leadership**



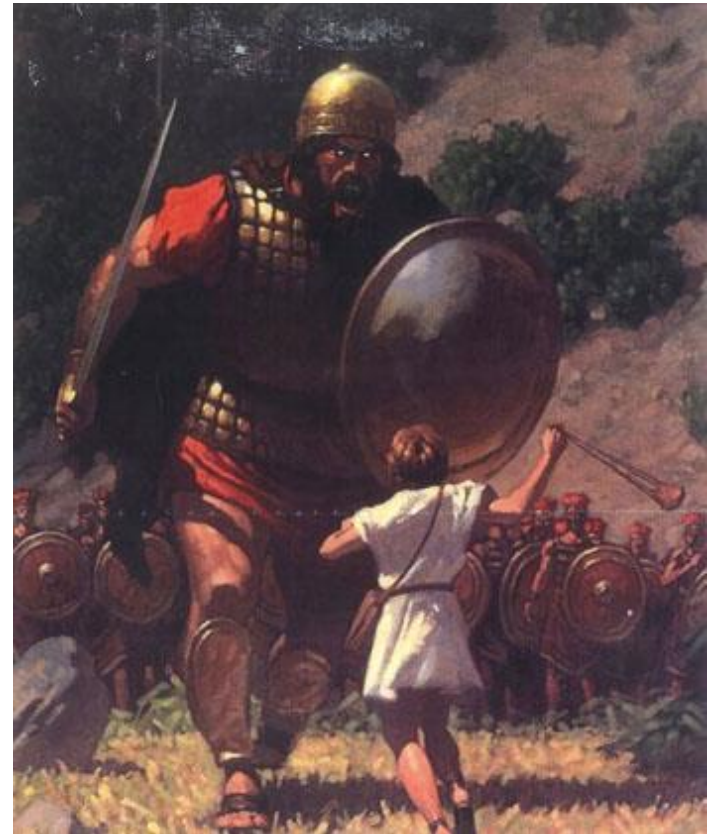
3 Main Independent Pillars In A Robust Nuclear Safety System



What do I mean by strong?

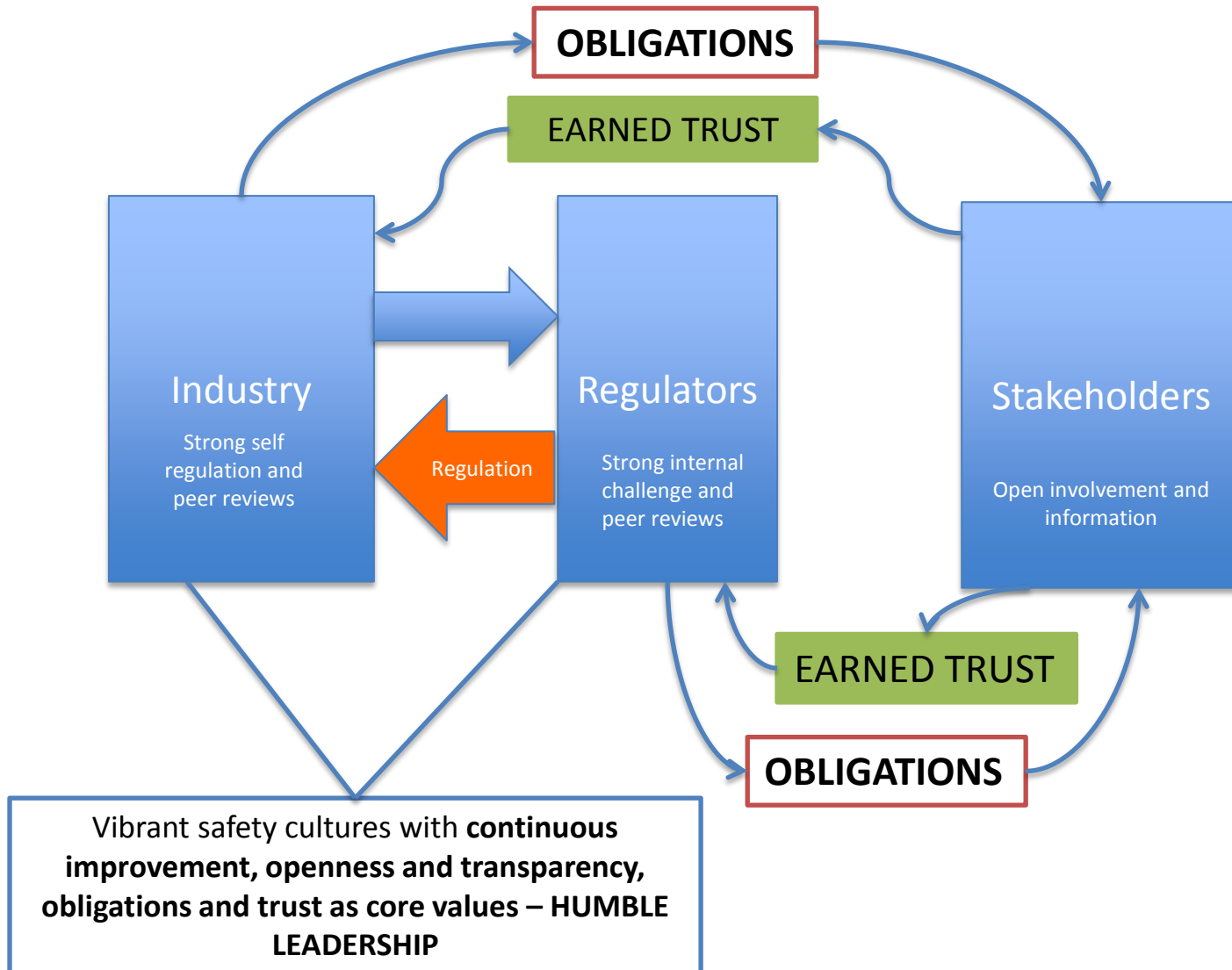
Inner strength not brute strength:

- Strong enough to listen and absorb others' ideas
- Strong enough to not be afraid of challenge
- Strong enough to welcome new ideas and learn from others
- Strong enough to tell it as it is
- Strong enough to recognise when you got it wrong and show that you are learning from it



David and Goliath
Skills, Strategy & Inner Strength for
Success

A Robust Nuclear Safety System – Importance of Values



Importance of Nuclear Leadership

Leading with humility

- Setting the vision, nurturing the culture, and living the values

“The heavier the stock of rice, the lower its head.”

Harmony - A Common Goal for Decommissioning

- A **common goal** for the 3 pillars of a robust nuclear safety system:
 - **Industry**
 - **Regulator**
 - **Stakeholders** (public, government, etc.)

- **Risk Reduction**

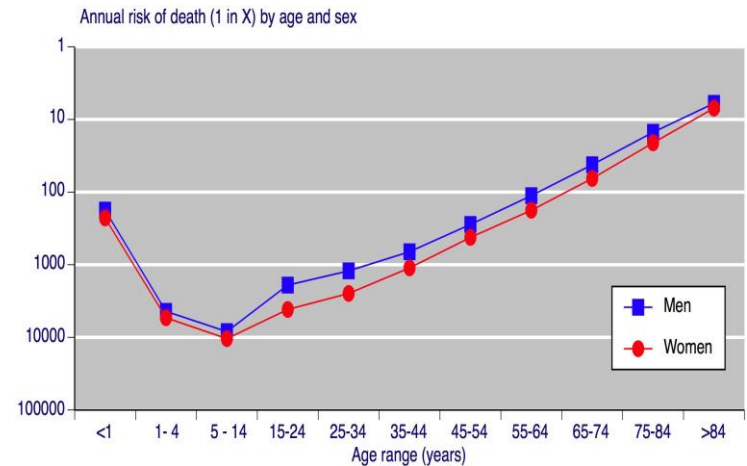
Decommissioning is Risk Driven and needs the 3 Pillars to work in Harmony to achieve a Common Goal of Risk Reduction
- A Fundamental Way

What is Risk and Safety?

- Risk – chance of bad consequences, loss (= $F \times C$)
- Safety – Freedom from Risks
- No such thing as absolute safety
- Living is risky
- We tolerate risks to achieve benefits
- Some examples ...

Examples of Risk

- My overall chance of dying next year \approx 1 in a 100
- My chance of dying in a car accident while driving on holiday in Japan \approx 1 in 10,000
- My chance of dying while travelling by train in Japan \approx 2 in 1000,000
- My chance of dying eventually from my radiation exposure at Daiichi in May 2011 \approx 4 in 1000,000



Regulation in Decommissioning

- When hazardous radioactive material (spent fuel, damaged fuel, waste, etc) is held in old, deteriorating, or unstable conditions **priority** is to recover it and store in facilities built to modern nuclear safety standards
- **Regulators and others accept** that during recovery:
 - Risk of an accident or unplanned release may increase to achieve long term
 - Workers dose may increase above normal operating levels
 - Discharges to the environment may increase above normal levels
 - And, storage of the material may be in an **interim state** pending final conditioning for disposal

Similarities & Differences when Regulating High Hazard Degraded Fuel Facilities

Similarities:

- Licensee has prime responsibility for safety
- Regulator to ensure safety
- Regulator independent
- Regulator not isolated

Differences:

- Regulators cannot stop operations to reduce hazards
- Regulators want decommissioning as soon as reasonably practicable
- Regulators have to accept that risks may increase in the short term
- Some safety principles may have to be balanced against progress

Some Examples from the UK - Sellafield



Earlier Risk Reduction, Interim States and Working in Harmony for a Common Goal

Examples – Sellafield Legacy ponds & silos programme

1000bn ¥ clean-up programme

Most Hazardous Nuclear Site in UK

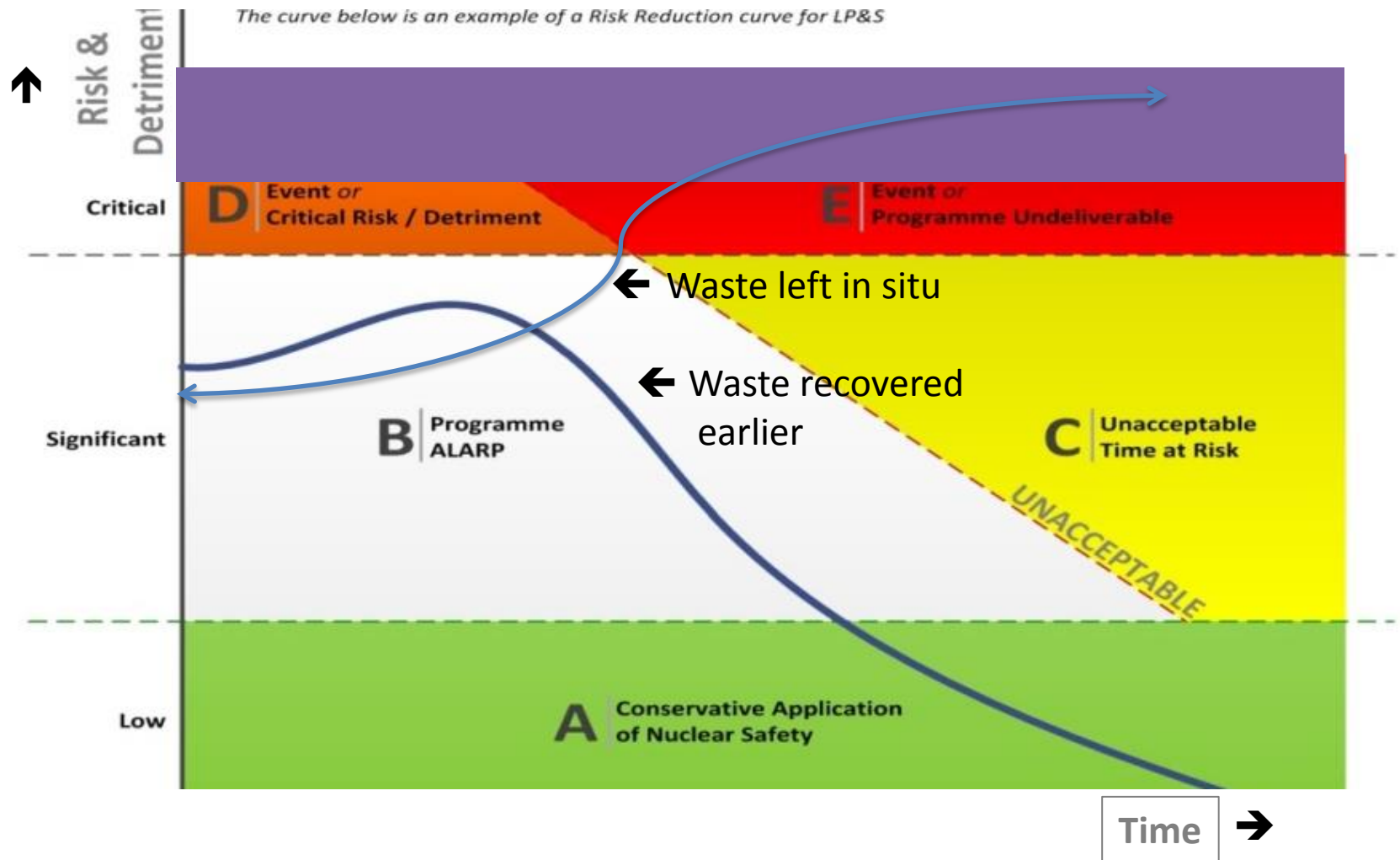
- Constructed in 1940-60's
- Used to store, cool and prepare 1000's of tonnes of fuel for reprocessing
- Stored inventory; spent fuel, radioactive sludges, wastes, miscellaneous items
- Facilities deteriorating, located in a very congested area of the site
- Very high levels of radiation and potential for contamination
- Ponds and silos are in the process of being safely emptied
- New plants required to process waste streams into a form for disposal



Image courtesy of Sellafield Ltd

Priority on major risk and hazard reduction

Sellafield – Legacy Ponds and Silos Risk Framework



Example 1: Magnox Swarf Storage Silos



Example 1: Magnox Storage Silos

- Used to tip swarf from the de-cladding of spent Magnox fuel into water filled silos
- One of the Highest Hazard Potential nuclear facilities
- Up to 3% spent fuel carryover over decades of Magnox programme
- Building built in 1950s
- Major Issues with H_2 generation, exothermic corrosion $Mg + H_2O \rightarrow$
- Stopped tipping swarf but encapsulate
- Building strengthened, and active liquor removed & treated – about 3% of overall activity = 1/10 overall release form Chernobyl

- But ...
- Still massive hazard potential associated with rest of waste in silos
- All agree need to reduce risk further

Magnox Swarf Storage Silos

Original Proposal

- Recover Magnox swarf, etc when plants available to condition waste into form for deep geological disposal store
- Single process from retrieval to product compatible with disposal – 22 step mechanical retrievals, complex treatment and encapsulation and store
- Initial contract placed for project (total cost around £2.5b) and not start retrieving waste until later in 2020s
- Still time at risk challenge for all: earlier risk reduction needed

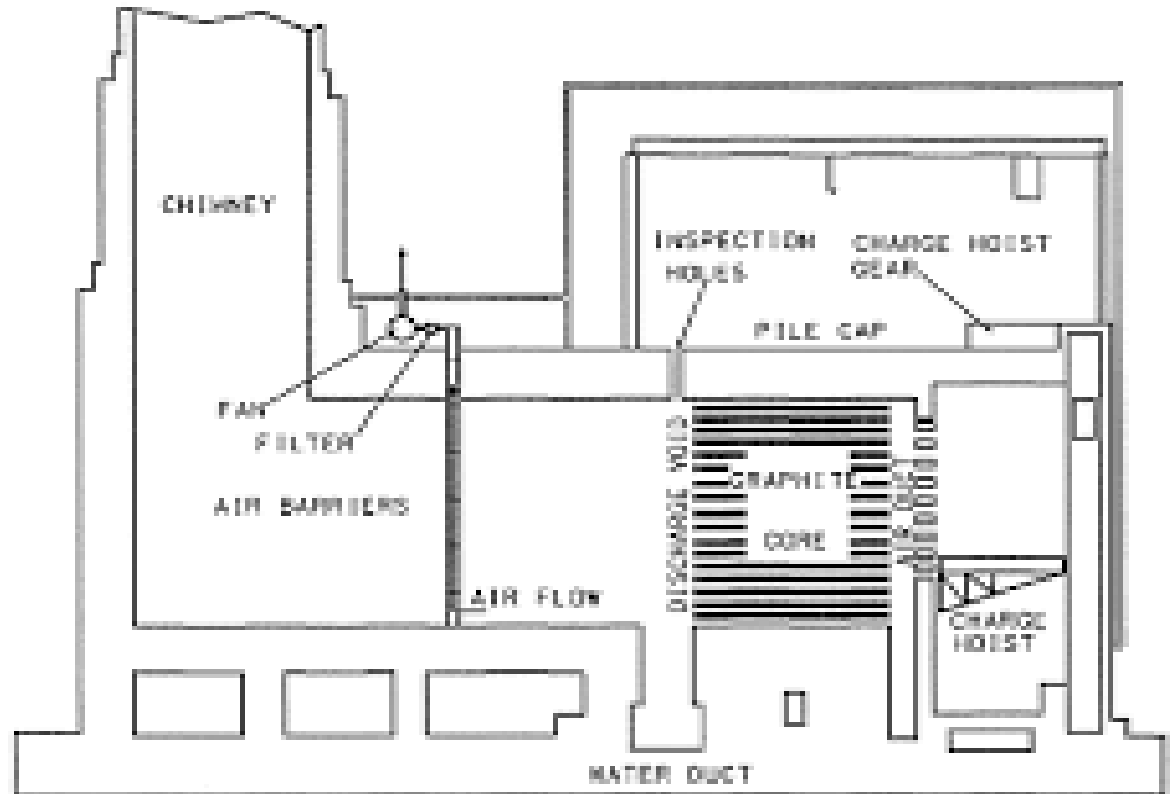


Magnox Swarf Storage Silos

Risk Optimisation Strategy

- **Collaboration** amongst independent regulators, licensees, NDA, Government, etc to develop a strategy based on earlier risk reduction
- **Regulator accepts:**
 - some increase in risk during retrieval
 - Some Decommissioning/Waste Management principles not met full
 - Waste stored in raw form in multi-barrier containment for some decades – INTERIM STATE before final disposal
- Retrieval and store in **raw interim state** in modern facilities significantly earlier and more reliably
- 3 step process with some decades later simple waste finishing for disposal

Example 2: Decommissioning Facilities dealing with fuel from the 1957 Windscale Fire



SECTION THROUGH PILE 1

AFTER INSTALLATION OF AIR BARRIERS

Pile 1 Decommissioning

- 15 the fuel and isotopes – 8500 items
- 4000te graphite – 30000 items
- 8500 m³ ILW
- Fuel in various states of damage and deterioration in core
- Fuel debris in channels
- Safety related work on graphite, Uranium hydride, etc
- Lot of work on encapsulation matrix and methodology
- Development of fuel channel retrieval tool



Windscale Pile Storage Facility

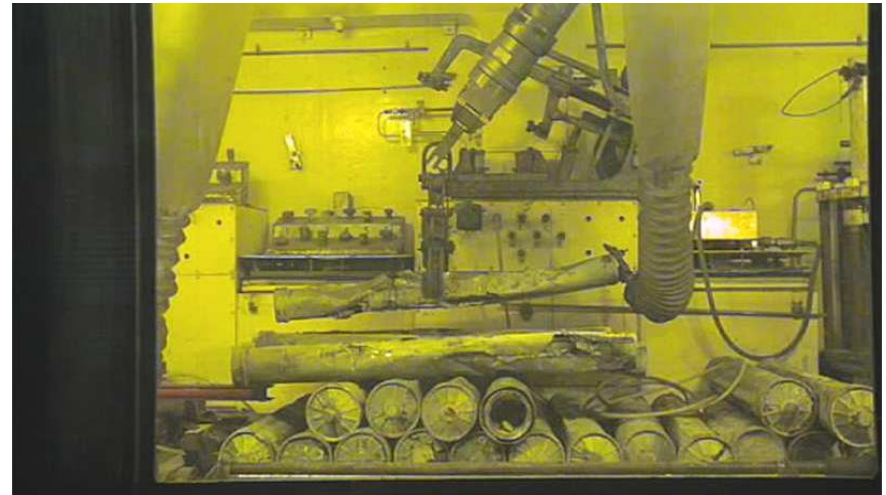
- Pile Fuel Storage Pond decommissioning
 - Used to store, cool and prepare fuel from Windscale piles
 - Built in late 1940s
 - Sat dormant for decades after Windscale fire
 - 650 tonne of waste including spent and damaged fuel
 - Similar issues to Fukushima Daiichi?:



First remove several 100 te of heavy contaminated equipment after surveys using ROVs

Waste, and Spent fuel removal including damaged fuel in various states of decay after over 50 years storage

- Have to process very carefully as unsure of condition including in some cases criticality hazard
- Started fuel retrieval in 2012 now completed having removed more than 100 tonne
- Stored in modern storage awaiting further processing – Interim State
- Drive was to **reduce time at risk**
- **Collaborate working** led to massive reduction in planned date for decommissioning – dewatering some 21 yrs ahead of schedule



Use high active caves with remote handling capability, used to handling other degraded fuel

The Sun is Rising – A Transition for Daiichi?

- **Crisis to calm** determined progress
- Built on Three pillars of a Robust Strong Nuclear Safety System working in **Harmony**
- Foundation Stone of **Values** – Humble, Integrity, Openness and Transparency, Obligations and Earning Trust
- Driven and sheltered by **Humble Leadership**
- A Common Goal - **Risk Driven Decommissioning**
- A **Fundamental Way** Decommissioning is risk driven and Needs the **3 Pillars to Work in Harmony** to achieve a Common Goal of Risk Reduction
- **Regulators and others accept change** from the norm
- **Decommissioning in Harmony for the benefit of the Japanese People - an Example to the World**

