ENSURING SAFE STEWARDSHIP OF LAND QUALITY ISSUES *VIA* THE IMPLEMENTATION OF A SAFETY CASE FOR CONTAMINATED LAND

F. Dennis, A. Oag, M. Liddiard
Environmental Programmes Department
UKAEA
Dounreay

M. Pearl
Technical Services Group
UKAEA
Harwell

ABSTRACT

UKAEA at Dounreay, a nuclear licensed site on the north coast of Scotland, is implementing a modern standards safety case for contaminated land. The safety case follows guidance given by the nuclear safety regulator in the UK and demonstrates that risks from chemically and radioactively contaminated land at Dounreay are as low as reasonably practicable.

The preferred strategy at Dounreay, as defined in the safety case, is to treat contaminated land as an on-going operation and integrate its management with the site's decommissioning activities and waste management strategy. As such the safety case is limited in scope to: 1) land in the resting state; 2) non-intrusive monitoring and characterisation; and 3) small-scale intrusive investigations. The safety case does not cover major construction or remedial works as these projects will be subject to individual safety cases.

This paper outlines the Dounreay Contaminated Land Safety Case and supporting documents and shows that integrated management of contaminated land can be demonstrated using traditional nuclear industry safety cases.

INTRODUCTION

The nuclear safety regulator in the UK: the Nuclear Installations Inspectorate (NII) has recently produced guidance for its inspectors which recommends that, unless it is an authorised disposal, radioactively contaminated land at nuclear licensed sites should be managed as an accumulation of radioactive waste [1]. As with other nuclear operations on a licensed site, it will therefore be subject to compliance with site nuclear licence conditions and the adequacy of the management arrangements will be justified and demonstrated through a modern standards safety case.

UKAEA's Dounreay site on the north coast of Scotland has been working with the NII to develop a safety case for contaminated land which will ensure the safety of site workers, contractors and visitors while also complying with relevant environmental standards. The objective of this paper is to discuss the main elements of the Dounreay Contaminated Land Safety Case and the philosophy behind contaminated land management at Dounreay.

Dounreay is currently undergoing decommissioning with a projected interim end state at 2036. This Operational Phase will be followed by an extended phase of institutional care before the site could be considered fully closed. The current preferred decommissioning strategy is to treat contaminated land as an on-going "operation" until 2036 and integrate its management with the decommissioning activities and the overall waste management strategy for the site.

The safety case:
- evaluates the health, safety and environmental impacts from current, and near term, operations associated with contaminated land;
- examines the current measures (controls, monitoring, remediation) applied to manage the contamination;
- considers whether these measures result in exposure to radioactivity that is as low as reasonably practicable (ALARP); and
- recommends improvements to the site's management arrangements.

As mentioned above, the emphasis of the Contaminated Land Safety Case is to demonstrate that current operations associated with contaminated land are safe and compliant with relevant environmental standards. The Safety Case therefore covers the decommissioning Operational Phase. It is recognised, however, that this Safety Case will evolve through the remaining lifecycle of the site, and that other contaminated land safety cases will need to be developed for the non-operational, post-decommissioning phases of the site. At Dounreay the post decommissioning phases correspond to a period of institutional care involving final site closure; and to the period of post-closure.

The approach adopted in the Operational Phase Safety Case is to manage contaminated land as a site-wide issue rather than to develop individual safety cases for each source, or source area. This has the advantage that consistency of approach is assured; and impacts are assessed relative to the collective effect. As an "operation" integrated with decommissioning, contaminated land interventions are based not only on risk factors but on the development needs of the site. The contaminated land management strategy is therefore based on in-ground containment with contaminant hazard removal integrated with facility decommissioning. This strategy ensures that the generation of chemical and radioactive waste is kept to a minimum and that risks to human health and the environment are acceptably low throughout the period of decommissioning.

SCOPE AND CONTENTS OF THE CONTAMINATED LAND SAFETY CASE

The Contaminated Land Safety Case presents the arguments and justification for the preferred management strategy. It covers all contaminated land on the site but is restricted in scope to:
1) land in the resting state where contamination may be dispersed by natural processes;
2) routine, non-intrusive monitoring and investigation, for example surface beta/gamma surveys;
3) intrusive investigations and sampling exercises to support land quality assessment and waste sentencing; and
4) small-scale, very near surface remedial works to remove "hot spots" of up to a few tonnes.

The Safety Case does not cover major construction or remedial works as these require additional safety and environmental justification and approval *via* the Dounreay Modifications Procedure. Table I presents the contents of the Safety Case and the documents that support the health, safety and environmental arguments.

Table I. Dounreay Contaminated Land Safety Case Documentation.

Safety Report:

- systematically summarises the health, safety and environmental arguments which justify the continued routine management of, and identified operations on, contaminated land;
- shows the adequacy of the arrangements for the managing contaminated land; and
- presents an implementation plan for improving contaminated land management.

Supporting Documentation

- Description of the radioactively and chemically contaminated land
- Inventory and conceptual model of radioactively contaminated land
- Categorisation report integrating chemical and radioactive contamination
- Hazard and risk assessment
- Transport and fate modelling, quantitative risk assessment from on-site contamination,
- Assessment of risks from on-site contamination to the foreshore;
- Assessment of risks from groundwater seepages;
- Assessment of hazard and risk from chemically contaminated land
- Waste management and safety management systems
- ALARP* review

* ALARP: as low as reasonably practicable is equivalent to ALARA, the difference being the implicit need to balance risks with costs in the former term.

Description and Inventory of Contaminated Land

The Safety Case is supported by a robust description of contaminated land and a well-developed inventory and conceptual model, which were developed subsequent to extensive information review. The historic data collected included:

- routine monitoring of areas vulnerable to contamination;
- routine monitoring of groundwater;
- investigative surveys to assess the impact from unique contaminating incidents;
- characterisation surveys associated with assessing land quality prior to carrying out major excavation works such as that associated with site infrastructure development or decommissioning;
- gamma flux monitoring of the surface of the soil to assess the extent of near-surface contamination;
- monitoring of activity in sub-surface non-active drains; and
- compliance information associated with new developments in legislation such as the land condition records required to support Integrated Pollution Prevention and Control Authorisations.

The above information was available in a variety of forms (e.g. paper, spreadsheet, word processor files, maps, diagrams) and required to be collated and presented in a single electronic format. To do this a records capture, management and assessment system was developed [2, 3]. This system, known as the Information Management and Geographical Evaluation System (IMAGES), ensured that survey data was transposed into a series of common templates based on spreadsheets which could be uploaded into an Oracle database. The information captured within IMAGES includes: in-field and laboratory analytical results, including analytical methods; 3-dimensional spatial or location data; drilling logs; and quality assurance/quality control information including meta-data.

An essential aspect of IMAGES is its link to a geographical information system (GIS). Spatial relationships between contaminants and key features such as natural and manmade drainage systems, soil profiles and buildings can therefore be established. This enables a spatially related contaminated land inventory to be developed. This inventory is, in turn, used to assess health, safety and environmental issues.

Superficial and subsurface geological, hydrogeological and hydrological attributes are also defined in IMAGES to facilitate assessment of potential contamination migration pathways. Spatial analysis enables visual display of the extent of "clean" or contaminated areas and this information supports a variety of excavation requirements including planning the waste disposal requirements, or re-use of excavated material.

A formal, integrated Phase I desk based survey has recently been carried out [4], the results of which have been incorporated directly into IMAGES to facilitate risk assessment and prioritisation for any mitigation or remedial activities.

Assessment of Potential Impact to Human Health and the Environment

To assess the effects of contamination on human health and the environment, the site is first represented as a number of three-dimensional compartments. Relationships are developed between the compartments in terms of contaminant transfer. A total of 37 contaminated areas across the site were modelled to define transport and impact on people and the environment.

The radioactive contaminant inventory used for the assessment is based on median, mean and 95^{th} percentile values (e.g. a contaminated land surveyor spends most of his working year surveying median levels of contamination and a lesser period surveying higher (95^{th} percentile) levels of contamination). This enabled an assessment of annual doses to be calculated relative to particular exposure scenarios. Table II presents the exposure scenarios to the most likely exposed groups.

The risk assessment shows that unless excavated in bulk, the risk to human health and the environment from the contamination is very low. In addition, most of the radioactive inventory will decrease by radioactive decay of the main contaminants (mostly Cs-137) within the period of institutional care of the site.

Organisational Management

Contaminated land issues cut across many organisational boundaries and involve site personnel from a number of operational areas: environmental management, estates management, building and facility managers, waste managers, and project managers associated with new developments or decommissioning. The starting point for dealing with many of the aspects of contaminated land management is to appreciate that it should be integrated into the development, decommissioning and stewardship strategy for the site, and that appropriate responsibilities should then be assigned and relevant interfaces identified.

Table II. Critical Groups and Contaminant Exposure Scenarios

Critical Group	Description
Public Farmer	Works adjacent to the site. Subject to external irradiation from the site and from ingestion of contamination in the soil and inhalation of dust.
Foreshore fisherman	Spends a period of time on the foreshore adjacent to the site. Subject to external irradiation from the site and from inhalation of dust. Also potential ingestion from inadvertent consumption of sediment associated with eating molluscs from the foreshore.
Site Worker Land surveyor	Spends a number of hours exposed to contamination whilst carrying out monitoring duties. Subject to direct irradiation and inhalation of dust.
Office worker	Inadvertently exposed to contamination from accidentally occupying a portable cabin above a contaminated area. Subject to external irradiation and inhalation of dust.
General estates worker	Inadvertently excavates the ground in an area of contamination without knowledge of the presence of contamination. Subject to external irradiation, inadvertent ingestion and inhalation of dust.

The Safety Case for contaminated land identifies these responsibilities and identifies the interfaces. The majority of the duties associated with contaminated land management are assigned to a post known as the Contaminated Land Responsible Manager (CLRM). The CLRM has visibility of all activities at Dounreay where contaminated land or the migration of contamination from the land may have an impact on human health and the environment. As such, he is required to approve documentation relating to the contaminated land issues associated with any project which involves land, the subsurface, groundwater and surface water. In addition he has specific duties relating to assessment and monitoring of land and groundwater quality on and off the Dounreay site.

The Contaminated Land Responsible Manager is specifically responsible for:

- providing expert technical advice on land quality management on site and ensuring that Corporate and Dounreay procedures and best practice are followed;
- implementing and maintaining the Safety Case for Contaminated Land;

- ensuring that any changes or revisions to processes and legislation with regards to contaminated land management are assimilated into working practice;
- identifying areas of contaminated land or potentially contaminated land (radiological and chemical);
- developing the strategy to deal with contaminated land on the Dounreay site, defining and implementing the work programme to meet the requirements of this strategy, and reviewing programme progress; and
- maintaining the land quality database (IMAGES).

PROCEDURAL MEASURES

The approach adopted for the management for contaminated land on the site is to:

- manage contaminated land as a whole as a "continuous operation" until the end of the period of decommissioning;
- base the prioritisation for intervention actions on risk assessment or on development needs;
- integrate contaminated land (hazard) removal with facility decommissioning. Where facilities will not be decommissioned for a number of years, and where contamination is known in the sub-surface below these facilities, then the contamination should be managed in-situ (e.g. using monitoring controls or active containment if necessary);
- minimise the generation of radioactive or chemical wastes where material has to be excavated as a consequence of developments or facility decommissioning; and
- ensure that at the end of the period of decommissioning the contaminated land will be passively safe (i.e. no active intervention is required to manage potential impacts from residual contamination).

Procedural controls have therefore been developed to ensure that the above considerations can be complied with. These procedural controls are defined as either: safety and environmental monitoring systems; operations in and on contaminated land; or maintenance of a knowledge-base about contaminated land. Examples of these procedural arrangements are given below.

Example of Safety and Environmental Monitoring Systems

The groundwater monitoring programme was designed to demonstrate that contaminants in groundwater are at levels that do not pose a risk to humans and the environment. An examination, maintenance, inspection and testing regime is in place to:

- inspect and maintain boreholes;
- ensure that groundwater samples are representative by appropriate sampling, storage and transportation protocols;
- ensure that analytical results are precise and accurate and that the analysis is to the correct method, by the correct instrument and that the detection limits are appropriate;
- ensure that the results are input into data sheets correctly;
- ensure that the data is analysed and trends are recorded.

Quality assurance and quality control documentation associated with the above include method statements, calibration certificates, records of competency of staff and inspection/compliance records.

Example of Operations in, or on, Contaminated Land

Procedural controls for working on land include those associated with operations such as excavations. Excavations may be in actual or potentially contaminated land, or which may adversely alter groundwater movement such that provision has to be made to deal with the potential for contamination of the groundwater and uncontrolled release to the environment. Before any excavation takes place therefore, an excavation permit is required. Prior to permit issue, an assessment by the CLRM (or an appointee from his team) of the area to be excavated is undertaken. The assessment includes potential contamination and examines the excavation method to ensure that wastes are minimised. The CLRM will only endorse the permit when he/she is satisfied that the excavation meets requirements with respect to contaminated land issues. Excavation permits that do not have an endorsement from the CLRM contravene site procedures and can result in serious consequences for those involved.

Example of Maintaining a Knowledge-base about Contaminated Land

The IMAGES land condition records management system has been developed as the definitive database and data management system associated with contaminated land. Records received as completed spreadsheet templates are checked for integrity before they are uploaded into the system. Any further amendments to the data go through a revision control process where the reason for the change is recorded as meta-data. GIS maps produced from site CAD maps and from IMAGES data also contain meta-data in order to ensure trace-ability.

The IMAGES system is regularly checked to ensure that it is functioning properly. In addition it is updated with respect to improved handling or to changes in some of the base software.

Implementation and Improvement Plan

In preparing the safety case for contaminated land management, a number of changes were identified, and further work is required to supplement the existing arrangements in order to ensure that effective control is maintained. These changes are defined and set out in a Safety Case Implementation and Improvement Plan. This plan also schedules the delivery dates by which the various changes and work needs to be carried out. Progress on delivery of the actions is routinely reviewed through the Dounreay Safety and Environmental Working Party, which is a management committee set up to review and approve documentation relating to health, safety and environmental issues associated with the site.

Issues identified in the Implementation and Improvement Plan include:

- investigations of areas of known contamination, particularly areas of chemical (non-radioactive) contamination;

- study of areas prior to land developments in order to confirm land quality and evaluate potential waste volumes (in terms of potentially exempt waste, very low level radioactive waste, low level waste and chemically contaminated waste);
- assessment of remedial measures for specific areas of concern;
- improvements to the control measures of specific areas of contaminated land;
- assessment of risks to biota from contaminated land;
- on-going maintenance of the IMAGES records management system;
- review of historical information with respect to potential radioactive and hazardous chemical practices and incidents that could have caused contamination of the subsurface; and
- on the basis of findings from the above, revise the contaminated land inventory and assess the implications to the quantitative risk assessment and exposure scenarios within the Safety Case.

CONCLUSIONS

The development of the Contaminated Land Safety Case at Dounreay has enabled UKAEA to demonstrate effective contaminated land management in line with regulatory guidance. The Safety Case enables systems and site procedures to be modified or developed to support site decommissioning and documents the management responsibilities and interfaces with those involved in aspects of contaminated land management. In addition, the Safety Case presents formally the strategy for contaminated land management at the site and assesses the related safety and environmental impacts. The forward implementation plan will ensure that radiological and chemical risks associated with contaminated land at Dounreay are as low as reasonably practicable.

REFERENCES

1. UK Nuclear Safety Directorate (2001). Guidance for Inspectors on the Management of Radioactive Material and Radioactive Waste on Nuclear Licensed Sites. Appendix 8 Management of Radioactively Contaminated Land. March 2001

2. Coppins G and Ayres M (2003). A Data Management and Geographical Information System (GIS) for the Management of Land Quality on UKAEA Sites. Proceedings of ICEM '03:The 9th International Conference on Radioactive Waste Management and Environmental Remediation September 21 – 25, 2003, Oxford, England

3. Pearl M, Coppins G and Dennis F (2003). Applying UKAEA's Data Management And Geographical Information System to the Development of a Safety Case for Contaminated Land. Proceedings of ICEM '03:The 9th International Conference on Radioactive Waste Management and Environmental Remediation September 21 – 25, 2003, Oxford, England.

4. Hitchins G, Coppins G, Bonniface J and Hitchins G (these proceedings). Contaminated Land Management: Defining And Presenting A Robust Prioritised Programme Using Integrated Data Management And Geographical Information Systems