LLW Repository Ltd

Waste Acceptance Procedure

Waste Characterisation Guide

WSC-GUI-WCH – Final Draft – February 2010

Contents

1. Introduction

LLW Repository Ltd provides a range of treatment and disposal services to Customers across the UK to support the management of lower activity radioactive waste through the Waste Services Contract. Our services include the treatment of metallic and supercompactable wastes as well as the disposal of low level waste. This Guide forms part of LLW Repository Ltd's Waste Acceptance Procedure.

1.1. Waste Acceptance Procedure

The Waste Acceptance Procedure is the collective term used for the arrangements that Customers follow to consign waste to LLW Repository Ltd for treatment and / or disposal. It forms part of the Waste Services Contract and it is a requirement for Customers to follow the Waste Acceptance Procedure when consigning waste to LLW Repository Ltd. This Guide, and the associated Process Diagram, Forms and Templates are also part of the Waste Services Contract.

The Waste Acceptance Procedure is split into a series of logical Processes that cover all aspects of waste management from forecasting through characterisation to treatment and disposal. The Processes are:

- Waste Forecasting
- Waste Assurance
- Waste Characterisation
- Waste Enquiry
- Waste Consignment
- Waste Receipt

Each Process within the Waste Acceptance Procedure can consist of a Process Diagram, a Guide, and various Forms and Templates.

Process Diagrams

Each Process within the Waste Acceptance Procedure is detailed in a Process Diagram. This Diagram highlights the key steps in each process and defines the actions that the Customer, LLW Repository Ltd and the Supplier will take to complete the process.

Guides

Each Process is supported by a Guide, i.e. this document. The Guide provides additional details about each process step, information requirements, actions and the objectives of the Process. The Guide also explains how each Form should be completed and the role of any Templates that LLW Repository Ltd completes.

Forms

Forms are used to provide relevant information at specific points within each Process. The Forms are to be completed by Customers and submitted to LLW Repository Ltd. Forms can be completed electronically and submitted to LLW Repository Ltd by e-mail.

Templates

Templates are completed by LLW Repository Ltd and issued to Customers to provide relevant information within a Process, such as a Quotation or an Approval. Templates will be completed electronically and issued to the Customer by e-mail.

1.2. Process Guide

This Guide provides support to Customers following the Waste Acceptance Procedure to consign waste to LLW Repository Ltd under the Waste Services Contract. It supports the relevant Process by providing details about each process step, the information requirements, key actions and the objectives of the relevant Process. This Guide also details how Customers should complete each Form required by the Process and introduces the Templates that are issued by LLW Repository Ltd. It should be read in conjunction with the Waste Acceptance Procedure Overview document which introduces each Process within the Procedure. The Overview document also explains the types of waste which can be consigned and the pre-requisites that must be met by Customers before using and / or completing a Process.

1.3. Help and Support

If you need any assistance or have any questions regarding this Guide, Process Diagram, or the associated Forms and Templates, please contact the LLW Repository Ltd Customer Team by telephone: (01946) 722000 or by e-mail: customerteam@llwrsite.com

2. Waste Characterisation Process

The Waste Characterisation Process must be completed and approved before a Customer can consign waste to LLW Repository Ltd through the Waste Services Contract. The Waste Characterisation Procedure is the process that Customers follow to provide LLW Repository Ltd with a physical, chemical and radiological characterisation of a wastestream

Customers following the Waste Characterisation Process must define a wastestream with a common radiological fingerprint to allow accurate characterisation of discrete waste packages. The Waste Characterisation Process can be completed at any time in the overall Waste Acceptance Procedure up until the submission of a Waste Consignment Information Form, when it must have been completed.

In addition to this Guide, the Waste Characterisation Procedure consists of:

- Waste Characterisation Process Diagram (Reference: WSC-PRO-WCH)
- Waste Characterisation Form (Reference: WSC-FOR-WCH)

The following sections of this Guide explain the Process Diagram and introduce any Templates produced by LLW Repository Ltd. The Appendices provide guidance on the subject of waste characterisation and the relevant information required to complete the Waste Characterisation Form associated with this Process.

2.1. Waste Characterisation Guidelines

Waste characterisation can be carried out in many different ways. LLW Repository Ltd recognises that each Customer will have a different approach to waste characterisation and may have developed their own procedures and techniques to follow. Given the wide range and diversity of lower activity radioactive waste, it is not practical to produce a Waste Characterisation Process that will comprehensively cover the full range of waste that needs to be characterised nor the techniques that could be used to do so.

The approach taken by LLW Repository Limited is to provide this guide to detail the steps that must be followed to complete the Waste Characterisation Process. The main body of this guide does not provide any information on how to characterise waste as it is up to the Customer to determine the best approach for their specific circumstances. However, in Appendix 1 of this guide LLW Repository Ltd has provided Waste Characterisation Guidelines that give an introduction to the subject of waste characterisation. These Guidelines are not mandatory but simply offer some advice to Customers when developing their waste characterisation plans.

Ultimately, it is up to the Customer to determine the processes and procedures that they will adopt to characterise their waste. This information must be summarised in the Waste Characterisation Form and LLW Repository Ltd will review the completed Form and determine if it can be approved.

2.2. Review Criteria

As this Guide does not provide a prescriptive approach for Customers to follow when characterising their waste, it is recognised that there will be variations in the quantity and quality of information provided within each Waste Characterisation Form. However, LLW Repository Ltd must review each form and determine if it can be approved. To support Customers when preparing a Waste Characterisation Form, this section of the Guide outlines the Review Criteria that LLW Repository Ltd uses to consider the acceptability of the Form.

For operational and regulatory purposes, LLW Repository Ltd must have an accurate knowledge of the physical, chemical and radiological properties of the waste consigned for treatment and / or disposal. This knowledge is entirely based on the descriptions submitted by its Customers through the Waste Enquiry, Waste Characterisation and Waste Consignment Processes. It is LLW Repository Ltd's duty to ensure that the characterisation methods used in those processes are of a sufficient quality, and are suitable for the waste forms to be consigned.

LLW Repository Ltd's overall objective for waste characterisation is to ensure that waste is adequately characterised so that it can be segregated to the most appropriate waste treatment or disposal route. The characterisation should also be as realistic as possible to minimise pessimistic assumptions that lead to over declaration of activity content in the Waste Consignment Information Form as this artificially uses up the radiological capacity of the Low Level Waste Repository with "phantom activity".

In reviewing a Waste Characterisation Form, LLW Repository Ltd considers the following aspects:

- Robustness of the Characterisation Process
- Relevance to the Selected Treatment or Disposal Option
- Radioactivity Content Trigger Levels
- Suitability of Activity Assessment Methods

Robustness of the Characterisation Process

LLW Repository Ltd realises that characterisation must be fit-for-purpose and that the level of effort required may vary significantly to achieve the same level of confidence in the declared results of the characterisation process. LLW Repository Ltd also recognises that there may be constraints on the level of characterisation that the Customer can achieve due to a range of issues such as safety and regulatory considerations. To rationalise the decision making

process, the wastestream will be considered based on its complexity and the stability of its fingerprint over time taking into account Customer constraints.

The complexity and stability of the wastestream will be inferred from the waste history and process knowledge detailed in the Waste Characterisation Form or through discussions with the Customer.

The complexity refers to the number of contamination processes, contaminants and difficult-to-measure radionuclides in the fingerprint. A simple waste type will consist of only a few radionuclides that are all easy to measure or easy to correlate, usually as a result of a single source of contamination in a well described process. A complex waste form has multiple radionuclides, from complex or multiple processes, and usually requires extensive laboratory analysis to be fully characterised.

The stability refers to the variability of the radionuclide array over the time period of the wastestream as defined in the Waste Characterisation Form. A stable wastestream will always exhibit the same radionuclides in the same ratio, while variable wastestreams will show various radionuclides, or radionuclides in various ratios in different waste consignments. The variability may be the result of a process with waste of various origins, or waste from the decommissioning of a large area with various contamination and contaminants sources.

Complexity and stability are considered together to give four types of wastestream as follows:

Type	Process Examples
Simple / Stable	Spent Sources Spent Fuel Enrichment Fuel Fabrication
Complex / Stable	Power Generation Reprocessing
Simple / Variable	Some Laboratory Wastes
Complex / Variable	Legacy Wastes Some Decommissioning Wastes

The waste characterisation process, both for fingerprinting and for characterising waste packages, will be easier for simple and stable wastestreams than for complex and variable wastestreams. Correspondingly, different levels of effort will be expected from Customers for characterisation depending on the complexity and stability of the waste described in the Waste Characterisation Form. For each type, the following information would be required either presented within the completed Form or references to relevant detailed documentation:

Type	Information Requirements

Type	Information Requirements
Simple / Stable	Process Knowledge + Radionuclide(s) Used + Analysis Results + Fingerprint Calculation
Complex / Stable	As for Simple / Stable plus a justification for waste consignment characterisation method
Simple / Variable	As for Complex / Stable plus justification for the wastestream definition and / or geographical extent
Complex / Variable	As Simple / Variable plus case by case specific requirements

The Waste Characterisation Form will be reviewed in line with these information requirements. Customers are advised to seek guidance from LLW Repository Ltd before completing a Waste Characterisation Form to support the development of their waste characterisation activities.

LLW Repository Ltd will consider any sampling that has taken place in relation to the complexity and stability of the wastestream and quantity of waste to be covered under the fingerprint. Where the waste is complex and variable, it is anticipated that a wide ranging sampling campaign would be completed to fully define an appropriate fingerprint or that the wastestream has been broken down into smaller portions that allow it to be considered less complex and variable.

Relevance to the Selected Treatment or Disposal Option

The level and form of waste characterisation required is closely linked to the treatment or disposal route selected for the waste. If the waste is to be segregated into lower categorisations or even characterised as being exempt from regulatory control, it is likely to require more intensive characterisation. LLW Repository Ltd will therefore review the methods and techniques that have been used in light of the Customer's chosen treatment or disposal route.

Radioactivity Content Trigger Levels

For waste to be consigned to the Low Level Waste Repository for disposal, it is important to consider the overall impact of the wastestream on the radiological capacity of the facility. LLW Repository Ltd has therefore set trigger levels that it uses to review each Waste Characterisation Form. Exceeding a trigger level does not necessarily mean the Waste Characterisation Form could not be accepted. The trigger levels apply to the total activity content and the specific activity set at the following levels:

Radionuclide	Total Activity Trigger Level (Gbq)	Specific Activity Trigger Level (Gbq/t)
Uranium	90	0.09
Radium-226 & Thorium-232	9	0.009
Other Alpha emitters	90	0.09
Carbon-14	15	0.015
Iodine-129	15	0.015
Tritium	3,000	3.0

Radionuclide	Total Activity Trigger Level (Gbq)	Specific Activity Trigger Level (Gbq/t)
Cobalt-60	600	0.6
Other Radionuclides[1]	4,500	4.5

[1] Others also includes the Cobalt-60 content of the waste

Suitability of Activity Assessment Methods

Whilst the definition of the fingerprint is key to successfully characterising waste, it is equally important to accurately assess the activity that is to be declared on the Waste Consignment Information Form. LLW Repository Ltd will therefore review the proposed activity assessment methods for a wastestream looking for robust processes that will improve the accuracy of the declaration.

2.3. Waste Characterisation Form Validity

The Waste Characterisation Form and the associated wastestream will be valid for three years once approved by LLW Repository Ltd. The Form must therefore be reviewed on a frequency of not less than every three years but changes to the characterisation information may force early review.

When the Waste Characterisation Form is due for review, the Customer must consider any changes that have taken place since the characterisation information was prepared and re-validate the wastestream. In cases where the characterisation remains valid, the Customer may re-submit the Form with an update to state that the waste characterisation remains valid. Where there are changes, the Customer must submit a new form detailing the revised waste characterisation. In all cases, a Waste Characterisation Form must be approved by LLW Repository Ltd before the wastestream can be used to consign waste.

Customers should also consider changes during the three year validity period that would impact on the waste characterisation. This could include changes in activity assessment techniques, additional samples that show changes in the fingerprint or a change in the status of a facility as it moves from operations to decommissioning. Where the changes do impact on the original characterisation information, Customers must submit a new Waste Characterisation Form for approval.

2.4. Process Diagram

The Waste Characterisation Process Diagram can be found in the Customer section of LLW Repository Ltd's website: www.llwrsite.com

The Process Diagram outlines the key process steps and responsibilities within each Process of the Waste Acceptance Procedure. There are three rows on the diagram to represent the actions and responsibilities of each Party:

- Customer
- LLW Repository Ltd
- Waste Treatment and / or Disposal Service Supplier

Each action or responsibility identified in a Process Step will be undertaken by the relevant party. In general, these actions and responsibilities may be carried out by any person working for or on behalf of the relevant organisation. However, in certain situations, it may be necessary for steps to be taken by a key role holder identified in the Waste Services

Contract. The vertical dotted lines on the Process Diagram split the process into sub-sections that represent key points in the process such as the submission of a Form or the approval of a submission. These sub-section markers are designed to aid navigation through the steps.

2.5. Step by Step Guide

This Section provides a detailed Step By Step guide through the Process Diagram identifying actions, roles and responsibilities and performance measures within the Waste Characterisation Process. The Step Numbers relate directly to the Waste Characterisation Process Diagram.

The Waste Services Contract places responsibilities upon the Service Manager and the Customer Representative for the Waste Characterisation Process. This Step by Step Guide should therefore be read in conjunction with the relevant sections of Schedule 1 of the Waste Services Contract – Conditions of Contract.

LLW Repository Ltd has identified Performance Measures within the Step by Step Guides of each Waste Acceptance Procedure process. A Performance Measure means a set timescale for completing a step within the Waste Acceptance Procedure. If the process step cannot be completed in this timescale, the Service Manager and the Customer Representative may agree additional time to complete the process step. Failure to meet a Performance Measure by any Party will not invoke any formal contractual action. However, regular poor performance against one or more Performance Measures will be discussed by the Service Manager and the Customer Representative to identify actions to improve performance.

Step	Process Guidance, Actions and Performance Measures	Responsibility
1	The Waste Characterisation Process ensures that waste is characterised in advance of Customers using LLW Repository Ltd's Waste Treatment and Disposal Services. Customers must determine the volume of waste to be characterised though it must all have the same radiological fingerprint.	Customer
2	LLW Repository Ltd can provide advice, guidance and support to Customers at any stage during the Waste Characterisation Process. It is best to engage early to ensure that the identification of the waste volume and the characterisation activities will meet LLW Repository Ltd's requirements.	Customer / LLW Repository Ltd
3	The Customer will need to develop background information about the waste, such as the process and waste history. This information can then be used to develop a Waste Characterisation Plan which will define how the activities that need to be completed, such as sampling, will fully characterise the waste. Customers are encouraged to share their plans with LLW Repository Ltd prior to carrying out sampling and analysis.	Customer
4	Once the plan of characterisation activities has been identified,	Customer

Step	Process Guidance, Actions and Performance Measures	Responsibility
	the Customer will then follow the plan and complete activities such as waste sampling, analysis and interpretation of the sample results.	
5	Information gathered through the completion of the waste characterisation activities is documented in the Waste Characterisation Form along with information on how the waste will be managed. Once complete, the Form can be submitted to LLW Repository Ltd for review.	Customer
6	On receipt of the Waste Characterisation Form, LLW Repository Ltd will review the content, and where necessary provide comments back to the Customer. *Performance Measure:* LLW Repository Ltd will provide a response to the Waste Characterisation Form within 30 working days.	LLW Repository Ltd
7	LLW Repository Ltd will approve the wastestream and return the signed Waste Characterisation Form back to the Customer if no queries or issues have been identified during the review. If they have any queries or comments, they will be fed back to the Customer and discussed as necessary.	LLW Repository Ltd
8	Where additional action or information is required, the Customer may enact LLW Repository Ltd recommendations or arrange discussions with LLW Repository Ltd to agree the requirements of the revised submission.	Customer
9	The Customer should incorporate any agreed amendments into the Waste Characterisation Form. The Customer then re-submits the Form for review. Where a revised form is submitted LLW Repository Ltd will attempt to review and approve the re-submitted Form more quickly than a new Waste Characterisation Form submission.	Customer
10	Following the decision to approve the submitted Waste characterisation Form, LLW Repository Ltd will request a signed copy of the agreed Waste Characterisation Form from the Customer.	LLW Repository Ltd
11	The Customer signs the Waste Characterisation Form and returns the signed copy to LLW Repository Ltd.	Customer
12	LLW Repository Ltd signs the approval section of the Waste Characterisation Form and returns the full approved version back to the Customer.	LLW Repository Ltd
13	LLW Repository Ltd will issue the Waste Characterisation Form	LLW Repository Ltd

Step	Process Guidance, Actions and Performance Measures	Responsibility
	to any Waste Services Supplier that requires the information to carry out the relevant treatment and / or disposal service.	
14	The Waste Services Supplier will use the information provided in the Waste Characterisation Form to carry out the relevant treatment and / or disposal service.	Supplier

3. Forms

3.1. Waste Characterisation Form

The Waste Characterisation Form is to be completed by Customers wishing to use LLW Repository Ltd's waste treatment and / or Disposal Services through their existing Waste Services Contract or for new customers seeking approval of a Quantity of Waste for Treatment and Disposal prior to contracting with LLW Repository Ltd.

Customers using the Waste Characterisation Form must define a quantity of waste. However, this can be for almost any waste volume for any of the Treatment and / or Disposal services, such as a one-off large item, a single or multi-year operational wastestream, an entire decommissioning project or a single consignment of mixed waste, provided that all wastes share a common radiological fingerprint.

The Waste Characterisation Form must be completed as fully as possible. However, it remains a summary document of the information the Customer has gathered. It is therefore acceptable to provide references to more detailed information as required. LLW Repository Ltd may require access to referenced documents to complete the review of the Waste Characterisation Form. Where sections are not applicable or cannot be completed, Customers should state the reason why.

The Waste Characterisation Form requires Customers to complete the following sections:

Section	Purpose
Customer Information	Provides essential Customer Information and Contact Details for use in conjunction with the Waste Enquiry Process
Wastestream Identification	Information about the wastestream itself including identification code, links to previous wastestreams and effective dates
Waste Information	Details the background to the wastestream against the key elements: waste description, waste origin, facility history, facility status, and information sources
Waste Sampling	Provides details of the sampling, testing or other activities that have been completed to support the development of the wastestream
Radiological Properties	Defines the waste fingerprint on the basis of the sampling and analysis carried out

Section	Purpose
Physical Properties	Details the nature of the waste including any restricted materials and how they will be controlled
Waste Conditioning	Describes any conditioning that must be carried out to make the waste suitable for the relevant treatment or disposal option
Activity Assessment	Provides information on the activity assessment techniques to be used including equipment selection
Waste Packaging	Defines the proposed packaging options to used to consign waste from the wastestream
Supporting Information	Provides details of optioneering assessments that have been carried out and any relevant reference documents
Customer Declaration	This reminds Customers of responsibilities accepted by signing the Form and following the Waste Acceptance Procedure. There are also sub-sections that are used by LLW Repository Ltd to approve the wastestream and process and monitor the progress of the Waste Characterisation Form.

Appendix 2 provides page by page visual guidance to support Customers in completing the Waste Characterisation Form.

4. Templates

There are no Templates associated with the Waste Characterisation Process. All the required information is addressed in the Waste Characterisation Form.

Appendix 1: Waste Characterisation Guidelines

1. Introduction

These Waste Characterisation Guidelines have been developed to support Customers in characterising their waste. They simply provide an introduction to the key features of waste characterisation and some techniques that can be applied by Customers. They are not mandatory. Waste characterisation is a vast subject and these Guidelines do not provide a comprehensive guide to all possible methods. The methods presented in the document do not constitute a rigid list of approved techniques and alternative methods not presented here may be better suited to specific applications.

1.1. Scope

These Guidelines are intended for a wide audience and cover topics of interest to all waste producers. Advice is provided on waste quantity definition, fingerprinting and best practice in measurement techniques with the focus on characterising a waste consignment's radiological properties prior to disposal at the Low Level Waste Repository.

In addition to the radioactive components, radioactive waste may contain non-radioactive components, such as heavy metals and organics, which can result in harmful effects on human health and the environment. In some cases, radionuclides can exhibit chemical toxicity as well. The treatment or disposal of radioactive waste containing such hazardous materials must comply with appropriate regulations and their properties need to be well defined, quantified and taken into account in the selection of treatment and disposal options.

1.2. Objectives

The objectives of these Waste Characterisation Guidelines are:

- To provide guidance to support Customers completing the Waste Characterisation Form (WSC-FOR-WCH) and the radiological elements of the Waste Consignment Information Form (WSC-FOR-WCI)
- To provide guidance on characterisation as a strategic process in waste management, from selection of a waste quantity for disposal to consignment characterisation prior to treatment and / or disposal
- To provide guidance on characterisation method selection for different solid waste types and packaging, covering several techniques, such as: Process Knowledge, Destructive Assay (DA) and Non Destructive Assay (NDA)

Customers using a waste characterisation approach that follows these Guidelines should be able to routinely perform waste characterisation that:

- Allows segregation of waste for treatment and / or disposal, in particular, the segregation of very low level waste from low level waste
- Does not require excessively conservative assumptions to ensure that low level waste radiologic limits are not exceeded.
- Minimises the fraction of declared activity which is not actually present in the waste, i.e. the "phantom activity", when consigning waste for treatment and / or disposal

2. Characterisation Strategy

The purpose of waste characterisation is to allow proper control of radioactive waste management to be exercised through all steps of the waste lifecycle. A strategy for waste characterisation must be established before production of waste to allow proper planning of treatment and disposal of the waste in accordance with the relevant Waste Acceptance Criteria. The Customer must determine the level of effort that is required to characterise their waste on the basis of a range of considerations. Usually, waste characterisation will use one or more methods from the following:

- ***Process knowledge (PK)***: process knowledge is the sum of information that can be assembled on the process(es) that generated contamination and the material being contaminated and/or activated. It covers normal and incidental operations. It must always be used to define the scope and extent of the following steps required to properly characterise waste. The knowledge of the process and any incidents is required to select the proper radionuclides that must be analysed and quantified, and therefore the sampling methods and type of sampling used, while the extent and relative levels of the contamination on material/equipment and building structures defines the size and locations of the sampling campaign.

- ***Destructive Assay (DA)***: usually conducted in the lab on samples, it is an accurate characterisation method that can access information which other methods cannot reveal, such as alpha radioactivity within the waste, or soft beta activity. The overall results are dependent on how representative the samples collected for analysis are, making the sampling campaign planning a key phase for the success of the DA. Key questions must be answered in the planning phase, such as: How many samples are required? Where should they be taken? What type of sampling is required? As the analysis techniques are very selective, the scope of the analysis must be carefully selected using process knowledge information to decide what radionuclides to measure.

- ***Non Destructive Assay (NDA)***: NDA methods are used for in-situ analysis or to quantify the activity of a waste package for a specific or a list of specific radionuclides, or for total Gamma, Beta or Alpha activity. NDA covers a very wide range of assays with different purposes and different levels of accuracy and resolution. The selection of the proper and fit-for-purpose method(s) requires the prior knowledge of the objective of the measurement, and the possibilities and limitations of the diverse methods available.

The strategy for waste characterisation will add value if characterisation is carried out at the appropriate time in the waste lifetime and the following guidelines should be considered when planning long term waste management strategy.

1. In general, waste characterisation performed on limited quantities of waste, as opposed to assaying transport or disposal containers:
    - Is easier and more accurate, delivering improved quality cost effective data
    - Requires less assumptions, often pessimistic, leading to over-declaration of activity
    - Suffers less from inaccuracies due to self-absorption of radiation
    - Does not require multiple handling of the waste.

2. Early characterisation typically has better access to process knowledge compared to deferred characterisation where information may be more difficult to locate or may be unavailable.

3. Wastestream Definition

The Waste Characterisation Process within the Waste Acceptance Procedure does not explicitly define a wastestream. This is to allow Customers to decide on how best to define and categorise their wastes for characterisation purposes. The quantity should primarily be defined by its Nuclide Vector, or fingerprint, and therefore the waste to be characterised must share a common history and geographical and / or process origin. The quantity of waste may be a single wastestream or a group of wastestreams that share a common fingerprint. In these guidelines, the waste quantity will be referred to as the wastestream.

The wastestream should be defined with the objective of a fingerprint as simple and as constant through the wastestream as practicable. This will ensure the ease and accuracy of future characterisation for specific waste consignments and the correct application of the Waste Acceptance Criteria.

Defining a quantity of waste for treatment and / or disposal should be initiated by a thorough desk study to identify the potential causes of contamination and their geographical spread with their relative amounts. A waste quantity should be made up of waste contaminated with a single source or multiple sources with a ratio of contaminants as constant as practicable, which may have been present simultaneously or sequentially.

The validity of the desktop model will be assessed during the fingerprint analysis and will be apparent from the distribution of the radionuclides in the samples analysed. A valid wastestream should have at least one radionuclide present in similar relative abundance in all samples.

Where contaminated and activated waste is found within a wastestream, a cautious approach must be taken to activity assessment, which may include model calculations and measurements as activation products and contamination may be responsible for varying relative abundance within a waste quantity.

4. Waste Fingerprint

The fingerprint is the list of radionuclides, with their proportion related to total activity, which are anticipated in any part of the wastestream and with any waste package. A wastestream is characterised primarily by its fingerprint, so, ideally all waste items and waste consignments should display the same radionuclides in the same proportion. However, some degree of variation is always anticipated within any fingerprint, especially for those associated complex or variable wastestreams.

Knowing the fingerprint, it is possible to assess the total activity of a waste quantity by measuring only the activity of one radionuclide and inferring all others, based on their relative amounts to the measured radionuclide.

Defining a fingerprint is likely to comprise the following steps, each one listed below with its main objective:

- **Desktop Study:** To list all potential radionuclides present and map the spatial distribution of activity using plant history as the basis of the assessment
- **Selection of Potential Treatment or Disposal Routes:** To consider any specific Waste Acceptance Criteria requirements and the required radionuclides to report in the fingerprint
- **Sampling Campaign Planning:** To ensure completeness and balance of radionuclides in samples by targeting all nuclides identified in the Desktop Study and work with the selected laboratory to define the sampling type / quantity requirements
- **Sampling:** Collect good quality sample for analysis and despatch undisturbed to the selected laboratory
- **Sample Analysis:** To measure the selected radionuclides activity in samples
- **Analysis Results Review:** To compare the results against the sampling plan and the desktop study to ensure accuracy of sample analysis data
- **Fingerprint Calculation:** To calculate the relative amount of each reported radionuclide from the sample analysis results and the relative radionuclide contamination in the wastestream

The use of a fingerprint to assess other radionuclides activity is only advisable when the following conditions are met:

- An easy-to-measure (measurable by non-destructive assay) radionuclide or key nuclide (KN) is present in relatively constant proportion to other radionuclides
- The KN represents a significant proportion of the waste activity

The fingerprint should be used to infer the total waste activity, and the activity of difficult-to-measure radionuclides. Radionuclides other than the KN which can readily be measured by Non Destructive Assay should not be inferred from the KN activity. More than one KN may be used for improved measurement.

4.1. Desktop Study

The objective of a desktop study is to define the list of radionuclides potentially present in the wastestream, their spatial distribution and the relative activity of the various components: areas, items, etc.; contributing to the total activity of the wastestream.

Specifically, the fingerprint desktop study will consider the factors listed below:

Facility History or Processes:

The plant history, accessed from construction and operational records, health physics records, and operator's experience, including where possible operators from various phases of the plant history, or the current operational processes can be used to define:

- The various processes or activities carried out in the plant including a list of the radioactive products that were present in the process. All data from previous sampling, waste analysis, feed and products records should be used at this stage
- The mechanism by which the waste has become contaminated must be understood and will dictate the acceptable methods for sampling: hot, or acidic or liquid environment in a process may induce fixed contamination that cannot be accessed with swabs

- For each phase in the plant's history, a model of the spatial distribution of contamination and any relevant health physics records. This will allow the relative contribution of each plant area to the total activity to be assessed
- Accidental or incidental contamination that may be responsible for a variation in contamination levels and may differ from the average fingerprint. These are likely to be identified in relevant operational and health physics reports. The mechanism and geographical area of contamination are often different from those of normal process contamination and specific sampling method may be required

Selection of Potential Treatment or Disposal Routes:

The selection of a treatment or disposal route for a wastestream is primarily based on the physical form of the waste, and its expected activity. The selected treatment or disposal facility may specify in its Waste Acceptance Criteria the requirements for activity and fingerprint reporting including a list of radionuclides which must be included in the fingerprint analysis.

More than one treatment or disposal route may be anticipated, a careful review of the different Waste Acceptance Criteria will allow a selection of radionuclides that will enable future flexibility in the waste management.

4.2. Sample Campaign Planning

The validity of sampling and analysis data is highly dependent upon a defensible sample plan. Defensible sample plans must encompass every aspect of the sampling process from collection of the sample to reporting of the analytical results.

The wastestream must be sampled for radioisotopic analysis to determine the fingerprint. An appropriate sample programme ensures that all radionuclides are represented in a sample that can readily be analysed by the selected laboratory.

The sample plan must target areas with high contamination. The presence of contamination at detectable levels in the samples enables an easier analysis providing meaningful results. The sampling plan must ensure that all contamination streams are represented to quantify the radionuclides present which will enable the generation of the fingerprint. It is, in that respect, very different from a sampling campaign targeting the assessment of the wastestream activity, for which random samples would be collected. For that reason, the same sample plan cannot be applied to derive both the average activity and the fingerprint of the wastestream. However, these two objectives may be achieved within the same sampling campaign.

Due to the volatility and mobility of tritium the presence of tritium in a process must trigger specific sampling and treatment methods to assess tritium presence and migration in the various components of the wastestream

A good sample plan will be derived from an appropriate desktop study. For example, knowledge of the plant history will provide the spatial distribution of contamination and range of radionuclides likely to be present and the heath physics records will indicate where contamination is found in higher quantities. The sampling plan should:

- Target all radionuclides likely to be present
- Target different areas of the structure from which the wastestream originates

- Target all types of contamination process: loose contamination for airborne or low temperature contamination, fixed contamination when a fixating process is suspected from the plant history, high temperature process, use of fixative, successive paint coats on contaminated areas etc. Swabbing may be used if contamination was deposited: 1) in non aggressive conditions i.e. conditions not conductive to contamination being engrained in the material, 2) at low temperature, if only one source of contamination is present or if the contamination is loose rather than fixed. In aggressive conditions – high or low pH, strong oxidising or reductant environments, contamination may penetrate metal and other materials. If contamination deposited may have been fixed by paint or fixative, then surface swabbing will not have meaningful results and intrusive sampling is required
- Target sample collection on areas where known contamination levels will yield meaningful analysis results
- Include enough samples to ensure a statistically representative sampling of the wastestream, given its size and the complexity of its history, including incidental or accidental conditions.

Early discussion with the selected laboratory is required to ensure the suitability of the sample form and size for Destructive Analysis.

The number of samples must be sufficient to accurately assess the ratio of radionuclides and to identify any variation in these ratios.

When Customers are characterising legacy wastes, which in some cases are already conditioned, it is recognised that sampling opportunities may be limited. Customers should use the Waste Characterisation Form to detail what radiological information is available. Advice can be sought from LLW Repository Ltd to help determine a suitable sample plan.

4.3. Sampling

Laboratories have limitations on the nature and the size of the samples they can process. There are many sampling techniques available and the selection of the right one is entirely dependent on the waste's physical composition and the nature of the contaminants. The quality of the sampling process is important and prior agreement with the selected laboratory before collecting and sending samples is essential. The following principles should be followed:

- Samples should not be disturbed or further contaminated after being collected
- Samples should be immediately packaged into a suitable container, ensuring that the samples will remain undisturbed when sent to the selected laboratory
- Samples may benefit from being bulked for analysis where there are many small samples with low activity levels
- Samples must be adequately labelled to ensure that each sample is traceable back to a record of its precise location
- Care should be taken to ensure that the method of sample collection is appropriate to the contamination present, i.e. heat inducing, mechanical sampling methods may not be suitable for use where tritium or other gaseous nuclides are present as it may lead to the nuclide being under represented in the sample
- Sample preparation requirements should be identified
- Surface swabbing may be used. Work with the laboratory to select the swabbing media and the swabbing area in relation to the contaminant concentration
- Care should be taken to avoid cross contamination of samples

4.4. Sample Analysis

The objectives of the sample analysis are:

- To identify the principal radionuclides
- To identify a radionuclide easily measurable for future measurements, i.e. the key nuclide (KN)
- To quantify the relative activity of the principal radionuclides

Several methods may be available, and the choice will be made on the basis of:

- Expected level of accuracy
- Costs
- Delay

When practical, the analysis should only be performed in a laboratory which has obtained an independent quality certification for the selected process.

The results of the analysis may modify the original selected treatment and /or disposal route or may require additional or alternative samples to be taken and analysed. A comprehensive review of the results is necessary before the fingerprints are used in the Waste Characterisation Form.

4.5. Analysis Results Review

The review of analysis results data has the following objectives:

- To check that the results are consistent with the available data sources
- Presence of all expected radionuclides
- To confirm that the sum of activities from identified radionuclides is consistent with measured total activity
- The accuracy of the analysis is consistent with the requirements of the sample plan If not, the quality of the sampling should be improved and new samples taken
- The uncertainty is kept below a defined value consistent with the requirements of the sample plan. If not, the sample plan may need to be reviewed

The possibility of consigning waste that does not comply with the relevant Waste Acceptance Criteria of the relevant treatment and / or disposal facility must be avoided by selecting a wastestream with a restricted variation of radionuclide ratios. Highly variable ratios in samples originating from different areas indicate uncorrelated origins. If this is the case, it may be beneficial to divide the wastestream into smaller portions with each one representing a more homogeneous population.

When this splitting option is not possible, great care must be taken to assess the contribution of the various areas to the total activity of the wastestream and the fingerprint ratios must be weighted to the proportion of the total activity due to a specific area and the radionuclides associated. If achieved, the activity of any specific sample might be under- or over-estimated, but the overall activity of the wastestream will be correctly assessed.

4.6. Fingerprint Derivation

When deriving a fingerprint, a decision must be made to select the list of radionuclides to include and the key radionuclide to which other radionuclides relative abundance will be referred to.

The fingerprint requires the evaluation of the relative contribution of the different areas sampled to the total wastestream activity. The relative activity of each radionuclide in the sample is weighted by a coefficient representing the contribution of the area of origin of the sample to the total wastestream activity.

The radionuclide's activity should be normalised before deriving the fingerprint, to avoid over-representation of higher activity samples.

5. Activity Assessment

Once a Waste Characterisation Form has been reviewed and accepted by LLW Repository Ltd, Customers can begin the process to consign waste from that wastestream to LLW Repository Ltd. The radiological information required for treatment and disposal services is detailed in the Waste Consignment Information form. It includes activity for a list of radionuclides and total alpha and non-alpha activity.

The method used for determining activity must be detailed in the Waste Characterisation Form. When possible, methods using direct measurement of a key radionuclide and inferring activities from other alpha and beta radionuclides using the fingerprint ratios are preferred. Surface contamination values may be used to derive bulk activity. Methods relying on computer models and calculation codes are used when measurement is not possible.

Whilst the fingerprint represents an average of the radionuclide array over the wastestream lifetime and variations in the radionuclides found in specific waste consignments are accepted, the activity assessment method(s) described in the Waste Characterisation Form must apply to the full range of waste consignments to be consigned using the fingerprint. The method of activity assessment should therefore be appropriate to the fingerprint and when a key radionuclide is selected for activity assessment it must be present in all contamination sources / samples, with sufficient abundance, and be measurable in all waste packages. It is acceptable to have a range of activity assessment methos in one Waste Characterisation Form and to use these for different waste consignments and types of waste being consigned under the same fingerprint.

This section presents methods that may be used to assess activity.

5.1. Bulk Measurement

Alpha Measurement

Alpha bulk measurement is not usually possible for waste packages, as alpha particles travel only a very short distance within solids, a few microns, and therefore most of the alpha particles cannot be detected, even on contact. Instead, radiochemistry must be used on samples obtained from the waste and prepared for analysis. The samples must be representative of the waste content for the results to be valid. This method works with homogenous waste.

Beta Measurement

Beta particles travel a short distance, and although this distance is greater for beta than it is for alpha particles, direct bulk measurement is not usually possible. Only high energy beta emitters may in some circumstances be measured directly. With some beta emitters, such

as H-3 (Tritium), Ni-63 and C-14, no direct measurement is possible, and radiochemistry must be used in the absence of alternative methods. However, in some cases, beta measurements are preferable to gamma measurements because there is reduced sensitivity to other radionuclides in the vicinity.

Gamma Measurement
Gamma measurement is widely used and provides good results when a correct fingerprint or a robust model relating activity to dose rate is available. A large range of equipment is available for gamma bulk measurement, adapted to a large range of operational and quality requirements, from simple hand-held dose rate meters to sophisticated systems based on hyper pure Germanium detectors.

When measuring bulk activity, some recurring issues affect the measurement, regardless of the method and the equipment used:

- **Background Radiation:** The background levels should be as low as reasonably practicable and should be subtracted from the readings measured from the package

- **Radiological Homogeneity of the Waste:** Contamination may not be homogenously distributed in the waste package. Several measurements, on different faces of the package need to be taken. Depending on the method used, either an average or the maximum value will be used for activity calculation. Other methods may be used to reduce the effect of heterogeneity, such as conveyor belt measurement, rotating platforms, sub-sampling of packages and package content modelling

- **Physical Homogeneity of the Waste:** Different physical matrices in the waste package will cause absorption, and measured dose rate, to vary. This effect may induce large errors in the assessed activity. When using a detector with spectrometric capability, it may be possible to use the differential absorption of multiple gamma peaks, that originate from the same radionuclide, to estimate the absorption factor, if required. Systems have been specifically designed to estimate and compensate for the heterogeneity in density / absorption rate, as a tomographic model

5.2. Dose Rate to Activity Conversion

This method relies on the measurement of gamma emitting radionuclides from the waste package. It applies only to waste packages emitting gamma radiation with a dose rate sufficiently above the background radiation levels.

When no spectrometry capability is present on measuring equipment, the activity must be derived from a dose rate to activity conversion factor (ACF). This conversion factor may be obtained experimentally, by measuring packages containing similar waste of known activity, determined by analytical or spectroscopic method, or computed using a computer model. Deterministic or Monte-Carlo models require that waste is correctly described in terms of radionuclides, matrix, density and standard package geometry. Obtaining a robust ACF may require both methods to be combined and cross-checked. The method used to derive the ACF must be detailed in the Waste Characterisation Form. The conversion factor will only apply to dose rates taken on packages using a standard geometry.

The dose rate measurement operating process and the repeatability of the conditions: distance to package, background measurement, detector calibration, void spaces in the waste; are critical in achieving good results with this method. Several issues must be

considered, such as constant source to equipment distance, edge-effects where the equipment sees only part of the package. It may be preferable, when the dose rate is sufficient, to measure the dose rate at a distance allowing a large fraction of the package to be "viewed" by the detector. Contact dose rates should not be used. Instead, average dose rates at a known distance should be used.

Equipment
This method may be applied using simple hand-held dose rate meters. The rate meter type must be specified in the measurement procedure and have a suitable counting efficiency and energy response.

An improvement to the method is achieved with detectors associated with a counting window, which limits the energy of the counted gamma photons below a threshold, or above and below thresholds. Carefully selecting the threshold in relation to the potential contaminant radionuclide improves the measurement by rejecting interfering radionuclides.

Large detectors may be used in a fixed installation, with better total efficiency and the availability of shielding to prevent background radiation from interfering with the measurement.

Potential Problems
As the method usually relies on direct readings on a rate meter, with the detector being moved around the package to measure the activity, several errors may affect the result:

- **Reading:** Not allowing sufficient time for the reading to stabilise
- **Adequate Use of the Probe:** Variable distances to the package, the probe being fully covered by the package, edge effects and variations in measurement times
- **Background Radiation:** Not selecting s low background area, not ensuring the background radiation is consistent in all directions when measuring the different faces of a package.

5.3. Spectrometry to Activity Conversion

Spectrometry will identify discrete radionuclides by the energy of the peaks in the gamma spectrum. The most common way of deriving the activity is to measure the activity of a key radionuclide, then apply scaling factors from the fingerprint to derive the activity of all the other radionuclides. Scaling factors define the relationship between readily detectable radionuclides and other radionuclides. The list of detected radionuclides and their specific ratios in the total activity are defined by the fingerprint. The total activity of the contaminating radionuclides is determined by dividing the directly measured radionuclide activity by the fraction of activity from that radionuclide in the fingerprint. The activities of all other radionuclides are obtained by multiplying their respective activity fractions, from the fingerprint, by the total activity. Alpha and beta contamination can be inferred from the key gamma radionuclide.

At least one key radionuclide must be present in sufficient concentration that it can be accurately quantified with appropriate equipment.

Equipment
There is a very large choice of equipment available for gamma spectrometry, from handhelds to complex systems. Detectors of several technologies exist, and differ, among other factors, by their resolution and their counting efficiency.

A higher resolution will allow separation of nearby energy peaks, and a better separation of radionuclides. It is essential with complex fingerprints, or fingerprints mixing radionuclides with energy peaks at near-similar energies, when there are a number of other radionuclides in the waste which could otherwise interfere with the measurement. High Resolution detectors are commonly made of hyper-pure Germanium (Ge) crystals.

The intrinsic counting efficiency is the ratio of the number of counts detected to the number of photons reaching the detector, and is independent of the source / detector geometry. However the most significant efficiency is the absolute full-energy peak efficiency. This is the ratio of the number of full-energy counts detected to the number of full-energy photons emitted by the source. This parameter makes it possible to convert the sample activity to the number of counts detected. As increasing resolution and efficiency are associated with higher equipment price, a decision will be needed to invest wisely with consideration for the expected radionuclides and activity to be measured. It must be remembered that to achieve the same measurement quality with a lower efficiency detector will require increased counting time and thus potentially higher operating costs.

Potential Problems
Without going into problems exhibited by different types of equipment, the following generic issues must be considered:

- Proximity of energy peaks may render some radionuclides detection difficult, when peak resolution is not sufficient. The presence of other radionuclides peaks (where available), or of the radionuclide progeny, can be used to resolve ambiguities.
- Heterogeneity in waste (source distribution, density and matrix) may alter results. The common ways to alleviate heterogeneity issues are to rotate the package while measuring it or to assay it on multiple faces and combine the results. One additional step is to measure a slice of the waste package at a time, usually while rotating the package on a turn table, scanned systems. The package may also be subdivided into smaller packages with more homogenous waste. Alternatively, complex systems are available that are designed to assess and correct for variable densities inside a waste package, using gamma tomography or muon transmission through the package. Combining measurement with X-ray allows better representation of the geometric distribution of the various matrixes within the package

High Resolution detectors may have operational constraints and usually are most costly to procure and to operate than low resolution equipment. Hyper pure Germanium detectors require cooling, with an electric cooler or liquid nitrogen. Prior to operation, a detector must be cooled for the required period of time.

5.4. Surface Monitoring

Surface monitoring may be carried out by direct measurement or by taking swabs for alpha and beta contamination.

The activity will then be extrapolated from the surface contamination to the total activity using ratios.

This method is prone to large errors due to:

- Contamination measurement based on swabs is inherently inaccurate because of the uncertainty of contamination fraction transferred to the swab, which depends on the

swab media, the surface smoothness and the force applied on the swab. This is not a suitable technique for porous materials as the surface contamination may not be representative of the bulk contamination

- The heterogeneity of contamination, which makes extrapolation from a limited area inaccurate. Contamination is often concentrated in areas not easily assessed by swabbing or for which the transfer ratio is variable and excessively difficult to estimate
- The inaccuracy of surface calculation for a complex shaped object

6. Information Sources

There are a number of recognised standards and publications relating to the characterisation of radioactive waste. These Guidelines use many of the principles and techniques outlined in these standards and publications. Customers are directed to the following key references for further information on characterisation methods:

- Strategy and Methodology for Radioactive Waste Characterization, IAEA-Tecdoc-1537, IAEA, Vienna, 2007
- Clearance and Exemption Principles, Processes and Practices for Use by the Nuclear Industry, A Nuclear Industry Code of Practice, Issue 1.01, Clearance and Exemption Working Group, August 2006
- Radiometric non-destructive assay, McClelland, P, Lewis, V E, Measurement Good Practice Guide No. 34, National Physical Laboratory, January 2003
- Guidance on Systematic Planning using the Data Quality Objectives Process (QA/G-4), EPA/240/B-06/001, United States Environmental Protection Agency, February 2006

Appendix 2: Waste Characterisation Form Completion

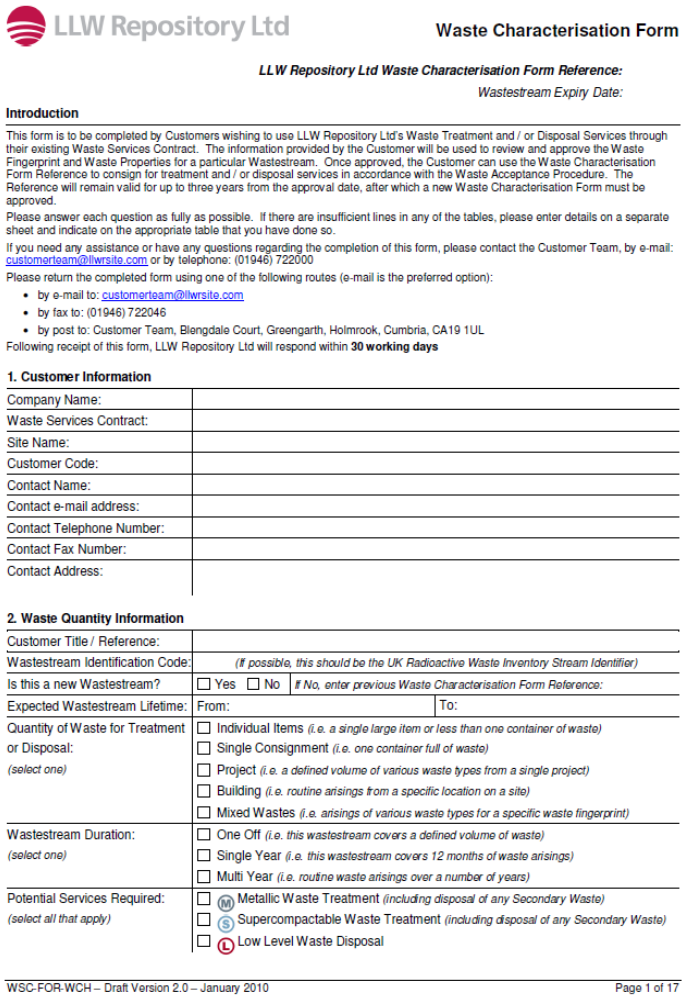
The **Customer Information** section provides the contact information for LLW Repository Ltd for the duration of the wastestream. The information required in this section is standard for all LLW Repository Ltd Waste Acceptance Procedure Forms.

The **Company Name** is the company who is managing the volume of waste and the progress through the Waste Acceptance Procedure, not necessarily the Site Owner, and holds the Waste Services Contract with LLW Repository Ltd.

The **Site Name** refers to the Site where the waste exists, not the registered office of a company (if different).

The **Customer Code** can be found within the Contract Data Schedule of the Customer's Waste Services Contract.

The **Contact Name** and contact details should be for the person LLW Repository Ltd communicates with for this wastestream.



LLW Repository Ltd

Waste Characterisation Form

LLW Repository Ltd Waste Characterisation Form Reference:

Wastestream Expiry Date:

Introduction

This form is to be completed by Customers wishing to use LLW Repository Ltd's Waste Treatment and / or Disposal Services through their existing Waste Services Contract. The information provided by the Customer will be used to review and approve the Waste Fingerprint and Waste Properties for a particular Wastestream. Once approved, the Customer can use the Waste Characterisation Form Reference to consign for treatment and / or disposal services in accordance with the Waste Acceptance Procedure. The Reference will remain valid for up to three years from the approval date, after which a new Waste Characterisation Form must be approved.

Please answer each question as fully as possible. If there are insufficient lines in any of the tables, please enter details on a separate sheet and indicate on the appropriate table that you have done so.

If you need any assistance or have any questions regarding the completion of this form, please contact the Customer Team, by e-mail: customerteam@llwrsite.com or by telephone: (01946) 722000

Please return the completed form using one of the following routes (e-mail is the preferred option):

- by e-mail to: customerteam@llwrsite.com
- by fax to: (01946) 722046
- by post to: Customer Team, Blengdale Court, Greengarth, Holmrook, Cumbria, CA19 1UL

Following receipt of this form, LLW Repository Ltd will respond within **30 working days**

1. Customer Information

Company Name:	
Waste Services Contract:	
Site Name:	
Customer Code:	
Contact Name:	
Contact e-mail address:	
Contact Telephone Number:	
Contact Fax Number:	
Contact Address:	

2. Waste Quantity Information

Customer Title / Reference:	
Wastestream Identification Code:	*(If possible, this should be the UK Radioactive Waste Inventory Stream Identifier)*
Is this a new Wastestream?	☐ Yes ☐ No *If No, enter previous Waste Characterisation Form Reference:*
Expected Wastestream Lifetime:	From: To:
Quantity of Waste for Treatment or Disposal: *(select one)*	☐ Individual Items *(i.e. a single large item or less than one container of waste)* ☐ Single Consignment *(i.e. one container full of waste)* ☐ Project *(i.e. a defined volume of various waste types from a single project)* ☐ Building *(i.e. routine arisings from a specific location on a site)* ☐ Mixed Wastes *(i.e. arisings of various waste types for a specific waste fingerprint)*
Wastestream Duration: *(select one)*	☐ One Off *(i.e. this wastestream covers a defined volume of waste)* ☐ Single Year *(i.e. this wastestream covers 12 months of waste arisings)* ☐ Multi Year *(i.e. routine waste arisings over a number of years)*
Potential Services Required: *(select all that apply)*	☐ (M) Metallic Waste Treatment *(including disposal of any Secondary Waste)* ☐ (S) Supercompactable Waste Treatment *(including disposal of any Secondary Waste)* ☐ (L) Low Level Waste Disposal

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The **Waste Quantity Information** section provides high level details of the wastestream.

The **Customer Title/Reference** is generated by the Customer to allow them to manage each Form through its lifecycle.

The **Wastestream Identification Code** is a code supplied by the Customer for this specific wastestream. Where possible, this should be the UK Radioactive Waste Inventory Stream Identifier for this wastestream. If required, LLW Repository Ltd can provide a Wastestream Identification Code.

The **Expected Wastestream Lifetime** should detail the estimated date of the first and last waste deliveries. This allows LLW Repository Ltd to appreciate the timescales over which this waste will arise.

The Customer selects the options within **Quantity of Waste for Treatment or Disposal**, **Wastestream Duration**, and **Service Required** in line with their specific needs. This helps provide the context for the wastestream and how it is to be used.

The **Waste Information** section provides more detailed information about the waste covered by this Waste Characterisation Form.

The **Waste Description** should provide a detailed description of the waste. Physical dimensions and the type of material will help give context. It is also useful to know where the waste has arisen from and its current status.

LLW Repository Ltd

Waste Characterisation Form

3. Waste Information

Waste Description:

(What waste is covered by this Wastestream? Please provide a description of the waste and where it arises, or has arisen, from)

Waste Origin:

(From what process does the waste originate? Please provide a description of the process)

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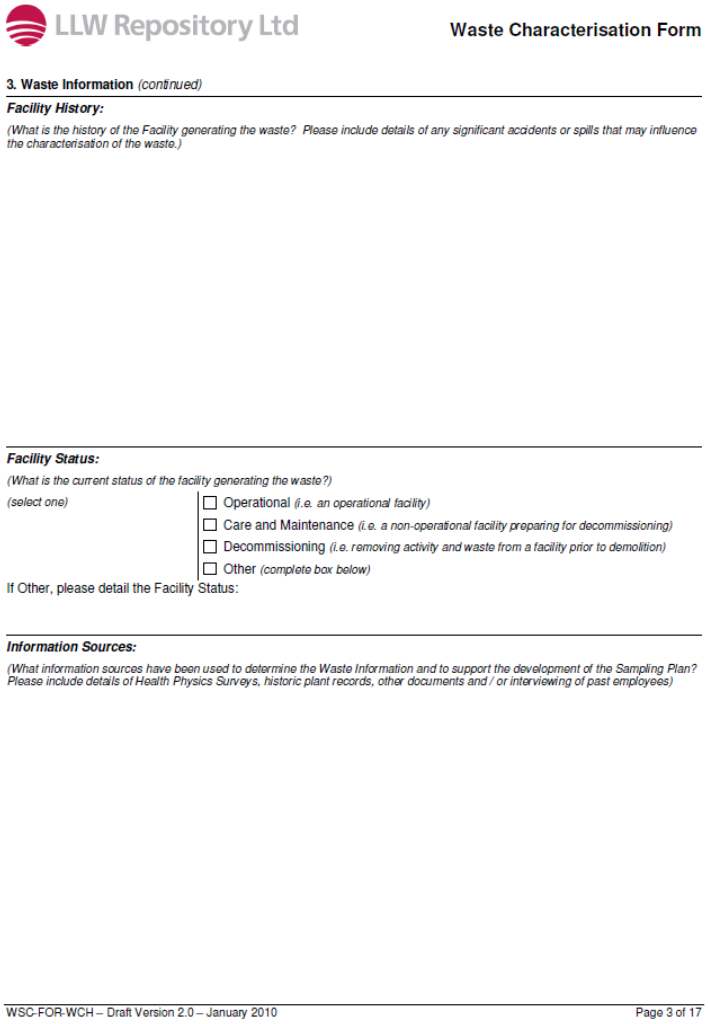
The **Waste Origin** should describe the process that generated the waste in the first place, such as nuclear fuel reprocessing , as this will give an indication of the likely radionuclide content of the waste fingerprint.

The **Waste Information** section continues on this page.

Facility History provides more detailed information about the source of the waste including details of any spills or accidents that may have impacted on the radiological or physical properties of the waste covered by this Waste Characterisation Form.



LLW Repository Ltd — Waste Characterisation Form

3. Waste Information *(continued)*

Facility History:

(What is the history of the Facility generating the waste? Please include details of any significant accidents or spills that may influence the characterisation of the waste.)

The **Facility Status** table is a simple tick box detailing what status the facility is.

Where Other is selected the Customer should describe the facility status in the relevant box.

Facility Status:

(What is the current status of the facility generating the waste?)

(select one)

- ☐ Operational *(i.e. an operational facility)*
- ☐ Care and Maintenance *(i.e. a non-operational facility preparing for decommissioning)*
- ☐ Decommissioning *(i.e. removing activity and waste from a facility prior to demolition)*
- ☐ Other *(complete box below)*

If Other, please detail the Facility Status:

Information Sources:

(What information sources have been used to determine the Waste Information and to support the development of the Sampling Plan? Please include details of Health Physics Surveys, historic plant records, other documents and / or interviewing of past employees)

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The **Information Sources** used to detail this **Waste Information** section should be highlighted here. This information gives details of how the understanding of the nature of the waste has been developed and provides confidence that the sampling plan has been developed to appropriately.

The **Waste Sampling** section requires details of the sampling activities that have been completed to support the development of the waste characterisation.

The **Sampling Plan** section allows Customers to set out how the the sampling campaigns were planned.

Information is provided here to provide confidence that a representative sampling programme has been completed to determine the waste fingerprint.

LLW Repository Ltd

Waste Characterisation Form

4. Waste Sampling

Sampling Plan:

(What was the plan to provide representative samples of the waste to be consigned? Please include details of the following information: Locations / Zones of Sampling, Proposed number of Samples taken, Sampling Techniques, Justification of the Sample Plan (e.g. summary of Best Available Techniques Report)

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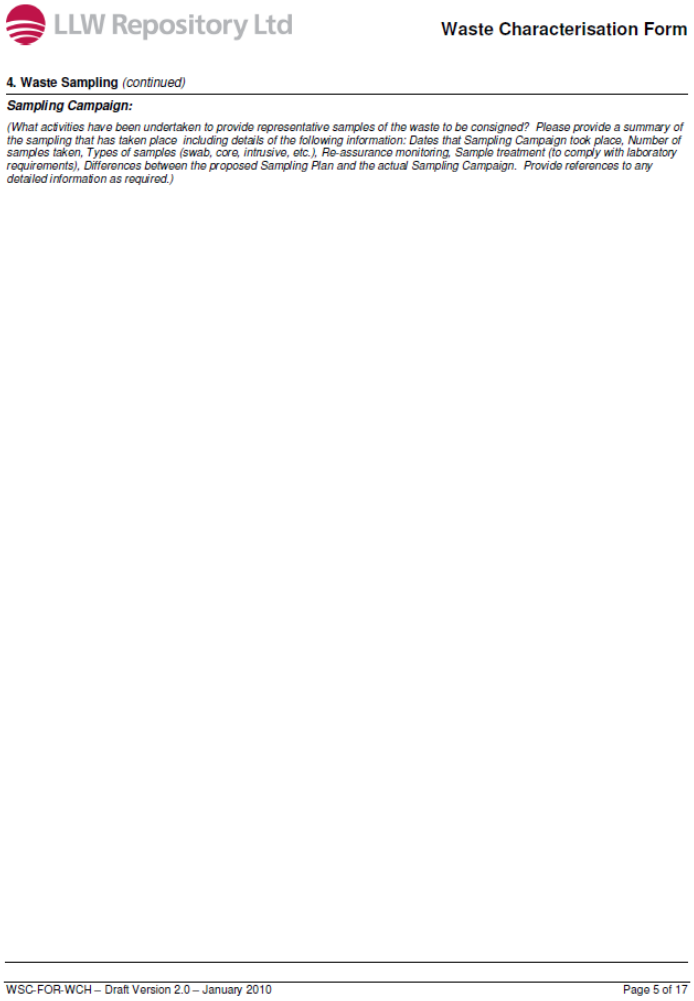
The **Waste Sampling** section continues on this page.

The **Sampling Campaign** section is used to provide details on how the Sampling Plan was implemented and data on the actual suite of samples taken.

LLW Repository Ltd wish to understand how effectively the plan was put into action.



LLW Repository Ltd

Waste Characterisation Form

4. Waste Sampling *(continued)*

Sampling Campaign:

(What activities have been undertaken to provide representative samples of the waste to be consigned? Please provide a summary of the sampling that has taken place including details of the following information: Dates that Sampling Campaign took place, Number of samples taken, Types of samples (swab, core, intrusive, etc.), Re-assurance monitoring, Sample treatment (to comply with laboratory requirements), Differences between the proposed Sampling Plan and the actual Sampling Campaign. Provide references to any detailed information as required.)

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The **Waste Sampling** section continues on this page.

The **Sample Analysis** section is used to detail the analysis that was completed on samples. It should provide details of the laboratory used and details of the suite of analysis that was completed.

LLW Repository Ltd — Waste Characterisation Form

4. Waste Sampling *(continued)*

Sample Analysis:

(What analysis was undertaken on the Samples obtained during the Sampling Campaign? Please include details of the Laboratory that was used, their accreditation, all Radiometric and Chemical properties that were analysed for reasons why these were selected, any Radiometric and Chemical analysis that was omitted from the analysis and the reasons why, Other analysis that was carried out, Summary of analytical techniques used).

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The **Waste Sampling** section continues on this page.

The **Sample Results** section allows Customers to set out the results from the sample analysis work. This summarises the output from the analysis and what has been identified.

References to laboratory reports can be made here, but LLW Repository Ltd require a summary of the results rather than a simple attachment of the report for this section.

LLW Repository Ltd — Waste Characterisation Form

4. Waste Sampling *(continued)*

Sample Results:

(What were the Results of the Sample Analysis? Please include details of Radiological and Non-Radiological results, any hazardous properties that have been identified, how the Waste Fingerprint has been derived including modelling techniques and assumptions?)

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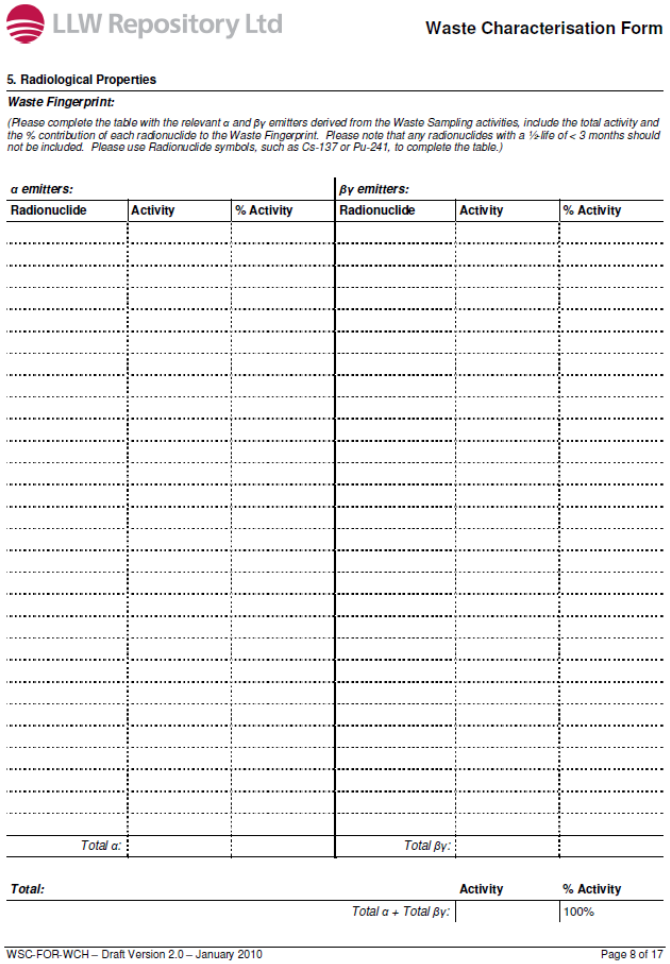
The **Radiological Properties** section is the heart of the Waste Characterisation Form. This is where the **Waste Fingerprint** is documented. The table should be completed with the relevant Radionuclides identified through the Sample Analysis

It is split into two columns. On the left hand side are isotopes that will make up the Total Alpha Activity. On the right hand side are isotopes that will contribute to the Total Non Alpha Activity. The % contribution to the Fingerprint is also required with the total being 100%.

Customers should enter the best available information into this section. This information will have an impact upon the radiological safety case management of both the Supplier and the LLW Repository Facilities and will impact on what service options are available.



LLW Repository Ltd — Waste Characterisation Form

5. Radiological Properties

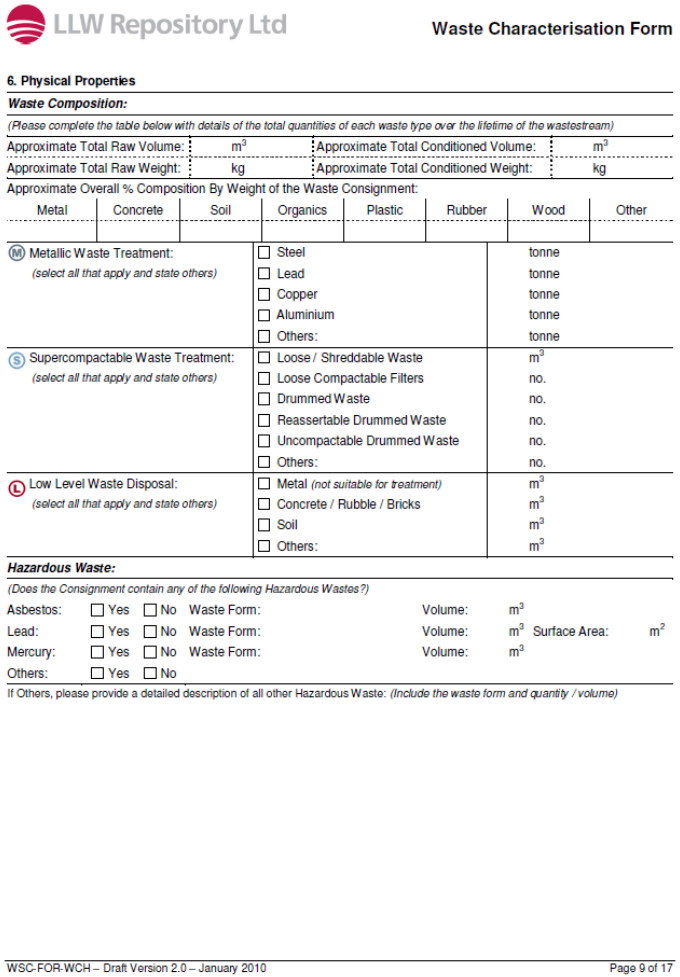
Waste Fingerprint:

(Please complete the table with the relevant α and βγ emitters derived from the Waste Sampling activities, include the total activity and the % contribution of each radionuclide to the Waste Fingerprint. Please note that any radionuclides with a ½-life of < 3 months should not be included. Please use Radionuclide symbols, such as Cs-137 or Pu-241, to complete the table.)

α emitters:			*βγ emitters:*		
Radionuclide	**Activity**	**% Activity**	**Radionuclide**	**Activity**	**% Activity**
Total α:			*Total βγ:*		

Total:	**Activity**	**% Activity**
Total α + Total βγ:		100%

The **Hazardous Waste** section within the Form should be completed by assessing against the relevant Waste Acceptance Criteria document for each treatment and / or disposal service selected in section 2 of the form. The volumes, physical properties, and chemical properties of the Hazardous Waste should be included, along with particular types of a Hazardous Waste (e.g. Type of Asbestos)



LLW Repository Ltd — Waste Characterisation Form

6. Physical Properties

Waste Composition:

(Please complete the table below with details of the total quantities of each waste type over the lifetime of the wastestream)

Approximate Total Raw Volume:	m^3	Approximate Total Conditioned Volume:	m^3
Approximate Total Raw Weight:	kg	Approximate Total Conditioned Weight:	kg

Approximate Overall % Composition By Weight of the Waste Consignment:

Metal	Concrete	Soil	Organics	Plastic	Rubber	Wood	Other

(M) Metallic Waste Treatment: *(select all that apply and state others)*	☐ Steel	tonne
	☐ Lead	tonne
	☐ Copper	tonne
	☐ Aluminium	tonne
	☐ Others:	tonne
(S) Supercompactable Waste Treatment: *(select all that apply and state others)*	☐ Loose / Shreddable Waste	m^3
	☐ Loose Compactable Filters	no.
	☐ Drummed Waste	no.
	☐ Reassertable Drummed Waste	no.
	☐ Uncompactable Drummed Waste	no.
	☐ Others:	no.
(L) Low Level Waste Disposal: *(select all that apply and state others)*	☐ Metal *(not suitable for treatment)*	m^3
	☐ Concrete / Rubble / Bricks	m^3
	☐ Soil	m^3
	☐ Others:	m^3

Hazardous Waste:

(Does the Consignment contain any of the following Hazardous Wastes?)

Asbestos:	☐ Yes ☐ No	Waste Form:		Volume:	m^3	
Lead:	☐ Yes ☐ No	Waste Form:		Volume:	m^3	Surface Area: m^2
Mercury:	☐ Yes ☐ No	Waste Form:		Volume:	m^3	
Others:	☐ Yes ☐ No					

If Others, please provide a detailed description of all other Hazardous Waste: *(Include the waste form and quantity / volume)*

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Information provided in the **Waste Composition** allows LLW Repository Ltd to assess the make up of the waste volume. Customers provide an overview of the approximate volumes and weights associated with the total arisings from the wastestream and the % composition by material type.

The Waste Composition is divided into the types of waste that can be treated by each service. Against each service the 'Others' option can be selected. By typing over the word 'Others' Customers can add specific information this other waste type.

The **Physical Properties** section continues on this page.

The **Restricted Materials** section is used to highlight any materials that have to be excluded from the waste or must be made safe prior to consigning the waste.

It should be read in conjunction with the Waste Acceptance Criteria.

Any materials marked as present must have the Form of the Material identified and the estimated volume of that material.

LLW Repository Ltd — **Waste Characterisation Form**

6. Physical Properties *(continued)*

Restricted Materials:

(Please complete the tables below with details of the total quantities of each restricted waste type over the lifetime of the wastestream)

Material Restricted by the Disposal Authorisation:

(Does the wastestream contain any materials that are restricted by the Low Level Waste Repository's RSA93 Disposal Authorisation?)

Material:	*Material Present?*	*Form of Material Present?*	*Quantity*
Metals and other materials which readily react either with water or air with the evolution of heat or flammable gases	☐ Yes ☐ No		Volume: m^3
Explosive Materials	☐ Yes ☐ No		Volume: m^3
Liquids with flashpoint less than 21 °C absorbed on solid materials	☐ Yes ☐ No		Volume: m^3
Strong oxidising agents	☐ Yes ☐ No		Volume: m^3
Pressurised gas cylinders or pressurised aerosol containers	☐ Yes ☐ No		Number:
Materials which generate or are capable of generating toxic gases, vapours or fumes harmful to persons handling the waste	☐ Yes ☐ No		Volume: m^3
Chemical complexing or chelating agents	☐ Yes ☐ No		Volume: m^3

Material Restricted by the Waste Acceptance Criteria:

(Does the wastestream contain any materials that are restricted by LLW Repository Ltd's Waste Acceptance Criteria?)

Material:	*Material Present?*	*Form of Material Present?*	*Quantity*
Free Liquid	☐ Yes ☐ No		% By Weight: %
Oil and / or Grease	☐ Yes ☐ No		% By Weight: %
Putrescible Wastes	☐ Yes ☐ No		% By Weight: %
Ion Exchange Materials	☐ Yes ☐ No		Volume: m^3
Fire Hazard Materials	☐ Yes ☐ No		Volume: m^3
Strong Acid or Alkaline Compounds	☐ Yes ☐ No		Volume: m^3
Hazardous Biological, Pathogenic or Infectious Materials	☐ Yes ☐ No		Volume: m^3
Materials which react significantly on contact with water or cement grout	☐ Yes ☐ No		Surface Area: m^2
Hazardous Substances and / or Non-Hazardous Pollutants	☐ Yes ☐ No		Volume: m^3
Sealed Sources	☐ Yes ☐ No		Quantity: no.

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The **Physical Properties** section continues on this page.

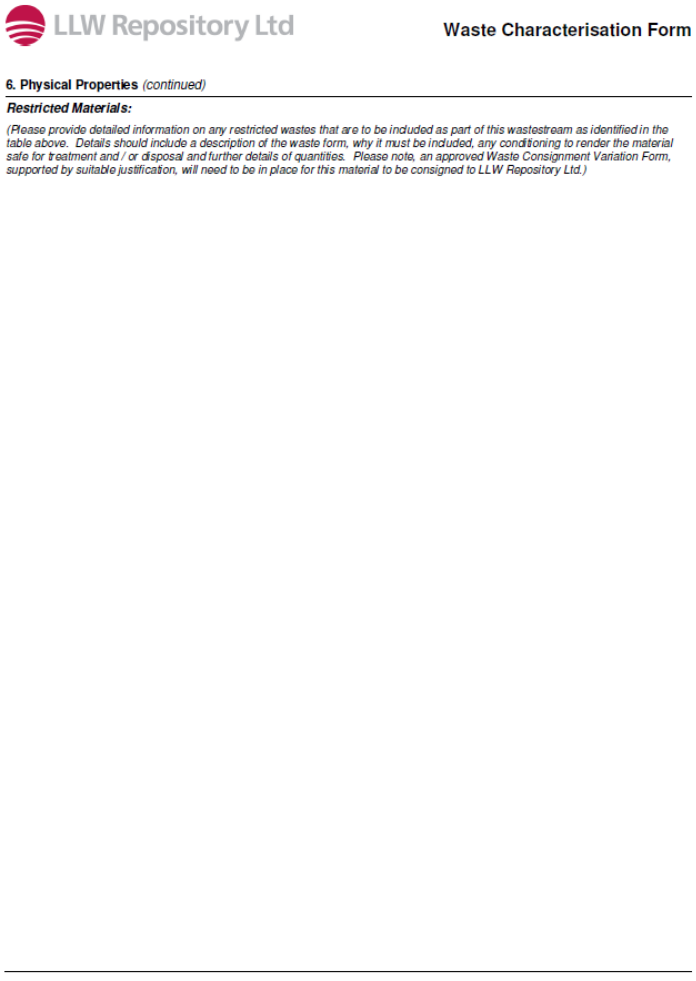
The **Restricted Materials** section continues on this page. Customers provide further details of any restricted material, classified through the Disposal Authorisation or the Waste Acceptance Criteria, that customers propose to treat or dispose of through the LLW Repository Ltd waste services.

This section must include a detailed description of what the material is and the proposals for managing it.

It will be necessary to provide suitable justification for the inclusion of any restricted materials. This can be achieved by reference to the Supporting Information section 10, and any associated BAT / BPEO / BPM Assessments.

Please note, the Waste Consignment Variation Forms would also be required for the inclusion of any restricted materials in a specific consignment. This allows LLW Repository Ltd to track exactly where these restricted materials are within their treatment process and at the Low Level Waste Repository.

Some restricted materials cannot be consigned under any circumstances. Advice is available from LLW Repository Ltd.



LLW Repository Ltd Waste Characterisation Form

6. Physical Properties *(continued)*

Restricted Materials:

(Please provide detailed information on any restricted wastes that are to be included as part of this wastestream as identified in the table above. Details should include a description of the waste form, why it must be included, any conditioning to render the material safe for treatment and / or disposal and further details of quantities. Please note, an approved Waste Consignment Variation Form, supported by suitable justification, will need to be in place for this material to be consigned to LLW Repository Ltd.)

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The **Waste Conditioning** section provides details of any pre-treatment to be carried out.

This may include encapsulation of sludges or resins to stabilise the disposal product or chemical and / or physical treatment prior to packaging.

The techniques proposed will also require approval through a Waste Consignment Variation Form for a specific consignment. This allows LLW Repository Ltd to track exactly where these preconditioned materials are within their treatment process and at the Low Level Waste Repository

LLW Repository Ltd Waste Characterisation Form

7. Waste Conditioning

(What conditioning will the waste undergo before it is consigned to LLW Repository Ltd for treatment and / or disposal? Include details of the waste to be conditioned, why it needs to be conditioned, the conditioning technique to be used and the final product. Please note, an approved Waste Consignment Variation Form will need to be in place for the waste conditioning technique to allow conditioned waste to be consigned to LLW Repository Ltd.)

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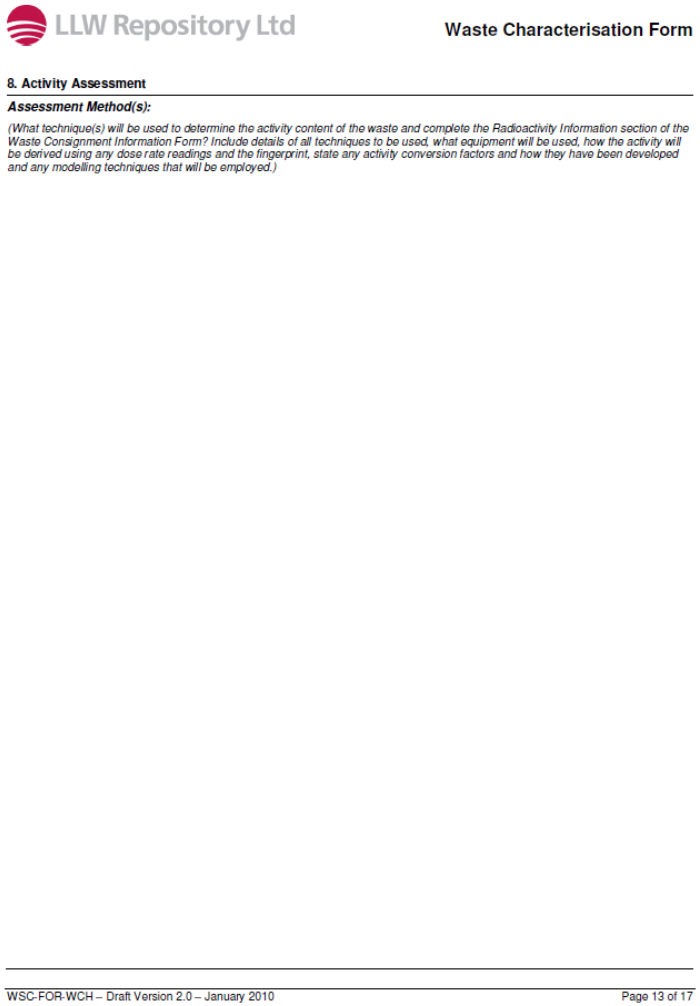
The **Activity Assessment** section is a key element of the Waste Characterisation Form as it sets out the techniques and equipment to be used to convert activity measurements into the activity declaration on the Waste Consignment Information Form.

This is the stage of the Waste Acceptance Procedure where waste is about to be consigned for the provision of LLW Repository Ltd waste services.

It is important that all relevant techniques are described here. LLW Repository Ltd will use the information provided here in their overall consideration of the Waste Characterisation Form to ensure that the Customer will be able to provide an accurate declaration of activity for a specific consignment.

It is important that the techniques are efficient and accurate as overly conservative values of activity will impact on the radiological capacity at disposal facilities and limit future use, i.e. the eradication of 'phantom activity'.



LLW Repository Ltd Waste Characterisation Form

8. Activity Assessment

Assessment Method(s):

(What technique(s) will be used to determine the activity content of the waste and complete the Radioactivity Information section of the Waste Consignment Information Form? Include details of all techniques to be used, what equipment will be used, how the activity will be derived using any dose rate readings and the fingerprint, state any activity conversion factors and how they have been developed and any modelling techniques that will be employed.)

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The **Waste Packaging** section allows Customers to set out their preferences for packing the waste and which Transport or Disposal Containers they would propose to use. The containers listed are the common types and the selection of the 'Other' box allows Customers to enter their own preference by typing over the word 'Other'.

Any proposal by the Customer must be considered by LLW Repository Ltd and the relevant Waste Services Suppliers before it could be accepted.

LLW Repository Ltd — Waste Characterisation Form

9. Waste Packaging

(What packaging options will be used to package waste from this wastestream for consignment to LLW Repository Ltd?)

Packaging Option Used: *(select all that apply)*	(M) Metallic Waste Treatment:	☐ Half Height ISO Container (Type 2910) ☐ Other *(complete box below)*
	(S) Supercompactable Waste Treatment:	☐ Loose in Transport Container (Type 0075) ☐ 200 litre drums in a Transport Container ☐ Other *(complete box below)*
	(L) Low Level Waste Disposal:	☐ Half Height ISO Container (Type 2910) ☐ Third Height ISO Container (Type 2989) ☐ Other *(complete box below)*

If the packaging option is "Other", or if more than one packaging option is to be used, please describe how the waste consigned from this wastestream will be packaged: *(Include details of primary and secondary containment where appropriate)*

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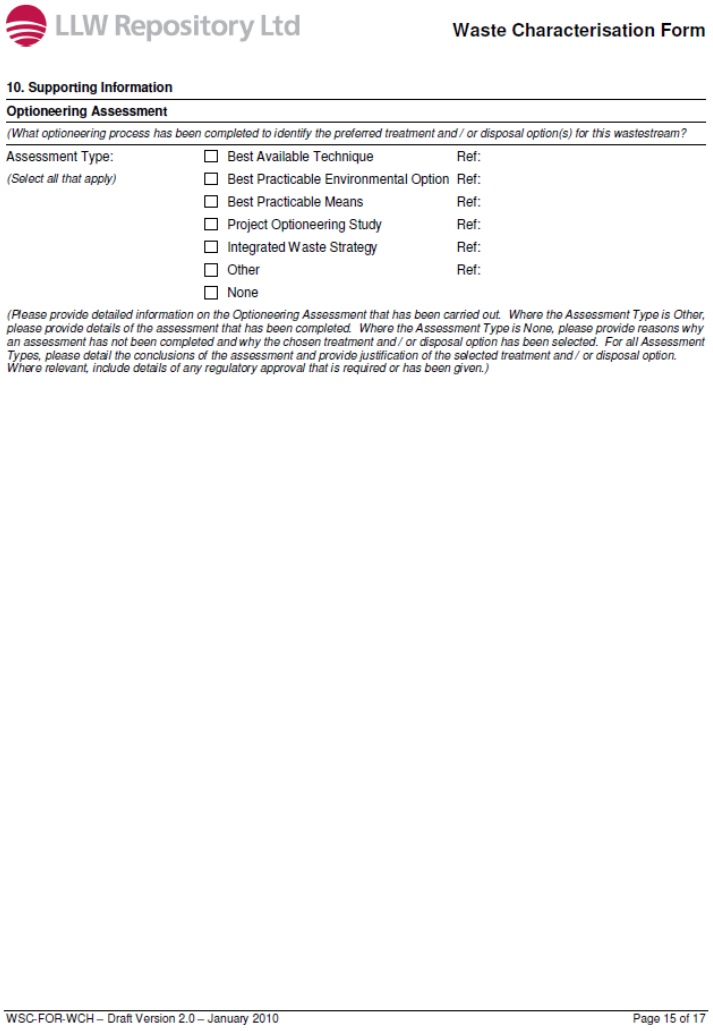
The **Supporting Information** section allows Customers to provide details of any **Optioneering Assessments** that have been completed to support the key decision statements made in completing the Form. As an example, this Supporting Information can take the form of a Best Available Technique Assessment.

These optioneering activities are an important aspect in approving a wastestream as LLW Repository Ltd will look to ensure that relevant waste management options have been considered and that the waste management hierarchy is being applied appropriately.

The assessments listed are the common types known to LLW Repository Ltd and the selection of the 'Other' box allows Customers to enter their own preference by completing the text box below.

Where 'None' is selected, the Customer will have to provide reasons why no optioneering assessment has been completed and supply a justification for the selected waste management option(s).



LLW Repository Ltd — Waste Characterisation Form

10. Supporting Information

Optioneering Assessment

(What optioneering process has been completed to identify the preferred treatment and / or disposal option(s) for this wastestream?

Assessment Type:	☐ Best Available Technique	Ref:
(Select all that apply)	☐ Best Practicable Environmental Option	Ref:
	☐ Best Practicable Means	Ref:
	☐ Project Optioneering Study	Ref:
	☐ Integrated Waste Strategy	Ref:
	☐ Other	Ref:
	☐ None	

(Please provide detailed information on the Optioneering Assessment that has been carried out. Where the Assessment Type is Other, please provide details of the assessment that has been completed. Where the Assessment Type is None, please provide reasons why an assessment has not been completed and why the chosen treatment and / or disposal option has been selected. For all Assessment Types, please detail the conclusions of the assessment and provide justification of the selected treatment and / or disposal option. Where relevant, include details of any regulatory approval that is required or has been given.)

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The **Supporting Information** section continues on this page.

The **References** section provides details of any supporting references the Customer has used to complete the Waste Characterisation Form. It may include the Sampling Plan or a Management Procedure, etc.

To fully review the Waste Characterisation Form so that a wastestream can be approved, it may be necessary for LLW Repository Ltd to request copies of reference documents from the Customer.

LLW Repository Ltd Waste Characterisation Form

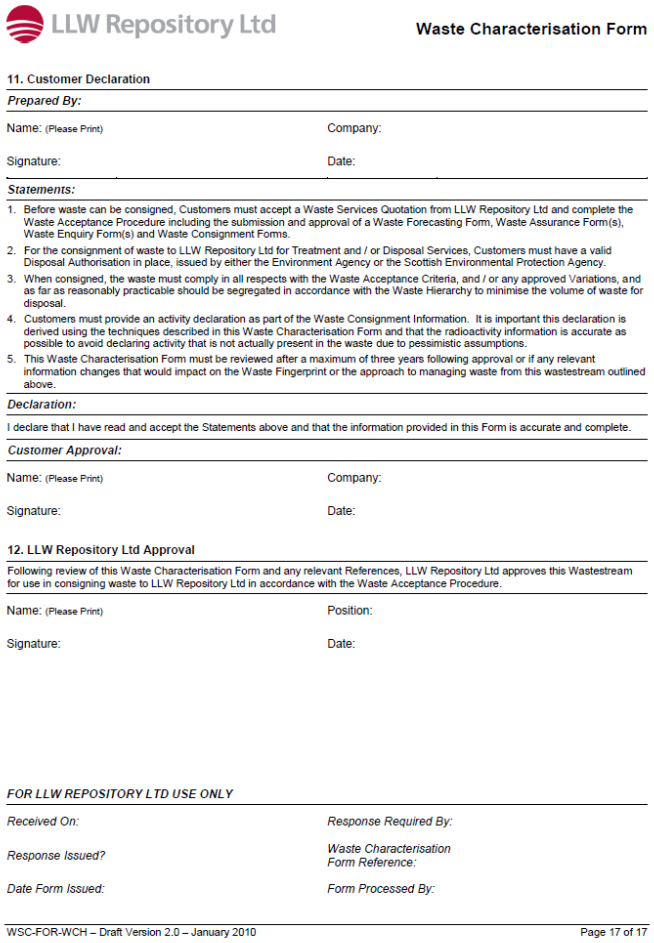
10. Supporting Information *(continued)*

References:

(What reference documents are relevant to the development of this wastestream and the completion of the Waste Characterisation Form? Please note, LLW Repository Ltd may request copies of references if required to support the review of this wastestream.)

The **Customer Declaration** section reminds the Customer of the responsibilities they accept by signing this Form and following the Waste Acceptance Procedure.

The Form needs to be signed by the person who prepared the form and after the declaration by a Customer Representative who is able to confirm the Statements have been met.



LLW Repository Ltd — Waste Characterisation Form

11. Customer Declaration

Prepared By:

Name: (Please Print) Company:

Signature: Date:

Statements:

1. Before waste can be consigned, Customers must accept a Waste Services Quotation from LLW Repository Ltd and complete the Waste Acceptance Procedure including the submission and approval of a Waste Forecasting Form, Waste Assurance Form(s), Waste Enquiry Form(s) and Waste Consignment Forms.
2. For the consignment of waste to LLW Repository Ltd for Treatment and / or Disposal Services, Customers must have a valid Disposal Authorisation in place, issued by either the Environment Agency or the Scottish Environmental Protection Agency.
3. When consigned, the waste must comply in all respects with the Waste Acceptance Criteria, and / or any approved Variations, and as far as reasonably practicable should be segregated in accordance with the Waste Hierarchy to minimise the volume of waste for disposal.
4. Customers must provide an activity declaration as part of the Waste Consignment Information. It is important this declaration is derived using the techniques described in this Waste Characterisation Form and that the radioactivity information is accurate as possible to avoid declaring activity that is not actually present in the waste due to pessimistic assumptions.
5. This Waste Characterisation Form must be reviewed after a maximum of three years following approval or if any relevant information changes that would impact on the Waste Fingerprint or the approach to managing waste from this wastestream outlined above.

Declaration:

I declare that I have read and accept the Statements above and that the information provided in this Form is accurate and complete.

Customer Approval:

Name: (Please Print) Company:

Signature: Date:

12. LLW Repository Ltd Approval

Following review of this Waste Characterisation Form and any relevant References, LLW Repository Ltd approves this Wastestream for use in consigning waste to LLW Repository Ltd in accordance with the Waste Acceptance Procedure.

Name: (Please Print) Position:

Signature: Date:

FOR LLW REPOSITORY LTD USE ONLY

Received On: *Response Required By:*

Response Issued? *Waste Characterisation Form Reference:*

Date Form Issued: *Form Processed By:*

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The **LLW Repository Ltd Approval** section is where the Form will be signed by LLW Repository Ltd to approve the wastestream.

The sub-section at the bottom of the page is used by LLW Repository Ltd to process and monitor the Form through the process.