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Gentleman:

RADIOLOGICAL WASTE CHARACTERIZATION GUIDANCE

Reference: WHC-EP-0063, "Hanford Radioactive Solid Waste Packaging, Storage, and Disposal Requirements," Rev.1, dated September 1989.

Attachment 2 was prepared to assist waste generators in documenting the type and quantity of radionuclides in solid waste as required by DOE Order 5820.2a. The radiological waste characterization documentation should be either referenced in or become a part of the Low-Level Waste (LLW) Certification Plan required to ship solid waste to Hanford Low-Level Burial Grounds.

Please refer all questions and/or comments to the specified contacts listed in attachment 1.

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- Developing Plans for Sampling/Documenting Radionuclides Characterization:
  D. W. Medley, Radiation Engineering (509)376-4180

- Low-Level Waste Certification:
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- Misc. Questions on WHC-EP-0063-1:
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"SPECIFIC GUIDANCE FOR WASTE GENERATORS ON RADIOLOGICAL CHARACTERIZATION OF TRANSURANIC AND LOW-LEVEL WASTES"

1.0 PURPOSE:

This document has been prepared to provide specific guidance to waste generators shipping waste for storage or disposal per WHC-EP-0063, "Hanford Site Radioactive Solid Waste Acceptance Criteria". This guidance is specifically directed at what constitutes process knowledge when defining radionuclides in the waste. This guidance plus that provided for RCRA must be used in developing the waste certification documents.

1.1 BACKGROUND:

Radionuclide identification and quantification have always been a requirement for transportation. However, the majority of the curies have been designated as mixed fission products (MFP).

The issuance of DOE Order 5820.2A, "Radioactive Waste Management", effective September 22, 1988 requires that these practices be improved and that each radionuclide be identified and quantified. This Order requires that:

- Waste containers classified as greater that class C as defined in 10CFR61 be stored until a permanent repository is designated.
- A performance assessment be performed for all waste disposal areas.
- Hazardous, dangerous, and toxic chemical constituents as identified in EPA regulations and Washington State Administrative Code be identified, quantified and treated before disposal.
- Specific waste practices be examined from the point of generation to disposal to ensure that they are performed cost effectively and safely with respect to personnel and the environment.
- Transuranic (TRU) and low level waste (LLW) and their mixed waste subcategories be certified for disposal per approved detailed certification plans that are based on a Quality Assurance program defined in NQA-1.

The impacts of this Order are significant. It requires major changes in waste management practices to achieve compliance with 5820.2A.

All of the above is being done to protect the environment and to improve credibility of DOE operations with the public. Figure 1 "Radioactive Waste Disposal Overview" is provided as background information in an attempt to explain some of the concerns. High level and transuranic waste are being emplaced in geologic repositories. If this is really needed to protect the environment, how can we say that waste material just below these limits is environmentally safe in shallow land burial?

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Draft versions of DOE 5820.2A identified different waste classes. The differences in disposal environments at the various DOE sites resulted in the final DOE Order defining the class C+ and delegating the responsibility for each site to develop its own waste classification system based on site specific performance assessments (PA).

This brings us to our present status of defining the radionuclides which will affect Hanford and setting the limits which will affect the long term Hanford environment. This requires that the disposal areas be modeled such that projections can be made on the long term migration of radionuclides and hazardous chemical constituents into the biosphere. Criteria were also provided to ensure that a person and the environment are protected from an inadvertent intrusion into the disposal area. The PA consequently must address both migration and intrusions.

One segment of data that is needed is the quantities of radionuclides that will be in the waste. This leads us to why this document was prepared. It is our intent to provide you, the generator, with sufficient guidance to produce good technical documentation of the radionuclides in the waste shipped for storage or disposal.

This is going to be an iterative process, i.e., it will tell us what you have so we can determine which ones are important. The Interim Hanford classification system defined in WHC-EP-0063-1 Appendix D is a starting point in defining what is important. Its basis is the same as required by the NRC in 10CFR61 except the concentration limits are lower. The concentration limits were obtained from the draft DOE Order issued on December 31, 1987. This was considered necessary because of the current debate between DOE and the NRC over the health physics data to be used as described in the note of Table D-1 (WHC-EP-0063-1 Appendix D). Admittedly this approach is conservative however it permits development of instrumentation, assay equipment and strategies that can be used independent of which health physics (ICRP-2 vs 30) numbers are finally adopted by the NRC/DOE. This would not be true if we pursued the higher concentration levels because the instrumentation, etc. may not be able to detect lower concentrations. Our intent is not to endorse the lower limit but rather to try to make sure we only have to go through this phase one time.

We have established a temporary lower limit of 1% by activity and weight as a practical matter to avoid identifying all trace elements. The four elements ^{14}C, ^{99}Tc, ^{129}I and ^{79}Se have a 0.1% limit because we have some evidence that they will be major contributors in the migration releases. As a starting position, tritium (^{3}H) isn't included because of its short half-life when compared to the time for migration. Figure 2 is provided to help point out that the radionuclide distribution resulting from 1% by activity is different from 1% by weight. This difference is usually overlooked when using specific activity to perform conversions between grams and curies. The radionuclides based on greater than 1% by weight are ^{239}Pu, Th, and uranium (depleted, enriched and natural). The distribution by activity is ^{137}Cs, MFP, ^{147}Pm, ^{238}Pu, ^{239}Pu, ^{241}Pu, and ^{90}Sr. The distribution we are asking for is the combination of the above with the result that the terms "MFP", "uranium" and "thorium", will be replaced by specific radionuclides.

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We believe that much of the information at each facility already exists but hasn't been assembled into a single document. If it doesn't exist it will have to be completed near term. The remainder of this document identifies areas where we think it may exist and if not, how you should proceed with obtaining the required data.

1.2 DETAILED REQUIREMENTS

Each waste generator must carry out a compliance program to ensure proper certification of waste in accordance with WHC-EP-0063. Generator programs to characterize waste streams (i.e., to determine radionuclide concentrations and waste classes) may, depending upon the particular operations at the generator's facility, range from simple to complex. In general, more sophisticated programs are appropriate for generators whose waste is classified "Intermediate" or "High" and that will require stabilization; for those in which minor process variations may cause a change in waste stream composition, or for generators where there is a reasonable possibility that the waste contains concentrations of radionuclides which exceed concentration limits for Class High waste.

There are two ways to provide the inventory information required to certify the contents of a container of waste.

The first is to take a representative sample from each container and perform detailed analysis of its radioactive constituents. There is great difficulty in obtaining a "representative" sample, the analysis is very time consuming and the total process is quite costly. In most cases this method is not considered practical.

The second method requires the characterization of each waste stream, then the performance of non-destructive assay (NDA) of each container of waste and subsequent calculation of its contents. NDA techniques are discussed in Section 4.0. This second method is the recommended approach.

1.3 WHAT IS A WASTE STREAM

Waste "stream" implies an ongoing activity. As an example, the PUREX facility generates a number of liquid waste "streams" which are piped to storage tanks for later permanent disposal. Solid radwaste usually originates from liquid wastes as materials such as piping, rags and adsorbents become contaminated from contact. All of the liquid waste streams from PUREX differ from one another in their radioactive content. Solid radwaste that originates from (is contaminated by) each of these liquid streams then becomes a solid waste "stream".

A "solid" waste stream is, therefore, the more or less constant flow of solid radioactively contaminated waste from a part (or all) of a facility where the radionuclidic constituents do not change with respect to each other and with time.

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2.0 WHAT TO CHARACTERIZE

Characterization is required for all different sources of waste. This means that, within a facility, wherever chemical or mechanical processes cause changes to the chemical composition of materials, new mixes of radionuclides exist and each of these streams must be characterized. For a facility like PUREX where the relative concentrations of radionuclides vary by orders of magnitude as spent fuel is passed through many processes, characterization is required wherever a process stream divides.

3.0 HOW TO CHARACTERIZE

A generator's program should be specific to his particular facility, and should consider the radiological and other hazardous characteristics of the different waste streams generated by the facility. The principal characterization methods which may be used either individually or in combination are:

- Materials accountability
- Process knowledge and historical data
- Sampling and analysis

The following discussion outlines instances and conditions whereby each basic method, or combination of methods, would be acceptable in achieving compliance with waste acceptance criteria requirements. It may be desirable or necessary for some generators to employ a combination of methods.

3.1 MATERIALS ACCOUNTABILITY

A given quantity (and resulting concentration) of specific radioactive materials may be known to be contained within a given waste, or may be inferred by determining the difference between the quantity of radioactive material entering and exiting a given process. This procedure is expected to be most useful for generators who receive and possess only a limited number of different radioisotopes in known concentrations and activities (e.g, holders of source material, special material, special nuclear material, or specific byproduct material).

An example of the use of this method would be a laboratory at which known amounts of radioisotopes are used for research activities, the waste from which is ultimately disposed of as radioactive waste.

Another example would be a nuclear materials plant in which the radionuclide content of a particular process vessel (e.g., a resin bed) is determined on the basis of measurements of influent and effluent streams.

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This method may also be used to determine the absence of particular radionuclides. That is, for most generators, the absence of a particular radionuclide may be determined through a knowledge of the types of radioisotopes received and processed, as well as the process producing the waste. For example, if a generator receives, processes, and uses only ^{90}S, there is no need to measure the waste stream for other isotopes such as ^{129}I or ^{137}Cs. However, there must be solid analytical data to back this up.

3.2 PROCESS KNOWLEDGE AND HISTORICAL DATA

Waste generators probably have much data already available to help in characterization. Effluent reports, SAR's and production reports all can be used to aid in documenting the waste characteristics provided they have a solid analytical basis.

Sampling and analysis are an integral part of any facility process. Many facilities are required to take liquid or solid samples from different points in their process to test for a material's purity, radiological constituents, concentration, etc. For example, quality assurance samples are taken to ensure that the "product" meets required specifications. Samples are transferred to a laboratory for destructive analysis and the results are recorded. The results show historical knowledge of a process. This knowledge gives an invaluable source to help define the radionuclide characteristics.

Radioactive solid wastes, by definition, are solid wastes generated in radiologically controlled areas and contaminated above threshold limits. Areas generating these wastes may already be routinely smeared for removable contamination by health physics technologists (HPTs). Operational Health Physics (OHP) regulates this routine surveillance program per the WHC-CM-4-10 Radiation Protection manual (section 10.5.5). Both routine or non-routine radiological smears can provide characterization information.

Environmental record samples are another way to obtain characterization data and show classification by source. With permission from the Environmental Protection Group, the environmental record sample can be cut in half with one half being analyzed by destructive analysis while the other half is saved and counted as a record of the radionuclides emitted to the environment as an effluent. The results can also be used as an indicator to show the variability in facility processes.

The WHC-CM-4-10 "Radiation Protection Manual" (section 12.5.2) requires that ambient air (sampling and) monitoring systems shall be placed in strategic locations to detect and evaluate airborne contamination at work locations. The basis used in selecting these monitoring systems might be used in defining the source term for solid waste. In many cases, continuous air monitors (CAMs) are set up to monitor the air at piping which produces radioactive solid waste (e.g. filterbox filters). The CAM's extension piping will penetrate and monitor some of the same radionuclides as those in the area of interest. With the permission of OHP, CAM filters can also be analyzed to indicate the stability (variability) of facility processes.

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These and other sources can be used to help in characterization. It is vital however, that the completeness and validity of data be determined to be sure by these types of data do not introduce conflicting information.

3.3 SAMPLING AND ANALYSIS

Where no other data exist, representative samples of process streams and contamination must be taken and analyzed. The commercial nuclear industry typically performs wipedowns of areas to obtain samples for characterization. This approach is also valid at Hanford.

The important product of this characterization effort is, for each waste stream, the relative concentration of all the radionuclides with respect to each other. This permits the use of nondestructive assay (NDA) in determining the total content of a container of waste.

All waste samples require laboratory analysis. Support for these analyses should be obtained through the Office of Sample Management. This WHC group coordinates all onsite and offsite analytical lab support. The single point of contact for this support is Joan Kessner who can be reached at 373-3507.

4.0 NDA TECHNIQUES, USES, AND LIMITATIONS

Nondestructive assay (NDA) refers to the measurement of the radioactive contents (but not the hazardous components) of the waste. Unlike destructive analysis techniques, NDA does not alter the waste in any way since the container and its contents are analyzed as a whole. NDA techniques operate by measuring the radiation emitted by the radionuclides in the waste. From a practical standpoint, NDA cannot measure alpha or beta-emitting substances and must rely on the measurement of gamma and neutron-emitting radionuclides.

For the NDA of wastes containing fission and/or activation products, ^{137}Cs and ^{60}Co gamma emissions are measured, their quantities estimated and all the other radionuclide quantities calculated from ratios derived from the characterization data. "Box monitors" and "curie monitors" are typical names for these types of systems.

Hand held and portable monitors can be used once rigid procedures are established for placement of the detector at locations around the waste container. Software has been written and is in use in the commercial nuclear industry to take a series of handheld measurements and calculate the contents of a waste container from a specific waste stream.

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The NDA of TRU containing waste is more complex but systems such as segmented gamma scanners are used to determine the contents of drums holding more that 10 grams of fissile material. The only way to determine whether a drum of waste is LLW or TRU is with a passive-active-neutron system. These systems can reliably calculate TRU content of a drum to levels of 10nCi/gm.

Certification of waste is a generator responsibility. The only way to certify waste is through characterization of the waste and then the subsequent NDA of each container. It may be possible to contract out the NDA function, as is done for LLW/TRU determination using the TRUSAF facility. The reason for this is that the TRUSAF system costs about $750K. Equipment for fission and activation product NDA is inexpensive and probably represents a cost effective approach for generators. It should be noted that TRU waste requires the inventory of fission and activation products (if any) as well as the TRU content.

5.0 RADIONUCLIDE CONCENTRATION

NDA provides a calculation of the total amount of each radionuclide that is present in a container of waste. In order to classify that container the concentration of each radionuclide must then be determined.

The concentrations of fission and activation products may be averaged over the volume of the waste.If the concentration units are expressed as curies per gram, (as is the case for low-level uranium and transuranic waste) the concentration is averaged over the mass of the waste. This requirement needs interpretation because of different types and forms of TRU and low-level waste. Principal considerations include: (a) whether the distribution of radionuclides within the waste can be considered reasonably homogeneous, and (b) whether the volume of the waste container is significantly larger than the volume of the waste itself, and the differential volume consists largely of void space.

Most waste streams may be considered homogeneous for purposes of determining radionuclide concentrations. Such waste streams would include, for example, spent ion-exchange resins, filter media, solidified liquids, and contaminated soil. Contaminated trash waste streams, which are composed of a variety of miscellaneous materials, may be considered homogenous for purposes of determining radionuclide concentrations when placed or compacted in shipping or disposal containers.

When determining radionuclide concentrations, the volume (weight in the case of TRU) of the waste itself is used. If void space is small (10% or less) then the volume of the container may be used. The weight of the container is <u>never</u> included with the weight of the waste in determining TRU concentration.

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6.0 HOW TO CLASSIFY WASTE

A container of waste cannot be classified until the concentration of each radionuclidic (and hazardous) constituent is known. Table D-1 from Appendix D of WHC-EP-0063 is used to determine the classification of LLW and is reproduced here as Figure 3. Without regard to fission or activation product content, waste is classified as TRU if it meets the definition in paragraph 3.1.1 of WHC-EP-0063.

The concentration limits in Table D-1 are based on single radionuclide waste sources. Most Hanford low-level waste streams will contain a mixture of radionuclides. If the radioactive waste contains a mixture of radionuclides, it must be classified as follows:

a. **Waste Mixture With Any Combination Of Radionuclides Listed In Table D-1:** Determine the total concentration by the "sum of the fractions" rule. This is done by dividing each radionuclide's concentration by the appropriate limit taken from Table D-1 and adding the resulting values. This sum of the fractions must be less than or equal to 1, if the waste is to be classified per that particular column.

EXAMPLE: If the waste is known to have a mixture of radionuclides A, B, and C in concentrations of C_A, C_B, and C_C and the applicable concentration limits from Table D-1 Column 1, are $Limit_A$, $Limit_B$, and $Limit_C$, respectively, then the classification of Low is obtained if the following relationship results in a sum that is less than or equal to 1:

$$\frac{C_A}{Limit_A} + \frac{C_B}{Limit_B} + \frac{C_C}{Limit_C} \leq 1$$

If this sum exceeds 1, then repeat the calculation using $Limit_A$, $Limit_B$, and $Limit_C$ from the next higher waste classification (Column 2 for Classification "Intermediate," and Column 3 for Classification "High").

Remember that the same "sum of the fractions"rule applies to the radionuclide concentrations and their associated limits for each column in Table D-1. When the sum is calculated to be less than or equal to 1, the classification of the mixture has been verified. If the sum using Column 3 values is greater than 1, then the waste is classified as GTCH and must be stored until an appropriate disposal strategy is developed and approved.

b. **Waste Mixtures With No Radionuclides Listed In Table D-1** - If the waste mixture does not have any radionuclides listed in Columns 1, 2 or 3 of Table D-1, then it is classified as Low.

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7.0 COMBINING OF WASTE STREAMS

A waste stream has a unique radionuclidic characterization. Economy of operation may be realized by combining several waste streams into one and using a composite characterization. This composite is developed by taking the worst case relative concentration for each radionuclide and assembling a new characterization. Having done this, it is important to look at typical NDA results, calculate new absolute concentrations for each radionuclide and determine if the waste classification will change. If no change in classification occurs, combining of the streams should be done. If however, the waste should be reclassified from LLW to TRU or from class Low to class Intermediate (or higher) then the higher costs of disposal should be weighed against the other benefits of combining.

8.0 VERIFICATION AND RECHARACTERIZATION

Verification consists in performing enough testing and analysis to demonstrate that the characterization of a waste stream is still valid. Where processes are stable, verification should be performed annually. Verification must be performed to demonstrate that, when small changes in a process occur characterization does not change materially (i.e., to change waste classification). Recharacterization is always required for large process changes and whenever verification fails.

9.0 SUMMARY

Figure 4 is presented to summarize the logical flow of the characterization and classification process described herein. Once this effort has been completed for all waste streams of a generator's facility, the process of packaging, non destructively assaying and certificating of packages can be performed for the shipment of waste to the appropriate treatment, storage or disposal (TSD) facility.

Westinghouse Hanford Company — DEFENSE WASTE MANAGEMENT DIVISION

SOLID WASTE TECHNOLOGY

RADIOACTIVE WASTE DISPOSAL OVERVIEW

- HIGH LEVEL WASTE
  - VITRIFIED
  - ENTOMBED IN TUFF 1000 FT. UNDERGROUND
- TRANSURANIC WASTE
  - LIMITED TREATMENT
  - ENTOMBED IN SALT 2150 FT. UNDERGROUND
- LOW LEVEL WASTE
  - o CLASS C+
    - LAND BAN
    - DISPOSAL TBD
  - o HIGH ACTIVITY
    - TREATMENT, ENGINEERED BARRIERS AND DEPTH TO BE SPECIFIED
  - o INTERMEDIATE ACTIVITY
    - LIMITED TREATMENT
    - SHALLOW LAND BURIAL
  - o LOW ACTIVITY
    - LIMITED TREATMENT
    - SHALLOW LAND BURIAL
  - o BELOW REGULATORY CONCERN
    - LIMITED TREATMENT
    - SANITARY LAND FILL

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Figure 1

Isotopic Distribution for Transuranic Waste from 1970 to December 31, 1988[a].

Isotope	Gram quantity	Curie quantity (Ci)	Specific activity (Ci/g)	Activity (%)	Weight (%)
^{241}Am	1.836 E+02	6.304 E+02	3.433 E+00	–	–
^{243}Am	5.276 E+01	9.761 E+02	1.850 E−01	–	–
^{14}C	–	1.600 E+00	–	–	–
^{141}Ce	3.509 E−08	1.000 E−03	2.850 E+04	–	–
^{144}Ce, ^{144}Pr	1.662 E+01	5.302 E+04	3.190 E+03	4.0	–
^{252}Cf	2.000 E+00	1.290 E+03	6.450 E+02	0.1	–
^{245}Cm	4.822 E+01	7.566 E+00	1.569 E−01	–	–
^{60}Co	1.973 E+00	2.232 E+03	1.131 E+03	0.2	–
^{137}Cs, ^{137}Ba	1.941 E+02	1.679 E+04	8.650 E+01	1.3	–
^{155}Eu	8.192 E−02	3.810 E+01	4.651 E+02	–	–
^{3}H	7.057 E−04	6.803 E+00	9.640 E+03	–	–
^{85}Kr	9.506 E+00	3.730 E+03	3.924 E+02	0.3	–
Li	5.900 E+00	5.900 E+00	1.000 E+00	–	–
Mixed fission products	–	8.826 E+05	–	66.5	–
^{237}Np	3.537 E+02	2.493 E+00	7.049 E−03	–	–
^{147}Pm	4.339 E+01	4.023 E+04	9.271 E+02	3.0	–
^{238}Pu	5.293 E+03	1.657 E+04	1.740 E+01	6.9	–
^{239}Pu	4.417 E+05	2.712 E+04	6.140 E−02	2.0	2.2
^{240}Pu	2.702 E+04	6.457 E+03	2.390 E−01	0.5	0.1
^{241}Pu	1.599 E+03	1.791 E+05	1.120 E+02	13.5	–
^{242}Pu	9.413 E+01	3.671 E−01	3.900 E−03	–	–
^{106}Ru, ^{106}Rh	1.581 E+00	5.291 E+03	3.346 E+03	0.4	–
^{90}Sr, ^{90}Y	1.191 E+02	1.654 E+04	1.389 E+02	1.2	–
Th	6.151 E+05	6.748 E−01	1.097 E−06	–	3.1
U-D	1.450 E+07	4.876 E−01	3.362 E−06	–	72.8
U-E	3.568 E+05	7.714 E+00	2.162 E−05	–	1.8
U-N	3.966 E+06	2.729 E+00	6.880 E−07	–	19.9
^{233}U	8.293 E+03	7.994 E+01	9.639 E−02	0.1	–
Totals	1.993 E+07	1.021 E+06	–	–	–

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Figure 2

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Table D-1. Radionuclide Concentration.

Radionuclide	Half-life (yr)	Column 1 Low DOE limit (Ci/m^3)	Column 2 Intermediate DOE limit (Ci/m^3)	Column 3 High DOE limit (Ci/m^3)
^{3}H	1.2 E+01	5 E+00	5 E+01	--
^{10}Be	2.5 E+06	2 E+00	[a]	2 E+01
^{14}C	5.7 E+03	6 E-04	--	6 E-03
^{36}Cl	3.1 E+05	3 E-04	--	3 E-03
^{60}Co	5.3 E+00	3 E+02	7 E+02	--
^{59}Ni	8.0 E+04	3 E+00	--	3 E+01
^{63}Ni	9.2 E+01	2 E+01	7 E+01	4 E+02
^{90}Sr	2.8 E+01	5 E-03	5 E+00	9 E+02
^{94}Nb	2.0 E+04	8 E-04	--	8E-03
^{99}Tc	2.1 E+05	7 E-03	--	7 E-02
^{129}I	1.2 E+07	1 E-03	--	1 E-02
^{137}Cs	3.0 E+01	2 E-02	2 E+00	2 E+03
^{241}Pu	1.3 E+01	5 E+01	--	9 E+02
Alpha-emitting transuranic radionuclides	>20	10[b,c]	--	100[b,c]
^{79}SE	6.5 E+04	7 E-03	--	7 E-02
~~^{93}Nb~~	~~2.0E+04~~	~~3E-04~~	--	~~3 E+03~~

Deleted

NOTE: This table is modeled on the waste classification system developed by the U.S. Nuclear Regulatory Commission (NRC) in 10 CFR 61. These values are upper limit concentrations of specific radionuclides for the INVERSE computer model developed by the NRC. The actual concentration limits are also based on the internal dose models, ICRP-30 and ICRP-48, which have been adopted by DOE for all radiation exposure calculations for internally deposited radionuclides. These limits are numerically smaller than the NRC limits, in part, because the NRC limits are based on the earlier internal dose model ICRP-2. The list of radionuclides includes several long-lived fission product and neutron-capture induced radionuclides that can occur in significant amounts in defense waste, but which are insignificant in commercial waste. Values for other radionuclides may be developed during the development of the Hanford Performance Assessments for disposal of waste at the Hanford Site.

[a]A dash indicates no values are provided.

[b]Expressed in units of nanocuries per gram of waste.

[c]Number selected in accordance with already-established limits and definitions.

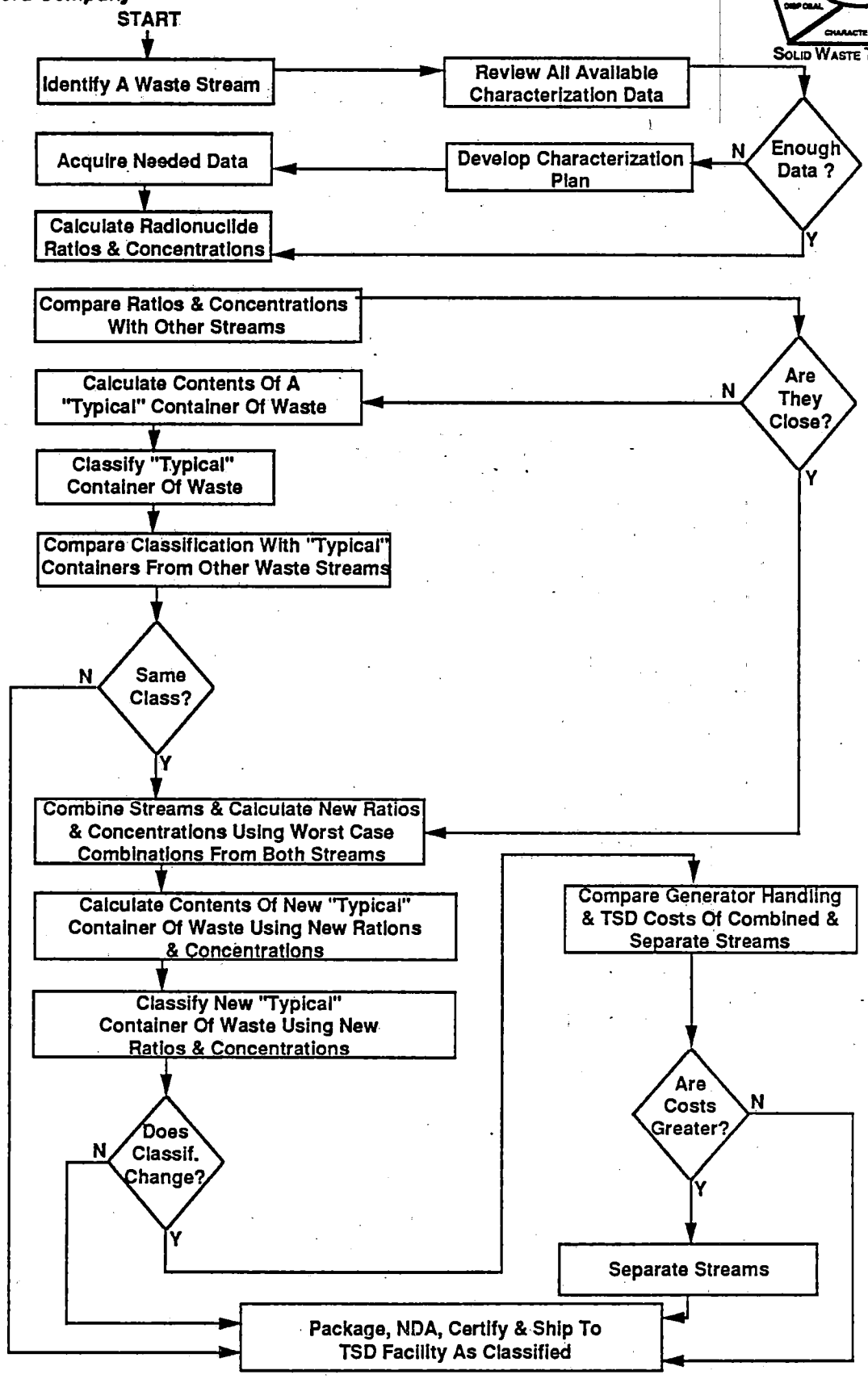
pst 89-7283-App. D-1

Figure 3

Westinghouse Hanford Company

DEFENSE WASTE MANAGEMENT DIVISION

SOLID WASTE TECHNOLOGY



LOGICAL FLOW OF CHARACTERIZATION & CLASSIFICATION ACTIVITIES

WE'RE MAKING SURE...

900214.1 TRUC wpg

Figure 4

9 0 1 1 7 8 4 0 8 9 2

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Subject
CHARACTERIZATION GUIDANCE

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Approval		Date	Name	Location	w/att
			Correspondence Control	A3-01	X
			M. R. Adams	H4-55	X
			M. D. Aichele	T4-01	X
			S. E. Albin	T1-06	X
			L. K. Aldrich	L6-59	X
			S. J. Amir	R2-82	X
X	MBA	3-21-90	B. C. Anderson	R2-82	X
			D. L. Armstrong	R2-82	X
			J. E. Atterberry	T6-14	X
			K. A. Ayster	R2-82	X
			S. M. Baker	S2-62	X
			W. B. Barton	S6-70	X
			G. M. Bell	A5-55	X
			T. L. Bennington (2)	S1-52	X
			J. C. Bergam	T4-01	X
			A. E. Blackman	S5-80	X
			V. L. Blanchard	R2-82	X
			K. W. Bledsoe	S5-80	X
			D. G. Blevins	T6-14	X
			R. W. Bloom	K6-48	X
			D. J. Bishop	S5-04	X
			L. E. Borneman	H4-50	X
			D. L. Bouse	T4-40	X
			R. V. Bowersock	S5-80	X
			H. C. Boynton	R2-82	X
			J. D. Briggs	T6-14	X
			M. J. Brown	T1-30	X
			R. W. Brown	T4-01	X
			G. P. Burchell	L4-75	X
			G. D. Carpenter	R2-85	X
			M. C. Carrigan	R3-27	X
			R. J. Cash	L4-55	X
			J. E. Chulos	T4-01	X
			L. E. Clay	S5-80	X
			L. L. Cole	X6-21	X
			J. E. Cottrell	T7-20	X
			P. A. Craig	R1-51	X
			T. F. Dale	S5-51	X
			J. A. Dawson	T5-54	X
	MAR 22 1990		P. W. Deja	R3-32	X
	"Entire Dist"		J. A. Devanney	X0-04	X
		3-1266	B. R. Dickey	R1-43	X
			J. F. Dickman	P7-78	X

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Subject
CHARACTERIZATION GUIDANCE

Internal Distribution

Approval		Date	Name	Location	w/att
			Correspondence Control		X
			P. C. Doto	R3-01	X
			R. M. Doyle	T3-28	X
			V. T. Dunnett	R2-82	X
			K. A. Dupont	N1-68	X
			G. T. Dukelow	R2-97	X
			J. H. Eide	G1-35	X
			J. H. Ellis	S5-66	X
			M. W. Ellis	S5-80	X
			G. E. Entrop	T3-25	X
			G. C. Evans	H4-57	X
			S. M. Faulk	N2-40	X
			B. R. Fitzpatrick	T5-05	X
			J. G. Francik	T6-14	X
			J. M. Garcia	X0-04	X
			R. B. Gelman	S1-51	X
			R. P. Genoni	L0-05	X
			D. M. Gerboth	T5-54	X
			R. J. Giroir	T3-28	X
			S. D. Godfrey	S5-80	X
			W. H. Grams	R2-82	X
			M. Haas	T4-10	X
			G. E. Hansen	S6-70	X
			D. G. Harlow	R2-01	X
			J. A. Harris	T6-22	X
			D. J. Hart	R2-52	X
			W. M. Harty, Jr.	B2-04	X
			P. L. Hemsworth	T4-01	X
			R. C. Hill	B4-53	X
			R. W. Higbee	S6-60	X
			V. L. Hoefer	X0-42	X
			C. R. Hoover	G2-05	X
			J. H. Hummer	L0-05	X
X	WWJ	3-21-90	W. G. Jasen	R2-82	X
			S. R. Johnson	S4-39	X
			M. C. Jones	R2-82	X
			J. L. Juette	X6-21	X
			J. H. Kessner	T5-07	X
			D. R. Kibbe	R2-82	X
			P. F. Kison	S5-65	X
			M. S. Kitts	X6-21	X
			G. J. LeBaron	S5-80	X
			M. D. LeClair	H4-50	X

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Internal Distribution

Approval		Date	Name	Location	w/att
			Correspondence Control		X
			J. S. Lee	T4-01	X
			J. B. Levine	X3-50	X
X	[illegible]	3/21/90	D. W. Lindsey	R2-82	X
			R. M. Lipinski	R2-82	X
			E. F. Loika	L4-73	X
			J. B. Maier	T4-01	X
			E. J. Manthos	T5-07	X
			D. C. Margolin	S5-80	X
			M. L. Martin	X8-29	X
			R. L. Martin	L3-52	X
			B. A. Mayancsik	R2-82	X
			D. L. McCall	G1-35	X
			D. C. McCann	R2-82	X
			M. W. McCoy	P7-68	X
			T. J. McDonald	R2-82	X
			P. C. Miller	N2-04	X
			E. C. Mincey (3)	T5-08	X
			G. J. Miskho	T5-50	X
			J. A. Mortensen	R3-02	X
			K. J. Moss	R3-08	X
			R. D. Mudd	T7-20	X
			A. J. Naser	T5-12	X
			D. W. Nelson	L6-74	X
			R. L. Nelson	S5-65	X
			D. J. Newland	N2-51	X
			J. E. Nolan	B3-01	
			R. C. Nichols	B3-02	X
			E. M. Nordquist	N1-68	X
			S. H. Norton	T3-28	X
			F. H. Nunamaker	L6-37	X
			H. E. Oens	T5-05	X
			P. C. Ohl	S1-52	X
			M. A. Ortega	R2-82	X
			W. L. Osborne	R2-82	X
			G. C. Owens	L6-59	X
			R. B. Pan	S2-03	X
			J. L. Pappan	G2-10	X
			T. R. Pauly	R2-93	X
			J. E. Perham	T4-01	X
			A. G. Pines	R3-02	X
			R. K. P'Pool	S5-65	X
			A. D. Poor	G4-11	X

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Author	Addressee	Correspondence No.
R. J. Roberts	Distribution Page 4 of 4	9051607

Subject

CHARACTERIZATION GUIDANCE

Internal Distribution

Approval		Date	Name	Location	w/att
			Correspondence Control		X
			B. E. Poremba	R2-82	X
			E. A. Porter	H4-50	X
			D. L. Powell	L4-32	X
			D. R. Pyzel	T4-01	X
			A. B. Rau	L4-31	X
			J. P. Reisenauer	R3-08	X
			J. A. Remaize	X6-21	X
X			R. J. Roberts	R2-97	X
			R. S. Rodriquez	S5-03	X
			A. E. Schilling	T5-05	X
			L. D. Schwartz	L6-40	X
X	[illegible]	3/21/90	J. L. Scott	R2-87	X
			E. F. Serabia	S1-52	X
			J. B. Shannon	T3-21	X
			J. P. Sloughter	T6-18	X
			F. M. Smith	G1-35	X
			K. R. Smith	S5-80	X
			D. T. Smoot	S6-61	X
			D. R. Speer	R2-77	X
			R. T. Steele	P7-22	X
			R. W. Stevenson	S6-80	X
			R. G. Stickney	R2-82	X
			C. R. Stroup	T4-10	X
			T. H. Sunday	H4-21	X
			C. S. Sutter	T5-07	X
			D. J. Swaim	N2-34	X
			M. M. Serkowski	S6-80	X
			C. L. Thomas	T5-08	X
			M. E. Thurman	L6-40	X
			W. T. Tyler	T1-25	X
			L. M. Walker	S5-03	X
			R. R. Ware	T4-10	X
			D. J. Watson	X0-41	X
			E. A. Weakley	L6-28	X
			D. L. Wegener	X6-18	X
			G. A. Whitney	R2-87	X
			S. A. Wiegman	H4-50	X
			S. T. Willett	T7-20	X
			D. W. Wilson	R1-51	X
			C. M. Winkler	S5-03	X
			E. J. Wright	T5-54	X
			R. L. Wright	S5-03	X
			K. L. Young	N1-40	X
			EDMC	H4-22	X

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