REPACKAGING A TRANSURANIC WASTE STREAM FOR WIPP DISPOSAL

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ABSTRACT

Los Alamos National Laboratory (LANL) conducted a project to certify 102 standard waste boxes (SWBs) of non-mixed transuranic (TRU) waste for the first shipments to the Waste Isolation Pilot Plant (WIPP). To meet the decay heat limit of the WIPP Waste Acceptance Criteria, the LANL repackaging process had to accomplish four objectives: 1) reduce the amount of Pu-238 in any or all of 36 existing TRU waste drums, expanding the waste to 102 drums; 2) certify the amount of plutonium in each drum; 3) place the drums into SWBs, at one drum per SWB; and 4) remove all but one layer of confinement around the waste. To meet the requirements of the New Mexico Environment Department for non-mixed waste, the repackaging included a complete waste inspection to eliminate potential hazardous waste constituents. To meet these objectives, LANL developed methods for controlling Pu-238 contamination, for assaying problematic waste matrices, and for dividing waste equally among containers.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) has opened as a disposal facility for non-mixed transuranic (TRU) waste. Non-mixed TRU waste contains TRU constituents but does not contain hazardous chemical components as defined by the Resource Conservation and Recovery Act (RCRA). To provide non-mixed waste for shipping and emplacement at WIPP, the Department of Energy (DOE) reviewed its sites and found the most likely candidate waste stream at Los Alamos National Laboratory (LANL). The LANL waste stream consists of heterogeneous debris contaminated with gram amounts of plutonium 238 (Pu-238) and is shown by the acceptable knowledge process to be free of RCRA hazardous materials.

To certify the waste according to the WIPP Waste Acceptance Criteria (WAC)[1], the LANL Transuranic Waste Characterization/Certification Project (TWCP) team initiated a repackaging project to prepare the waste for certification. Waste generators at LANL TA-55 had packaged the waste in drums with more Pu-238 radionuclide material than is allowed for drum containers with two layers of confinement (see Table I). The drums had too much Pu-238, and they therefore exceeded the decay heat limit specified in the WIPP WAC and could not be shipped.

The project's primary objective was to divide waste from 36 drums with too much Pu-238 into 102 containers[2] that each held the right amount based on decay heat criteria shown in Table I. LANL chose to meet the WIPP WAC decay heat criteria as follows:

1) place into a drum an amount of Pu-238 waste that did not exceed decay heat limit for an SWB having a single layer of confinement,
2) certify the amount of Pu-238 by an approved assay method,
3) place the drum into an SWB, and
4) safely remove the drum liner layer of confinement from around the waste, thereby increasing the decay heat (wattage) allowed.

LANL chose SWB packaging instead of drum packaging because the only drum TRUCON code[3] available for shipping drums defined four layers of packaging, and that many layers would mean a prohibitive limit on Pu-238 loading. However, the TRUCON code for shipping SWBs allows a single layer of packaging, which significantly expands the limit for Pu-238 loading. Based on the decay heat limit of 0.3515 Watts per SWB with one layer of confinement, only 102 SWBs would be needed to complete the project, whereas if drums were used, 1,727 drums with up to four layers of confinement would be required because of the decay heat limit of 0.0207 Watts per drum. Fewer packages would mean less data entry to provide the required documentation and would represent a waste volume avoidance of over 140 cubic meters.

DECAY HEAT

Decay heat is a measure of the hydrogen generating potential of the waste and is controlled by transportation regulations.[4] The intent of the regulations is to ensure that no inner packaging layer will contain a potentially explosive mixture of hydrogen and air. The allowed decay heat in packages prepared for WIPP depends on the waste matrix and the number of layers of confinement in the packaging (see Table I). For this project, LANL selected 36 drums of non-mixed TRU waste with up to 4.6g of Pu-238 in each and up to four layers of confinement. As seen on the "Watts per Drum" chart in Table I, the limit for such waste is 0.0207 Watts/drum (0.036g of Pu-238). For the waste to meet these limits, it would need to be packaged into 1,727 drums. By reducing the number of layers of confinement around the waste and by putting the waste into larger containers, LANL was able to increase the possible Pu-238 loading of each container by 17 times, to 0.3515 Watts/SWB (0.613g of Pu-238), as seen on the "Watts per SWB" chart in Table I. The increase in allowable decay heat meant that repackaging the most heavily loaded drum would require only 8 SWBs instead of 128 drums.

STAGES OF REPACKAGING

In order to match the plutonium content of the waste to the wattage limit, LANL had to complete two stages of repackaging. The intermediate repackaging of the waste into drums was required because an assay instrument large enough to handle SWBs was not available. The waste had to be placed in a drum and assayed before it could be placed into an SWB. The two stages of repackaging used the following steps.

Table I
Decay Heat Limits per Drum or Standard Waste Box (in Watts)
(after Table 6-1 DOE/WIPP 89-004)

Watts per Drum

Waste Matl Type	Number of Layers of Confinement								
	0	1	2	2a	3	4	5	6	Metal
I.1	0.2060	0.1797	0.1594		0.0466				
I.2	0.2536	0.2212	0.1962		0.0573	0.0418			
I.3	0.8241	0.7189	0.6375		0.1863	0.1359			
II.1	0.2251	0.1924	0.0869	0.1680	0.0561	0.0414	0.0328	0.0272	
II.2									40.000
III.1	0.1126	0.0962	0.0434	0.0840	0.0280	0.0207	0.0164	0.0136	

Original waste would have required 1,727 drums with four layers of confinement.

Original waste wattage limit

Watts per Standard Waste Box (SWB)

Waste Matl Type	Number of Layers of Confinement							
	0	1	2	3	4	5	6	Metal
I.1	0.9132							
I.2	1.1240							
I.3	3.6528							
II.1	1.0206	0.7029	0.5361	0.1222	0.0690			
II.2								40.000
III.1	0.5103	0.3515	0.2680	0.0611	0.0345			

Repackaged waste wattage limit

Required 102 SWBs with one layer of confinement.

Stage One

- open an original candidate drum of waste
- breach all the layers of confinement
- inspect the waste for any RCRA constituents or WIPP non-compliant conditions
- select a portion of the waste based on its Pu-238 content and place it into a new drum
- prepare the drum for shipment and storage at LANL TA-54 Area G (in case the complete repackaging cycle could not be completed)
- assay the drum

Stage Two

- place the drum in an SWB along with blocking and bracing material
- breach any layers of confinement remaining from the repackaging operation
- close the SWB and prepare it for storage, shipment, and disposal at WIPP
- complete the documentation process.

THE WASTE

The waste consisted of drums containing from 0.7g to 4.6g of Pu-238 (including two times the uncertainty). The drums were originally packaged from 1993 to 1997 at the LANL TA-55 plutonium processing facility, and most of the waste was in either of two packaging configurations – bundles inside a bag, or loose waste in a vented metal can that was inside a bag (see Figure 1). The waste consisted mostly of rubber work gloves, glove box gloves, lab ware, and decontamination and processing materials. Waste generators provided sufficient documentation to show, among other things, the packaging configuration, radionuclide content, RCRA codes, and waste type. The drums typically contained less than 50 pounds of waste and were not full volumetrically, but were more than full based on decay heat. That is, they exceeded the WIPP WAC wattage limit from Table I.

STAGE ONE REPACKAGING

Out of available stock at the LANL TA-54 TRU waste storage area, the TWCP Site Project Manager selected thirty six candidate drums from the TA-55-43 waste stream and requested Real Time Radiography (RTR), shipment to the WCRRF, Headspace Gas Analysis and Sampling (HGAS), filter replacement, and staging at the WCRRF. Then WCRRF operators brought one drum at a time (the parent drum) into the WCRRF, transferred the waste in to the Waste Characterization Glove Box (WCG), and prepared two new output drums (daughter drums) to receive the partitioned waste (see Figure 2). After reviewing the documentation, they opened the parent drum, weighed, described the waste[5], and decided how to load the daughter drums. They made drum loading decisions based on the original radioassay at TA-55. During waste examination but before opening any packages, operators removed and rejected any items suspected of being classified as RCRA hazardous to avoid contaminating the other waste in the drum, and they remediated conditions that were not compliant with the WIPP WAC. Finally, they placed compliant waste packages into daughter drums and detached (bagged off) the daughter drums and the empty parent drum from the WCG.

The non-destructive assay (NDA) team analyzed the daughter drums for radionuclide content including many isotopes of uranium, neptunium, plutonium, and americium. Decay heat was the limiting factor for the WIPP WAC because of the high Pu-238 content. Drums fell into four categories based on NDA results: 1) known compliant with wattage limit (50%); 2) too highly loaded or “hot” (17%); 3) could not be reliably

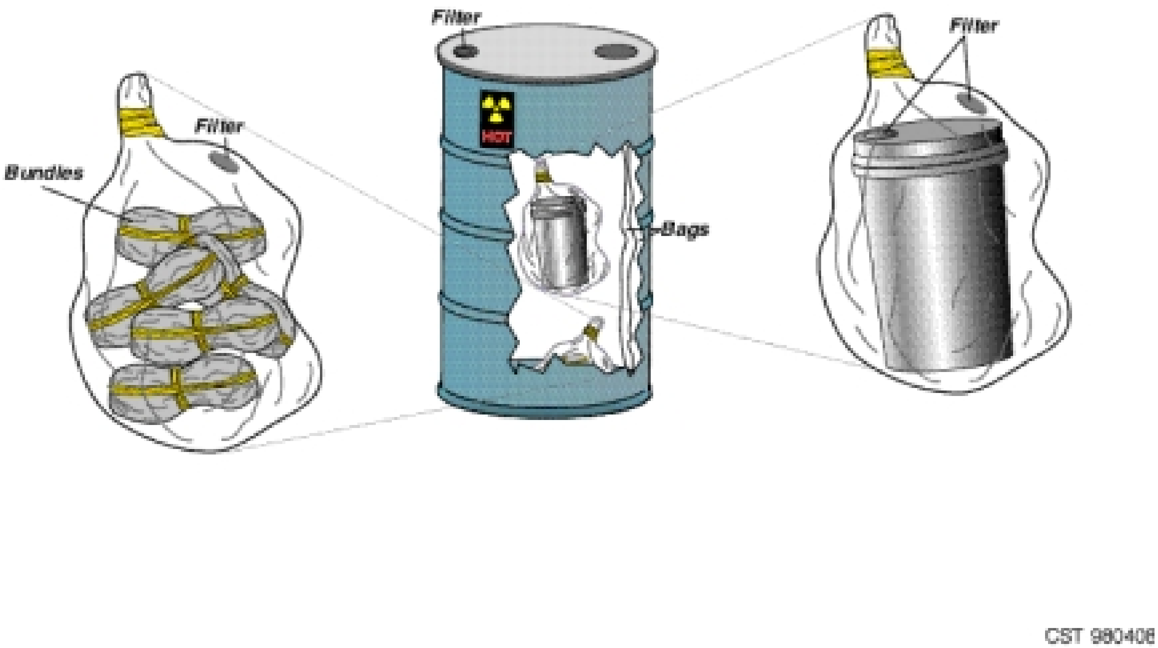

Fig. 1 Pu-238 packaging at TA-55.

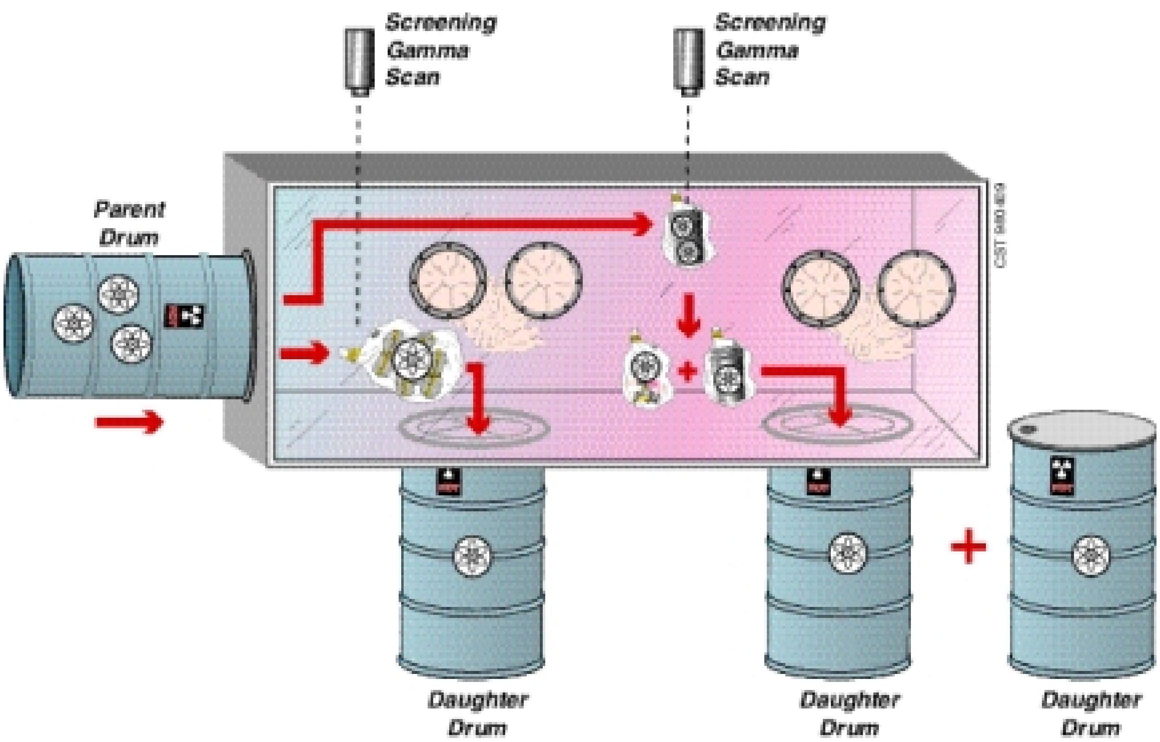

Fig. 2. Stage one repackaging

assayed with passive-active neutron (PAN) assay instruments alone (33%). The daughter drums that were too hot were returned to stage one for repackaging into granddaughter drums. The drums requiring additional assay with other instruments were measured with segmented tomographic gamma spectroscopy and other gamma scanning methods.

PROBLEMS AND IMPROVEMENTS

Glove Bags

Early in the project, two releases of Pu-238 triggered continuous air monitor (CAM) alarms during bag outs. Neither event caused personnel exposure because of the proper use of engineering and administrative controls and proper personnel protective equipment (i.e. full face respirators). In order to prevent future CAM alarms, WCRRF personnel placed waste packages inside glove bags before splitting them for repackaging. They sorted the waste and twisted the glove bag into pods, each containing a portion of the original waste. To breach the new extra layers of protection, the operators punctured the bags by forcing a dampened cheese cloth plug through with a rigid tool. The plug remained in the hole to keep particles from escaping and further contaminating the glove box while the operators gently lowered an appropriate number of pods into a new drum. Additional precautions included wiping the inside of the drum bag liner with damp cheese cloth before bagging off and using a local exhaust fan to capture any airborne particles that may have been released during bag off operations. No additional CAM alarms were associated with the process after these measures were initiated to control contamination. Although the extra precautions caused the process throughput to decrease from four output drums per day to less than two output drums per day, it did prevent weeks of down time during facility recovery from release events, and it reduced the risk of worker uptake of dangerous material.

Screening Assays

For the first drums through the process, repackaging personnel partitioned the waste based solely on the original assay data from the waste generator, but as the project matured, the NDA team developed a correlation between the certifiable PAN data and data from a portable gamma scanning instrument. The absolute amount of Pu-238 could be inferred based on the rate of 766.4 keV gamma emissions of Pu-238 detected with a high purity germanium detector. The rate of emissions could be correlated to a gram amount of Pu-238, but this correlation was generally not done because the gamma screen could not account for uncertainty in the certified PAN instrument. Therefore, a relative measure, showing that one package was equal to another, was the most useful for repackaging.

WCRRF operators installed the gamma scanner and began using it to determine how to partition the waste to avoid exceeding the decay heat limit of a drum. The NDA team advised the repackaging team how many daughter drums should be made from each parent drum based on their certified PAN assays or calibrated gamma scans. The WCRRF operators determined how to divide the waste into portions of equal decay heat for loading into daughter drums. Using the gamma scan reduced the over-wattage rejection rate of daughter drums to zero. This particular gamma screening technique did not provide a certifiable radioassay because the system had not been qualified by the Carlsbad Area Office of DOE, so it was still necessary to assay the repackaged drums with a certified radioassay system.

STAGE TWO REPACKAGING

Stage two repackaging consisted of taking a drum from stage one and placing it into a specially prepared SWB along with three empty drums (for blocking and bracing). Repackaging personnel prepared SWBs by gluing a special sleeve with gloves into the interior of the box (see Figure 3). After placing the four drums and some tools in the SWB and sealing the top of the sleeve, operators reached into the bag via the gloves and removed the waste drum lid or bung and then used a knife to slash any remaining drum liner bags.

The slashing was required in order to meet the packaging requirements of TRUCON Code LA125A for number of layers of confinement. Operators wearing air-purifying respirators conducted the slashing operation inside the airlock of a large walk-in glove box. Once operators had slashed all the remaining layers of confinement, they surveyed the SWB and removed it from the glove box and sealed it with the lid and labeled it for shipment and disposal at WIPP.

DISCUSSION AND LESSONS LEARNED

LANL identified several problems during the project. One of them was release of the extremely mobile Pu-238 in to the work environment. Another was the inability of PAN assay, in some waste drums, to separate the very small Pu-238 neutron signal from the substantial neutron noise of subsequent radioactive decays. Project planners also knew that some drums would not be repackaged properly, leading to a predicted rejection rate of about 20%. They assumed that they would refine the methods throughout the process and reduce the rejection rate to nearly zero. Another major problem that repackaging staff faced was the production of data reports for the new waste packages. LANL learned the following lessons.

- The contamination potential of Pu-238 waste is sufficiently severe that normal waste handling techniques should be augmented with glove bags inside gloveboxes, extra decontamination, and local HEPA filtered exhaust during bag out operations. Operators should prepare accordingly and allow extra time and materials cost.

- PAN assay may not be suitable for all waste matrices. In particular, strong alpha particle emitters such as Pu-238 can cause high neutron emissions from reactions not associated with spontaneous decay of plutonium, and PAN cannot determine the source of the neutrons. The Pu-238 waste stream was particularly challenging because there were few decay neutrons in relation to the number of alpha-n reaction neutrons.

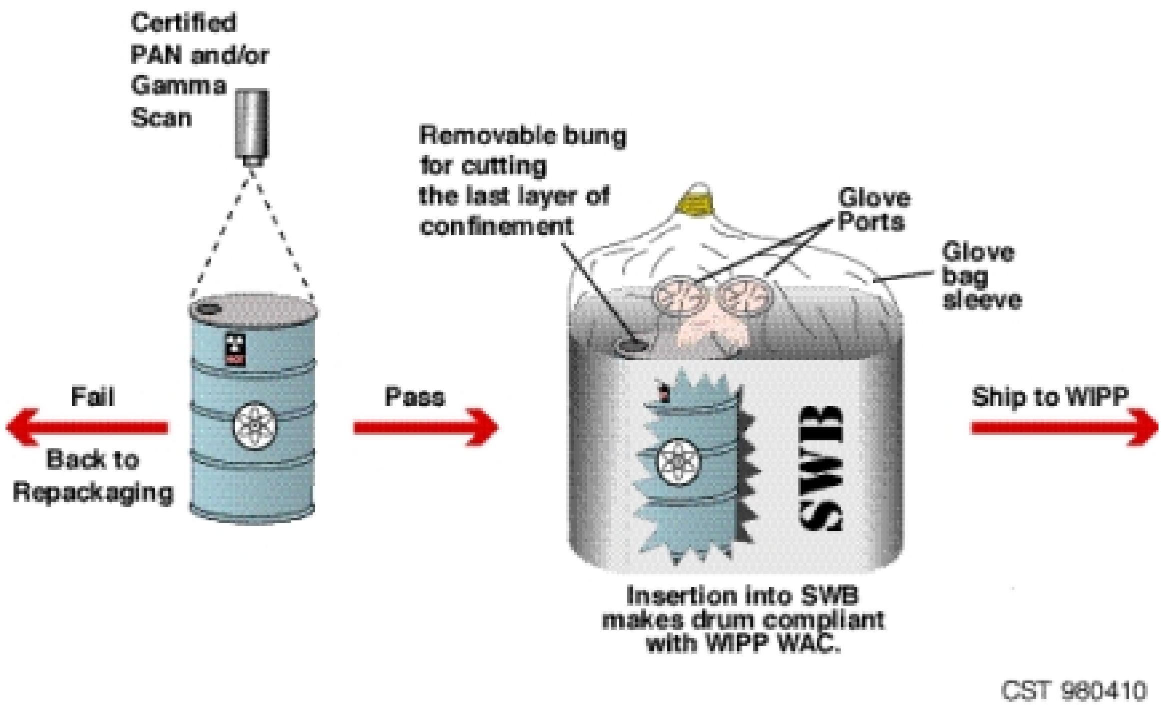

Fig. 3. Stage two repackaging.

In this case, instruments such as the segmented tomographic gamma scanner are useful in conjunction with PAN or as a stand-alone method. The mobile Segmented Tomographic Gamma Scanner was certified near the end of the project and provided additional certified radioassay capability.

- Pre-screening a parent drum with a certified radioassay instrument helps operators decide how many daughter drums to make. Generator assays using unqualified instruments are not as helpful.

- A real time gamma screening instrument, when calibrated against a qualified system and used as a tool for splitting waste items during repackaging, can substantially decrease the rejection rate of repackaged waste. Instruments, even though uncertified to WIPP quality assurance objectives, can be used at the time of repackaging, (for screening purposes only) to inform the operators if they have partitioned the waste equally. The 766.4 keV gamma decay scan reduced the rejection rate of daughter drums to zero.

- Batch data reports for the repackaging process had never been defined, controlled by procedures, or submitted to WIPP for certification, so the process went through several iterations. Repackaging was also complicated by having to transcribe all the data by hand and quality check the transcription and calculations. Data reports for the 102 packages total about 800 pages and about 9000 separate entries just for repackaging. Automated data entry from the TWCP database will facilitate future projects and lower the data entry costs substantially.

LANL produced 135 potentially certifiable drums from 30 parent drums during the stage one repackaging process. These included twenty six re-repackaged daughter or granddaughter drums, leaving fifty six empty drums, managed as low level waste, which were used as blocking and bracing during stage two repackaging. The project was interrupted by a sampling program for the New Mexico Environment Department[6], but it still produced feed stock for 204 cubic meters of road-ready waste in nine months at a cost of about $1.014M, excluding the cost of local transportation, RTR, HGAS, and NDA. The first 11 SWBs have been certified, and the remaining 93 will be completed when stage two repackaging resumes. Stage two repackaging will take about four months to complete at a cost of about $0.4M.

CONCLUSIONS

LANL provided non-mixed waste for the first shipments to WIPP by repackaging a Pu-238 waste stream. The original waste would have required 1,727 drums to meet the decay heat limit of the WIPP WAC, but by removing layers of confinement and using SWBs instead of drums, the number of containers was reduced to 102. The repackaging involved opening drums of waste, expanding the volume into more drums, assaying the drums, placing the drums into standard waste boxes, and removing layers of confinement. LANL developed methods for controlling Pu-238 contamination, for partitioning the waste equally using gamma spectroscopy, and for assaying drums having a small signal to noise ratio. LANL continues to work on an integrated and automated data entry system to streamline its TRU waste preparation and certification. Meanwhile, the first non-mixed transuranic waste is ready for shipment to WIPP.

ENDNOTES

1 *Waste Acceptance Criteria For The Waste Isolation Pilot Plant*. Revision 5. DOE/WIPP-069 Carlsbad, New Mexico, U.S. DOE Carlsbad Area Office (1996)

2 The number of SWBs (102) is based on a DOE performance measure established for LANL. To certify that number of containers, LANL created 135 daughter drums in case some of the repackaged drums were still uncertifiable.

3 *TRUPACT-II Content Codes (TRUCON).* Revision 10. DOE/WIPP-89-004 Carlsbad, New Mexico, U.S. DOE Carlsbad Area Office (1996)

4 *TRUPACT-II Safety Analysis Report for Packaging.* Revision 10. Prepared by Westinghouse Electric Corporation, Waste Isolation Division, Carlsbad, NM, (1998)

5 LANL performed visual examination on five of the parent drums as required by the *Transuranic Waste Characterization Quality Assurance Program Plan*, CAO-94-1010, Department of Energy, Carlsbad, New Mexico, (April1995)

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[6] S. T Kosiewicz, D. E. Michael, P. K. Black, I. Triay, L. A. Souza, “Sampling and Analysis Validates Acceptable Knowledge On LANL Transuranic, Heterogeneous, Debris Waste,” Accepted for Presentation/Publication at WM’99 Symposia, Tucson, AZ, (March 1999)