Federal Record: Y	**Package, Supplement or Correction: N**	**QA:N/A Inclusionary**
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01/19/2001 01:23:18 PM	**Tammie Burrel/YM/RWDOE**	**NON-QA INCLUSIONARY**

From: Pat O'Leary/YM/RWDOE

Date: 01/18/2001 02:04 PM

To: Dan Thomas/YM/RWDOE@CRWMS
cc: Peter Noel/YM/RWDOE@CRWMS, wolf@cmt.anl.gov
bcc:
Subject: Draft GE RCA data Qual. Documents

Email Content:

Dan,

DQP is the data qualification plan. DQR is the data qualification report. Both are Draft but essentially complete.

Peter and Steve,

Please review and comment on DQR.doc. The DQP.doc is a mirror of DQR so I will reflect any necessary changes accordingly.

Thanks,

Pat


DQR_rca.doc


DQP_rca.doc

Expand Recipients:
Created/Updated By:

Title: **Data Qualification Report: GE Radiochemical Assay Results for TMI-1 and QC-1 Fuel Samples**

Document Identifier: TDR-UDC-NU-000003 REV 00

Originator: Patrick M. O'Leary

Lead: Daniel A. Thomas

Responsible Manager: Hugh Benton

Draft Date: January 26, 2001

(Replace this page with the Development Plan (DP) Checklist and Cover Sheet before issuing document.)

1. OBJECTIVE AND SCOPE

The objective of this report is to document the data qualification process for the GE Radiochemical Assay Data for fuel rod samples irradiated in the Three Mile Island Unit 1 and Quad Cities Unit 1 nuclear reactors. The results of this qualification will allow the GE radiochemistry assay data to be used in the isotopic model benchmarking effort required by the USNRC.

2. DATA FOR QUALIFICATION

The enclosed radiochemical assay data are recommended to be qualified in accordance with AP-SIII.2Q. This data will be used in the isotopic model benchmarking effort required by the USNRC.

3. METHOD OF QUALIFICATION

The qualification method to be used is "Corroborating Data." This method was selected in accordance with Attachments 2 and 3 of AP-SIII.2Q *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data.* These data and analytical methods will be compared to similar analytical methods and measurements performed on similar samples by Argonne National Laboratory (ANL) personnel. The technical approach to be used in satisfying the four evaluation criteria listed in Section 5.0 is given as follows:

1) The analytical methods used at the GE-Valecitos Nuclear Center (GE-VNC) hot-cell facility, described in references 1 and 2, will be compared to the analytical methods used at ANL (reference 3). The comparison will consider the adequacy of the GE methods, relative to the ANL methods for the purposes of identifying and quantifying radionuclide compositions of irradiated nuclear fuel samples.

2) Two nearby samples taken from Quad Cities Unit 1 rod C7 will be compared. The comparison of relative concentrations will demonstrate that the two different analytical methods produce similar results.

The ANL measurement data was selected because it was performed under the DOE QARD.

4. DATA QUALIFICATION TEAM

Mr. Dan Thomas (Manager, Waste Package Department), assigned three individuals to the qualification team. Personnel were selected because of their expertise and experience in nuclear fuel depletion analysis and radionuclide measurement systems, and because they were independent of the initial process of assay measurements.

Patrick M. O'Leary -Chairperson. Patrick M. O'Leary has a B.S. in Nuclear Engineering and a M.S. in Engineering Management. Mr. O'Leary has more than 20 years of experience associated with the

modeling, measurement and analysis of irradiated commercial nuclear fuels. His experience includes the quantitative and qualitative analysis of fission and activation products associated with irradiated PWR and BWR fuel assemblies.

Peter M. Noel –Technical Representative. Peter Noel has a B.S. in Nuclear Engineering. Mr. Noel has more than 13 years of experience associated with the modeling and analysis of irradiated commercial PWR and BWR nuclear fuel assemblies. His experience includes the prediction of fission product and actinide radionuclide concentrations for use in spent nuclear fuel criticality analyses.

Stephen F. Wolf, Ph.D. Technical representative. Dr. Wolf is a staff chemist in the Chemical Technology Division at Argonne National Laboratory. He received his Bachelor of Science in Chemistry in 1987 and his Doctor of Philosophy in Analytical Chemistry in 1993 from Purdue University. He has 13 years experience as a radioanalytical chemist. His current research activities are centered on the application of ICPMS and HPLC-ICPMS and as tools for the analysis of determination of fissile and neutron absorbing nuclides in high-burnup spent nuclear fuel, as well as trace-level radionuclides in environmental and matrices. He is a member of the following profession societies: American Chemical Society Analytical Division, Nuclear Technology Division; American Association for the Advancement of Science; American Geophysical Union; Meteoritical Society; American Nuclear Society; Materials Research Society; American Society of Testing and Materials. He has authored or co-authored over 100 technical papers, reports, and abstracts in the areas of analytical chemistry, radioanalytical chemistry, nuclear materials research, and cosmochemistry.

5. EVALUATION CRITERIA

Four criteria were considered to evaluate the quality of TIC: 249347 and TIC: 249348 when the corroborating data method was used. These criteria were selected to incorporate the considerations in Attachment 2 of AP-SIII.2Q and the applicable qualification process attributes listed in Attachment 3 of AP-SIII.2Q.

1. Was the literature (i.e., corroborative data) reviewed adequate and comprehensive?
2. Was the literature (i.e., corroborative data) sufficient for selecting values appropriate for their intended use?
3. Were the inferences and decisions made to select the parameter values clearly identified, justified, and documented?
4. Was the analysis conducted in accordance with applicable QA procedures?

6. RECOMMENDATION CRITERIA

The following recommendation criteria were considered. The data were to be recommended as qualified if:

1. The extent and quality of the corroborative data are sufficient and no additional data sources are identified that should have been considered.
2. The selection criteria are sufficient for selecting values appropriate for their intended use.
3. The selection process was sufficiently documented and correctly followed so that it can be repeated and the same values selected.
4. QA procedures were followed to control the process for development of the analysis.

Thus, a change in qualification status is to be recommended if there are no negative findings in any of these criteria that would result in questions about the technical validity of the isotopic assay values.

7. EVALUATION RESULTS

Criteria one, two and three are satisfied by the following technical evaluation of the GE-VNC data. The technical evaluation (3) is based on several actions: examination of two documents summarizing the methodologies employed in this work (1,2), visited the personnel at the facilities where work was performed, and compared results of analyses of samples possessing near-identical irradiation histories (1,2). A comparison of these near identical results is graphically depicted in Figures 1 and 2. The available information supports data qualification.

The available technical documentation and laboratory visits both indicate that, while the analytical procedures utilized by GE-VNC differ slightly from those employed by ANL, the procedures are fundamentally identical in most cases. In the two cases where different techniques were used, the alternative approach was technically sound.

GE-VNC employed an open-vessel digestion procedure to dissolve the samples. The mineral acids and temperatures employed would be expected to dissolve all fuel matrix elements including actinides, lanthanides, and soluble fission products such as Cs. The only elements that this technique would not be expected to dissolve are those present in ε-particles such as Tc, Ru, Rh, Pd, and Mo. These elements were not included in GE-VNC results so that the dissolution would be adequate for their purposes.

GE-VNC used the high-precision technique of isotope dilution thermal ionization mass spectrometry for the determination of most U, Pu, Am, Cm, Nd, Sm, Eu, and Gd isotopes. Thermal ionization mass spectrometry has traditionally been the technique for determining isotopes of these elements in dissolved fuel [1] and provided the necessary chemical separations from interfering isobars are achieved, this methodology should produce quality data. ANL employed ICPMS as the method for mass-spectrometric determination.

Two nuclides were determined by essentially identical methods in both laboratories. Plutonium-238 activity determination was performed by α-spectrometry by benchmarking to the $^{239}Pu+^{240}Pu$ α-

activity in a Pu-separated sample. The ^{238}Pu concentration was then calculated based on the ^{239}Pu and ^{240}Pu concentrations as determined by ICPMS. Cesium-137 was determined by γ-spectrometry.

Two nuclides were determined by fundamentally different methods in both laboratories. GE-VNC determined ^{241}Am by α-spectrometry after chemical separation. This method differs from ANL's direct determination by gamma spectrometry. GE-VNC determined ^{237}Np by α-spectrometry after chemical separation with yield determination by γ-spectrometric determination of a ^{239}Np tracer. This method differs from ANL's direct determination by ICPMS. While the methods ^{241}Am and ^{237}Np differ from those employed by ANL, the procedures are fundamentally sound and should produce quality data. In both cases the isotopic spikes, standards, and analytical instrumentation employed by GE-VNC are all technically appropriate for the analyses that were performed.

Criterion four was satisfied because ANL has a QARD approved quality plan and followed those approved QA procedures to control the process for development of this analysis.

8. RECOMMENDATION FOR QUALIFICATION

No negative findings were documented that resulted in questions about the quality of the data. The qualification team therefore recommends that the status of data sets TIC: 249347 and TIC: 249348 be changed to qualified.

9. REFERENCES

1. GE 1999. *TRW Yucca Mountain Project Test Report Phase 1.* TRW Purchase Order No. A09112CC8A. GE Valecitos, California: TIC: 249347

2. GE 2000. *TRW Yucca Mountain Project Test Report Phase 2.* TRW Purchase Order No. A09112CC8A. GE Valecitos, California: TIC: 249348

3. ANL 2000. *Analysis of Spent Nuclear Fuel Samples From Three Mile Island and Quad Cities Reactors: Final Report.* November 2000. Chicago, Illinois: TIC: 249349

10. PROCEDURES

The following procedures may be used, as necessary, to implement this plan:

AP-2.13Q	*Technical Product Development Planning*
AP-3.15Q	*Managing Technical Product Inputs*
AP-6.1Q	*Controlled Documents*

AP17.1Q	*Record Source Responsibilities for Inclusionary Records*
AP-SIII.2Q	*Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*
AP-SIII.3Q	*Submittal and Incorporation of Data to the Technical Data Management System*

Figure 1. ANL and GE Samples from QC-1 Rod C7 Normalized to U-238

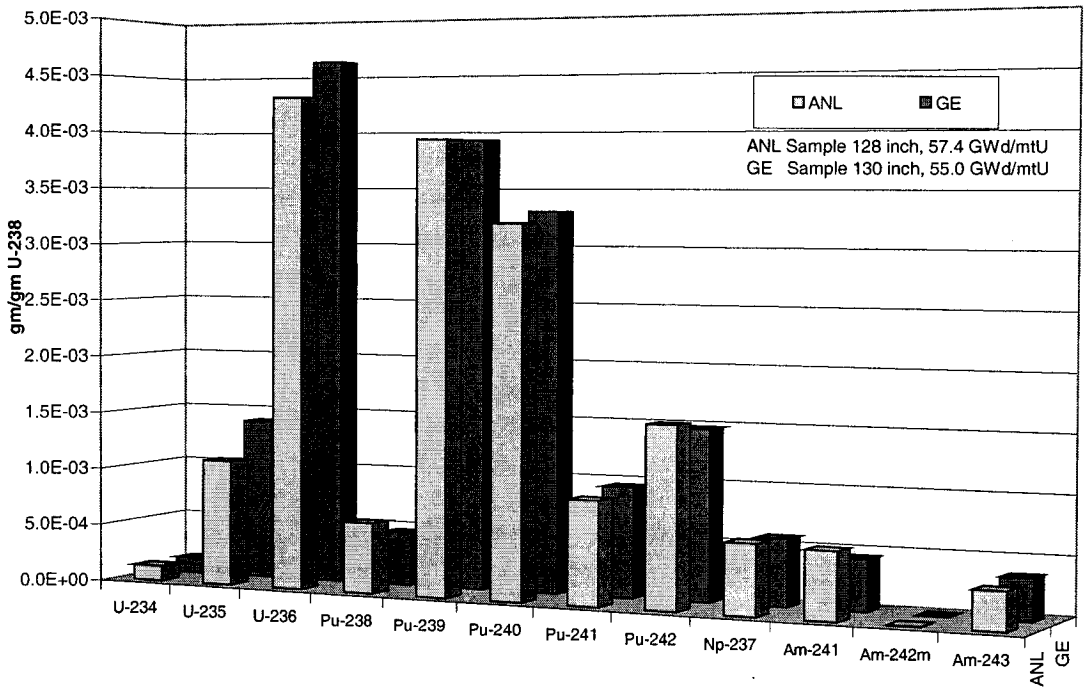
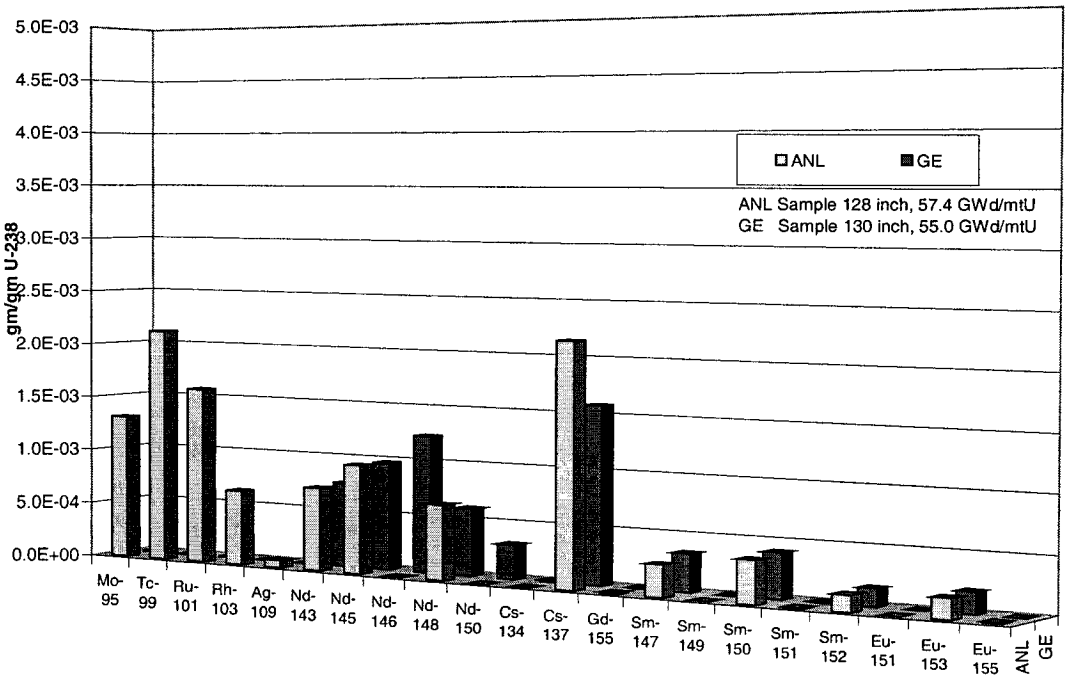


Figure 2. ANL and GE Samples from QC-1 Rod C7 Normalized to U-238



ENCLOSURE

GE Radiochemical Assay Data to be Qualified

The isotopic concentrations and burnup results for the 8 fuel samples investigated under Phase 1 of this contract are shown in Tables 1 through 11. Table 12 summarizes the estimated relative uncertainty, at the 95% confidence level, of each measurement.

Table 1
Burnup Analysis Summary

TRW Sample ID	Fuel Rod Identification	Sub-sample	"Normal" Nd Burnup Anal.	Including "non-spiked" Nd analysis	Burnup average MWd/MTU
1	TMI O1	1A2	2.58E+04	2.58E+04	2.58E+04
3	TMI O1	4C2D2	2.66E+04	2.67E+04	2.67E+04
4	TMI O12	1A2	2.37E+04	2.37E+04	2.37E+04
6	TMI O12	4A3C2	2.40E+04	2.40E+04	2.40E+04
11	QC-1 B1	3B	7.32E+04	7.59E+04	7.46E+04
12	QC-1 B1	5A2	5.31E+04	5.31E+04	5.31E+04
13	QC-1 C7	5A2	5.52E+04	5.49E+04	5.50E+04
14	QC-1 G5	5A2	4.56E+04	4.53E+04	4.55E+04

Table 2
Uranium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg U-234 per mg U-238	mg U-235 per mg U-238	mg U-236 per mg U-238
1	TMI O1	1A2	3.48E-04	2.35E-02	4.83E-03
3	TMI O1	4C2D2	3.35E-04	2.32E-02	4.99E-03
4	TMI O12	1A2	3.55E-04	2.51E-02	4.58E-03
6	TMI O12	4A3C2	3.48E-04	2.55E-02	4.68E-03
11	QC-1 B1	3B	1.54E-04	1.12E-03	5.93E-03
12	QC-1 B1	5A2	1.82E-04	3.75E-03	5.97E-03
13	QC-1 C7	5A2	1.28E-04	1.39E-03	4.62E-03
14	QC-1 G5	5A2	1.60E-04	3.30E-03	4.56E-03

Table 3
Plutonium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Pu238 Per mg U238	mg Pu-239 per mg U-238	mg Pu-240 per mg U-238	mg Pu-241* per mg U-238	mg Pu-242 per mg U-238
1	TMI O1	1A2	7.67E-05	5.81E-03	1.62E-03	8.04E-04	1.92E-04
3	TMI O1	4C2D2	1.00E-04	6.44E-03	1.83E-03	9.56E-04	2.36E-04
4	TMI O12	1A2	6.68E-05	5.79E-03	1.48E-03	7.34E-04	1.58E-04
6	TMI O12	4A3C2	8.29E-05	6.60E-03	1.61E-03	8.54E-04	1.76E-04
11	QC-1 B1	3B	6.58E-04	4.04E-03	3.61E-03	1.04E-03	1.99E-03
12	QC-1 B1	5A2	5.41E-04	4.61E-03	3.38E-03	1.08E-03	1.23E-03
13	QC-1 C7	5A2	4.58E-04	3.92E-03	3.30E-03	9.49E-04	1.47E-03
14	QC-1 G5	5A2	4.64E-04	5.80E-03	3.06E-03	1.16E-03	9.87E-04

* As of 4/7/99

Table 4
Neodymium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Nd-143 per mg U-238	mg Nd-145 per mg U-238	Mg Nd-146 Per mg U-238	mg Nd-148 per mg U-238	mg Nd-150 per mg U-238
1	TMI O1	1A2	7.95E-04	6.00E-04	5.56E-04	3.05E-04	1.38E-04
3	TMI O1	4C2D2	8.28E-04	6.21E-04	5.87E-04	3.21E-04	1.47E-04
4	TMI O12	1A2	7.51E-04	5.59E-04	5.12E-04	2.81E-04	1.26E-04
6	TMI O12	4A3C2	7.66E-04	5.64E-04	5.26E-04	2.88E-04	1.31E-04
11	QC-1 B1	3B	8.77E-04	1.23E-03	1.70E-03	8.02E-04	4.13E-04
12	QC-1 B1	5A2	9.75E-04	1.04E-03	1.25E-03	6.22E-04	3.11E-04
13	QC-1 C7	5A2	7.60E-04	9.70E-04	1.23E-03	6.05E-04	3.11E-04
14	QC-1 G5	5A2	8.58E-04	8.75E-04	1.04E-03	5.24E-04	2.67E-04

Table 5
Cesium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Cs-134 per mg of U-238 at count-time*	mg Cs-137 per mg of U-238 at count-time*
1	TMI O1	1A2	2.51E-05	9.71E-04
3	TMI O1	4C2D2	2.90E-05	1.03E-03
4	TMI O12	1A2	2.22E-05	9.05E-04
6	TMI O12	4A3C2	2.44E-05	9.18E-04
11	QC-1 B1	3B	2.49E-05	2.08E-03
12	QC-1 B1	5A2	1.77E-05	1.63E-03
13	QC-1 C7	5A2	1.77E-05	1.58E-03
14	QC-1 G5	5A2	1.28E-05	1.36E-03

* As of 3/19/99

Table 6
Europium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Eu-151 per mg U-238	mg Eu-153 per mg U-238
1	TMI O1	1A2	4.15E-07	8.05E-05
3	TMI O1	4C2D2	4.61E-07	8.80E-05
4	TMI O12	1A2	4.29E-07	7.37E-05
6	TMI O12	4A3C2	4.89E-07	7.69E-05
11	QC-1 B1	3B	5.57E-07	2.35E-04
12	QC-1 B1	5A2	5.53E-07	1.93E-04
13	QC-1 C7	5A2	4.67E-07	1.89E-04
14	QC-1 G5	5A2	6.71E-07	1.73E-04

Table 7
Samarium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Sm-147 per mg U-238	mg Sm-149 per mg U-238	mg Sm-150 per mg U-238	mg Sm-151 per mg U-238	mg Sm-152 per mg U-238
1	TMI O1	1A2	1.91E-04	4.32E-06	2.30E-04	1.36E-05	9.23E-05
3	TMI O1	4C2D2	1.94E-04	4.72E-06	2.47E-04	1.53E-05	9.54E-05
4	TMI O12	1A2	1.81E-04	4.32E-06	2.11E-04	1.38E-05	8.62E-05
6	TMI O12	4A3C2	1.79E-04	4.73E-06	2.17E-04	1.58E-05	8.41E-05
11	QC-1 B1	3B	3.84E-04	1.62E-06	5.28E-04	1.05E-05	1.88E-04
12	QC-1 B1	5A2	3.81E-04	1.97E-06	4.28E-04	1.08E-05	1.57E-04
13	QC-1 C7	5A2	3.42E-04	1.55E-06	4.06E-04	8.96E-06	1.58E-04
14	QC-1 G5	5A2	3.25E-04	1.97E-06	3.69E-04	1.24E-05	1.25E-04

Table 8
Gd-155 Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Gd-155 per mg U-238
1	TMI O1	1A2	2.46E-06
3	TMI O1	4C2D2	2.82E-06
4	TMI O12	1A2	2.03E-06
6	TMI O12	4A3C2	2.33E-06
11	QC-1 B1	3B	1.30E-05
12	QC-1 B1	5A2	9.99E-06
13	QC-1 C7	5A2	1.02E-05
14	QC-1 G5	5A2	1.23E-05

Table 9
Curium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	(Alpha Spec) mg Cm242* per mg U238	(Mass Spec) mg Cm242* per mg U238	mg Cm243 per mg U238	mg Cm244 per mg U238	mg Cm245 per mg U238
1	TMI O1	1A2	1.5E-08	2.2E-08	5.50E-08	2.66E-06	1.19E-07
3	TMI O1	4C2D2	2.6E-08	3.2E-08	1.04E-07	5.32E-06	2.81E-07
4	TMI O12	1A2	1.9E-08	2.7E-08	6.36E-08	2.89E-06	1.24E-07
6	TMI O12	4A3C2	1.8E-08	2.2E-08	6.99E-08	3.22E-06	1.67E-07
11	QC-1 B1	3B	ND	ND	1.82E-06	3.00E-04	1.91E-05
12	QC-1 B1	5A2	ND	ND	1.46E-06	1.12E-04	7.83E-06
13	QC-1 C7	5A2	ND	ND	1.31E-06	1.48E-04	8.75E-06
14	QC-1 G5	5A2	ND	ND	1.09E-06	1.01E-04	9.44E-06

* As of 3/29/99
ND =Not Detected

Table 10
Americium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Am241 per mg U238	mg Am242m per mg U238	mg Am243 per mg U238
1	TMI O1	1A2	1.22E-04	2.57E-07	1.60E-05
3	TMI O1	4C2D2	1.83E-04	4.46E-07	2.74E-05
4	TMI O12	1A2	1.62E-04	3.51E-07	1.80E-05
6	TMI O12	4A3C2	1.47E-04	3.97E-07	1.76E-05
11	QC-1 B1	3B	5.02E-04	1.42E-06	5.64E-04
12	QC-1 B1	5A2	5.14E-04	2.21E-06	2.89E-04
13	QC-1 C7	5A2	4.38E-04	1.37E-06	3.55E-04
14	QC-1 G5	5A2	5.64E-04	3.65E-06	2.48E-04

Table 11
Np-237 Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Np237 per mg U238	Re-spiked Replicate	Average mg Np237 per mg U238
1	TMI O1	1A2	3.24E-04		
3	TMI O1	4C2D2	3.89E-04		
4	TMI O12	1A2	3.23E-04		
6	TMI O12	4A3C2	3.50E-04		
11	QC-1 B1	3B	7.95E-04	7.79E-04	7.87E-04
12	QC-1 B1	5A2	6.60E-04	6.78E-04	6.69E-04
13	QC-1 C7	5A2	5.75E-04	5.64E-04	5.70E-04
14	QC-1 G5	5A2	5.64E-04	5.79E-04	5.71E-04

Table 12
Estimated Measurement Uncertainties

Isotope*	Estimated percentage uncertainty @95% confidence
U-238	1
U-234	1
U-235	1
U-236	1
Cs-134	3.5
Cs-137	3.5
Pu-238	5
Pu-239	1.2
Pu-240	1.2
Pu-241	1.2
Pu-242	1.2
Nd-143	1.5
Nd-145	1.5
Nd-146	1.5
Nd-148	1.5
Nd-150	1.5
Sm-147	1.7
Sm-149	1.8
Sm-150	1.7
Sm-151	1.7
Sm-152	1.7
Eu-151	1.7
Eu-153	1.8
Gd-155	2.7**
Am-241	7
Am-242	7
Am-243	7
Cm-242	20
Cm-243	5.5
Cm-244	5.5
Cm-245	5.5
Np-237	5.8

*reported as mg/mg U238 (except for the U-238 measurement)
**Interference

The isotopic concentrations and burnup results for the 6 fuel samples investigated under Phase 2 of this contract are shown in Tables 13 through 23. Table 24 summarizes the estimated relative uncertainty, at the 95% confidence level, of each measurement.

Table 13
Burnup Analysis Summary

TRW	Fuel Rod		Burnup (MWd/MTU)		
			"Normal" Nd	"non-spiked"	
Sample ID	Identification	Sub-sample	Burnup Anal.	Nd analysis	Average
2	TMI O1	3A2	2.98E4	2.99E4	2.99E4
5	TMI O12	3A2	2.65E4	2.65E4	2.65E4
7	TMI O13	1A2	2.24E4	2.32E4	2.28E4
8	TMI O13	3A2	2.63E4	2.64E4	2.63E4
9	QC-1 A2	3B1	7.05E4	6.96E4	7.00E4
10	QC-1 A2	5A1B	5.25E4	5.25E4	5.25E4

Table 14
Uranium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg U-234 Per mg U-238	mg U-235 per mg U-238	mg U-236 per mg U-238
2	TMI O1	3A2	3.25E-04	2.05E-02	5.34E-03
5	TMI O12	3A2	3.34E-04	2.33E-02	4.93E-03
7	TMI O13	1A2	3.65E-04	2.53E-02	4.49E-03
8	TMI O13	3A2	3.40E-04	2.34E-02	4.89E-03
9	QC-1 A2	3B1	1.60E-04	1.25E-03	5.90E-03
10	QC-1 A2	5A1B	1.84E-04	3.86E-03	5.91E-03

Table 15
Plutonium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	10.1.1.1.1 mg Pu238 per mg U-238	mg Pu-239 per mg U-238	mg Pu-240 per mg U-238	mg Pu-241* per mg U-238	mg Pu-242 per mg U-238
2	TMI O1	3A2	1.16E-04	5.98E-03	1.98E-03	9.79E-04	3.04E-04
5	TMI O12	3A2	9.40E-05	6.41E-03	1.76E-03	8.97E-04	2.20E-04
7	TMI O13	1A2	6.41E-05	5.77E-03	1.46E-03	7.04E-04	1.54E-04
8	TMI O13	3A2	9.29E-05	6.28E-03	1.73E-03	8.79E-04	2.16E-04
9	QC-1 A2	3B1	6.66E-04	3.94E-03	3.71E-03	9.98E-04	1.98E-03
10	QC-1 A2	5A1B	5.31E-04	4.47E-03	3.42E-03	1.02E-03	1.23E-03

*As of 4 Nov. 1999

Table 16
Neodymium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Nd-143 per mg U-238	mg Nd-145 per mg U-238	Mg Nd-146 per mg U-238	mg Nd-148 per mg U-238	mg Nd-150 per mg U-238
2	TMI O1	3A2	8.92E-04	6.87E-04	6.58E-04	3.58E-04	1.64E-04
5	TMI O12	3A2	8.16E-04	6.11E-04	5.76E-04	3.14E-04	1.43E-04
7	TMI O13	1A2	7.41E-04	5.51E-04	5.04E-04	2.77E-04	1.25E-04
8	TMI O13	3A2	8.11E-04	6.08E-04	5.72E-04	3.12E-04	1.42E-04
9	QC-1 A2	3B1	8.77E-04	1.21E-03	1.65E-03	7.79E-04	3.99E-04
10	QC-1 A2	5A1B	9.68E-04	1.03E-03	1.23E-03	6.13E-04	3.06E-04

Table 17
Cesium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Cs-134 per mg of U-238 at count-time*	mg Cs-137 per mg of U-238 at count-time*
2	TMI O1	3A2	2.76E-05	1.17E-03
5	TMI O12	3A2	2.27E-05	1.00E-03
7	TMI O13	1A2	1.76E-05	8.92E-04
8	TMI O13	3A2	2.27E-05	1.01E-03
9	QC-1 A2	3B1	1.85E-05	2.05E-03
10	QC-1 A2	5A1B	1.35E-05	1.62E-03

* As of 11/5/99

Table 18
Europium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Eu-151 per mg U-238	mg Eu-153 per mg U-238
2	TMI O1	3A2	4.74E-07	1.01E-04
5	TMI O12	3A2	5.02E-07	8.65E-05
7	TMI O13	1A2	4.48E-07	7.13E-05
8	TMI O13	3A2	4.99E-07	8.61E-05
9	QC-1 A2	3B1	5.72E-07	2.34E-04
10	QC-1 A2	5A1B	5.73E-07	1.92E-04

Table 19
Samarium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Sm-147 per mg U-238	mg Sm-149 per mg U-238	mg Sm-150 per mg U-238	mg Sm-151 per mg U-238	mg Sm-152 per mg U-238
2	TMI O1	3A2	2.20E-04	4.36E-06	2.78E-04	1.47E-05	1.07E-04
5	TMI O12	3A2	2.01E-04	4.44E-06	2.41E-04	1.51E-05	9.27E-05
7	TMI O13	1A2	1.86E-04	4.23E-06	2.06E-04	1.35E-05	8.47E-05
8	TMI O13	3A2	1.99E-04	4.42E-06	2.38E-04	1.51E-05	9.19E-05
9	QC-1 A2	3B1	3.96E-04	1.40E-06	5.23E-04	1.01E-05	1.92E-04
10	QC-1 A2	5A1B	3.86E-04	1.76E-06	4.23E-04	1.02E-05	1.59E-04

Table 3-20
Gd-155 Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-Sample	mg Gd-155 per mg U-238
2	TMI O1	3A2	3.09E-06
5	TMI O12	3A2	2.68E-06
7	TMI O13	1A2	2.10E-06
8	TMI O13	3A2	2.70E-06
9	QC-1 A2	3B1	1.28E-05
10	QC-1 A2	5A1B	9.97E-06

Table 21
Curium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-Sample	(Alpha Spec) mg Cm-242* per mg U-238	(Mass Spec) mg Cm-242* per mg U-238	mg Cm-243 per mg U-238	mg Cm-244 per mg U-238	mg Cm-245 per mg U-238
2	TMI O1	3A2	1.2E-08	2.3E-08	1.25E-07	7.68E-06	4.02E-07
5	TMI O12	3A2	1.1E-08	1.3E-08	1.07E-07	5.51E-06	2.90E-07
7	TMI O13	1A2	7.4E-09	7.5E-09	5.97E-08	2.62E-06	1.14E-07
8	TMI O13	3A2	1.1E-08	1.4E-08	1.01E-07	5.23E-06	2.74E-07
9	QC-1 A2	3B1	ND	ND	1.58E-06	2.47E-04	1.46E-05
10	QC-1 A2	5A1B	ND	ND	1.31E-06	1.01E-04	6.70E-06

* As of 26 Nov. 1999
ND =Not Detected

Table 22
Americium Isotope Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-sample	mg Am-241 per mg U-238	mg Am-242m per mg U-238	mg Am-243 per mg U-238
2	TMI O1	3A2	2.12E-04	4.53E-07	3.75E-05
5	TMI O12	3A2	2.22E-04	5.18E-07	2.96E-05
7	TMI O13	1A2	1.73E-04	3.36E-07	1.71E-05
8	TMI O13	3A2	2.16E-04	4.99E-07	2.85E-05
9	QC-1 A2	3B1	4.72E-04	1.35E-06	4.87E-04
10	QC-1 A2	5A1B	4.86E-04	1.90E-06	2.58E-04

Table 23
Np-237 Concentrations

TRW Sample ID	Fuel Rod Identification	Sub-Sample	mg Np-237 per mg U-238
2	TMI O1	3A2	4.23E-04
5	TMI O12	3A2	3.72E-04
7	TMI O13	1A2	3.01E-04
8	TMI O13	3A2	3.71E-04
9	QC-1 A2	3B1	7.82E-04
10	QC-1 A2	5A1B	6.78E-04

Table 24
Estimated Measurement Uncertainties

Isotope*	Estimated percentage uncertainty @95% confidence
U-238	1
U-234	1
U-235	1
U-236	1
Cs-134	3.5
Cs-137	3.5
Pu-238	5
Pu-239	1.2
Pu-240	1.2
Pu-241	1.2
Pu-242	1.2
Nd-143	1.5
Nd-145	1.5
Nd-146	1.5
Nd-148	1.5
Nd-150	1.5
Sm-147	1.7
Sm-149	1.8
Sm-150	1.7
Sm-151	1.7
Sm-152	1.7
Eu-151	1.7
Eu-153	1.8
Gd-155	2.7**
Am-241	7
Am-242	7
Am-243	7
Cm-242	20
Cm-243	5.5
Cm-244	5.5
Cm-245	5.5
Np-237	5.8

*reported as mg/mg U-238 (except for the U-238 measurement)
**Interference