UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION AND INDOOR AIR
National Analytical Radiation Environmental Laboratory
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August 7, 2014

MEMORANDUM

SUBJECT: Analysis of Measurability of Superfund PRG Concentrations Using Radiological Laboratory Measurement Techniques

FROM: John G. Griggs, Director
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Office of Radiation and Indoor Air

TO: Stuart A. Walker, Superfund Remedial Program's National Radiation Expert
Office of Superfund Remediation and Technology Innovation (OSRTI),
Science Policy Branch (SPB)

This memorandum is in response to your request for information on the ability of a radiological laboratory to measure concentrations of radioactive contamination in various media that correspond to the Superfund remedial program risk range of 10^{-6} to 10^{-4}, using standard laboratory techniques. I am attaching a copy of an analysis that NAREL conducted for EPA's radiological incident response efforts. This includes many of the same radionuclides that are also commonly found at Superfund sites.

Please note that this analysis was a snapshot of measurement capabilities which have been improving in recent years. The concentrations were provided to NAREL from risk calculations using the PRG calculators that may differ from actual site-specific PRG calculator runs as the calculators are updated or site-specific information is used.

Please let me know if we can be of any further assistance.

Attachment
Radiological Laboratory Capacity Estimates Based on Selected Preliminary Remediation Goals

Radiological Laboratory Capacity

Estimates Based on Selected

Preliminary Remediation Goals

August 7, 2014

prepared by

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Radiological Laboratory Capacity Estimates Based on Selected Preliminary Remediation Goals

Introduction[1]

Following a radiological or nuclear incident, prompt feedback of real-time measurement results will be crucial in supporting decisions regarding the health and safety of the public.

Both field and laboratory measurements will be used for this assessment because they provide decisionmakers with data needed to perform a variety of incident response activities. Real-time measurements and samples will be needed for a variety of matrices and different geographic locations and environmental conditions. To ensure defensible decisionmaking, the data quality objectives and measurement quality objectives[2] for an incident must be tailored to address issues specific to the radionuclides and matrices of concern, and the locations and environmental conditions in and beyond areas directly impacted by the event.

Measurements using field instruments will likely predominate, especially in earlier stages of an incident, when the levels of radioactivity are the highest and preliminary estimates of the type of radiation and activity levels present must be rapidly determined so that protective actions can be implemented effectively and without delay. Field measurements can effectively and rapidly identify the most heavily impacted areas so that actions can be taken to protect the population affected by the event. Field measurements, however, tend to be less radionuclide-specific and may not be capable of reliably detecting radionuclides with weakly penetrating radiations at actionable levels. Thus, field crews will also gather samples and send them to radiochemistry laboratories for rapid, independent confirmation of field measurements using more definitive and lower uncertainty results. Radiochemistry laboratories will be called on to analyze these samples to provide many of the most sensitive and accurate measurements for a large number of specific radionuclides to meet measurement quality objectives for detection capability and uncertainty needed to support decisionmaking by the Incident Commander (IC) or designee.

As the response to the incident progresses through the intermediate and recovery phases, action levels will become progressively lower as decisions are based on longer-term goals, and efforts will shift toward identifying progressively lower levels of contamination. Large areas will need to be quickly characterized and cleared for long-term use and habitation. There will be a need for increasingly sensitive and accurate radionuclide-specific analyses, and expectations for stringent measurement quality will increase. Laboratories will be needed to provide critical measurement capabilities and capacity. Accordingly, the DQOs and MQOs needed to support decisionmaking will become increasingly more demanding of analytical measurements.

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[1] This discussion has been excerpted and revised from *Uses of Field and Laboratory Measurements During a Radiological or Nuclear Incident*, EPA 540- R-12-007, Montgomery AL, 2012.

[2] "Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the study objectives, define the most appropriate type of data to collect, determine the most appropriate conditions from which to collect the data, and specify tolerable limits on decision error rates. … Measurement Quality Objectives (MQOs) can be viewed as the analytical portion of the DQOs and are therefore project-specific." [MARLAP (2004), Section 1.4.9]

Radiological Laboratory Capacity Estimates Based on Selected Preliminary Remediation Goals

A variety of methods are available for measuring radionuclides and their radioactive emissions. Any method selected must be capable of reliably meeting established MQOs (i.e., a performance-based approach). This includes selecting and validating appropriate techniques for sampling and analysis.

Throughout the process, field and laboratory measurements need to be coordinated in a manner that ensures that appropriate decisions will be made based on the phase of the incident and the action levels and concentrations of the radionuclides that need to be analyzed. Given the enormity of radioanalytical realities, complementary abilities and strengths of various types of field measurements coupled with laboratory measurements will be needed to address all of the challenges posed by incident response.

Discussion of Estimates of Laboratory Capacity

Radioanalytical sample demand following an incident involving radiochemical or nuclear agents will be unprecedented. The need to determine the nature and extent of contamination and, in a timely manner, to evaluate the effectiveness of decontamination activities to support consequence management decisions, will result in sample throughput demands orders of magnitude greater than laboratories currently experience. Presumably, demand will be much greater for incidents involving multiple radionuclides, especially if they include pure alpha and beta emitters. Analytical demand will be significantly greater in the case of an improvised nuclear device, or multiple simultaneous incidents. In the case of such an incident, it will be necessary to rapidly identify radioanalytical capabilities and capacities to support the analysis of many thousands of samples taken both during and after the incident.

EPA has performed a series of Incident Response Capability and Capacity Assessments at commercial and DOE radiochemistry laboratories across the country. In the one-and-a-half day assessments, laboratories have voluntarily provided estimates of available capabilities and capacity to support analytical needs following an incident with radiological or nuclear materials. This data is based on a series of snapshots taken over a three year period. They reflect the laboratories' best estimates of "available capacity" for single test / matrix combinations at the time of the assessment. The estimates reflect known competing commitments that will reduce the laboratory's capacity for analyzing environmental samples during a response to an incident (e.g., radiobioassay, food analysis, or support of critical monitoring programs such as those at operating nuclear sites).

When interpreting these results, it is critically important to consider that the estimates rely on simplifying assumptions. The most significant of these is that the demand is for a single test / matrix combination. Thus, estimates of overall capacity cannot be summed for more than one test matrix combination since they likely rely on sets of shared resources at the laboratory.

Radiological Laboratory Capacity Estimates Based on Selected Preliminary Remediation Goals

While the overall picture of relative capacity is not expected to change dramatically, the specific mix of tests and matrices requested during an incident response will impact capacity, often to a quite substantial degree. Thus, during an incident response, it will be critical to promptly contact the appropriate labs to obtain their best estimates of current available capacity.

Methodology of the Capability and Capacity Assessments

A series of Incident Response Capability and Capacity Assessments were performed at commercial and DOE radiochemistry laboratories across the country over a several year period. During one-and-a-half day visits by one scientist, laboratories voluntarily provided estimates of capabilities and capacity. The assessment looked at 21 radionuclide parameters in each of four typical environmental matrices: water, soil, air filters and swipes. Each of these test / matrix combinations were evaluated at two activity levels. Low activity level assumed routine levels such as those used for drinking water compliance testing and routine environmental monitoring (with similar overall activity levels in the analytical aliquant for non-water matrices). The elevated activity estimates assume activities two to three orders of magnitude above routine environmental levels.

Prior to finalizing the estimates, a brief assessment was performed to determine the general state of systems, resources, procedures, and method performance at the laboratory. Assuming that this assessment did not turn up practices, procedures, equipment, or method performance data that could be incompatible with the production of quality data, or other conditions that would be inconsistent with the laboratory's estimate of throughput, the capability / capacity estimates received from the laboratory were left challenged. When potential inconsistencies were encountered, (e.g., no SOP for a given test, gross problems with QC data, personnel not trained, etc.) the laboratory was asked to consider whether the factor(s) in question would impact their ability to deliver defensible data for the parameter in question. Laboratories consistently made appropriate adjustments to their estimates of capability/capacity, and those are the results that are reported here.

Despite every attempt to obtain reliable estimates of capacity, estimates of laboratory capacity are subject to the interpretation of the individual supplying the estimate. For this reason, the assessors worked to apply normalizing factors and assisted laboratories in making estimates that would be intercomparable. The normalizing factors assumed:

- **Only a single test / matrix combination will be analyzed;**
- The supply of samples for analysis is infinite;
- The effort will continue indefinitely (for at least a year);
- Samples will be screened for gross alpha / beta prior to processing;

- Only currently available resources (i.e., approved procedures, trained personnel, available facilities and equipment, calibrated instrumentation, etc.) will be brought to bear; theoretical or undeveloped capabilities and capacity are not included;
- The laboratory's procedures, QA plan, and internal QC protocols apply.

Laboratories often overlook the bigger picture when estimating capacity. For example, if a laboratory can only report results for 100 results per day, the capacity for any test cannot be 500 samples per day even no matter how many analysts are trained and instruments are calibrated. Similarly, if a there were a critical problem in the area of quality assurance, (i.e., no SOP, performance evaluation data indicates grossly inconsistent or problematic results), it should be concluded that a laboratory does not maintain capability for the test in question. In other words, lacking capability to perform a test precludes assignment of capacity for that test.

Combining the estimates of capacity with the on-site assessment proved to be quite effective in helping laboratories provide more reliable and intercomparable estimates of capacity. It was not at all uncommon for laboratories to adjust their capacity estimates, often by one or more orders of magnitude relative to pre-assessment survey amounts. Thus, in spite of significant uncertainty associated with absolute estimates of capacity (due to myriad confounding factors), the normalizing assumptions applied during the on-site assessment process appear to yield reasonably robust estimates of *relative* capacity.

Throughput Estimates for Swipe Samples Based on Preliminary Remediation Goals (PRGs) from the Superfund Preliminary Remediation Goals (SPRG) Calculator

Radionuclide	Matrix	Analytical Technique	Target 10^{-6} risk PRG for removable contamination per SPRG calculator (pCi/cm^2)	Attainable risk level that is consistent with capacity evaluations	Combined capacity (20 labs) samples/week[#,$]	RMDA met	Aliquant size used for calculations	Count time used for calculations (minutes)
Am-241	Swipe	Rapid alpha spectrometry	8.1E-06	1E-04	2860	x	100 cm^2	300
Po-210	Swipe	Rapid alpha spectrometry	1.1E-03	1E-06	840	x	100 cm^2	180
Pu-238	Swipe	Rapid alpha spectrometry	7.4E-06	1E-04	2905	x	100 cm^2	420
Pu-239 ($^{239/240}$Pu)	Swipe	Rapid alpha spectrometry	6.7E-06	1E-04	2905	x	100 cm^2	420
Pu-240 ($^{239/240}$Pu)	Swipe	Rapid alpha spectrometry	6.7E-06	1E-04	2905	x	100 cm^2	420
Th-230	Swipe	Rapid alpha spectrometry	7.8E-06	1E-04	2705	x	100 cm^2	720
Th-232	Swipe	Rapid alpha spectrometry	5.1E-06	1E-04	2705	x	100 cm^2	720
U-234	Swipe	Rapid alpha spectrometry	1.9E-05	1E-04	2830	x	100 cm^2	120
U-235[&]	Swipe	Rapid alpha spectrometry	2.2E-05	1E-04	2830	x	100 cm^2	120
U-238[&]	Swipe	Rapid alpha spectrometry	2.4E-05	1E-04	2830	x	100 cm^2	120
Sr-90 +D	Swipe	Gas proportional counting	2.3E-03	1E-05	1760	x	100 cm^2	20
Tc-99	Swipe	Liquid scintillation counting	1.5E-02	1E-06	1950	x	100 cm^2	45
Co-60	Swipe	Gamma spectrometry	1.9E-02	1E-05	2950	x	100 cm^2	60
Cs-137+D	Swipe	Gamma spectrometry	1.6E-02	1E-05	2950	x	100 cm^2	60
I-131	Swipe	Gamma spectrometry	5.4E+00	1E-06	2950	x	100 cm^2	60
Ir-192	Swipe	Gamma spectrometry	7.9E-01	1E-06	2950	x	100 cm^2	60
Rn-220	Swipe	Gamma spectrometry	3.9E+09	1E-06	2950	x	100 cm^2	60
Rn-222	Swipe	Gamma spectrometry	6.3E+05	1E-06	2950	x	100 cm^2	60
H-3	Swipe	Liquid scintillation counting	2.0E+00	1E-06	2950	x	100 cm^2	60
I-129	Swipe	Beta-gamma counting	2.2E-03	1E-04	535	x	100 cm^2	60
Ra-226	Swipe	Rapid alpha spectrometry	1.9E-05	1E-04	510	x	100 cm^2	120
Ra-226	Swipe	EPA 903.0 or equiv.	1.9E-05	1E-04		x	100 cm^2	270
Ra-226	Swipe	EPA 903.1 or equiv.	1.9E-05	1E-04		x	100 cm^2	30
Ra-228	Swipe	Gamma (inference, ^{228}Ac)	1.5E-04	--	--	--	-- --	--
Ra-228	Swipe	EPA - 904.0 or equiv.	1.5E-04	1E-04	835	x	100 cm^2	90

RMDA - required minimum detectable activity;

[#] Combined estimate of throughput available to EPA for the 20 largest labs running a single test for incident response for a sustained duration of one year are based on laboratory capacity audits of the 20 laboratories

[&] Note that there are no estimates of capacity for ^{232}Th, ^{238}U and ^{235}U which can also be run by ICP-MS. While most labs can analyze for total uranium, they have not developed capability to differentiate between ^{235}U and ^{238}U.

[$] Throuput estimates assume sustained (steady state) production. Processing times vary considerably from lab to lab. Typical times needed for different parts of the process are : sample receipt - 2-3 hours; sample prep and separations, 0.25-1.5 days; counting, 1-8 hours, reporting and review, 0.5-1 day.

Throughput Estimates for Air Samples Based on Preliminary Remediation Goals (PRGs) for External Air

Radionuclide	Matrix	Analytical Technique	Target 10^{-6} Risk PRG for external air (no decay) (pCi/m^3)	Attainable risk level that is consistent with capacity evaluations	Combined capacity (20 labs) samples/week[#,$]	RMDA met	Aliquant size used for calculations	Count time used for calculations (minuntes)
Am-241	Air	Rapid alpha spectrometry	595	1E-06	2860	x	2 m^3	120
Po-210	Air	Rapid alpha spectrometry	950000	1E-06	840	x	2 m^3	120
Pu-238	Air	Rapid alpha spectrometry	131000	1E-06	2905	x	2 m^3	120
Pu-239 ($^{239/240}$Pu)	Air	Rapid alpha spectrometry	116000	1E-06	2905	x	2 m^3	120
Pu-240 ($^{239/240}$Pu)	Air	Rapid alpha spectrometry	133000	1E-06	2905	x	2 m^3	120
Th-230	Air	Rapid alpha spectrometry	26500	1E-06	2705	x	2 m^3	120
Th-232	Air	Rapid alpha spectrometry	55600	1E-06	2705	x	2 m^3	120
U-234	Air	Rapid alpha spectrometry	68200	1E-06	2830	x	2 m^3	120
U-235[&]	Air	Rapid alpha spectrometry	58.4	1E-06	2830	x	2 m^3	120
U-238[&]	Air	Rapid alpha spectrometry	179000	1E-06	2830	x	2 m^3	120
Sr-90 +D	Air	Gas proportional counting	1420	1E-06	1760	x	2 m^3	60
Tc-99	Air	Liquid scintillation counting	80100	1E-06	1950	x	2 m^3	45
Co-60	Air	Gamma spectrometry	3.1	1E-06	2950	x	3 m^3	60
Cs-137+D	Air	Gamma spectrometry	14.5	1E-06	2950	x	2 m^3	60
I-131	Air	Gamma spectrometry	--	--	--	--	--	--
Ir-192	Air	Gamma spectrometry	10.3	1E-06	2950	x	2 m^3	60
Rn-220	Air	Gamma spectrometry	21600	1E-06	2950	x	2 m^3	60
Rn-222	Air	Gamma spectrometry	20900	1E-06	2950	x	2 m^3	60
H-3	Air	Liquid scintillation counting	--	--	--	--	--	--
I-129	Air	Beta-gamma counting	--	--	--	--	--	--
Ra-226	Air	Rapid alpha spectrometry	1340	1E-06	510	x	2 m^3	120
Ra-226	Air	EPA 903.0 or equiv.	1340	1E-06		x	2 m^3	150
Ra-226	Air	EPA 903.1 or equiv.	1340	1E-06		x	2 m^3	30
Ra-228	Air	Gamma (inference, ^{228}Ac)	--	--	--	--	--	--
Ra-228	Air	EPA - 904.0 or equiv.	--	--	--	--	--	--

RMDA - required minimum detectable activity

[#] Combined estimate of throughput available to EPA for the 20 largest labs running a single test for incident response for a sustained duration of one year are based on laboratory capacity audits of the 20 laboratories

[&] Note that there are no estimates of capacity for ^{232}Th, ^{238}U and ^{235}U which can also be run by ICP-MS. While most labs can analyze for total uranium, they have not developed capability to differentiate between ^{235}U and ^{238}U.

[$] Throuput estimates assume sustained (steady state) production. Processing times vary considerably from lab to lab. Typical times needed for different parts of the process are : sample receipt - 2-3 hours; sample prep and separations, 0.25-1.5 days; counting, 1-8 hours, reporting and review, 0.5-1 day.

Throughput Estimates for Air Particulate Samples
Based on Preliminary Remediation Goals (PRGs) for Ambient Air

Radionuclide	Matrix	Analytical Technique	Target 10^{-6} Risk PRG for ambient air (no decay) (pCi/m^3)	Attainable risk level that is consistent with capacity evaluations	Combined capacity (20 labs) samples/week[#,$]	RMDA met	Aliquant size used for calculations	Count time used for calculations (min)
Am-241	Air	Rapid alpha spectrometry	1.9E-04	1E-05	2526	x	54 m^3	480
Po-210	Air	Rapid alpha spectrometry	4.9E-04	1E-05	740	x	54 m^3	120
Pu-238	Air	Rapid alpha spectrometry	1.6E-04	1E-05	2571	x	54 m^3	270
Pu-239 ($^{239/240}$Pu)	Air	Rapid alpha spectrometry	1.6E-04	1E-05	2571	x	54 m^3	270
Pu-240 ($^{239/240}$Pu)	Air	Rapid alpha spectrometry	1.6E-04	1E-05	2571	x	54 m^3	270
Th-230	Air	Rapid alpha spectrometry	1.9E-04	1E-05	2411	x	54 m^3	420
Th-232	Air	Rapid alpha spectrometry	1.2E-04	1E-05	2411	x	54 m^3	420
U-234	Air	Rapid alpha spectrometry	4.6E-04	1E-05	2496	x	54 m^3	210
U-235[&]	Air	Rapid alpha spectrometry	5.7E-04	1E-05	2496	x	54 m^3	210
U-238[&]	Air	Rapid alpha spectrometry	4.7E-02	1E-06	2496	x	54 m^3	240
Sr-90 +D	Air	Gas proportional counting	3.8E-01	1E-06	1581	x	54 m^3	30
Tc-99	Air	Liquid scintillation counting	1.4E-01	1E-06	1715	x	54 m^3	30
Co-60	Air	Gamma spectrometry	4.3E-01	1E-06	2280	x	54 m^3	90
Cs-137+D	Air	Gamma spectrometry	1.1E-01	1E-06	2280	x	54 m^3	90
I-131	Air	Gamma spectrometry	2.2E-01	1E-06	2280	x	54 m^3	90
Ir-192	Air	Gamma spectrometry	2.2E+04	1E-06	2280	x	54 m^3	90
Rn-220	Air	Gamma spectrometry	2.1E+04	1E-06	2280	x	54 m^3	60
Rn-222	Air	Gamma spectrometry	9.4E+01	1E-06	2280	x	54 m^3	30
H-3	Air	Liquid scintillation counting	3.3E-02	1E-06	1415	x	54 m^3	130
I-129	Air	Beta-gamma counting	4.6E-04	--	--		54 m^3	--
Ra-226	Air	Rapid alpha spectrometry	1.0E-03	1E-05	510	x	54 m^3	120
Ra-226	Air	EPA 903.0 or equiv.	2.0E-01	1E-06		x	54 m^3	30
Ra-226	Air	EPA 903.1 or equiv.	2.0E-01	1E-06		x	54 m^3	30
Ra-228	Air	Gamma (inference, ^{228}Ac)	2.7E-01	1E-05	2280	x	54 m^3	60
Ra-228	Air	EPA - 904.0 or equiv.	2.7E-01	1E-06	815	x	54 m^3	30

RMDA - required minimum detectable activity

[#] Combined estimate of throughput available to EPA for the 20 largest labs running a single test for incident response for a sustained duration of one year are based on laboratory capacity audits of the 20 laboratories

[&] Note that there are no estimates of capacity for ^{232}Th, ^{238}U and ^{235}U which can also be run by ICP-MS. While most labs can analyze for total uranium, they have not developed capability to differentiate between ^{235}U and ^{238}U.

[$] Throuput estimates assume sustained (steady state) production. Processing times vary considerably from lab to lab. Typical times needed for different parts of the process are : sample receipt - 2-3 hours; sample prep and separations, 0.25-1.5 days; counting, 1-8 hours, reporting and review, 0.5-1 day.

Throughput Estimates for Soil Samples
Based on Preliminary Remediation Goals (PRGs) for Residential Soil

Radionuclide	Matrix	Analytical Technique	Target 10^{-6} Risk PRG for residential soil (pCi/g)	Attainable risk level that is consistent with capacity evaluations	Combined capacity (20 labs) samples/week[#,$]	RMDA met	Aliquant size used for calculations	Count time used for calculations (minutes)
Am-241	Soil	Rapid alpha spectrometry	1.8	1E-06	2860	x	1 gram	120
Po-210	Soil	Rapid alpha spectrometry	38.2	1E-06	890	x	1 gram	120
Pu-238	Soil	Rapid alpha spectrometry	2.95	1E-06	2855	x	1 gram	120
Pu-239 ($^{239/240}$Pu)	Soil	Rapid alpha spectrometry	2.58	1E-06	2855	x	1 gram	120
Pu-240 ($^{239/240}$Pu)	Soil	Rapid alpha spectrometry	2.58	1E-06	2855	x	1 gram	120
Th-230	Soil	Rapid alpha spectrometry	3.46	1E-06	2745	x	1 gram	240
Th-232	Soil	Rapid alpha spectrometry	3.07	1E-06	2745	x	1 gram	180
U-234	Soil	Rapid alpha spectrometry	4.02	1E-06	2820	x	1 gram	120
U-235[&]	Soil	Rapid alpha spectrometry	0.192	1E-06	2820	x	2 gram	270
U-238[&]	Soil	Rapid alpha spectrometry	4.48	1E-06	2820	x	1 gram	120
Sr-90 +D	Soil	Gas proportional counting	0.24	1E-06	1625	x	2 gram	240
Tc-99	Soil	Liquid scintillation counting	0.261	1E-06	1925	x	2 gram	120
Co-60	Soil	Gamma spectrometry	0.0389	1E-06	3065	x	1500 gram	30
Cs-137+D	Soil	Gamma spectrometry	0.0615	1E-06	3065	x	1500 gram	30
I-131	Soil	Gamma spectrometry	63.8	1E-06	3065	x	1500 gram	30
Ir-192	Soil	Gamma spectrometry	3.15	1E-06	3065	x	300 gram	30
Rn-220	Soil	Gamma spectrometry	7.86E+08	1E-06	3065	x	300 gram	30
Rn-222	Soil	Gamma spectrometry	1.30E+05	1E-06	3065	x	300 gram	30
H-3	Soil	Liquid scintillation counting	0.882	1E-06	2320	x	5 gram	45
I-129	Soil	Beta-gamma counting	0.613	1E-05	805	x	2 gram	120
Ra-226	Soil	Rapid alpha spectrometry	0.199	1E-06	695	x	2 gram	240
Ra-226	Soil	EPA 903.0 or equiv.	0.199	1E-06		x	2 gram	150
Ra-226	Soil	EPA 903.1 or equiv.	0.199	1E-06		x	1 gram	30
Ra-228	Soil	Gamma (inference, ^{228}Ac)	0.269	1E-06	3065	x	500 gram	30
Ra-228	Soil	EPA - 904.0 or equiv.	0.269	1E-06	675	x	2 gram	300

RMDA - required minimum detectable activity

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[&] Note that there are no estimates of capacity for ^{232}Th, ^{238}U and ^{235}U which can also be run by ICP-MS. While most labs can analyze for total uranium, they have not developed capability to differentiate between ^{235}U and ^{238}U.

[$] Throuput estimates assume sustained (steady state) production. Processing times vary considerably from lab to lab. Typical times needed for different parts of the process are : sample receipt - 2-3 hours; sample prep and separations, 0.25-1.5 days; counting, 1-8 hours, reporting and review, 0.5-1 day.