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SINGLE-SHELL TANK COMPONENT CLOSURE DATA QUALITY OBJECTIVES

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Abstract: This document describes the data quality objectives to support component closure of the single-shell tanks. The type, quantity and quality of data required to make component closure evaluations are specified. This revision of the DQO adds laser scanning as a tool to estimate residual waste volumes (Sections 7.0 and 8.1), modifies the CCMS equation based on additional CCMS testing results (Section 7.0), and revises the description of sampling methods to include sampling and design using the Extended Reach Sluicing System.

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LIST OF TERMS

Abbreviations and Acronyms

AMS	Articulating Mast System
CAD	computer aided design
CAS	Chemical Abstracts Service
CCMS	video-camera/CAD modeling system
CFR	*Code of Federal Regulations*
CH2M HILL	CH2M HILL Hanford Group, Inc.
CI	confidence interval
CLARC	Cleanup levels and risk calculations
CVAA	cold vapor atomic absorption
DF	dilution factor
DOE	U.S. Department of Energy
DQO	Data quality objective
DST	double-shell tanks
Ecology	State of Washington Department of Ecology
EDTA	ethylene diamine tetra acetic acid
EPA	U.S. Environmental Protection Agency
EQL	estimated quantitation limit
GC/ECD	gas chromatography/electron capture detector
GC/MS	gas chromatography/mass spectrometry
GEA	gamma energy analysis
GMA	gravimetric moisture analysis
HFFACO	*Hanford Federal Facility Agreement and Consent Order*
IC	ion chromatography
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductively coupled plasma/mass spectrometry
IDL	instrument detection limit
LCS	laboratory control sample
MARS	Mobile Arm Retrieval System
MDL	method detection limit
MRS	mobile retrieval system
MS	Modified Sluicing
MTCA	Model Toxics Control Act
N/A	not applicable
NIST	National Institute of Science and Technology
NP	not performed
NPH	Normal Paraffin Hydrocarbons
NRC	U.S. Nuclear Regulatory Commission
ORP	U.S. Department of Energy, Office of River Protection
ORSS	Off-riser sampling system
PCB	polychlorinated biphenyls
PNNL	Pacific Northwest National Laboratory

LIST OF TERMS, Continued

QA	quality assurance
QC	quality control
RESRAD	Residual Radioactivity Modeling
RPD	relative percent difference
SST	single-shell tank
SVOC	semivolatile organic compound
TBP	Tributyl Phosphate
TGA	thermogravimetric analysis
TIC	tentatively identified compound
UCL	upper confidence limit
UHC	underlying hazardous constituent
VOA	Volatile organic analysis
VOC	volatile organic compound
WAC	*Washington Administrative Code*
WRPS	Washington River Protection Solutions

Units

Ci	Curies
ft^3	cubic feet
g	grams
M	molarity of moles per liter
mg/g	milligrams per gram
mg/L	milligrams per liter
mg/kg	milligrams per kilograms
mL	milliliters
mrem	millirem
%	percent
Ci/m^3	Curies per cubic meter
nCi/g	Nanocuries per gram
pCi/g	picocuries per gram
pCi/mL	picocuries per milliliter
µg	micrograms
µL	microliters

GLOSSARY

Closure action/activity	Refers to component closure actions and/or activities throughout this document.
A	Identifies constituents from the Part A Permit.
R	Identifies constituents requested by the risk assessment group.
U	Identifies constituents as Underlying Hazardous Constituents.
W	Identifies constituents in Table 4.4 of the *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project* (PNNL-12040)

1.0 INTRODUCTION

A key closure activity associated with Hanford Site cleanup is retrieval of as much single-shell tank (SST) waste as technically possible. Currently a second retrieval technology deployment is required if the first retrieval technology does not meet the residual waste volume (waste remaining in individual SSTs after completion of waste retrieval) requirements and a third technology deployment is possible. To accomplish closure of the SST farms, information addressing the residual waste remaining after retrieval is required. Data are required to address risk assessment and to assess retrieval performance criteria in accordance with RPP-13774, *Single-Shell Tank System Closure Plan*. In addition, this DQO will cover closure information needs required by DOE M 435.1-1 *Radioactive Waste Management Manual*, Chapter II. Required information includes but is not limited to the volume of the residual waste left in the tanks and the concentration of certain constituents (see Section 4.0) in the residual waste. The concentration and the volume of the residual waste will provide the inventory of the constituents in the residual waste. Release rate data are also needed for risk model development. In addition, data may be needed to evaluate retrieval technologies for future tank waste retrieval activities.

In order to determine the concentrations of the constituents of concern, samples of the solids remaining in the SST after retrieval is complete are required (liquid samples are not required if specific conditions are met, see Section 8.2.1). The waste retrieval operations are detailed in process control plans prepared for each tank. Retrieval actions are a component closure activity; however, retrieval will be complete in some tanks prior to permit issuance in accordance with the *Hanford Federal Facility Agreement and Consent Order* (HFFACO) (Ecology et al. 1989) M-45 milestones.

This document describes the Data Quality Objective (DQO) process undertaken to ensure appropriate data are collected to support the component closure activities for all SSTs (100 series and 200 series tanks) and describes sampling and analytical requirements for that purpose. The DQO process was implemented in accordance with TFC-ENG-CHEM-C-16, *Data Quality Objectives for Sampling and Analyses,* and the U.S. Environmental Protection Agency (EPA) QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006), with some modifications to accommodate project or tank specific requirements and constraints.

The DQO process is iterative. Therefore, this DQO will be updated when requirements change (e.g., addition or deletion of constituents to be analyzed), changes in available equipment, changes in retrieval methods, etc. Changes to the DQO document can be initiated by involved or affected groups (i.e., State of Washington Department of Ecology [Ecology], the U.S. Department of Energy, Office of River Protection [ORP], and Washington River Protection Solutions LLC [WRPS] organizations). All of these groups will be informed of changes to the DQO.

Ecology will not address information directly related to the strict application of the U.S. Department of Energy (DOE)/Atomic Energy Agency orders or regulations in this DQO. However, Ecology will address information related to mixed waste and radionuclides as required by regulations, guidance, and the HFFACO (Ecology et al. 1989), as well as retrieval/closure agreements, documents, and plans.

2.0 PROBLEM STATEMENT

The objective of a problem statement is to clearly define the problem (the reason analytical data are required) so the focus of the project (SST component closure actions) will be unambiguous. With the objective of the problem statement in mind, the scope of this DQO can be outlined in the following statements:

- The DQO process will address only the component closure activities for SSTs.
- This DQO will not address soil sampling and analysis or any actions associated with ancillary equipment in the tank farm. Therefore, the component closure action boundary for the SSTs will be the exterior of the tank walls. However, the closure action criteria will be consistent with and support final closure of the tank farms. Because the development of this DQO did not focus on soil and ancillary equipment (pipes, pits, vaults, etc.), this DQO does not adequately serve as a basis for final closure of the tank farms. These issues will be addressed in separate component closure DQOs or in DQOs for the closure of the tank farms.

Considering the purpose and scope of this DQO, a concise statement of the problem can be written as follows:

- Conduct component closure activities for SSTs in a manner that contributes to final closure of the tank farms.

The principal study question (PSQ) identifies key unknown conditions that reveal the solution to the problem. Generally, the PSQ requires data to be resolved. The PSQ that addresses the problem statement above is:

- Does the residual waste in a SST meet the volume requirements of the HFFACO M-45-00 milestone, the requirements in DOE M 435.1-1, Chapter II.B(2)(a) *Waste Incidental to Reprocessing* (WIR) and support Washington Administrative Code (WAC) 173-303-610 (2) closure performance standards for protection of human health and the environment that allow component closure activities to continue?

3.0 DECISION STATEMENTS

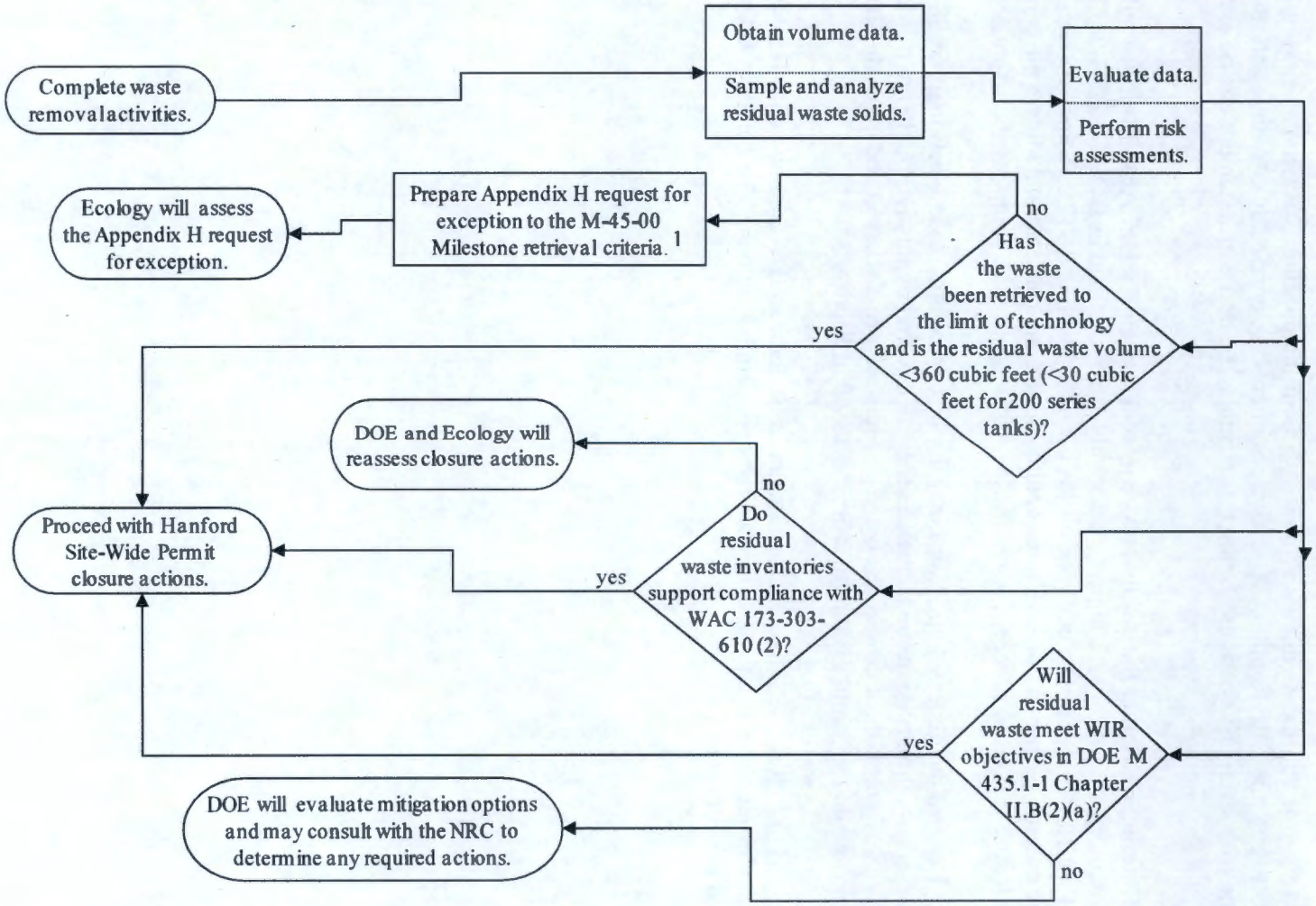
Decision statements link alternative actions with the principal study question and express a choice between alternative actions. Decision statements are created by combining the study questions with alternative actions. Using this formula, the decision statement can be expressed as:

- Determine whether the residual waste in a SST meets the HFFACO M-45-00 milestone requirements, radiological performance objectives defined in DOE M 435.1-1, Chapter II.B(2)(a) and supports compliance with WAC 173-303-610 (2) closure performance standards for protection of human health and the environment and allows the component closure actions to proceed, or requires reassessment of the component closure actions.

Figure 3-1 shows the general logic flow chart for the component closure action of an SST. The flow chart shows the decisions and activities that are covered by this DQO and are needed to address an SST component closure action. The decisions are discussed and expanded in Section 6.0 while the sampling activities are discussed in Section 8.0.

As indicated in Figure 3-1, all three decisions must be addressed to continue with Hanford Site-Wide Permit closure actions. The decisions are parallel actions. The decision rules are discussed in Section 6.0.

Figure 3-1. SSTs Component Closure Action Logic Flow Chart.



[1] Note: Appendix H does not apply to tanks retrieved under the terms of the Consent Decree in State of Washington v. Department of Energy, Case No. 08-5085-RMP (E.D. Wa. October 25, 2010), hereafter called the Consent Decree.

4.0 DATA INPUTS

This section describes the information required to address the problem statement and the decision statement shown above. As mentioned above, three types of data are required for the component closure of an SST: volume data, chemical constituent concentrations, and radionuclide constituent concentrations. The volume data are required to address one of the decision rules (see Section 6.0) and used with constituent concentrations to determine constituent inventories in the residual waste. Radionuclide inventories and concentrations are required to address DOE M 435.1-1 WIR requirements as well as performance assessment and disposal requirements.

Constituent release rate tests are conducted from samples collected through this DQO (see Section 8.0). The requirements for the release rate tests are controlled by test plans and are not discussed in this DQO. The test results are used to develop a release rate model specific to Hanford tank waste.

4.1 ANALYTICAL PARAMETERS

An analytical strategy for the component closure action of an SST was developed during DQO process meetings. This strategy is based on analyzing for major constituent categories (volatile organic compounds [VOC], semivolatile organic compounds [SVOC], inorganics, and radionuclides) by a set of specific analytical methods. The strategy identifies specific or "primary" constituents (*Hanford Facility Dangerous Waste Part A Permit Application* [Part A] [CH2M HILL 2003], underlying hazardous constituents [UHC] from 40 CFR 268.48, "Universal Treatment Standards," and radionuclides from 10 CFR 61.55, "Waste Classification") that will be analyzed with the quality control (QC) specified in this DQO. In the event that a constituent identified on the secondary list is determined to affect the risk assessment, it shall be added to the primary list. The secondary constituents (those constituents that can be detected with the analytical methods being used but not on the primary list) will be reported using the QC indicated in the strategy described for each analytical group.

The following sections discuss the major constituent categories: organic, inorganic, and radiochemical. The sections include flow charts illustrating the analytical strategy and tables specifying the SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* as the preferred organic and inorganic analytical methods. In addition, the tables show the Part A, UHC, 10 CFR 61.55, and risk assessment (primary) constituents covered by these analytical methods. Some constituents may be measured by more than one method. In these cases, the selection of the method may depend on the action limits required for a decision, method detection limits, or the expectation that the constituent is present.

The SW-846 methods are listed in this document without suffixes indicating the latest revisions. However, when conducting analyses, the latest revision is preferred.

Waste analyses will be performed utilizing the applicable methods outlined in SW-846. However, SW-846 methods may require substitutions, deviations, and modifications to address radiological concerns and some matrix conditions found in the Hanford Site tank waste. It is

understood that those changes and their effects on method performance have been documented to demonstrate that analytical procedures can provide satisfactory performance for the intended use of the data. The documentation of changes (e.g., substitutions, deviations or modifications) to analytical methods shall be in writing, maintained at the laboratory, and available for inspection upon request by authorized representatives of the regulatory authorities and WRPS. All attempts will be made to meet the data quality objectives.

In addition to the data requirements described above, data may be required between retrieval technology deployments to help determine the second technology to be deployed. The required data will be determined after the initial retrieval technology is complete. The required data will depend on the configuration of the waste remaining after the initial retrieval, the retrieval technologies available for deployment, etc. The required data could vary from physical properties, chemical analyses, and dissolution tests. If this data is collected, Ecology will be informed when it is available.

4.1.1 Organics

Organic analysis requirements are divided into two sections. The first section captures the general requirements for a Hanford tank farm to undergo retrieval. These requirements are applicable when there is no organic sample data on residual waste from that tank farm. The list of required organic analytes will be re-evaluated for addition or reduction after organic data are collected from a number of tanks in that farm. The second section specifies the requirements for samples of residual waste in the C Farm tanks that are yet to be sampled for component closure. The tanks include 241-C-101, 241-C-102, 241-C-104, 241-C-105, 241-C-107, 241-C-109, 241-C-110, 241-C-111, and 241-C-112. The list of required organic analytes for these tanks has been reduced based on an evaluation of existing data on C Farm residual wastes.

4.1.1.1 General Organic Requirements

Other than plant solvents, the amount of organic constituents that may have entered the tank waste is expected to be small in volume and highly variable compared to the inorganic and radionuclide components that make up the largest fraction of the wastes. These organic constituents are subject to hydrolytic and radiolytic chemical reactions that lead to changes in their composition. Because of the large amount of uncertainty in their composition, a strategy for effectively evaluating the primary constituents is needed as well as a way that effectively evaluates the tentatively identified compounds (TICs). Detected organic constituents that are not part of the calibration mix (primary constituents) are TICs. The strategic approach for analyzing VOCs and SVOCs is shown in Figure 4-1.

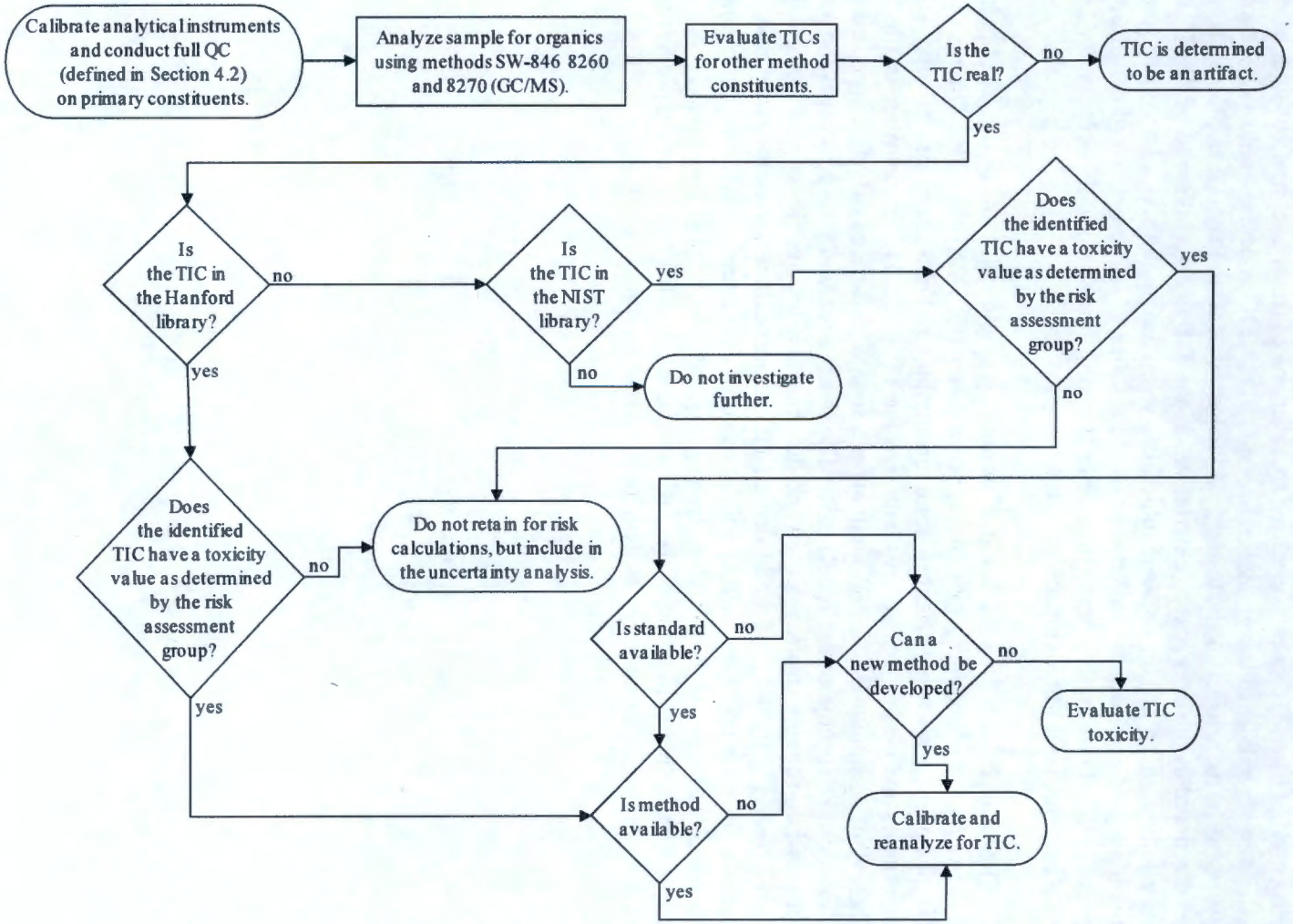
Based on the strategy (see Figure 4-1) for organic components, the primary constituents would be analyzed with the specified level of QC (see Section 4.2). This means they would be included in the calibration of the gas chromatographs and method detection limits (MDLs) would be determined for each constituent for the appropriate sample preparation required.

Because the volatile organic analysis (VOA) calibration standards are normally prepared in methanol, this constituent cannot be included as an analyte.

The flow chart (Figure 4-1) shows the process for evaluating these TICs to support component closure action decisions. Some TICs are the result of bleeding from the chromatographic column being used. Other TICs may be caused by reactions of the waste matrices with surrogates added to the sample as part of the analytical process. If the TIC is determined by the responsible chemist to be an artifact of the testing, no further evaluation is needed. These TICs are flagged and discussed in the data package narrative. If the TIC is determined to be "real," it will be evaluated against a gas chromatographic library containing the secondary compounds of interest. This library of compounds (called the "Hanford Library") is composed of constituents that have been identified as possibly being present in Hanford Site waste in the Regulatory DQO (PNNL-12040) but not identified as primary constituents.

The "Hanford Library" was developed by running single standards of the constituents on the laboratory's gas chromatography/mass spectrometry (GC/MS) systems. The results of these analyses provide accurate retention time information and mass response factors for these compounds and permit a better evaluation of the TIC. If a TIC is identified in the "Hanford Library" of compounds, a semi-quantitative estimate (estimated off of an archived one point calibration) of its concentration is made. The risk assessment group receives the analytical reports when the reports are released and determines if the toxicity of any identified TIC is a concern (see Figure 4-1). If the identified TIC does not have a toxicity value in standard databases or scientific literature, it will be reported in the retrieval data report but not retained for the risk assessment. If the TIC does have a toxicity value in standard databases or scientific literature, a further evaluation of the TIC is conducted. This can be as simple as recalibrating and reanalyzing or as complex as developing a new analytical method.

Figure 4-1. Strategy for Organic Analyses.



If the TIC is not found in the "Hanford Library" of compounds, then the TIC will be evaluated against the standard National Institute of Standards and Technology (NIST) library of compounds. This library has over 100,000 compounds. However, because they are collected on different instruments from those used for the actual analysis, the retention times and response factors will be different. Before the analyst can name or identify the TIC, the analyst must be confident that the chromatogram and mass spectra match well enough to name the compound. If the analyst cannot confidently name the compound, it is identified as an unknown and no further action is required. When a TIC is identified in the NIST library, then the TIC will be evaluated in a similar manner as a "Hanford Library" TIC.

The standard SW-846 methods may not be the best suited for some TIC compounds. If the sensitivity or the quality of the data is not adequate for making confident decisions, then it may be necessary to develop an improved method. The best available analytical technologies and methods shall be used for the residual waste characterization. These methods shall be applied to future samples where these TICs may be identified.

TICs are identified using the Reconstructed Ion Chromatogram. The Reconstructed Ion Chromatogram is evaluated for TICs by identifying peaks that have not already been identified as target compounds according to the following criteria. The criteria discussed below are from revision three of Volume 4 of DOE-RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents*.

The library match for a TIC should be higher than 75% before this detailed evaluation is initiated. The method-specified tune criteria should be met. Special attention to the tune at low masses should be taken when evaluating volatile compounds. The concentration of a TIC should be greater than 10% of the nearest internal standard or estimated 5 nanogram on column injection, whichever is smaller. Early (injection peak) and late eluting peaks (column bleed and coeluting compounds) should have adequate background subtraction to permit use of these TIC criteria. If isotopic patterns are present, the mass ratios should agree with the reference spectrum within 10%. The base mass peak for the sample should be the same as the reference spectrum. If a molecular ion is present in the reference spectrum, the sample should also have a molecular ion mass. Reference spectrum ions greater than 20% should be in the sample spectrum. Sample ions greater than 20% that are not in the reference spectrum need to be evaluated. Major sample ions (greater than 20%) should match relative intensities to the base peak to those same ratios for the reference spectrum within 10-30%.

The TIC evaluation is limited to the 30 largest TICs for the volatile organic analysis and the 30 largest for the semivolatile analysis meeting the criteria discussed above.

A TIC compound may be upgraded to a positively identified compound. This is achieved by obtaining the compound, analyzing it under same conditions as the initial identification, and matching retention time and mass spectrum. This can be accomplished if it is considered necessary to meet program requirements.

Table 4-1 shows constituents analyzed by SW-846 method 8260 VOC and considered primary for this DQO. In addition, the table shows the reason for inclusion as a primary constituent

(found in the Part A or UHC) and which of these primary constituents are found in the Regulatory DQO (PNNL-12040). Constituents identified with asterisks may be determined by more than one method. All method numbers discussed in this section are SW-846 methods.

Table 4-2 shows method 8270 SVOC considered primary for this DQO. In addition, the table shows the reason for inclusion as a primary constituent (found in the Part A or UHC) and which of these primary constituents are found in the Regulatory DQO (PNNL-12040).

Table 4-1. Method 8260 VOC Analyses For Primary Constituents.

Constituent	CAS	Reason for Inclusion	Comments
1,1,1-Trichloroethane	71-55-6	A, U, W	
1,1,2,2-Tetrachloroethene	127-18-4	A, W	
1,1,2,2-Tetrachloroethane	79-34-5	A, U, W	
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	A, U, W	
1,1,2-Trichloroethane	79-00-5	A, U, W	
1,1,2-Trichloroethylene	79-01-6	A, U, W	
1,1-Dichloroethene	75-35-4	A, U, W	
1,2-Dichloroethane	107-06-2	A, U, W	
Chloroethene (vinyl chloride)	75-01-4	A, U, W	
2-Butanone(MEK)	78-93-3	A, U, W	
2-Nitropropane	79-46-9	A	
2-Propanone (Acetone)	67-64-1	A, U, W	
4-Methyl-2-pentanone (MIBK)	108-10-1	A, U, W	
Benzene	71-43-2	U, W	
Carbon disulfide	75-15-0	A, U, W	
Carbon tetrachloride	56-23-5	A, U, W	
Chlorobenzene	108-90-7	A, U, W	
Chloroform	67-66-3	A, U, W	
Dichloromethane (methylene chloride)	75-09-2	A, U W	
Ethyl Acetate	141-78-6	A, U,W	
Ethylbenzene	100-41-4	A, U, W	
Diethyl ether	60-29-7	A	
Isobutanol*	78-83-1	A	
Methanol	67-56-1	A, U, W	Will not be analyzed. See explanation in text.
n-Butyl alcohol (1-butanol)*	71-36-3	A, U, W	
Toluene	108-88-3	A, U, W	
trans-1,3-dichloropropene	10061-02-6	U, W	
Trichlorofluoromethane	75-69-4	A, U, W	
Xylenes (Mixed isomers of o-, m-, and p-)	1330-20-7	A, U	
o-Xylene	95-47-6	A, W	
m-Xylene	108-38-3	A, W	
p-Xylene	106-42-3	A, W	

Notes:

CAS Chemical Abstracts Service
* Constituent may be analyzed by the VOC (8260) method or the SVOC (8270) method.
A Part A constituent.
U UHC constituent.
W Constituent in PNNL-12040.

Table 4-2. Method 8270 SVOC Analyses For Primary Constituents.

Constituent	CAS	Reason for Inclusion	Comments
1,2,4-Trichlorobenzene*	120-82-1	U, W	
2,4-Dinitrotoluene	121-14-2	A, U	
2,4,5-Trichlorophenol	95-95-4	A, U	
2,4,6-Trichlorophenol	88-06-2	U	
2,6-Bis (tert-butyl)-4-methylphenol	128-37-0	A, W	
2-Chlorophenol	95-57-8	U	
2-Ethoxyethanol	110-80-5	A	
2-Methylphenol (o-cresol)	95-48-7	A, U	
4-Methylphenol (p-cresol)	106-44-5	A, U	
Acenaphthene	83-32-9	U	
Butylbenzylphthalate	85-68-7	U	
Cresylic acid (cresol, mixed isomers)	1319-77-3	A	
Cyclohexanone	108-94-1	A, W	
Di-n-butylphthalate	84-74-2	U	
Di-n-octylphthalate	117-84-0	U	
N-nitroso-di-n-propylamine	621-64-7	U	
Fluoranthene	206-44-0	U	
Hexachlorobutadiene*	87-68-3	A, U, W	
Hexachloroethane*	67-72-1	A, U	
m-Cresol (3-Methylphenol)	108-39-4	A, U	
Naphthalene	91-20-3	U	
Nitrobenzene*	98-95-3	A, U, W	
n-Nitrosomorpholine	59-89-2	U	
o-Dichlorobenzene*	95-50-1	A, U, W	
o-Nitrophenol	88-75-5	U	
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	59-50-7	U	
Pyrene	129-00-0	U	
Pyridine*	110-86-1	A, U, W	
Tributyl phosphate	126-73-8	R, W	

Notes:

CAS	Chemical Abstracts Service.
*	Constituent may be analyzed by the SVOC (8270) method or the VOC (8260) method.
A	Part A constituent.
R	Risk assessment constituent.
U	UHC constituent.
W	Constituent in PNNL-12040.

In addition to the organic constituents shown in Table 4-1 and Table 4-2, polychlorinated biphenyls (PCBs) will be analyzed as primary constituents. In addition, percent water is required [analyzed by gravimetric moisture analysis (GMA) or thermogravimetric analysis (TGA)] for solids so the PCB concentration can be reported on a dry weight basis. The PCB concentration is determined using SW-846 method 8082.

Total PCB concentrations are calculated by summing the concentrations of seven Aroclors (1016, 1221, 1232, 1242, 1248, 1254, and 1260) found in a sample. The total PCBs in a sample are calculated by summing only detected Aroclors. If no Aroclors are detected, the total PCB concentration is considered the detection limit for the single most common Aroclor expected in the sample. Tank results indicate Aroclor 1254 is by far the most common Aroclor in Hanford Site tank waste. The policy of determining total PCB concentrations, as described above, is the policy of the EPA Manchester Laboratory for determining total PCB concentrations in a sample. In addition, this method was specified by agreement in a meeting with representatives from EPA Region 10, EPA Manchester Laboratory, Ecology, DOE, Pacific Northwest National Laboratory (PNNL), and CH2M HILL.

Table 4-3 shows the "Hanford Library" constituents for VOCs (method 8260) and SVOCs (method 8270). All of these constituents are found in the Regulatory DQO (PNNL-12040) and analyzed according to the strategy shown in Figure 4-1.

Table 4-3 includes constituents identified in the polynuclear aromatic hydrocarbon procedure 8310 and pesticide procedure 8081. These constituents are not expected in Hanford Site waste, and analyses by these methods will not be conducted unless detected by method 8270 and require additional delineation.

One VOC (butane) and four SVOCs (pentachloronaphthalene, hexachloronaphtahlene, tetrachloronaphthalene, and octachloronaphthalene) will not be included in the "Hanford Library." It was not possible to get butane into solution, and the four SVOCs could not be obtained as pure compounds suitable for a standard. The NIST library will be relied on for the identification of these compounds.

Table 4-3. Secondary Organic Constituents "Hanford Library." (2 Sheets)

Method 8260 VOC	CAS	Method 8270 SVOC	CAS
cis-1,3-Dichloropropene	10061-01-5	p-Nitrochlorobenzene	100-00-5
Ethylene dibromide (1,2, Dibromoethane)	106-93-4	1,4-Dinitrobenzene	100-25-4
Butane	106-97-8	1,4-Dichlorobenzene	106-46-7
1,3-Butadiene	106-99-0	Phenol	108-95-2
Acrolein (propenal)	107-02-8	Hexachlorobenzene	118-74-1
3-Chloropropene (Allyl chloride)	107-05-1	N,N-Diphenylamine	122-39-4
Propionitrile (Ethyl cyanide)	107-12-0	Pentachloronaphthalene	1321-64-8
Acrylonitrile	107-13-1	Hexachloronaphtahlene*	1335-87-1
2-Pentanone	107-87-9	Tetrachloronaphthalene	1335-88-2
Methylcyclohexane	108-87-2	Octachloronaphthalene	2234-13-1
n-Pentane	109-66-0	Isodrin*	465-73-6
5-Methyl-2-hexanone	110-12-3	Benzo[a]pyrene*	50-32-8

Table 4-3. Secondary Organic Constituents "Hanford Library." (2 Sheets)

Method 8260 VOC	CAS	Method 8270 SVOC	CAS
2-Heptanone	110-43-0	Dibenz[a,h]anthracene*	53-70-3
n-Hexane	110-54-3	1,3-Dichlorobenzene	541-73-1
Cyclohexane	110-82-7	3-Methyl-2-butanone	563-80-4
n-Octane	111-65-9	N-Nitroso-N,N-dimethylamine	62-75-9
4-Heptanone	123-19-3	Hexafluoroacetone	684-16-2
Acetic acid, n-butylester	123-86-4	Pentachloronitrobenzene (PCNB)	82-68-8
1,4-Dioxane	123-91-1	Pentachlorophenol	87-86-5
n-Heptane	142-82-5	2-sec-Butyl-4,6-dinitrophenol (Dinoseb)	88-85-7
Cyclopentane	287-92-3	1,1'-Biphenyl	92-52-4
Ethyl alcohol	64-17-5	Acetophenone	98-86-2
2-Propyl alcohol	67-63-0	Toxaphene*	8001-35-2
n-propyl alcohol (1-propanol)	71-23-8	Nitric acid, propyl ester	627-13-4
Bromomethane	74-83-9	Aldrin*	309-00-2
Chloroethane	75-00-3	alpha-BHC*	319-84-6
Acetonitrile	75-05-8	beta-BHC*	319-85-7
1,1 Dichloroethane	75-34-3	gamma-BHC (Lindane)*	58-89-9
Dichlorofluromethane	75-43-4	Dieldrin*	60-57-1
Chlorodifluoromethane	75-45-6	Endrin*	72-20-8
3-Methy-2-butanone*	563-80-4	1,1-Dimethylhydrazine	57-14-7
Hexafluoroacetone*	684-16-2	Methylhydrazine	60-34-4
2-Butenaldehyde (2-Butenal)	4170-30-3	n-Nitrosomethylethylamine	10595-95-6
Methyl isocyanate	624-83-9	n-Nitrosodi-n-butylamine	924-16-3
n-Propionaldehyde	123-38-6		
3-Heptanone	106-35-4		
Chloromethane	74-87-3		
n-Nonane	111-84-2		
Styrene	100-42-5		
Tetrahydrofuran	109-99-9		
Cyclohexene	110-83-8		
2-Methyl-2-propenenitrile	126-98-7		
2-Hexanone	591-78-6		
Triethylamine	121-44-8		
Oxirane	75-21-8		
2-Methyl-2-propanol	75-65-0		
Dichlorodifluoromethane	75-71-8		
1,2-Dichloro-1,1,2,2-tetrafluoroethane	76-14-2		
Heptachlor	76-44-8		
1,2-Dichloropropane	78-87-5		
1-Methylpropyl alcohol	78-92-2		
3-Pentanone	96-22-0		

Notes:

CAS Chemical Abstracts Service

* Constituent may be analyzed by an alternate method.

4.1.1.2 Organic Analysis Requirements for C Farm Tanks

As part of an iterative DQO process, the list of required organic analytes was re-evaluated using sample data collected from residual solids in C Farm tanks that have been retrieved. Only a small subset of the VOCs and SVOCs identified in Tables 4-1 and 4-2 have been detected in these samples. The detected VOCs and SVOCs were: phthalates (butyl benzyphthalates, di-n-butylphthalates, and di-n-octylphthalates), acetone, 2-butanone, 4-Methyl-2-pentanone, tributyl phosphate, 1,1,2-Trichloroethylene, and xylenes. All results were measured at concentrations near the laboratory detection limits. Phthlates were observed at a significant level in the laboratory blanks; confirming a common knowledge that these compounds are most likely to be contaminants from the plastic ware used at the laboratory. It was agreed that the list of required VOA and SVOA analytes for samples to be collected from C Farm tanks yet to be sampled for component closure will consist of these detected analytes, except for the phthalates.

Polychlorinated biphenyls (PCB) and organic salts such as acetate, formate, and oxalate were also detected. PCBs will continue to be analyzed on the C Farm samples. The salts will continue to be analyzed as discussed in Section 4.1.2. The organic analysis requirements for the remaining C Farm tanks (241-C-101, 241-C-102, 241-C-104, 241-C-105, 241-C-107, 241-C-109, 241-C-110, 241-C-111, and 241-C-112) are summarized in Table 4.4.

Table 4-4. Required Organic Analytes for Remaining C Farm Tanks

Organic Analyte	CAS Number	Analysis Method
1,1,2-Trichloroethylene	79-01-6	Method 8260 for VOA
2-Butanone (MEK)	78-93-3	Method 8260 for VOA
2-Propanone (Acetone)	67-64-1	Method 8260 for VOA
4-Methyl-2-pentanone (MIBK)	108-10-1	Method 8260 for VOA
Xylenes (Mixed isomers of o-, m-, and p-)	1330-20-7	Method 8260 for VOA
o-Xylene	95-47-6	Method 8260 for VOA
m-Xylene[1]	108-38-3	Method 8260 for VOA
p-Xylene[1]	106-42-3	Method 8260 for VOA
Tributyl phosphate	126-73-8	Method 8270 for SVOA
PCB	N/A	Method 8082 for Aroclors

Abbreviations: CAS= Chemical Abstracts Service; VOA=volatile organic analysis; SVOA=semivolatile organic analysis, PCB=polychlorinated biphenyls; N/A=not available

Note: [1]m-xylene and p-xylenes will be analyzed together as xylenes (m+p).

Evaluation of TICs for VOA and SVOA will be performed as discussed in the previous section.

4.1.2 Inorganics

The analytical strategy for inorganics is similar to that of the organics and is shown Figure 4-2. Although the inorganic methods do not have TICs, some inorganic analytical methods are capable of analyzing multiple constituents. This allows additional data to be obtained with minimum effort and costs. When these methods are utilized, all constituents will be reported. The secondary constituents will be analyzed with the same QC as the primary constituents. However, unlike the primary constituents, the secondary constituents will not be reanalyzed if they fall outside of the QC acceptance criteria shown in Table 4-7. Figure 4-2 shows the strategy

for the inorganic analytical methods for multiple constituents (e.g., inductively coupled plasma/atomic emission spectroscopy [ICP/AES]).

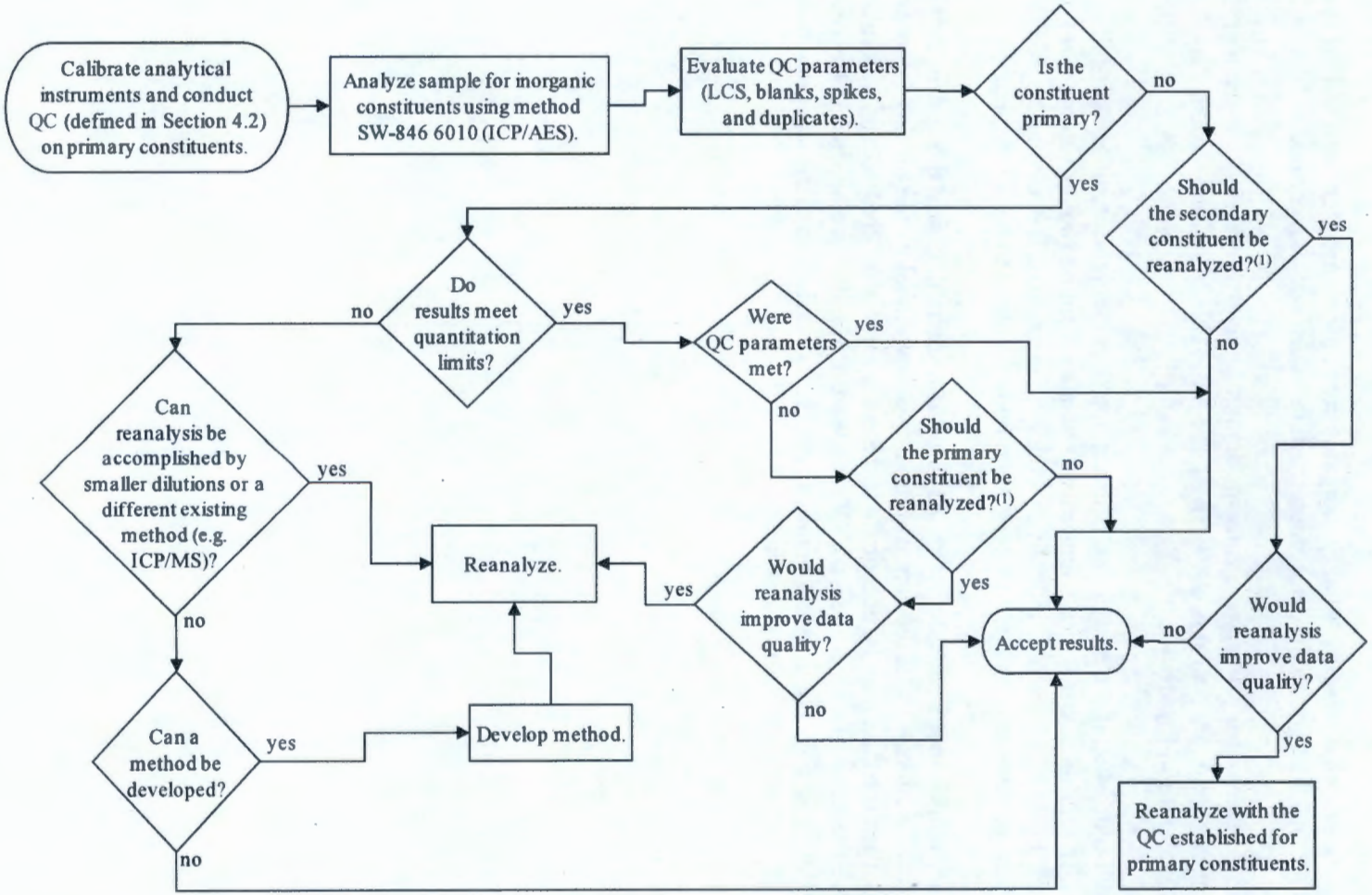
As with the organic analyses, the primary inorganic constituents are identified as Part A and UHC constituents. The secondary constituents will be addressed as indicated in Figure 4-2.

The analytical strategy for primary constituents that are analyzed by a single constituent analytical method (e.g., mercury) is shown in Figure 4-3. This is the same as the Part A and UHC analytical path in Figure 4-2.

As shown in Figure 4-2, if the primary constituent does not meet the quantitation limits (see Section 4.2), it would be reanalyzed using either a smaller dilution (larger sample size) or a more sensitive existing method, such as inductively coupled plasma/mass spectrometry (ICP/MS). If neither of these options is possible, then a new method may need to be developed.

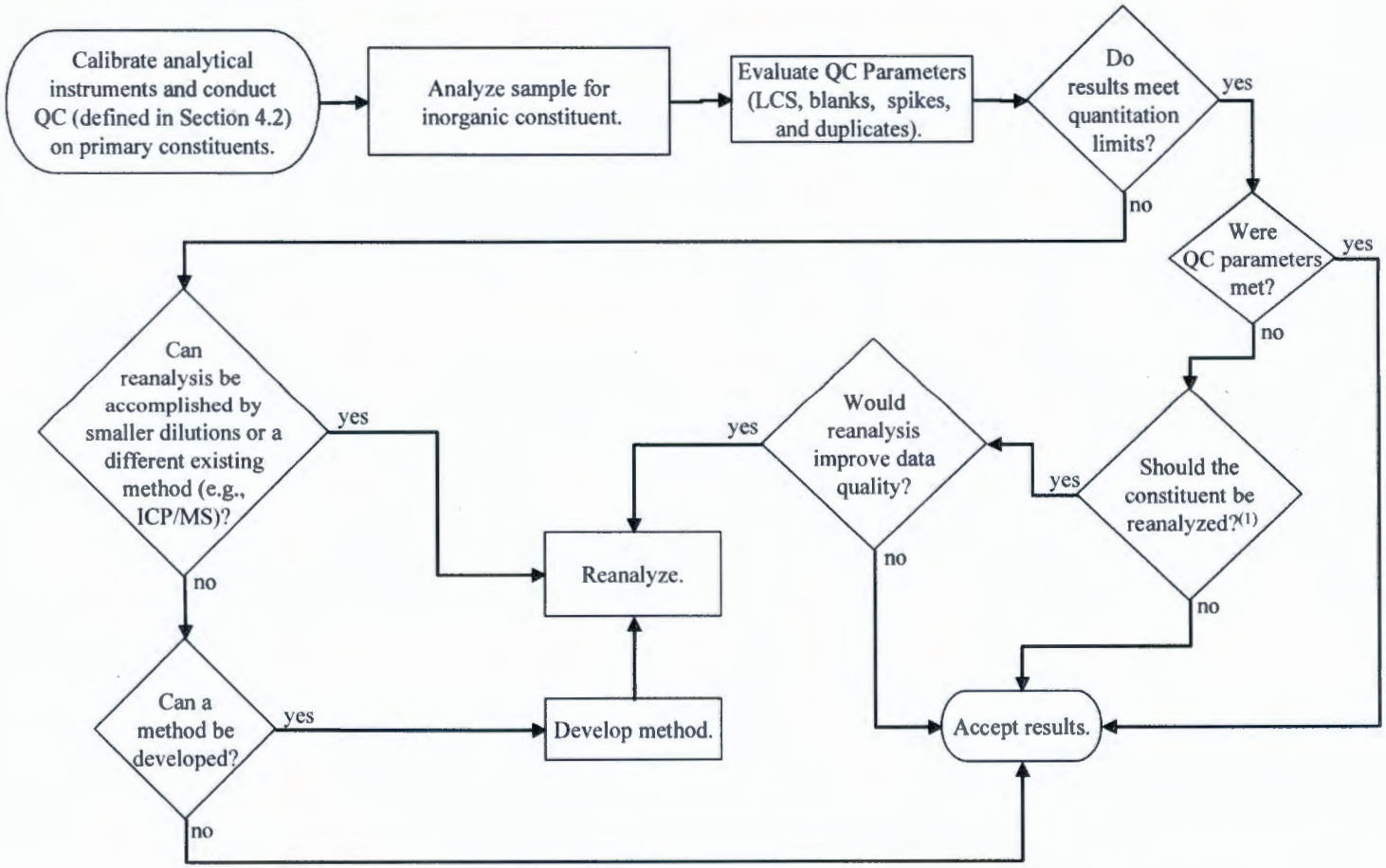
If a secondary constituent is detected, then the result is evaluated against the concentration levels of concern (see Section 4.3). If the concentration level is well below the levels of concern (see Section 4.3), then the data may be accepted. If the concentration of the secondary constituent is near or above the level of concern and the QC is adequate, the data are accepted. However, if the QC or uncertainty in the data does not permit a confident decision, then the sample would be reanalyzed as if it were a primary constituent.

Figure 4-2. Strategy for Inorganic Analyses Using Methods for Multiple Constituents.



(1) The decision to reanalyze a secondary constituent will be made by the Chemist, Project Coordinator, and Tank Coordinator

Figure 4-3. Strategy for Inorganic Single Constituent Analytical Method.



(1) The decision to reanalyze a secondary constituent will be made by the Chemist, Project Coordinator, and Tank Coordinator

The primary inorganic constituents and analytical methods for these constituents are shown in Table 4-4. As shown in Table 4-4, with the exception of mercury, metals are determined by ICP/AES. Mercury is determined by a cold vapor atomic absorption (CVAA) method [SW-846 7470 (for liquids) and SW-846 7471 (for solids)].

If the ICP/AES sensitivity is inadequate for some of the primary metals, they will be determined by alternative methods such as ICP/MS.

Eight anions (nitrate, nitrite, fluoride, acetate, formate, glycolate, oxalate, and cyanide) are identified as primary constituents. Fluoride, nitrate, nitrite, acetate, formate, glycolate, and oxalate are measured by ion chromatography (IC). This method can also provide secondary constituent information for other common anions. The IC analyses are normally performed on a water digestion of solids; however, this will not provide information on insoluble fluorides or chlorides.

The cyanide procedure uses a microdistillation and spectrophotometric measurement of the distilled cyanide. Solid samples are dissolved in ethylenediaminetetraacetic acid (EDTA) before distillation. This distillation has been demonstrated to be effective for the insoluble nickel ferrocyanides generated in some Hanford Site processes. There are no specific methods for ferrocyanide but the total cyanide measurement provides a conservative estimate.

Ammonia will be determined by the IC method. Because of the highly soluble nature of ammonia compounds, removal is expected during waste retrieval. Ammonia is normally measured using a microdistillation of the solids. Because of the volatile nature of ammonia in alkaline solutions, it is important to stabilize by acidifying as soon as possible.

The pH of solids is determined according to SW-846 method 9045. This method uses a 1:1 mix of solids with water and then the pH is measured. The titration method for hydroxide is not applied to solids.

Table 4-5. Primary Inorganic Constituents and Analytical Methods.

Constituent	Reason For Inclusion	Analytical Method	Alternate Method
Aluminum Al	R, W	6010 (ICP/AES)	6020 (ICP/MS)
Antimony Sb	R, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Arsenic As	A, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Barium Ba	A, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Beryllium Be	U, W	6010 (ICP/AES)	6020 (ICP/MS)
Cadmium Cd	A, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Chromium Cr	A, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Cobalt Co	R, W	6010 (ICP/AES)	6020 (ICP/MS)
Copper Cu	R, W	6010 (ICP/AES)	6020 (ICP/MS)
Iron Fe	R, W	6010 (ICP/AES)	6020 (ICP/MS)
Lead Pb	A, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Manganese Mn	R, W	6010 (ICP/AES)	6020 (ICP/MS)
Nickel Ni	U, W	6010 (ICP/AES)	6020 (ICP/MS)
Selenium Se	A, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Silver Ag	A, U, W	6010 (ICP/AES)	6020 (ICP/MS)
Strontium Sr	R	6010 (ICP/AES)	6020 (ICP/MS)
Thallium Tl	U, W	6010 (ICP/AES)	6020 (ICP/MS)
Uranium U	R, W	6010 (ICP/AES)	6020 (ICP/MS)
Vanadium V	U, W	6010 (ICP/AES)	
Zinc Zn	U, W	6010 (ICP/AES)	6020 (ICP/MS)
Mercury Hg	A, U, W	7470, 7471 (CVAA)	
Fluoride F^-	U, W	9056 (IC)	
Nitrite NO_2^-	R, W	9056 (IC)	
Nitrate NO_3^-	R, W	9056 (IC)	
Acetate $C_2H_3O_2^-$	R	9056 (IC)	
Formate CHO_2^-	R	9056 (IC)	
Glycolate $C_2H_3O_3^-$	R	9056 (IC)	
Oxalate $C_2O_4^{2-}$	R	9056 (IC)	
Cyanide CN^-	A, U, W	9014 (Spectrophotometric)	
Ferrocyanide $Fe(CN)_6^{4-}$	A, U, W	Estimated from total cyanide.	
Ammonium NH_4^+ [(a)]	W	EPA 300.7 (IC)	
pH [(a)]	W	9045	

Notes:

A	Part A constituent.
R	Risk assessment constituent.
U	UHC constituent.
W	Constituent in PNNL-12040.
CVAA	Cold vapor atomic absorption
IC	Ion chromatograpy.
ICP/AES	Inductively coupled plasma/atomic emissions spectroscopy.
ICP/MS	Inductively coupled plasma/mass spectrometry

[(a)] Constituents added during DQO process meetings.

For the following reasons, sulfide was eliminated as an analytical requirement in this DQO. Sulfides were not routinely used in Hanford Site processes. Limited use of sulfide may have occurred during the ferrocyanide processing of ^{137}Cs in the tanks. The other possible source of sulfides would be from the reduction of sulfates. However, this is unlikely in the high nitrate tank waste matrices. Soluble sulfide is not very stable and is easily oxidized by air. Any sulfide remaining in the waste is most likely present as insoluble metal sulfide. In addition, previous analyses have not detected sulfides in the Hanford Site tanks.

The secondary inorganic constituents are identified in Table 4-5. Most of these constituents are identified in the Regulatory DQO (PNNL-12040, Table 4.7). However, constituents from cerium through titanium (see Table 4-5) are determined by the ICP/AES method but not identified in the Regulatory DQO. Although some of the constituents in Table 4-5 are considered secondary because of their minimum risk, they are expected to be major components of the residual sludge and important to material balance calculations.

The ICP/MS method can be used as an alternative method for most of the constituents identified for ICP/AES. However, ICP/MS will not be run for these constituents unless results are generated as part of another analysis such as uranium isotopic or it becomes required as indicated in Figure 4-2.

Table 4-6. Secondary Inorganic Constituents.

Constituent	Constituent
Method 6010 (ICP/AES)	**Method 9056 (IC)**
Boron B	Bromide Br^-
Bismuth Bi	Chloride Cl^-
Calcium Ca	Phosphate PO_4^{3-}
Lithium Li	Sulfate SO_4^{2-}
Molybdenum Mo	
Magnesium Mg	
Sodium Na	
Phosphorus P	
Potassium K	
Rhodium Rh	
Sulfur S	
Silicon Si	
Tin Sn	
Tantalum Ta	
Tungsten W	
Yttrium Y	
Zirconium Zr	
Cerium Ce	
Europium Eu	
Lanthanum La	
Niobium Nb	
Neodymium Nd	
Palladium Pd	
Praseodymium Pr	
Rubidium Rb	
Ruthenium Ru	
Samarium Sm	
Tellurium Te	
Thorium Th	
Titanium Ti	

Notes:

IC ion chromatography
ICP/AES inductively coupled plasma/atomic emission spectroscopy

4.1.3 Radionuclides

The strategy for analyzing radionuclides is similar to the inorganic analytical strategy but the radionuclides have more single constituent analytical methods. The strategy for determining the analytical requirements for the radionuclides can be seen in Figures 4-4 and 4-5. Figure 4-4 shows the strategy for the radionuclide analytical methods for multiple constituents (i.e., gamma energy analysis (GEA)), while Figure 4-5 shows the strategy for radionuclide constituents that are analyzed by a single constituent analytical method. The primary radionuclides are those identified in 10 CFR 61.55, constituents (e.g., ^{79}Se) added for risk assessment needs, and those that could be major activity contributors. Potential major contributors are added to the primary list to address requirements in 10 CFR 61.41, "Protection of the General Population from Releases of Radioactivity" and 10 CFR 61.42, "Protection of Individuals from Inadvertent Intrusion." If it is determined additional radionuclide constituents are needed for performance assessment or other requirement, they will be added to the primary list. Table 4-6 shows the primary constituents required by this DQO, the reason the constituent is a primary, and the methods used for analysis.

As can be seen in Figures 4-4 and 4-5, the development of analytical methods to lower the quantitation limits will take place after risk evaluations indicate method development is necessary.

Table 4-7. Primary Radiochemistry Constituents.

Constituent	Reason for Inclusion	Analytical Method	Alternate Method
^{137}Cs	10 CFR 61.55	GEA	
^{60}Co	10 CFR 61.55	GEA	
^{152}Eu	Potential major activity contributor	GEA	
^{154}Eu	Potential major activity contributor	GEA	
^{155}Eu	Potential major activity contributor	GEA	
^{14}C	10 CFR 61.55	Liquid Scintillation Counting	
^{3}H	10 CFR 61.55	Liquid Scintillation Counting	
^{129}I	10 CFR 61.55	Low Energy Gamma Counting	
^{63}Ni	10 CFR 61.55	Liquid Scintillation Counting	
^{90}Sr	10 CFR 61.55	Beta Proportional Counting	
^{99}Tc	10 CFR 61.55	ICP/MS	Liquid Scintillation Counting
^{125}Sb	Risk assessment	GEA	
^{79}Se	Risk assessment	Liquid Scintillation Counting	
^{126}Sn	Risk assessment	ICP/MS	
^{231}Pa	Risk assessment	ICP/MS	
^{233}U	Potential major activity contributor	ICP/MS	
^{234}U	Potential major activity contributor	ICP/MS	
^{235}U	Potential major activity contributor	ICP/MS	
^{236}U	Potential major activity contributor	ICP/MS	

Table 4-7. Primary Radiochemistry Constituents.

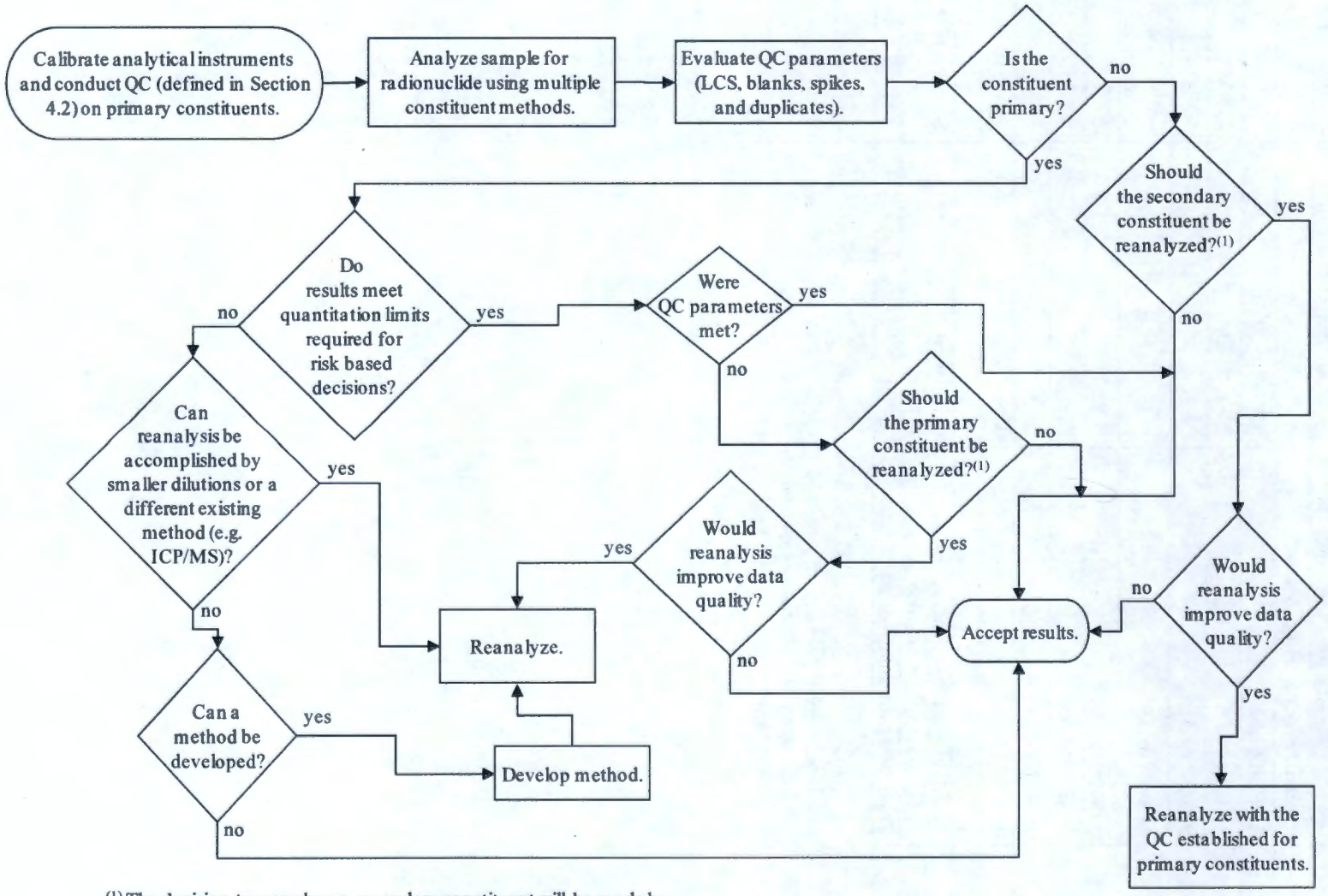
Constituent	Reason for Inclusion	Analytical Method	Alternate Method
^{238}U	Potential major activity contributor	ICP/MS	
^{237}Np	10 CFR 61.55	ICP/MS	
^{238}Pu	10 CFR 61.55	AEA	ICP/MS
$^{239/240}Pu$	10 CFR 61.55	AEA	ICP/MS as ^{239}Pu and ^{240}Pu
^{241}Pu	10 CFR 61.55	Calculate from ^{238}Pu & $^{239/240}Pu$	Liquid Scintillation Counting
^{242}Pu	Risk assessment	ICP/MS	
^{241}Am	10 CFR 61.55	AEA	ICP/MS
^{242}Cm	10 CFR 61.55	AEA	
^{243}Cm	10 CFR 61.55	AEA	
^{244}Cm	10 CFR 61.55	AEA	
^{228}Th	Possibly significant in some tanks.	Calculation	Separation/AEA[a]
^{230}Th	Possibly significant in some tanks.	ICP/MS	
^{232}Th	Possibly significant in some tanks.	ICP/MS	

Notes:

GEA Gamma energy analysis
ICP/MS Inductively coupled plasma/mass spectrometry
AEA Alpha energy analysis

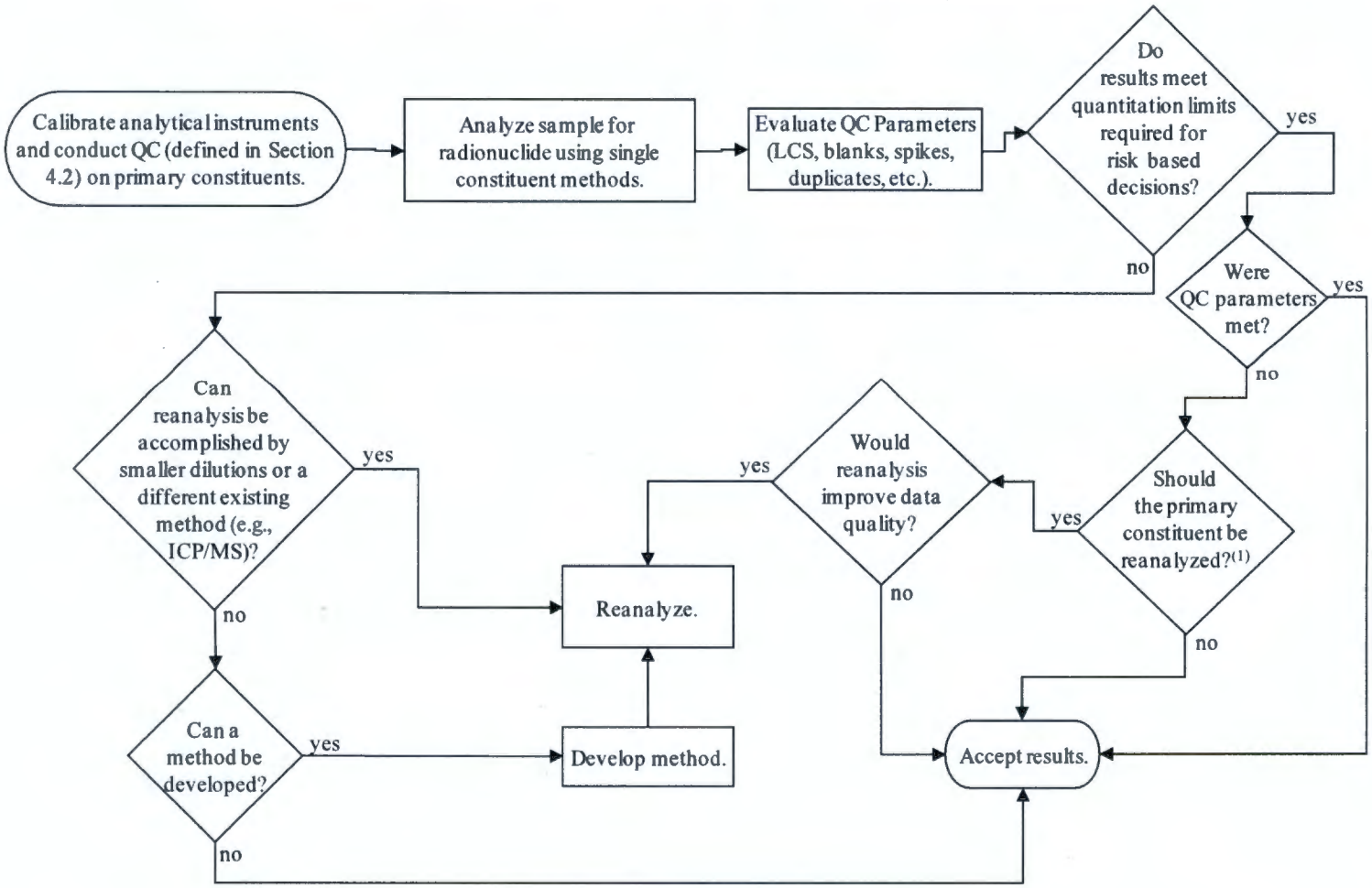
[a]This method requires development.

Figure 4-4. Strategy for Radionuclide Analyses Using Methods for Multiple Constituents.



(1) The decision to reanalyze a secondary constituent will be made by the Chemist, Project Coordinator, and Tank Coordinator

Figure 4-5. Strategy for Radionuclide Single Constituent Analytical Method.



(1) The decision to reanalyze a secondary constituent will be made by the Chemist, Project Coordinator, and Tank Coordinator.

The only truly multiple constituent analytical method for radiochemistry is GEA. Therefore, the secondary constituents are those found in the GEA library. If a constituent in the GEA library is detected, the concentration will be reported.

Additional isotopes other than those requested are not normally reported for ICP/MS because measurements are made by peak hopping rather than scanning. ICP/MS may identify other isotopes but is limited to the mass range scanned.

Only two gamma emitting isotopes, ^{137}Cs and ^{60}Co, are identified in 10 CFR 61.55. The other gamma emitting isotopes are added for other reasons (see Table 4-6). In most Hanford Site tank waste, ^{137}Cs is the dominant gamma-emitting isotope. Other isotopes may not be detected or will be reported at a high less than level by GEA because of the ^{137}Cs background.

^{129}I is measured by a chemical separation and low energy gamma counting.

^{79}Se is determined by liquid scintillation counting. There are no standards or tracers for ^{79}Se because these isotopes are not commercially available. Nonradioactive selenium is used to correct for chemical yields in the procedures.

The ^{230}Th and ^{232}Th can be determined by alpha analysis but are normally measured by ICP/MS because of their long half-life. ^{228}Th must be determined by calculation from ^{232}Th and ^{232}U estimates or from AEA . Determination of ^{228}Th by GEA may be impacted by high ^{137}Cs levels.

In addition to the constituents discussed above, a bulk density or solids specific gravity depending on the solids consistency is required. Bulk density is needed to determine waste inventories.

4.2 QUALITY CONTROL

Laboratories performing analyses in support of this DQO shall have approved and implemented QA Plans. These QA plans shall meet the DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Documents* (HASQARD), minimum requirements as the baseline for laboratory quality systems.

Field and trip blanks are not required for the solid sampling activity because the sampling and shipping conditions of the blanks would not be representative of the solid sample sampling and shipping conditions.

At a minimum, frequency for QC analyses (duplicate, matrix spike, blank, and laboratory control sample) will meet requirements in the referenced EPA methods. Where reference methods are not available (e.g., radionuclide analyses), the frequency will meet requirements established in laboratory procedures and QA plans.

QC acceptance criteria are specified in Table 4-7. EPA encourages the use of performance-based measurement systems when performing SW-846 chemical methods when analyzing solid waste. Therefore, performance measures (QC acceptance criteria) established by laboratory

statistical process control limits, when available, may be used instead of the administrative limits specified in table 4-7.

The QC criteria in Table 4-7 are goals for demonstrating reliable method performance. The laboratory's internal QA system will be used to evaluate the analytical data and processes whenever a criterion is exceeded. The laboratory may reanalyze based on the internal evaluation. Otherwise, the data will be further evaluated in accordance with the strategies in Figures 4-2 through 4-5. Primary constituent data not meeting the QC requirements will be noted accordingly and discussed in the narrative of the laboratory data report.

Table 4-8. Quality Control Parameters for Primary Constituents. (2 Sheets)

Constituents	Method	QC Acceptance Criteria		
		LCS % Recovery[a]	Spike % Recovery[b]	Solid % RPD[c]
Al, Ag, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Pb, Mn, Ni, Sb, Se, Sr, Tl, U, V, Zn	ICP/AES	80 – 120%	75 – 125%	≤30%
Hg	CVAA	80 – 120%	75 – 125%	≤30%
F^-, NH_4^+, NO_2^-, NO_3^-, $C_2H_3O_2^-$, CHO_2^-, $C_2H_3O_3^-$, $C_2O_4^{2-}$	IC	80 – 120%	75 – 125%	≤30%
CN^-	9014 (Spectrophotometric)	80 – 120%	75 – 125%	≤30%
pH [g]	See Text	± 0.1 pH Units	N/A	N/A
PCB	GC/ECD	70 – 130%	70 – 130%	≤30%
VOC	GC/MS	70 – 130%	70 – 130%	≤30%
SVOC	GC/MS	70 – 130%	70 – 130%	≤30%
% H_2O	TGA or GMA	80 – 120%	N/A	≤30%
Bulk Density	Gravimetric	N/A	N/A	≤30%
^{235}U, ^{238}U, ^{237}Np, ^{232}Th, ^{126}Sn	ICP/MS	80 – 120%	75 – 125%	≤30%
^{233}U, ^{234}U, ^{236}U, ^{230}Th,	ICP/MS	N/A[f]	N/A[f]	≤30%
^{228}Th	Calculation[h]	N/A	N/A	N/A
^{60}Co, ^{137}Cs, ^{125}Sb	GEA	80 – 120%	N/A[e]	≤30%
^{152}Eu, ^{154}Eu, ^{155}Eu	GEA	N/A	N/A[e]	≤30%
^{129}I	GEA	80 – 120%	N/A[d]	≤30%
^{14}C, ^{3}H	Liquid scintillation counting	80 – 120%	75 – 125%	≤30%
^{63}Ni	Liquid scintillation counting	80 – 120%	N/A[d]	≤30%
^{90}Sr	Beta counting	80 – 120%	N/A[d]	≤30%
^{99}Tc	ICP/MS	80 – 120%	75 – 125%	≤30%
^{79}Se	Liquid scintillation counting	NP	N/A[d]	≤30%
^{231}Pa	ICP/MS			
^{238}Pu	AEA	N/A[f]	N/A[d]	≤30%
$^{239/240}Pu$	AEA	80 – 120%	N/A[d]	≤30%
^{241}Pu	Calculation from ^{238}Pu and $^{239/240}Pu$	N/A	N/A	N/A
^{242}Pu	ICP/MS			
^{241}Am	AEA	80 – 120%	N/A[d]	≤30%
^{242}Cm, $^{243/244}Cm$	AEA	N/A	N/A	N/A

Notes:

Table 4-8. Quality Control Parameters for Primary Constituents. (2 Sheets)

Constituents	Method	QC Acceptance Criteria		
		LCS % Recovery[a]	Spike % Recovery[b]	Solid % RPD[c]

CVAA	Cold Vapor Atomic Absorption
GEA	Gamma Energy Analysis
GC/ECD	Gas Chromatography/Electron Capture Detector
GC/MS	Gas Chromatography/Mass Spectrometry
GMA	Gravimetric Moisture Analysis
IC	Ion Chromatography
ICP/AES	Inductively Coupled Plasma / Atomic Emission Spectroscopy
ICP/MS	Inductively Coupled Plasma / Mass Spectroscopy
QC	Quality Control
TGA	Thermogravimetric Analysis
N/A	Not applicable
NP	Not performed

(a) LCS = Laboratory Control Sample. This sample is carried through the entire analytical method, including the preparation process. The accuracy of a method is usually expressed as the percent recovery of the LCS. The LCS is a matrix with known concentration of constituents processed with each preparation and analyses batch. It is expressed as percent recovery; i.e., the amount measured, divided by the known concentration, times 100.

(b) For some methods, the sample accuracy is expressed as the percent recovery of a matrix spike sample. It is expressed as percent recovery; i.e., the amount measured, less the amount in the sample, divided by the spike added, times 100. One matrix spike is performed per analytical batch. Samples are batched with similar matrices. For other constituents, the accuracy is determined based on use of serial dilutions.

(c) RPD = Relative Percent Difference between the samples. Sample precision is estimated by analyzing duplicates taken separately through preparation and analysis. Acceptable sample precision is usually ≤ 30% for solids if the sample result is at least 10 times the instrument detection limit.

RPD = ((absolute difference between primary and duplicate)/mean) x 100

(d) Matrix spike analyses are not required for this method because a carrier or tracer is used to correct for constituent loss during sample preparation and analysis. The result generated using the carrier or tracer accounts for any inaccuracy of the method on the matrix. The reported results reflect this correction.

(e) The measurement is a direct reading of the energy and the analysis is not affected by the sample matrix; therefore, a matrix spike is not required.

(f) No standards are run for these constituents.

(g) pH is determined for solids as described in the text (see Section 4.1.2, last paragraph on page 23).

(h) Results for ^{228}Th are presently calculated; a separation/alpha energy analysis requires development.

Recommendations for ensuring sample integrity prior to analysis are provided in SW-846. The recommendations include type of sample container, holding time, preservation, and zero headspace in samples (for volatile components). These recommendations are generally based on sampling of environmental samples (e.g., soil, ground or river water). The recommendations are difficult to meet for Hanford Site tank waste samples. Because of their highly radioactive nature, extra precautions are used in the sample collection, shipping, and preparation for analysis to

minimize radiation exposure to the workers. The SW-846 recommendations are addressed below.

- Type of sample container – If liquid samples are required, they will be obtained using glass bottles with Teflon[1]-lined lids or Teflon-lined septum caps as needed. The appropriate bottle size and color is determined by the specific needs of the sampling event. For example, for extremely radioactive samples, smaller sample bottles may be required to minimize the radiation source. On the other hand, if a sampling event requires a large amount of sample material for a variety of analyses and tests, larger bottles may be used to minimize the number of samples and, therefore, the exposure time to the samplers. In other words, appropriate bottle size is determined by radioactivity of the waste to be sampled and the specific needs of the sampling events.

- Residual solid samples are generally obtained by clam shell, finger trap, the Off-Riser Sampling System (ORSS), or a drag sampler deployed by the Mobile Arm Retrieval System (MARS). When a clam shell, ORSS, or drag sampler is used, solids are placed into Teflon jars. Each jar is capped, placed in a shielded shipping container, and shipped to the laboratory. When a finger trap is used, the lower portion of the sampler, which contains the sample material, is removed from the device, wrapped in aluminum foil, placed into a Teflon jar, capped, and placed into a shielded container for shipping to the laboratory.

- Holding time – The extra precautions required to sample Hanford Site tank waste either lengthens the time required for each sampling, shipping, and analysis step or creates additional steps. For example: personnel must wear protective clothing and shielded gloves when collecting samples; samples must be stored and transported in shielded casks; samples are removed from the casks and transferred into shielded hot cells at the laboratory; samples are broken down and subsampled for analysis using remote manipulators; and samples are stored and analyzed in a manner consistent with fissile material requirements and personnel exposure control. Therefore, the recommended holding times for some analyses may not be met. However, efforts shall be made to minimize the duration between sampling and analysis of samples.

- Sample Preservation – Sample preservation could be temperature control, chemical preservation, or both. Controlling sample temperature during transport is difficult because samples are shipped in large, heavy, shielded casks. The cost of providing refrigeration capable of handling these casks would be prohibitive. Therefore, cooling of samples during transport is not required by this DQO. Efforts shall be made to maintain temperature of samples within the range of normal temperatures for the time of the year when the samples are collected. Hot cell space is limited and cannot accommodate large refrigeration units. However, limited (i.e., small) refrigeration capability shall be provided in the laboratory for samples for which cooling is critical (e.g., VOA, ammonia).

- Chemical preservations are not recommended for the Hanford Site tank waste. Hanford Site tank wastes commonly contain high levels of salt and will precipitate metals when preserved

[1] Teflon® is a registered trademark of I. E. DuPont De Nemours and Company, Inc., Wilmington, Delaware.

by adding acid. In addition, the waste is maintained at high pH (generally >12). Preserving the samples by adding acid may require a large amount of acid and may alter the chemical and physical characteristics of the waste. This would adversely affect the goal of assessing concentrations and physical properties of the waste, as it exists in the tank

- Zero headspace in sample bottles – To minimize loss of volatile components, SW-846 recommends that the sample bottles contain zero headspace. This recommendation is generally not achievable because of personnel exposure concerns. Upon removing a liquid sample from a tank, the sample bottle is quickly capped and placed in a shielded cask to minimize radiation exposure to the workers. Sampling personnel are not allowed to "top off" the samples. Therefore, a zero headspace is commonly not obtained.

While not all of the above recommendations can be met for every sample, efforts shall be made to minimize the potential impacts and the duration between sampling and analysis of the samples. When analyses have required holding times, the time between sampling the waste and the analysis of the waste will be reported in the data package.

The data report from the 222-S Laboratory will be a format IV data package. A format IV data package, as defined in ATL-MP-1011, *ATL Quality Assurance Project Plan for 222-S Laboratory*, is necessary because the data are expected to receive extensive review from outside individuals and organizations. The format IV data package is subject to internal laboratory QA verification and review including peer review prior to release. However, a third party validation of the data package is not required. The data package will include the data for all samples, including composites, segments, sub segments, drainable liquids, and associated blanks taken and analyzed during a single sampling activity. The data package shall be issued as a document approved for public release via an Engineering Data Transmittal Form or Document Release Form.

The data package is organized into two major parts: (1) a summary report section, and (2) a raw data compilation. Each data package section will be organized according to the type of analyses or activity where the data were generated. The summary report section is comprised of two subsections: (1) a narrative that identifies the methods used and discusses any unusual sample or QC results from each analysis or activity; and (2) summary tables of the sample and QC results. Each raw data activity is organized by analysis type and batch or by the time the activity occurred. For most analytical measurements, the batch arrangement requires the least duplication.

Examples of raw data included in the format IV data package are:

- GC chromatograms,
- GC/MS reconstructed ion chromatograms and quantitation reports,
- ICP integration data by constituent,
- Documentation of the amount of spiked material,
- Documentation of the amount of spiked surrogate,

- LABCORE completed work list reports,
- LABCORE data entry templates,
- Results of tracers and carriers, and
- Results of internal standards.

Prior to issuing the format IV data package, preliminary data will be available after the data are reviewed and approved by appropriate laboratory personnel. Complete QA/QC review will not be available until the format IV data package is released.

4.3 DETECTION LIMITS

Detection limits are commonly set an order of magnitude below the action limits required by the DQO. However, with the exception of Class C requirements for decision rule 3 (see Tables 6-1 and 6-2, and Table 4-12 column headed 10 CFR 61.55), definite action limits are not available. Therefore, Tables 4-8 through 4-12 are provided for information and comparison only. Tables 4-8 through 4-11 compare the WAC 173-340 limits to calculated MDLs provided by the 222-S Laboratory. Table 4-12 compares industrial and residential Residual Radioactivity Modeling (RESRAD) values to the calculated MDLs provided by the 222-S Laboratory.

The 222-S Laboratory MDLs in Tables 4-8 through 4-12 are based on the assumption that the radiation levels remaining in the residual waste after retrieval will still be sufficiently high to require the use of sample sizes and analytical procedures that are routinely used for characterization of high level waste samples. If the radiation levels are significantly lower, the 222-S Laboratory MDLs may be lowered by as much as a factor of 5 to 10 for many of the existing methods. This is accomplished by using larger sample sizes. Correspondingly, higher radiation levels could cause the 222-S Laboratory MDLs to increase because a sample may require dilution to be analyzed. Dilution of a sample may also be required because of matrix effects. The MDLs will be reported with the analytical results and will be based on the actual sample size.

As indicated above, detection limits are dependent on such things as sample size (dictated by sample activity and sample availability), methods, and matrix effects. Therefore, when no action limit is established the laboratory will provide the lowest practical detection limit, which depends on the circumstances noted above.

The source of the WAC 173-340 limits is shown in Appendix A. Where physical-chemical parameter values (the distribution coefficient, Kd value, and Henry's Law Constant) are not available in the cleanup levels and risk calculations (CLARC) 3.1 tables, parameter values were obtained from EPA Region 9 or default values of zero were used, as noted in Appendix A. The EPA Region 9 parameters are available at http://www.epa.gov/region09/waste/sfund /prg/index.htm.

Use of Model Toxics Control Act (MTCA) Method B and RESRAD values for comparison in Tables 4-8 through 4-12 does not imply that the associated SST component closure will be sufficient for tank farm closure performance standards. Analytical data generated according to

this DQO will be used to quantify the risk contribution of the SST component closure to the overall risk of the tank farm.

Table 4-9. Comparison: WAC 173-340 Limits to MDLs for Primary Organic Constituents. (3 Sheets)

CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8260 [a] (VOC) Estimated MDLs mg/kg	Method 8260 [a] (VOC) Estimated MDLs mg/L	CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8270[b] (SVOC) Estimated MDLs mg/kg	Method 8270[b] (SVOC) Estimated MDLs mg/L
67-64-1	Acetone (2-Propanone)	3.21E+00	4.38E-02	1.72E-03	83-32-9	Acenaphthene	9.79E+01	1.54E+00	6.6E-01
71-43-2	Benzene	4.48E-03	6.26E-03	2.7E-04	117-84-0	Bis-2-ethylhexyl phthalate (Dioctylphthalate)	5.32E+05	1.52E+00	8.4E-01
75-15-0	Carbon disulfide	5.65E+00	9.25E-03	4.8E-04	71-36-3	Butanol; n- (n-butyl alcohol)	6.62E+00	1.38E+00	2.31E+00
56-23-5	Carbon tetrachloride	3.10E-03	1.19E-02	4.4E-04	85-68-7	Butylbenzylphthalate	8.93E+02	1.63E+00	3.2E-01
108-90-7	Chlorobenzene	8.74E-01	7.73E-03	2.7E-04	95-57-8	Chlorophenol; 2-	9.43E-01	1.36E+00	1.08E+00
67-66-3	Chloroform	3.81E-02	9.46E-03	3.3E-04	108-39-4	Cresol; m- (3-Methylphenol)	3.20E+00	5.95E+00	2.46E+00
107-06-2	Dichloroethane; 1,2-	2.32E-03	6.43E-03	3.5E-04	95-48-7	Cresol; o- (2-Methylphenol)	4.66E+00	2.61E+00	1.14E+00
75-35-4	Dichloroethylene; 1,1- (Dichloroethene)	5.22E-04	1.03E-02	3.9E-04	106-44-5	Cresol; p- (4-Methylphenol)	3.20E-01	5.95E+00	unknown
75-09-2	Dichloromethane (methylene chloride)	2.54E-02	7.66E-03	4.5E-04	1319-77-3	Cresylic acid (cresol, mixed isomers)	Note [e]	3.73E+00	3.67E+00
10061-02-6	Dichloropropene; 1,3,- (trans-)	1.41E-03[f]	6.38E-03	3.2E-04	108-94-1	Cyclohexanone	3.20E+02	2.24E+00	3.1E-01
141-78-6	Ethyl acetate	1.61E+02	9.72E-03	2.9E-04	84-74-2	Dibutylphthalate (Di-n-butylphthalate)	1.14E+01	2.02E+00	5.4E-01
60-29-7	Ethyl ether (Diethyl ether)	9.09E+00	8.85E-03	3.9E-04	95-50-1	Dichlorobenzene; 1,2- (ortho-)	7.03E+00	1.38E+00	5.0E-01
100-41-4	Ethylbenzene	6.05E+00	1.55E-02	8.1E-04	121-14-2	Dinitrotoluene; 2,4-	1.89E-01	9.7E-01	5.1E-01
67-72-1	Hexachloroethane	2.49E-01	5.9E-03	5.3E-04	110-80-5	Ethoxyethanol; 2-	2.56E+01	7.3E-01	5.1E-01
78-93-3	Methyl ethyl ketone (2-Butanone)	2.18E+01	2.42E-02	7.9E-04	206-44-0	Fluoranthene	6.31E+02	9.2E-01	8.5E-01
108-10-1	Methyl isobutyl ketone (4-methyl-2-pentanone)	1.28E+01	1.33E-02	3.4E-04	87-68-3	Hexachlorobutadiene	6.05E+00	3.4E-01	4.6E-01
79-46-9	Nitropropane; 2-	1.84E-05	1.58E-02	1.03E-03	78-83-1	Isobutyl alcohol (Isobutanol)	5.47E+01	1.84E+00	2.63E+00
79-34-5	Tetrachloroethane; 1,1,2,2-	1.23E-03	6.53E-03	4.3E-04	128-37-0	methylphenol; 2,6-Bis(tert-butyl)-4-	None	9.4E-01	6.8E-01
127-18-4	Tetrachloroethene; 1,1,2,2-	9.10E-03	8.19E-03	3.1E-04	59-50-7	methylphenol; 4-Chloro-3- (p-Chloro-m-cresol)	None	4.9E-01	1.28E+00
108-88-3	Toluene	7.27E+00	7.32E-03	4.3E-04	91-20-3	Naphthalene	4.46E+00	6.2E-01	4.7E-01
76-13-1	trichloro-1,2,2-trifluoroethane; 1,1,2-	1.92E+03	1.01E-02	8.4E-04	98-95-3	Nitrobenzene	5.11E-02	6.5E-01	3.9E-01
71-55-6	Trichloroethane; 1,1,1-	1.58E+00	8.94E-03	3.0E-04	88-75-5	Nitrophenol; o-	None	1.58E+00	1.03E+00
79-00-5	Trichloroethane; 1,1,2-	4.27E-03	6.53E-03	2.7E-04	621-64-7	N-nitroso-di-n-propylamine;	5.60E-05	8.7E-01	1.03E+00

Table 4-9. Comparison: WAC 173-340 Limits to MDLs for Primary Organic Constituents. (3 Sheets)

CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8260 [a] (VOC) Estimated MDLs mg/kg	Method 8260 [a] (VOC) Estimated MDLs mg/L	CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8270[b] (SVOC) Estimated MDLs mg/kg	Method 8270[b] (SVOC) Estimated MDLs mg/L
79-01-6	Trichloroethylene; 1,1,2-	2.60E-02	1.18E-03	4.3E-04	59-89-2	Nitrosomorpholine; N-	None	7.7E-01	1.01E+00
75-69-4	Trichlorofluoromethane	7.23E+01	9.33E-04	3.8E-04	129-00-0	Pyrene	6.55E+02	1.50E+00	6.4E-01
75-01-4	Vinyl chloride (1-Chloroethene)	1.84E-04	4.45E-03	4.4E-04	110-86-1	Pyridine	3.87E-01	9.3E-01	5.5E-01
1330-20-7	Xylenes	9.14E+01	1.43E-02	1.28E-03	95-95-4	Trichlorophenol; 2,4,5-	5.75E+01	7.1E-01	1.21E+00
108-38-3	Xylene; m-	8.44E+01	8.81E-03	1.02E-03	88-06-2	Trichlorophenol; 2,4,6-	9.24E-02	7.5E-01	1.18E+00
95-47-6	Xylene; o-	9.19E+01	5.53E-03	4.4E-04	126-73-8	Tributyl phosphate	7.0E-01	4E-01	5.0E+00
106-42-3	Xylene; p-	1.72E+02	8.81E-03	1.02E-03					
120-82-1	1,2,4 - Trichlorobenzene	3.0E+00	1.02E-03	6.7E-04					
		Constituent Limits 0.05[c] mg/kg	Method 8082[d] PCBs MDL mg/kg	Method 8082[a] PCBs MDL mg/L					
11104-28-2	Aroclor 1221	Note c	0.026	7.1E-03					
11141-16-5	Aroclor 1232	Note c	0.46	4.6E-02					
12674-11-2	Aroclor 1016	Note c	0.081	3.78E-02					
53469-21-9	Aroclor 1242	Note c	0.084	2.6E-02					
12672-29-6	Aroclor 1248	Note c	0.027	1.3E-02					
11097-69-1	Aroclor 1254	Note c	0.016	4.03E-3					
11096-82-5	Aroclor 1260	Note c	0.113	2.86E-02					

Table 4-9. Comparison: WAC 173-340 Limits to MDLs for Primary Organic Constituents. (3 Sheets)

CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8260 [a] (VOC) Estimated MDLs mg/kg	Method 8260 [a] (VOC) Estimated MDLs mg/L	CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8270[b] (SVOC) Estimated MDLs mg/kg	Method 8270[b] (SVOC) Estimated MDLs mg/L

Notes:

CAS	Chemical Abstracts Service
VOC	Volatile Organic Compound
SVOC	Semivolatile Organic Compound
MDL	Method Detection Limits
Shaded MDLs	Constituents where the MDLs are above WAC 173-340 limits.
unknown	MDL estimate is unknown.
None	Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating limits.

[a]For solids, 8260 MDL assumes a 0.5-g sample size. If the sample has a high dose rate, a smaller samples size and larger MDL may result. For liquid, 8260 and 8082 MDL basis for liquids – assumes a 10-mL sample size. If the liquid is too radioactive, the sample size may be reduced to 1 mL, and the MDLs would be 10 times higher.

[b]For solids, 8270 MDL assumes a 2-g sample size. SW-846 30-g sample, 222-S Laboratory 1-g sample. The ratio of dilution factor is 30 g/ 1 g x 2 mL / 1 mL = 60. Example: SW-846 EQL = 5 mg/g, 222-S Laboratory EQL = 5 mg/g x 60 = 300 mg/g. For liquid, 8270 MDL basis assumes a 10-mL sample size. If the liquid is too radioactive or foams, the sample size may be reduced by a factor of 10 or more resulting in corresponding higher MDLs.

[c]0.05 mg/kg is for total PCBs.

[d]For solids, 8082 MDL assumes a 1-g sample size.

[e]Constituent limits are presented for the individual isomers, m-Cresol (CAS 108-39-4), p-Cresol (CAS 106-44-4), o-Cresol (CAS No. 95-48-7) instead of for the mixed isomers of cresol (also called cresylic acid (CAS 1319-77-3))

[f]Constituent limit is for 1,3-Dichloropropene (CAS 542-75-6) instead of the isomer trans-1,3-Dichloropropene.

Table 4-10. Comparison: WAC 173-340 Limits to MDLs for Secondary Organic Constituents. (2 Sheets)

CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8260 (VOC) Estimated MDLs mg/kg	Method 8260 (VOC) Estimated MDLs mg/L	CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8270 (SVOC) Estimated MDLs mg/kg	Method 8270 (SVOC) Estimated MDLs mg/L
123-86-4	Acetic acid, n-butylester	None	0.1	0.5	98-86-2	Acetophenone	6.40E+00	0.4	5
75-05-8	Acetonitrile	2.82E-01	0.1	0.5	309-00-2	Aldrin	5.04E-03	28	unknown
107-02-8	Acrolein (propenal)	6.5E-01	0.1	1.0	50-32-8	Benzo[a]pyrene	1.37E-01	40	3
107-13-1	Acrylonitrile	3.33E-04	0.1	0.5	92-52-4	Biphenyl; 1,1'-	7.55E+02	0.4	5
107-05-1	Allyl chloride (3-Chloropropene)	3.20E+00	0.1	unknown	4170-30-3	Butenaldehyde; 2- (2-Butenal)	None	0.4	unknown
74-83-9	Bromomethane	5.18E-03	0.1	0.5	100-00-5	Chloronitrobenzene (p-Nitrochlorobenzene)	6.56E-02	0.4	5
106-99-0	Butadiene; 1,3-	3.55E-04	0.1	0.5	541-73-1	Dichlorobenzene; 1,3-	None	40	3
75-45-6	Chlorodifluoromethane	None	0.1	0.5	106-46-7	Dichlorobenzene; 1,4- (para-)	3.00E-02	40	3
74-87-3	Chloromethane	3.34E-02	0.1	0.1	53-70-3	Diebenzo[a,h]anthracene	1.37-01	40	3
110-82-7	Cyclohexane	1.30E+03	0.1	0.5	60-57-1	Dieldrin	2.82E-03	28	unknown
110-83-8	Cyclohexene	None	0.1	unknown	57-14-7	Dimethylhydrazine; 1,1-	1.35E-04	0.4	unknown
287-92-3	Cyclopentane	None	0.1	0.5	100-25-4	Dinitrobenzene; 1,4- (para-)	4.5E-02	0.4	1.2
76-14-2	Dichloro-1,1,2,2-tetrafluoroethane; 1,2-	None	0.1	0.5	88-85-7	Dinoseb (2-sec-Butyl-4,6-dinitophenol)	2.80E-02	0.4	6
75-71-8	Dichlorodifluoromethane	2.90E+01	0.1	0.1	122-39-4	Diphenylamine; N,N-	1.60E+00	0.4	5
75-34-3	Dichloroethane; 1,1-	4.37E+00	0.1	0.5	72-20-8	Endrin	4.40E-01	34	unknown
75-43-4	Dichlorofluoromethane	None	0.1	0.5	118-74-1	Hexachlorobenzene	1.50E-02	40	3
78-87-5	Dichloropropane; 1,2-	3.30E-03	0.1	0.5	319-84-6	Hexachlorocyclohexane; alpha- (alpha-BHC)	5.45E-04	18	unknown
10061-01-5	Dichloropropene; 1,3- (cis-)	1.41E-03[a]	0.1	0.4	319-85-7	Hexachlorocyclohexane; beta- (beta-BHC)	2.27E-03	18	unknown
123-91-1	Dioxane; 1,4-	3.18E-02	0.1	0.5	1335-87-1	Hexachloronaphtahlene	None	0.4	5
64-17-5	Ethyl alcohol	None	0.1	0.5	684-16-2	Hexafluoroacetone	None	0.4	5
75-00-3	Ethyl chloride (Chloroethane)	3.03E-02	0.1	0.5	591-78-6	Hexanone; 2-	None	0.4	5
106-93-4	Ethylene dibromide (1,2-Dibromoethane)	2.83E-06	0.1	0.5	465-73-6	Isodrin	None	0.4	6
75-21-8	Ethylene oxide (Oxirane)	1.83E-04	0.1	0.5	58-89-9	Lindane (gamma-BHC)	2.09E-03	28	unknown
76-44-8	Heptachlor	3.78E-03	26	unknown	563-80-4	Methy-2-butanone; 3-	None	0.4	5
142-82-5	Heptane; n-	None	0.1	0.5	126-98-7	Methyl-2-propenenitrile; 2-	6.57E-03	0.4	unknown
110-43-0	Heptanone; 2-	None	0.1	0.5	60-34-4	Methylhydrazine	3.18E-04	0.4	unknown
106-35-4	Heptanone; 3-	None	0.1	1.0	627-13-4	Nitric acid, propyl ester	None	0.1	unknown
123-19-3	Heptanone; 4-	None	0.1	0.5	62-75-9	Nitrosodimethylamine; N-	6.86E-06	0.4	5

Table 4-10. Comparison: WAC 173-340 Limits to MDLs for Secondary Organic Constituents. (2 Sheets)

CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8260 (VOC) Estimated MDLs mg/kg	Method 8260 (VOC) Estimated MDLs mg/L	CAS No.	Chemical Name	WAC 173-340 Limits mg/kg	Method 8270 (SVOC) Estimated MDLs mg/kg	Method 8270 (SVOC) Estimated MDLs mg/L
110-54-3	Hexane; n-	9.62E+01	0.1	0.5	2234-13-1	Octachloronaphthalene	None	0.4	5
624-83-9	Methyl isocyanate	None	0.1	unknown	1321-64-8	Pentachloronaphthalene	None	0.4	5
110-12-3	Methyl-2-hexanone; 5-	None	0.1	0.5	82-68-8	Pentachloronitrobenzene (PCNB)	1.35E-03	unknown	6
75-65-0	Methyl-2-Propanol; 2-	None	0.1	0.5	87-86-5	Pentachlorophenol	1.15E-02	132	15
108-87-2	Methylcyclohexane	1.54E+03	0.1	0.5	109-66-0	Pentane; n-	None	0.4	9
78-92-2	Methylpropyl alcohol; 1- (2-butanol)	None	0.1	0.5	108-95-2	Phenol	4.39E+01	40	3
111-84-2	Nonane; n-	None	0.1	0.5	123-38-6	Propionaldehyde; n-	None	0.4	unknown
111-65-9	Octane; n-	None	0.1	0.5	1335-88-2	Tetrachloronaphthalene	None	0.4	5
107-87-9	Pentanone; 2-	None	0.1	0.5	8001-35-2	Toxaphene	1.53E-01	unknown	unknown
96-22-0	Pentanone; 3-	None	0.1	0.5					
107-12-0	Propionitrile (Ethyl cyanide)	None	0.1	0.5	121-44-8	Triethylamine	5.19E-02	0.4	unknown
67-63-0	Propyl alcohol; 2-	None	0.1	0.5	10595-95-6	n-Nitrosomethylethylamine		0.2	4
71-23-8	Propyl alcohol; n- (1-propanol)	None	0.1	0.5	924-16-3	n-Nitrosodi-n-butylamine		0.2	4
100-42-5	Styrene	3.28E-02	0.1	0.3					
109-99-9	Tetrahydrofuran	None	0.1	0.5					

Notes:

CAS	Chemical Abstracts Service
VOC	Volatile Organic Compound
SVOC	Semivolatile Organic Compound
MDL	Method Detection Limits
Shaded MDLs	Constituents where the MDLs are above the WAC 173-340 limits.
unknown	MDL estimate unknown. MDLs for secondary components are not measured but estimated from literature. Data are not available for these compounds and methods.
None	Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating limits.

[a] Constituent limit is for 1,3-Dichloropropene (CAS 542-75-6) instead of the isomer cis-1,3-Dichloropropene.

Table 4-11. Comparison: WAC 173-340 Limits to MDLs for Primary Inorganic Constituents. (2 Sheets)

Metals	WAC 173-340 Limits mg/kg	Primary Method 6010 (ICP/AES)[a] MDLs mg/kg	Alternate Method 6020 (ICP/MS)[b] MDLs mg/kg		Primary Method 6010 (ICP/AES)[a] MDLs mg/L	Alternate Method 6020 (ICP/MS)[b] MDLs mg/L
Antimony Sb	5.42E+00	10.6			10.6	
Aluminum Al	4.52E+01	2.75			26.6	
Arsenic As	3.40E-02	25.7	0.2		25.7	5.0E-01
Barium Ba	9.23E+02	10.5	2.00E-03		10.5	5.0E-03
Beryllium Be	6.32E+01	0.65	2.00E-03		0.7	5.0E-03
Cadmium Cd	5.00E+00	1.05	2.02E-02		1.1	5.0E-02
Cobalt Co	None	2.55			2.6	
Copper Cu	2.63E+02	6.1			6.1	
Iron Fe	1.32E+03	10.05			10.1	
Lead Pb	2.50E+02	11.75	2.00E-01		11.8	5.0E-01
Manganese Mn	5.02E+01	0.55			0.6	
Nickel Ni	1.30E+02	5.5			5.5	
Seleniun Se	5.20E+00	25.9	2.00E-01		25.9	5.0E-01
Silver Ag	1.36E+01	2.75	6.00E-04		2.8	1.5E-03
Strontium Sr	2.92E+03	0.55			0.6	
Thallium Tl	1.59E+00	75.6	4.00E-04		75.6	1.0E-03
Uranium U	1.32E+00	25.75			25.8	
Chromium Cr	2.00E+00 (Total Cr)	2.6	8.00E-02		2.6	2.0E-01
Vanadium V	5.60E+02	2.6	6.00E-03		2.6	1.5E-02
Zinc Zn	5.97E+03	1.05	6.00E-03		1.1	6.00E-02
	Constituent Limits mg/kg	**Primary Method 7470/71 (CVAA) MDLs mg/kg**			**Primary Method 7470/71 (CVAA) MDLs mg/L**	
Mercury Hg[c]	2.09E+00	0.05			0.005	
Anions	**Constituent Limits mg/kg**	**Primary Method 9056 (IC)[d] MDLs mg/kg**			**Primary Method 9056 (IC)[d] MDLs mg/L**	
Fluoride F^-	1.60E+01	20			100	
Nitrate NO_3^-	4.00E+01 (as nitrogen)	280			1400	
Nitrite NO_2^-	4.00E+00 (as nitrogen)	200			1000	
Acetate $C_2H_3O_2^-$	None	400			2000	

Table 4-11. Comparison: WAC 173-340 Limits to MDLs for Primary Inorganic Constituents. (2 Sheets)

Metals	WAC 173-340 Limits mg/kg	Primary Method 6010 (ICP/AES)[a] MDLs mg/kg	Alternate Method 6020 (ICP/MS)[b] MDLs mg/kg		Primary Method 6010 (ICP/AES)[a] MDLs mg/L	Alternate Method 6020 (ICP/MS)[b] MDLs mg/L
Formate CHO_2^-	None	400			2000	
Glycolate $C_2H_3O_3^-$	None	400			2000	
Oxalate $C_2O_4^{2-}$	None	200			1000	
	Constituent Limits mg/kg	**Primary Method 9010/9014 (Spec.) MDLs mg/kg**			**Primary Method 9010/9014 (Spec.) MDLs mg/L**	
Cyanide CN^- [e]	8.00E-01	2.5			2.5	
Ferrocyanide $FE(CN)_6^{4-}$	Analyzed as cyanide					
Cation	**Constituent Limits mg/kg**	**Primary Method EPA 300.7 MDLs mg/kg**			**Primary Method EPA 300.7 MDLs mg/L**	
NH_4^+	Not regulated	120			1.2	

Notes:

Shaded MDLs	Constituents where the MDLs are above the WAC 173-340 limits.
MDL	Method Detection Limits
CVAA	Cold Vapor Atomic Absorption.
GEA	Gamma Energy Analysis.
IC	Ion Chromatography.
ICP/AES	Inductively Coupled Plasma / Atomic Emission Spectroscopy.
ICP/MS	Inductively Coupled Plasma / Mass Spectroscopy
Spec.	Spectrophotometric
None	Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating limits.

[a] ICP/AES for solids assumes dilution factor (DF) = 500, 0.5g-50 mL-2mL-10. For liquid, it assumes high salt dilution factor and an acid digest, DF = 500, 1.0mL-50 mL-1mL-10mL. ICP MDLs based on 3050 digest.

[b] Solids ICP/MS based on dilution factor = 2000. Liquid ICP/MS assumes high salt dilution factor and an acid digest, DF = 5000, 1.0 mL-50 mL-0.1mL-10mL. ICP/MS MDLs may be based on instrument detection limits (IDLs) and could be 10 times larger.

[c] Hg assumes a 0.005 µg detection limit and a 0.1g sample size.

[d] For solids, IC assumes a dilution factor = 2000 for water digest and a 50 µL loop. For liquid, IC assumes high salt dilution factor and an water digest DF= 10000, 0.1mL-10mL-0.1mL-10mL and a 50 µL loop.

[e] For solids, CN^- assumes a 0.1g solid with EDTA solution. For liquid, CN^- high salt dilution factor assumes 0.1 mL sample is distilled.

Table 4-12. Comparison: WAC 173-340 Limits to MDLs for Secondary Inorganic Constituents.

Metals	WAC 173-340 Limits mg/kg	Method 6010 (ICP/AES) MDLs mg/kg	Method 6010 (ICP/AES) MDLs mg/L	Anions	WAC 173-340 Limits mg/kg	Method 9056 (IC) MDLs mg/kg	Method 9056 (IC) MDLs mg/L
Boron B	1.12E+01	10.75	10.8	Bromide Br^-	None	240	1200
Bismuth Bi	None	25.8	25.8	Chloride Cl^-	1.00E+03	30	150
Calcium Ca	None	6.25	6.3	Phosphate PO_4^{3-}	None	240	1200
Potassium K	None	157	157	Sulfate SO_4^{2-}	1.00E+03	280	1400
Lithium Li	None	0.9	0.9				
Molybdenum Mo	1.63E+01	2.7	2.7				
Magnesium Mg	None	26.25	26.3				
Sodium Na	None	22.4	22.4				
Phosphorus P	None	9.8	9.8				
Rhodium Rh	None	25.75	25.8				
Sulfur S	None	11.4	11.4				
Silicon Si	None	5.05	5.1				
Tin Sn	2.50E+04	25.65	25.7				
Tantalum Ta	None	25.45	25.5				
Tungsten W	None	42.85	42.9				
Yttrium Y	None	0.6	0.6				
Zirconium Zr	None	1.2	1.2				
Cerium Ce	None	10.5	10.5				
Europium Eu	None	5.55	5.6				
Lanthanum La	None	2.75	2.8				
Niobium Nb	None	5.0	5.0				
Neodymium Nd	None	5.05	5.1				
Palladium Pd	None	75.75	75.8				
Praeseodynium Pr	None	26.05	26.1				
Rubidium Rb	None	254	254				
Ruthenium Ru	None	25.65	25.7				

Table 4-12. Comparison: WAC 173-340 Limits to MDLs for Secondary Inorganic Constituents.

Metals	WAC 173-340 Limits mg/kg	Method 6010 (ICP/AES) MDLs mg/kg	Method 6010 (ICP/AES) MDLs mg/L	Anions	WAC 173-340 Limits mg/kg	Method 9056 (IC) MDLs mg/kg	Method 9056 (IC) MDLs mg/L
Samarium Sm	None	5.35	5.4				
Tellurium Te	None	25.55	25.6				
Thorium Th	None	4.85	4.9				
Titanium Ti	None	0.65	0.7				

Notes:

Shaded MDLs Constituents where the MDLs are above the WAC 173-340 limits.
Constituents where the limits are close to or below MDLs.
ICP/AES Inductively Coupled Plasma / Atomic Emission Spectroscopy
IC Ion Chromatography
None Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating limits.

Table 4-13. Dose Limits and MDL Comparisons for Primary Radionuclides. (3 Sheets)

Analyte	Analytical Method	Alternate Analytical Method	Limits For Comparison To MDLs				MDLs pCi/g	MDLs pCi/mL
			Source Industrial RESRAD-15 pCi/g	Source Industrial RESRAD-GW pCi/g	Source Residential RESRAD-GW pCi/g	Source 10 CFR 61.55 Class C Waste pCi/g		
^{241}Am	Alpha Counting		3.35E+02			9.00E+03	5.50E+03	1.10E+02
^{14}C	Liquid Scintillation Counting		3.31E+04	2.91E+02	4.65E+00	5.33E+06	4.00E+02	4.00E+01
^{242}Cm	Alpha Counting					9.00E+03	5.50E+03	1.10E+02
^{243}Cm	Alpha Counting		1.10E+02			9.00E+03	5.50E+03 (as $^{243/244}Cm$)	1.10E+02 (as $^{243/244}Cm$)
^{244}Cm	Alpha Counting		7.44E+02			9.00E+03	5.50E+03 (as $^{243/244}Cm$)	1.10E+02 (as $^{243/244}Cm$)
^{60}Co	GEA		4.90E+00				9.00E+03	2.50E+03
^{137}Cs	GEA		2.34E+01			3.07E+09	1.25E+04	2.50E+02
^{152}Eu	GEA		1.14E+01				1.80E+04	6.50E+04
^{154}Eu	GEA		1.03E+01				1.25E+04	4.60E+04
^{155}Eu	GEA		4.26E+02				2.20E+04	8.10E+04
^{3}H	Liquid Scintillation Counting		6.69E+04	4.10E+03	4.82E+01		4.60E+02	4.60E+01
^{129}I	Low Energy Gamma Counting		3.08E+03	2.02E+00	1.20E-01	5.33E+04	2.00+04	1.00E+03
^{63}Ni	Liquid Scintillation Counting		4.03E+03			4.67E+08	5.00E+3	1.00E+02
^{237}Np	ICP/MS		5.92E+01			9.00E+03	3.80E-02 1.05E+04[a]	9.52E-02 2.10E+02[a]

Table 4-13. Dose Limits and MDL Comparisons for Primary Radionuclides. (3 Sheets)

Analyte	Analytical Method	Alternate Analytical Method	Limits For Comparison To MDLs				MDLs pCi/g	MDLs pCi/mL
			Source Industrial RESRAD-15 pCi/g	Source Industrial RESRAD-GW pCi/g	Source Residential RESRAD-GW pCi/g	Source 10 CFR 61.55 Class C Waste pCi/g		
^{238}Pu	Alpha Counting	ICP/MS	4.70E+02			9.00E+03	1.70E+03 6.84E+02[a]	3.40E+01 1.71E+03[a]
^{239}Pu	Alpha Counting	ICP/MS	4.25E+02			9.00E+03 (as $^{239/240}Pu$)	1.70E+03 (as $^{239/240}Pu$) 7.44E+00[a]	3.40E+01 (as $^{239/240}Pu$) 1.86E+01 [a]
^{240}Pu	Alpha Counting	ICP/MS	4.26E+02			9.00E+03 (as $^{239/240}Pu$)	1.70E+03 (as $^{239/240}Pu$) 2.27E-00[a]	3.40E+01 (as $^{239/240}Pu$) 5.86E+00[a]
^{241}Pu	Calculate from ^{238}Pu & $^{239/240}Pu$	Liquid Scintillation Counting	1.11E+04			3.50E+09	1.65E+04[a]	1.80E+04[a]
^{242}Pu	ICP/MS							
^{231}Pa	ICP/MS							
^{125}Sb	GEA						5.5E+06	2.0E+04
^{79}Se	Liquid Scintillation Counting		1.97E+05				1.00E+03	1.00E+02
^{90}Sr	Beta Proportional Counting		2.41E+03		3.29E+01	4.67E+09	1.65E+03	3.30E+01
^{99}Tc	ICP/MS	Liquid Scintillation Counting	4.12E+05	1.71E+02	1.93E+00	2.00E+06	5.00E+03 3.40E+01[a]	1.00E+02 2.55E+01 [a]
^{126}Sn	ICP/MS						4.00E+02	2.0E+00
^{228}Th	Calculation	Seperation/ AEA	7.73E+00		2.86E+02		6.00E+05[a]	2.70E+06 ([a])
^{230}Th	ICP/MS		2.01E+01				2.88E-01	7.21E-01
^{232}Th	ICP/MS		4.80E+00				4.40E-05	6.60E-05
^{233}U	ICP/MS					9.00E+03	1.74E-01	4.34E-01

Table 4-13. Dose Limits and MDL Comparisons for Primary Radionuclides. (3 Sheets)

Analyte	Analytical Method	Alternate Analytical Method	Limits For Comparison To MDLs				MDLs pCi/g	MDLs pCi/mL
			Source Industrial RESRAD-15 pCi/g	Source Industrial RESRAD-GW pCi/g	Source Residential RESRAD-GW pCi/g	Source 10 CFR 61.55 Class C Waste pCi/g		
^{234}U	ICP/MS		2.66E+03 (as $^{233/234}U$)	3.95E+01 (as $^{233/234}U$)	6.70E-01 (as $^{233/234}U$)	9.00E+03	3.75E-02	9.38E-02
^{235}U	ICP/MS		1.01E+02 (as $^{235/236}U$)	3.92E+00 (as $^{235/236}U$)	6.70E-02 (as $^{235/236}U$)	9.00E+03	4.32E-05	1.19E-04
^{236}U	ICP/MS						5.18E-04	1.29E-03
^{238}U	ICP/MS		5.04E+02	3.81E+01	6.50E-01	9.00E+03	4.37E-04	9.24E-04

Notes:

GEA Gamma Energy Analysis.
ICP/MS Inductively Coupled Plasma / Mass Spectroscopy
RESRAD-15 Single radionuclide concentration corresponding to a dose of 15 mrem per year above background calculated by RESRAD for 200 Area industrial soil
RESRAD-GW Single radionuclide concentration calculated by RESRAD to be protective of groundwater for 200 Area industrial soil.

Most radiochemical methods are based on a fusion with a DF= 500.
GEA MDLs for liquids are based on high concentrations of ^{137}Cs in samples. For solids, a low ^{137}Cs level was assumed.
ICP/MS MDLs for solids may be based on IDLs. MDLs may be 10 times higher depending on matrix and analyte.
MDLs for liquid assume a high salt/high dose liquid and a sample size of 0.1mL.
The ICP/MS MDL estimates for liquid assume a high salt and a DF of 5000. Larger sample sizes may be possible if the salt and dose concentrations of the liquids are lower.

[a] Method detection limits for alternate methods.

5.0 STUDY BOUNDARIES

This step in the DQO process defines the spatial and temporal boundaries for the required sampling and analyses needed to make the necessary decisions. The spatial boundaries define the physical area to which the decisions will apply and where the samples should be taken. The temporal boundaries describe the timeframe that the data will represent and when the samples should be taken. In addition, this portion of the DQO addresses any sampling constraints.

5.1 SPATIAL AND TEMPORAL BOUNDARIES

As stated in the DQO scope statements, the spatial boundary for the sampling and analyses covered by this DQO is only the SSTs. Therefore, the boundary will be the exterior of the tank walls. The soil and ancillary equipment (pipes, pits, vaults, etc.) in the tank farm will be addressed in separate component closure DQOs or in DQOs for the closure of the tank farms.

The data collected will be used to support SST component closure actions. The temporal boundary for the data collected per this DQO will be the final closure of the SST farms. Because the data will represent the condition of the residual waste in the SSTs, the timing of the sample collection must reflect these conditions. Section 8.0 describes the sampling plan including the timing of the samples. This DQO will be in effect until the sampling and analysis for the component closure activities are complete.

5.2 SAMPLING CONSTRAINTS

Sampling events for SSTs contend with the usual sampling constraints encountered in sampling Hanford Site tank waste. These constraints include operational constraints such as the type of sampling devices available, riser location and availability, the configuration of the residual waste after retrieval, and waste activity concerns (radiation exposure to the workers). Other considerations for sampling and analysis are resource limitations on the number of samples and sample handling considerations (see Section 4.2). The sampling plan is discussed in Section 8.0.

6.0 DECISION RULES

The DQO process includes development of decision rules, which define the actions to be taken as a result of exceeding an action limit. Decision rules require action limits and alternative actions that will be taken if an action limit is exceeded. Decision rules are expressed as "if then" statements that incorporates the parameter of interest, the scale of decision making, the action limit, and the actions that would result from resolution of the decision rule. For this DQO, the following decision rules were developed to address the decision statement in Section 3.0 and the decisions shown in Figure 3-1. As can be seen in Figure 3-1, the decisions are not sequential

but are applied in parallel. Therefore, all of the decision rules must be met before component closure actions can continue.

With the exception of the first decision rule, the decision rules have action limits that are indirectly applied to the sampling covered by this DQO. Most of the decisions rules are based on risk assessment calculations. The sampling and analyses conducted under this DQO are used in the risk assessments.

The first decision (see Figure 3-1) addresses the residual waste volume remaining in a SST after completion of waste retrieval to the maximum extent possible. This decision rule is:

- If the residual waste volume within a SST has been retrieved to the maximum extent possible and is <360 cubic feet (<30 cubic feet for 200 series tanks), then component closure actions for that SST, as specified in the Hanford Site-Wide Permit, can proceed; otherwise, prepare an Appendix H request for an exception to the HFFACO (Ecology et al. 1989) milestone M-45-00 retrieval criteria. (Note: Appendix H does not apply to tanks retrieved under the terms of the Consent Decree.

Commonly, an action limit is a concentration at which point a predetermined action is taken depending on whether the results of the analyses are above or below the specified action limit. To account for uncertainty in the data, analytical results are compared to the action limits at a previously agreed to confidence limit. Uncertainty for this decision rule is discussed in Section 7.0.

The second decision (see Figure 3-1) addresses the concentration of constituents of concern within the residual waste in the SSTs and addresses risk assessment. The decision rule is:

- If the residual waste inventories, following evaluation in a risk assessment, support compliance with WAC 173-303-610(2), and the risk assessment is approved by Ecology through incorporation of the closure plan into the *Resource Conservation and Recovery Act* (RCRA) Site-Wide Permit, then component closure actions for the SST can proceed; otherwise, the component closure actions will be reassessed.

The third decision shown in Figure 3-1 addresses radiological requirements found in DOE M 435.1-1 Chapter II.B(2)(a). The requirements in DOE M 435.1-1 Chapter II.B(2)(a) can be addressed with the following four decision rules.

The first decision rule for DOE M 435.1-1 Chapter II.B(2)(a) addresses the requirement to remove key radionuclides to the maximum extent that is technically and economically practical. The decision rule can be stated as follows.

- If the key radionuclides are removed to the maximum extent that is technically and economically practical, then component closure actions for the SST can proceed; otherwise, DOE will evaluate mitigation options including additional retrieval or treatment and may consult with the U.S. Nuclear Regulatory Commission (NRC) to determine additional actions.

The second decision rule addresses the performance objectives set out in 10 CFR Part 61, Subpart C, "Performance Objectives." The decision rule can be stated as follows.

- If the performance assessment indicates the concentrations of radioactive material which may be released to the general environment in an annual dose is less than an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public, then component closure actions for the SST can proceed; otherwise, DOE will evaluate mitigation options and may consult with the NRC to determine any required actions.

The third decision rule addresses the requirements in DOE M 435.1-1 Chapter IV.P(1), *Performance Objectives*. The decision rule can be stated as follows.

- If the performance assessment indicates the total effective dose to a representative member of the public is less than 25 mrem from all exposure pathways (excluding the dose from radon and its progeny in air), and 10 mrem via the air pathway (excluding the dose from radon and its progeny in air), and an average flux of 20 pCi/m^2/s at the surface of the disposal facility or 0.5 pCi/L of air applied at the boundary of the facility, then component closure actions for the SST can proceed; otherwise, DOE evaluates the need to retrieve additional radionuclides and/or provide additional barriers.

The fourth decision rule addresses the requirements for Class C low-level waste found in 10 CFR 61.55, "Waste Classification." Radionuclide concentrations relative to 10 CFR 61.55 Class C concentration limits (Tables 6-1 and 6-2) will be based on concentrations in drill cuttings that would result if an inadvertent intruder (uninformed driller) drilled through the waste and stopped at the steel liner at the bottom of the tank. This provides more conservative concentrations than would result if the driller continued to groundwater.

The fourth decision rule can be stated as follows.

- If the risk assessment indicates an intruder (drilling into the waste) will not be exposed to greater than Class C waste as described in 10 CFR 61.55, then component closure actions for the SST can proceed; otherwise, DOE will evaluate mitigation options and may consult with the NRC to determine any required actions.

Tables 6-1 and 6-2 show the chemical constituents and concentrations used to determine the upper limits for Class C waste. The method to determine Class C waste using these tables is described in 10 CFR 61.55.

Table 6-1. 10 CFR 61.55 Table 1 Class C Concentration Limits for Long-Lived Radionuclides.

Constituents	Concentration	Units
^{14}C	8	Ci/m^3
^{99}Tc	3	Ci/m^3
^{129}I	0.08	Ci/m^3
^{241}Pu	3,500	nCi/g
^{242}Cm	20,000	nCi/g
Sum of the concentrations of the following alpha emitting nuclides: ^{241}Am, ^{243}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}Pu$	100	nCi/g

Notes:

Ci/m^3 Curies per cubic meter
nCi/g Nanocuries per gram

Table 6-2. 10 CFR 61.55 Table 1 Class C Concentration Limits for Short-Lived Radionuclides.

Constituents	Concentration	Units
^{63}Ni	700	Ci/m^3
^{90}Sr	7,000	Ci/m^3
^{137}Cs	4,600	Ci/m^3

Notes:

Ci/m^3 Curies per cubic meter

In addition to the decision rules discussed above, two SSTs (241-S-102 and 241-S-112) have additional HFFACO requirements for component closure. The HFFACO milestone requirements addressing the removal of long lived radioisotopes (^{99}Tc, ^{79}Se, ^{14}C, ^{129}I, ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, and ^{238}U) from tank 241-S-102 (milestone M-45-05A) and tank 241-S-112 (milestone M-45-03C) were considered in the preparation of this DQO. Milestone M-45-05A requires removing "...approximately 490 Ci..." from tank 241-S-102 while milestone M-45-03C requires removing "...approximately 550 Ci..." from tank 241-S-112 based on the best basis inventory as of August 1, 2000. According to the best basis inventory as of August 1, 2000, tank 241-S-102 contained 487 Ci and tank 241-S-112 contained 555 Ci of the long lived radioisotopes.

A DQO process meeting (February 3, 2004) was held to discuss the DQO approach to the HFFACO issue outlined in the previous paragraph. The meeting attendees were composed of representatives from ORP, Ecology, and CH2M HILL. With the above information in mind, the DQO process team agreed that if the HFFACO volume requirement (360 cubic feet) is achieved, the requirement to remove approximately 490 Ci of long-lived radioisotopes from tank 241-S-102 and approximately 550 Ci from tank 241-S-112 would also be achieved. No separate decision rule would be necessary to address this requirement.

If the data do not meet the requirements for proceeding with component closure actions, as indicated by the decision rules listed above, the component closure actions may be accomplished by decisions made from the alternative requirements. However, this DQO does not address those decisions.

7.0 ERROR TOLERANCE

As mentioned in Section 6.0, an action limit is a concentration at which point a predetermined action is taken depending on whether the results of the analyses are above or below the specified action limit. To account for uncertainty in the data, analytical results are compared to the action limit at an established statistical confidence interval.

The uncertainty in determining the volume of residual waste in a SST can be established for the waste on the bottom of the tank, residual waste in equipment void spaces, residual waste on stiffener rings, and residual waste on the tank walls. These four areas contribute to the total residual waste volume. The uncertainty in estimating residual waste volume can be caused by various things, such as as-built deviations from construction drawings; creep or warping due to thermal effects; instrumentation uncertainty (e.g., level gauges and flow meters); material remaining in transfer lines; etc.

Four methods are available to estimate the residual waste on the bottom of the tank. These methods are the video-camera/computer aided design (CAD) modeling system (CCMS), volume displacement using the ENRAF[2] to measure removed volume, and volume displacement using a flow meter to measure removed volume and laser scanning. See Section 8.1 for a description of the volume measurements.

The approach using CCMS data is to use total least squares analysis to derive a regression line from the collection of data pairs consisting of a CCMS operator's estimate of the volume of a surrogate waste pile whose actual volume is known. The waste piles used were part of testing programs in the Cold Test Facility in 2004 and 2006. The testing program was conducted according to test plan RPP-17663, *Test Plan for the Video Camera/CAD Modeling System*. The following equations to determine residual waste volume remaining after retrieval were developed from this data.

Actual Volume (residual waste in ft^3) = 1.125 * CCMS reading + 0.53 ft^3.
95% Upper Bound = 1.132 * CCMS reading + 17.1 ft^3

The development of these statistical equations is discussed in RPP-37110, Rev. 1, *Computer/CAD Modeling System Test Results*. These equations are applicable for the 100 series and 200 series tanks.

Both of the volume displacement methods and their associated uncertainties in residual waste volume measurements are developed in RPP-RPT-39601, *Determination of Residual Waste Volume by Liquid Displacement*, and RPP-CALC-42733, *Determination of Single-Shell Tank*

[2] ENRAF is a trademark of Enraf B. V., Delft, The Netherlands.

Waste Volume as a Function of Waste Level (B, C, T, and U Farm 100 Series Tanks). The formula used to determine the residual waste volume by the two displacement methods is:

RWV = V(L1) – VT + Evap + ΔHoldUp + WasteAboveL1 + EquipmentReceivingTank + WasteDissolution

Where,

RWV = residual waste volume;

L1 = liquid level in the SST after liquid is added to cover the solids in the tank;

V(L1) = volume in SST below L1;

VT = volume transferred to the double-shell tank (DST), measured using either ENRAF measurements in the DST or using the flow meter;

Evap = water lost by evaporation from the sending SST or the receiving DST during the transfer, discussed in Section 3.7 of RPP-RPT-39601;

ΔHoldUp = change in volume of the waste remaining in the transfer line after completion of the transfer, discussed in Section 3.4 of RPP-RPT-39601;

EquipmentReceivingTank = volume of equipment in the receiving DST that is submerged by the waste transfer, discussed in Section 3.8 of RPP-RPT-39601;

Waste Dissolution = underestimate of the volume of waste transferred to the DST as a result of dissolution of solids in the DST by the incoming liquid, discussed in Section 3.9 of RPP-RPT-39601.

Some of the components in the formula will be different for the retrieval of each tank and will be determined on a case by case basis. The overall uncertainty depends, in part, on the methods used to measure the volume transferred to the DST (ENRAF or flow meter). The development of the uncertainty formulas for the two displacement methods is described in RPP-RPT-39601.

The formula for the uncertainty (the approximation for the 95% one – tailed upper confidence level (see RPP-RPT-39601)) in the volume displacement method using the ENRAF to measure the volume transferred is:

$$UCL_{RWV} = RWV + \sqrt{(31.454d + 14.49)^2 + (31.232(L3 - L2) + 1.686)^2}$$

Where,

L2 = level measured in the DST prior to the transfer.

L3 = level measured in the DST after the transfer.

d = height of liquid above top of tank dish

The formula for the uncertainty (the approximation for the 95% one – tailed upper confidence level (see RPP-RPT-39601)) in the volume displacement method using a flow meter to measure the volume transferred is:

$$UCL_{RWV} = RWV + \sqrt{(31.454d + 14.49)^2 + \left(\frac{1.645}{2} 0.005VT\right)^2}$$

Laser scanning using a FARO Focus[3D,3] is a new tool developed for residual waste volume estimates. The laser scanner requires availability of a 12 inch riser or larger and its use may be limited by obstructions within the tank. However, the laser scanner provides a direct method to measure tank waste volumes and project actual tank dimensions. Like the CCMS method, tank drawings and visual observation of the tank are needed to define actual tank boundaries. However, laser scanning provides actual measurements of the tank boundaries wherever the surface is visible, eliminates some of the subjectivity of CCMS estimates and enables direct measurements of waste on the walls and stiffener rings (RPP-RPT-58401, *Tank 241-C-104 Laser Scanning Test Report*). The FARO Focus[3D] laser scanner measurements are accurate to within 2 mm.

The best estimate of the residual waste volume left in the tank after retrieval will be determined by using the CCMS and/or laser scanning methods for measuring residual waste. The appropriate upper confidence limit formula will then be applied to the measured volume for comparison to the action limit (360 cubic feet).

In addition to the residual waste on the floor of the tank, a determination of the residual waste on the walls and stiffener rings is required to obtain a total residual waste volume. Based upon the review of the videos and/or use of the laser scanner, an evaluation of the residual waste on the stiffener rings and walls is made using a best estimate value and a visual estimate of thickness of the waste on the rings and how much of the rings contain waste. Equipment in the tank is also evaluated to determine the existence of void spaces that could contain waste. In these cases, the void spaces are conservatively assumed to be filled with waste unless a compelling reason can be made that justifies a change in this assumption. The assumptions concerning residual waste on the stiffener rings, in the void space of equipment, and on the tank walls are best estimate values and do not allow the determination of a confidence interval. The waste calculated to be on the stiffener rings, in equipment void spaces, and on the tank walls are added to the amount in the bottom of the tank to determine the total residual waste left in the tank.

When using one of the volume displacement methods of determining residual waste, only waste on the walls and stiffener rings above the final rinse would require the visual estimation described above.

[3]FARO Focus[3D] is a registered trademark of FARO, Lake Mary, Florida.

The actual action limits for the decision rule addressing the second decision in Figure 3-1 depend on the risk assessment process and modeling that are not available at this time. Therefore, the uncertainties associated with this decision rule cannot be compared to an action limit. However, the 95% confidence limit will be determined for each analyzed constituent, as appropriate. When the actual action limits are established, as the risk assessment process matures, they can be incorporated into the decision rule.

As stated above, the third decision in Figure 3-1 is addressed with four decision rules. The action limits for the first decision rule are subjective and analytical results cannot be compared directly to the action limits. An evaluation will be made of the data to determine the alternative action taken.

The second, third, and fourth decision rules for the third decision in Figure 3-1 do have action limits; however, there is not a direct comparison of the analytical data with the action limits. Results of the performance assessments and risk assessments are compared to the action limits. Therefore, no uncertainties are determined for these decision rules.

8.0 SAMPLING DESIGN

Subjective sampling will be conducted when samples are obtained for closure (see Section 8.2). When samples are taken directly below a riser, sample locations will be selected based on riser availability and location of the remaining waste. When samples are taken away from risers, sample locations will be selected contingent on the location and appearance of the residual solid waste on the tank floor. Waste on the tank walls and stiffener rings is assumed to have the same composition as waste on the tank floor and does not need to be sampled.

In addition to supplying sufficient waste samples to address the analytical requirements in this DQO, residual solid waste will be obtained to conduct release rate tests. The sample quantity requested to conduct these tests is 120 g of solids. However, these tests can be conducted with less material than requested. Release rate data will be obtained from selected tanks and used in the risk assessment calculations.

A goal for the amount of material obtained during a sampling event for the 222-S Laboratory will be included in the Tank Sampling and Analysis Plan. After a sampling event, the amount of material collected will be evaluated to determine if the material collected is sufficient for the required analyses or an additional sampling event is needed. Sample material for the analytical requirements takes precedent over sample material for release rate tests if insufficient material cannot be collected for both activities. The analytical priorities in order of preference are radiochemistry (particularly for long half-life radionuclides), inorganic metals, inorganic anions, SVOCs, PCBs, and VOCs.

8.1 VOLUME MEASUREMENTS

As discussed in Section 7.0, residual waste volumes can be obtained by one of four methods. The method used to determine the residual waste volume will depend on various factors (e.g.,

tank configuration). The volume determinations will be conducted using the guidance document TFC-ENG-FACSUP- CD-22, *Post-Retrieval Tank Waste Volume Determination.*

The first method for estimating residual waste volume following waste retrieval actions is visual assessment of waste against known tank geometry using the CCMS and by determining the void space in any equipment in the tank which was in contact with waste. This system was developed in the Cold Test Facility for application to both 100 series and 200 series SSTs (RPP-17663 and RPP-37110) (see Section 7.0).

At the completion of waste retrieval operations, in-tank videos are taken. Residual waste volume measurements are obtained by inserting a video camera into a tank riser and obtaining a videotape of the tank interior. Based upon the visual analysis of the video a 3-dimension (3-D) model of the surface topography of the residual waste on the bottom of the tank is generated taking into account the configuration and dimensions of the tank. The 3-D CAD system algorithms then generate an estimate of the residual waste volume remaining on the bottom of the SST. Once this volume is determined, the equation described in Section 7.0 is applied to determine an estimate of the residual waste volume including the uncertainty.

In addition, based on the review of the in tank video, an evaluation of the residual waste on the stiffener rings is made using a conservative assumption that the residual waste is uniformly distributed on a ring when observed on a ring. Equipment in the tank is also evaluated to determine the existence of void spaces which could be filled with waste. It is conservatively assumed that all void spaces are filled completely with waste unless a compelling reason can be made that justifies a change in this assumption. The total residual waste volume is the sum of:

- The residual waste on the tank bottom (ft^3),
- The residual waste on the stiffener rings (ft^3),
- The residual waste in the equipment void spaces (ft^3), and
- The residual waste on the tank walls (ft^3).

During the DQO process meetings, the potential for waste on the tank walls was discussed, and it was determined the amount of waste on the tank walls would be minimal for tanks retrieved using modified sluicing (MS) method. In instances where a visually detectable quantity of residual waste adheres to the tank walls, an estimate of the amount of residual waste on the tank walls will be added to the residual waste volume.

The second and third methods of determining residual waste volume on the bottom of the tank are volume displacement methods. Both volume displacement methods use the ENRAF system to measure the total amount of waste in the sending tank before the last liquid is pumped out. The difference between the total amount of waste measured before the last waste is removed from the sending tank and the volume of waste removed determines the residual waste volume left in the sending tank.

The volume displacement methods can be used when liquid is used for retrieval (e.g. sluicing). These methods cannot be used where adding liquid to the SST may be a problem or if the bottom of the SST cannot be measured by the ENRAF. Due to the uncertainty of the elevation of the

ENRAF, the waste must be cleared and the actual bottom of the tank measured by the ENRAF so the elevation of the ENRAF in relation to the tank bottom can be more precisely determined. In addition, the ENRAF cannot be calibrated between readings and the final liquid rinse must cover all of the solids on the bottom of tank.

The difference between the two volume displacement methods (the second and third method of determining residual waste volume) is the way the volume of the last waste removed from the tank is determined. In the second residual waste volume measurement method, the ENRAF is used to measure the elevation of the waste in the receiver tank before and after the waste is sent to the receiver tank. The difference in the elevation measurements in the receiver tank will determine the volume of waste removed from the sending tank. The third method uses a flow meter to measure the volume of the final waste as it is transferred to the receiver tank.

The volume of waste on the stiffener rings and walls above the final liquid level in the retrieved tank is determined by the same method described for the CCMS. Any waste on the walls or stiffener rings below the final liquid level will be determined by volume displacement.

The fourth method is laser scanning. In this method a laser scanner is deployed in one or more 12 inch risers. The tank is scanned and point cloud data obtained inside the tank showing tank surfaces where visible and waste surfaces. This point cloud data is transferred to a 3D model such as AutoCAD Civil 3D or Polyworks. A model of the empty tank (tank surface) is then developed based on video, tank drawings and laser scan visual observations. The volume of waste in the tank bottom, on the stiffener rings and on the tank walls is determined as the difference between the laser scan measurements and the empty tank model.

The residual volume measurement methods handle porosity of the residual waste differently. The CCMS determines a bulk volume of the residual waste. The pore spaces are included in the residual waste volume measurement (unless porosity is applied to the calculation). In both volume displacement methods the porosity is accounted for in conducting the volume measurement. When the final liquid is added to the sending tank, pores in the residual waste will fill with liquid. As this liquid is pumped to the receiving tank, the pores will lose liquid, to the extent the liquid can be removed from the pores, providing a more accurate method of determining the volume of residual waste remaining in the tank after retrieval.

8.2 WASTE SAMPLING

Several factors determine how or if post retrieval samples are obtained. Liquid sampling is discussed in Section 8.2.1 and solid sampling in Section 8.2.2.

A sample may be composed of more than one grab. A grab is defined as the deployment of the sampling device [one clam shell, one finger trap, one bottle (for liquid samples), or one scoop from the ORSS]. Multiple grabs may be required to obtain enough material to complete all analyses required for one sample.

With the exception of the completed pre-retrieval sampling conducted in the C-200 tanks (see Section 8.2.5), pre-retrieval sampling is not planned for any tanks.

8.2.1 Liquid Samples

Post retrieval liquid samples will not be required when specific conditions are met. The conditions that must be met primarily depend on the liquid used during waste retrieval.

The DQO participants agreed no liquid samples will be required if raw water is used as the retrieval liquid. In addition, if supernatant is used as the retrieval liquid or if material (e.g., caustic or acid) is added to the tank to dissolve residual solids and subsequently sufficient water is used to rinse the solids, liquid samples will not be required. It was agreed that a triple rinse (a minimum of three times the estimated solids volumes for each rinse) of the residual waste would be considered sufficient.

If liquid samples are required, the general sampling plan for liquids is two samples from one riser. Also, liquid samples will be collected after completion of the final washing activities and prior to pumping the final liquid addition out of the tank.

When liquid samples are obtained, the quantity of liquid in one of the samples must be sufficient to perform a duplicate analysis. In addition, two bottles are required per sample to conduct the VOC analyses (two bottles for the sample and two additional bottles for the duplicate sample) and another two are required to conduct the SVOC analyses (two bottles for the sample and two additional bottles for the duplicate sample). If insufficient sample material is available for the rest of the required analyses, the contents from each pair of bottles may be combined after the VOC, SVOC, and ammonia subsamples are taken.

8.2.2 Solids Samples

A meeting will be held with ORP, Ecology, and the Tank Farm Contractor to determine the most appropriate sampling method for the residual waste in a tank. In determining which sampling system to use the configuration, quantity, and location of the solid waste after retrieval should be used along with cost and schedule.

The sampling strategy for solids is shown in Figure 8-1. As indicated in Figure 8-1, if samples of the residual solids cannot be obtained, component closure could be "placed on hold until" another alternative is selected. This alternative could include a decision not to sample.

Modified off-riser sampling, using finger trap samplers, can be accomplished when the Articulating Mast System (AMS) is used to retrieve a 200 series tank. This sampling technique is described in Section 8.2.3 and can be used when these conditions exist.

If the finger trap (except as described in Section 8.2.3) or clamshell devices are used without the ability to move waste (see below), one sample from one riser and two samples from a second riser (a sample and duplicate sample) will be required. A minimum of one duplicate analysis is required for one of the samples. Multiple grabs may be required to provide sufficient material for each sample.

If tank waste solids are distributed relatively evenly and thinly on the tank floor, the general sampling design is nine samples from nine locations. For example, one sample would be taken from each of nine equally divided tank floor sectors as shown in Figure 8-2. The ORSS or a drag sampler deployed by the Mobile Arm Retrieval System (MARS) would be a good candidate sampling method because each sampler has the capability of reaching almost anywhere in the tank. Three composites consisting of three samples each will be prepared and analyzed. More than one grab (i.e., one increment) could be taken at one location to provide sufficient material for that sample. For each tank, a minimum of one duplicate analysis is required for one of the composites.

In recent tank waste retrievals, residual solids typically do not cover the entire tank floor and the bulk of the solids are present in mounds of various sizes located near the tank wall. In this case, a tank-specific sampling design (i. e., number and locations of samples) that targets areas such that the samples represent the bulk of the waste will be developed by WRPS, concurred by ORP and Ecology, and documented in the tank-specific sampling and analysis plan. Samples may be taken using the ORSS, a drag sampler deployed by the MARS, or a grab sampler (e.g., clamshell, finger trap, or drag sampler) deployed by an ERSS, as appropriate. The samples may be analyzed individually or as composites depending on the agreed upon sampling design. A minimum of one duplicate analysis will be performed.

Additionally, solids may be mobilized and placed directly under a riser to facilitate sampling. For example, a mobile retrieval device such as the Foldtrack may be used to push residual solids from a designated sample location to an area directly under a riser and sampled with a finger trap or clamshell. The ability to move the residual solids will depend on the waste characteristics (consistency, particle size, etc.), waste location in the tank, retrieval method, etc. Waste from one sample location could be pushed under a riser, sampled, and pushed away to clear the area for the next sample. If this method is used, a tank-specific sampling design would be developed and concurred by WRPS, ORP, and Ecology.

Enough solid sample material is needed to accomplish the analytical requirements in this DQO and, if required, to perform the release rate tests. If solid samples are obtained from directly under two risers and release rate tests are required, it is desirable that release rate samples come from each riser sampled. If sample material is insufficient to supply both the 222-S Laboratory and PNNL, the analyses at 222-S Laboratory has precedent over the release rate test by PNNL.

Figure 8-1. Sampling Strategy for Solid Samples.

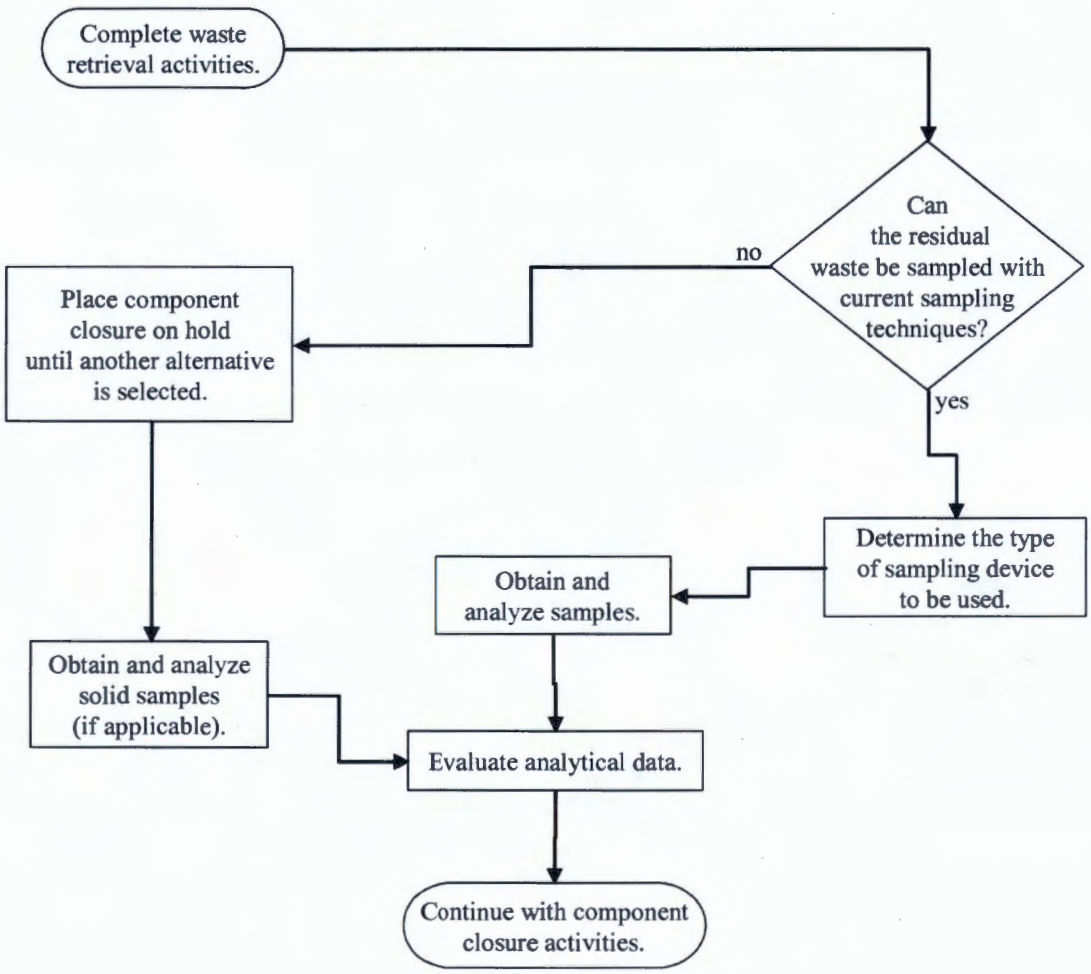
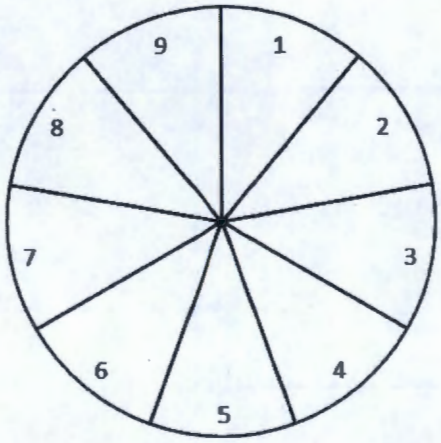


Figure 8-2. Example of Tank Floor Sectors Where Samples May Be Collected



8.2.3 Specific Strategy for C-200 Tanks

The C-200 series tanks (241-C-201, 241-C-202, 241-C-203, and 241-C-204) were retrieved using the AMS retrieval method.

The sampling strategy, developed specifically for the C-200 series tanks, included pre-retrieval sampling. Pre-retrieval sampling was conducted to ensure information was obtained on any residual waste left in the tanks. At the time revision 0 of the DQO was prepared, it was believed off-riser sampling could not be accomplished (discussed below), post retrieval solids may not be sufficient for sampling, and pre-retrieval samples would provide a reasonable estimate of residual waste composition and provide the best opportunity of obtaining data on any residual waste left in the tank. Pre-retrieval samples were considered because:

- The amount of waste in each tank was small, ranging from approximately 115 cubic feet in tank 241-C-201 to approximately 350 cubic feet in tank 241-C-203.
- The tanks contained primarily a single waste (Hot Semiworks) source minimizing the variability likely to be found in tanks with multiple waste types.
- The retrieval method was not expected to preferentially remove solids with certain characteristics (e.g., light solids).
- Post retrieval sampling may not have been possible due to the configuration (location and quantity) of any residual waste.

Originally, post retrieval sampling was to be obtained if the residual waste in the tank was > 30 cubic feet and the configuration (i.e., present under the risers and confirmed by video) of the residual waste permitted sampling to occur. However the assumption stated in the fourth bullet

above, was not realized because off-riser sampling was accomplished in three of the C-200 tanks (241-C-202, 241-C-203, and 241-C-204). The articulated mast was used to accumulate residual waste in sufficient depths to use the finger trap sampling device. The articulated mast moved the finger trap sampling device from below a riser over the location where the residual waste was accumulated. The mast acts as a fulcrum so the finger trap can be raised and lowered several times to sample the waste. Using the mast, the sampler is moved back to the riser for extraction from the tank. Tank 241-C-201 was not sampled because the articulated mast failed at the end of retrieval and there was no waste under the risers.

The sampling design for the C-200 series tanks, using the articulated mast and finger trap sampling device described above, is subjective. Sample locations are chosen in areas where the waste is sufficiently deep to use the finger trap. Two solid samples are collected, with each sample consisting of multiple grabs from different locations.

As with the fourth bullet, the third bullet assumption was not realized because the AMS did not operate as originally envisioned. More water was used than expected potentially allowing for the more soluble and smaller sized waste particles to be preferentially retrieved.

Due to the unrealized assumptions for the C-200 tanks, post retrieval samples will be obtained from 200 series tanks unless not sampling a specific tank can be justified and agreed to by ORP and Ecology. .

9.0 REFERENCES

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APPENDIX A

WAC 173-340 METHOD B CLEANUP LEVELS FOR CHEMICALS IN ORDER BY CHEMICAL ABSTRACT NUMBER

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

		Soil Direct Contact		Groundwater Cleanup Levels		Drinking Water MCL[b] ug/L	Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ugL		ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
50-32-8	benzo[a]pyrene	1.37E-01		1.20E-02		2.00E-01	1.20E-02	MTCA B	9.69E+02	CLARC 3.1	4.63E-05	CLARC 3.1	2.33E-01
53-70-3	dibenzo[a,h]anthracene	1.37E-01		1.20E-02			1.20E-02	MTCA B	1.79E+03	CLARC 3.1	6.03E-07	CLARC 3.1	4.29E-01
56-23-5	carbon tetrachloride	7.69E+00	5.60E+01	3.37E-01	5.60E+00	5.00E-03	3.37E-01	MTCA B	1.52E-01	CLARC 3.1	1.25E+00	CLARC 3.1	3.10E-03
57-12-5	cyanide		1.60E+03		3.20E+02	2.00E-01	2.00E+02	MCL	0.00E+00	Default	0.00E+00	Default	8.00E-01
57-14-7	dimethylhydrazine;1,1-	3.85E-01		3.37E-02			3.37E-02	MTCA B	0.00E+00	Default	0.00E+00	Default	1.35E-04
58-89-9	lindane [gamma-BHC]	7.69E-01	2.40E+01	6.73E-02	4.80E+00	2.00E-01	6.73E-02	MTCA B	1.35E+00	CLARC 3.1	5.74E-04	CLARC 3.1	2.09E-03
60-29-7	ethyl ether (diethyl ether)		1.60E+04		1.60E+03		1.60E+03	MTCA B	8.40E-02	Region 9	5.30E-04	Region 9	9.09E+00
60-34-4	methylhydrazine	9.09E-01		7.95E-02			7.95E-02	MTCA B	0.00E+00	Default	0.00E+00	Default	3.18E-04
60-57-1	dieldrin	6.25E-02	4.00E+00	5.47E-03	8.00E-01		5.47E-03	MTCA B	2.56E+01	CLARC 3.1	6.19E-04	CLARC 3.1	2.82E-03
62-75-9	nitrosodimethylamine;N-	1.96E-02		1.72E-03			1.72E-03	MTCA B	0.00E+00	Default	0.00E+00	Default	6.86E-06
67-64-1	acetone (2-Propanone)		8.00E+03		8.00E+02		8.00E+02	MTCA B	5.75E-04	CLARC 3.1	1.59E-03	CLARC 3.1	3.21E+00
67-66-3	chloroform (trichloromethane)	1.64E+02	8.00E+02	7.17E+00	8.00E+01		7.17E+00	MTCA B	5.30E-02	CLARC 3.1	1.50E-01	CLARC 3.1	3.81E-02
67-72-1	hexachloroethane	7.14E+01	8.00E+01	6.25E+00	1.60E+01		6.25E+00	MTCA B	1.78E+00	CLARC 3.1	1.59E-01	CLARC 3.1	2.49E-01
71-36-3	butanol;n- (n-butyl alcohol)		8.00E+03		1.60E+03		1.60E+03	MTCA B	6.92E-03	CLARC 3.1	3.61E-04	CLARC 3.1	6.62E+00
71-43-2	benzene	1.82E+02	2.40E+02	7.95E-01	2.40E+01	5.00E-03	7.95E-01	MTCA B	6.20E-02	CLARC 3.1	2.28E-01	CLARC 3.1	4.48E-03
71-55-6	trichloroethane;1,1,1-		7.20E+04		7.20E+03	2.00E+02	2.00E+02	MCL	1.35E-01	CLARC 3.1	7.05E-01	CLARC 3.1	1.58E+00
72-20-8	endrin		2.40E+01		4.80E+00	2.00E+00	2.00E+00	MCL	1.08E+01	CLARC 3.1	3.08E-04	CLARC 3.1	4.40E-01
74-83-9	bromomethane [methyl bromide]		1.12E+02		1.12E+01		1.12E+01	MTCA B	9.00E-03	CLARC 3.1	2.56E-01	CLARC 3.1	5.18E-03
74-87-3	chloromethane	7.69E+01		3.37E+00			3.37E+00	MTCA B	2.10E-01	Region 9	9.80E-01	Region 9	3.34E-02
75-00-3	ethyl chloride [chloroethane]					4.64E+00	4.64E+00	Region 9	8.80E-02	Region 9	4.50E-01	Region 9	3.03E-02
75-01-4	vinyl chloride [chloroethene; 1-]	6.67E-01	2.40E+02	2.92E-02	2.40E+01	2.00E+00	2.92E-02	MTCA B	1.86E-02	CLARC 3.1	1.11E+00	CLARC 3.1	1.84E-04
75-05-8	acetonitrile		4.80E+02		4.80E+01		4.80E+01	MTCA B	9.40E-02	Region 9	8.20E-04	Region 9	2.82E-01
75-09-2	dichloromethane (methylene chloride)	1.33E+02	4.80E+03	5.83E+00	4.80E+02	5.00E+00	5.00E+00	MCL	1.00E-02	CLARC 3.1	8.98E-02	CLARC 3.1	2.54E-02
75-15-0	carbon disulfide		8.00E+03		8.00E+02		8.00E+02	MTCA B	4.57E-02	CLARC 3.1	1.24E+00	CLARC 3.1	5.65E+00
75-21-8	ethylene oxide	9.80E-01		4.29E-02			4.29E-02	MTCA B	1.30E-02	Region 9	3.10E-03	Region 9	1.83E-04
75-35-4	dichloroethylene;1,1-	1.67E+00	7.20E+02	7.29E-02	7.20E+01	7.00E+00	7.29E-02	MTCA B	6.50E-02	CLARC 3.1	1.07E+00	CLARC 3.1	5.22E-04
75-69-4	trichlorofluoromethane		2.40E+04		2.40E+03		2.40E+03	MTCA B	9.60E-01	Region 9	4.00E+00	Region 9	7.23E+01
75-71-8	dichlorodifluoromethane		1.60E+04		1.60E+03		1.60E+03	MTCA B	3.50E-01	Region 9	4.10E+00	Region 9	2.90E+01
76-13-1	trichloro-1,2,2-		2.40E+06		4.80E+05		4.80E+05	MTCA B	0.00E+00	Default	0.00E+00	Default	1.92E+03

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[(a)].

		Soil Direct Contact		Groundwater Cleanup Levels		Drinking Water MCL[(b)] ug/L	Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ugL		ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
	trifluoroethane;1,1,2-												
76-44-8	heptachlor	2.22E-01	4.00E+01	1.94E-02	8.00E+00	4.00E-01	1.94E-02	MTCA B	9.53E+00	CLARC 3.1	4.47E-02	CLARC 3.1	3.78E-03
78-87-5	dichloropropane;1,2-	1.47E+01		6.43E-01		5.00E+00	6.43E-01	MTCA B	4.70E-02	CLARC 3.1	1.15E-01	CLARC 3.1	3.30E-03
79-00-5	trichloroethane;1,1,2-	1.75E+01	3.20E+02	7.68E-01	3.20E+01	5.00E+00	7.68E-01	MTCA B	7.50E-02	CLARC 3.1	3.74E-02	CLARC 3.1	4.27E-03
79-01-6	trichloroethylene (TCE; trichloroethene)	9.09E+01		3.98E+00		5.00E+00	3.98E+00	MTCA B	9.40E-02	CLARC 3.1	4.22E-01	CLARC 3.1	2.63E-02
79-34-5	tetrachloroethane;1,1,2,2-	5.00E+00		2.19E-01			2.19E-01	MTCA B	7.90E-02	CLARC 3.1	1.41E-02	CLARC 3.1	1.23E-03
79-46-9	nitropropane; 2-	1.05E-01		4.61E-03			4.61E-03	MTCA B	0.00E+00	Default	0.00E+00	Default	1.84E-05
82-68-8	pentachloronitrobenzene	3.85E+00	2.40E+02	3.37E-01	4.80E+01		3.37E-01	MTCA B	0.00E+00	Default	0.00E+00	Default	1.35E-03
83-32-9	acenaphthene		4.80E+03		9.60E+02		9.60E+02	MTCA B	4.90E+00	CLARC 3.1	6.36E-03	CLARC 3.1	9.79E+01
84-74-2	di-butyl phthalate		8.00E+03		1.60E+03		1.60E+03	MTCA B	1.57E-01	CLARC 3.1	3.85E-08	CLARC 3.1	1.14E+01
85-68-7	butyl benzyl phthalate		1.60E+04		3.20E+03		3.20E+03	MTCA B	1.38E+01	CLARC 3.1	5.17E-05	CLARC 3.1	8.93E+02
87-68-3	hexachlorobutadiene	1.28E+01	1.60E+01	5.61E-01	1.60E+00		5.61E-01	MTCA B	5.37E+01	CLARC 3.1	3.34E-01	CLARC 3.1	6.05E-01
87-86-5	pentachlorophenol	8.33E+00	2.40E+03	7.29E-01	4.80E+02	1.00E+00	7.29E-01	MTCA B	5.92E-01	CLARC 3.1	1.00E-06	CLARC 3.1	1.15E-02
88-06-2	trichlorophenol;2,4,6-	9.09E+01		7.95E+00			7.95E+00	MTCA B	3.81E-01	CLARC 3.1	3.19E-04	CLARC 3.1	9.24E-02
88-85-1	dinoseb (2-sec-butyl-4,6-dinitophenol)		8.00E+01		1.60E+01	7.00E+00	7.00E+00	MCL	0.00E+00	Default	0.00E+00	Default	2.80E-02
91-20-3	naphthalene		1.60E+03		1.60E+02		1.60E+02	MTCA B	1.19E+00	CLARC 3.1	1.98E-02	CLARC 3.1	4.46E+00
92-52-4	biphenyl;1,1-		4.00E+03		8.00E+02		8.00E+02	MTCA B	4.70E+01	Region 9	2.10E-02	Region 9	7.55E+02
95-47-6	xylene;o-		1.60E+05		1.60E+04	1.00E+04	1.00E+04	MCL	2.41E-01	CLARC 3.1	2.13E-01	CLARC 3.1	9.19E+01
95-48-7	cresol; o- (2-methylphenol)		4.00E+03		8.00E+02		8.00E+02	MTCA B	9.12E-02	CLARC 3.1	4.92E-05	CLARC 3.1	4.66E+00
95-50-1	dichlorobenzene;1,2-[ortho]		7.20E+03		7.20E+02	6.00E+02	6.00E+02	MCL	3.79E-01	CLARC 3.1	7.79E-02	CLARC 3.1	7.03E+00
95-57-8	chlorophenol;2-		4.00E+02		8.00E+01		8.00E+01	MTCA B	3.88E-01	CLARC 3.1	1.60E-02	CLARC 3.1	9.43E-01
95-95-4	trichlorophenol;2,4,5-		8.00E+03		1.60E+03		1.60E+03	MTCA B	1.60E+00	CLARC 3.1	1.78E-04	CLARC 3.1	5.75E+01
98-86-2	acetophenone		8.00E+03		1.60E+03		1.60E+03	MTCA B	0.00E+00	Default	0.00E+00	Default	6.40E+00
98-95-3	nitrobenzene		4.00E+01		8.00E+00		8.00E+00	MTCA B	1.19E-01	CLARC 3.1	9.84E-04	CLARC 3.1	5.11E-02
100-00-5	chloronitrobenzene;p-	5.56E+01		4.86E+00			4.86E+00	MTCA B	3.90E-01	Region 9	9.80E-01	Region 9	6.56E-02
100-25-4	Dinitrobenzene; 1,4-(para-)		3.20E+01		6.40E+00		6.40E+00	MTCA B	0.00E+00	Default	0.00E+00	Default	
100-41-4	ethylbenzene		8.00E+03		8.00E+02	7.00E+02	7.00E+02	MCL	2.04E-01	CLARC 3.1	3.23E-01	CLARC 3.1	6.05E+00
100-42-5	styrene	3.33E+01	1.60E+04	1.46E+00	1.60E+03	1.00E+02	1.46E+00	MTCA B	9.12E-01	CLARC 3.1	1.13E-01	CLARC 3.1	3.28E-02
106-42-3	xylene;p-						1.60E+04	MTCA B	3.11E-01	CLARC 3.1	3.14E-01	CLARC 3.1	1.72E+02

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

		Soil Direct Contact		Groundwater Cleanup Levels		Drinking Water MCL[b] ug/L	Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ugL		ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
106-44-5	cresol; p- (4-methylphenol)		4.00E+02		8.00E+01		8.00E+01	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E-01
106-46-7	dichlorobenzene;1,4-[para]	4.17E+01		1.82E+00		7.50E+01	1.82E+00	MTCA B	6.16E-01	CLARC 3.1	9.96E-02	CLARC 3.1	3.00E-02
106-93-4	ethylene dibromide (1,2-dibromoethane)	1.18E-02		5.15E-04		5.00E-02	5.15E-04	MTCA B	6.60E-02	CLARC 3.1	1.00E-01	Region 9	2.83E-06
106-99-0	butadiene;1,3-						1.14E-02	Region 9	7.20E-01	Region 9	7.30E+00	Region 9	3.55E-04
107-02-8	acrolein		1.60E+03		1.60E+02		1.60E+02	MTCA B	1.30E-01	Region 9	4.90E-03	Region 9	1.06E+00
107-05-1	allyl chloride [chloropropene; 3-]		4.00E+03		8.00E+02		8.00E+02	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E+00
107-13-1	acrylonitrile	1.85E+00	8.00E+01	8.10E-02	8.00E+00		8.10E-02	MTCA B	5.10E-03	Region 9	3.60E-03	Region 9	3.33E-04
107-87-2	methylcyclohexane						5.22E+03	Region 9	1.30E+01	Region 9	1.80E+01	Region 9	1.54E+03
108-38-3	xylene;m-		1.60E+05		1.60E+04	1.00E+04	1.00E+04	MCL	1.96E-01	CLARC 3.1	3.01E-01	CLARC 3.1	8.44E+01
108-39-4	cresol; m- (m-cresylic acid)		4.00E+03		8.00E+02		8.00E+02	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E+00
108-88-3	toluene		1.60E+04		1.60E+03	1.00E+03	1.00E+03	MCL	1.40E-01	CLARC 3.1	2.72E-01	CLARC 3.1	7.27E+00
108-90-7	chlorobenzene		1.60E+03		1.60E+02	1.00E+02	1.00E+02	MCL	2.24E-01	CLARC 3.1	1.52E-01	CLARC 3.1	8.74E-01
108-94-1	cyclohexanone		4.00E+05		8.00E+04		8.00E+04	MTCA B	0.00E+00	Default	0.00E+00	Default	3.20E+02
108-95-2	phenol		4.80E+04		9.60E+03		9.60E+03	MTCA B	2.88E-02	CLARC 3.1	1.63E-05	CLARC 3.1	4.39E+01
110-54-3	hexane;n-		4.80E+03		4.80E+02		4.80E+02	MTCA B	3.41E+00	CLARC 3.1	7.40E+01	CLARC 3.1	9.62E+01
110-80-5	ethoxyethanol; 2-		3.20E+04		6.40E+03		6.40E+03	MTCA B	0.00E+00	Default	0.00E+00	Default	2.56E+01
110-82-7	cyclohexane						3.47E+04	Region 9	9.60E-01	Region 9	8.20E+00	Region 9	1.30E+03
110-86-1	pyridine		8.00E+01		1.60E+01		1.60E+01	MTCA B	1.00E+00	Region 9	1.00E-01	Region 9	3.87E-01
118-74-1	hexachlorobenzene	6.25E-01	6.40E+01	5.47E-02	1.28E+01	1.00E+00	5.47E-02	MTCA B	8.00E+01	CLARC 3.1	5.41E-02	CLARC 3.1	1.50E-02
120-82-1	trichlorobenzene;1,2,4-		8.00E+02		8.00E+01	7.00E+01	7.00E+01	MCL	1.66E+00	CLARC 3.1	5.82E-02	CLARC 3.1	2.98E+00
121-14-2	dinitrotoluene;2,4-		1.60E+02		3.20E+01		3.20E+01	MTCA B	9.55E-02	CLARC 3.1	3.80E-06	CLARC 3.1	1.89E-01
121-44-8	triethylamine						1.22E+01	Region 9	1.30E-02	Region 9	3.70E-03	Region 9	5.19E-02
122-39-4	diphenylamine		2.00E+03		4.00E+02		4.00E+02	MTCA B	0.00E+00	Default	0.00E+00	Default	1.60E+00
123-91-1	dioxane;1,4-	9.09E+01		7.95E+00			7.95E+00	MTCA B	0.00E+00	Default	0.00E+00	Default	3.18E-02
126-73-8	tributyl phosphate	1.85E+02	1.60E+04	1.62E+01	3.20+03		1.62+01	Calc.	1.89+01	ORNL	6.13E-06	ORNL	6.18E+00
126-98-7	methacrylonitrile		8.00E+00		1.60E+00		1.60E+00	MTCA B	5.10E-03	Region 9	3.60E-03	Region 9	6.57E-03
127-18-4	tetrachloroethylene (PCE; tetrachlorethene)	1.96E+01	8.00E+02	8.58E-01	8.00E+01	5.00E+00	8.58E-01	MTCA B	2.65E-01	CLARC 3.1	7.54E-01	CLARC 3.1	9.10E-03
129-00-0	pyrene		2.40E+03		4.80E+02		4.80E+02	MTCA B	6.80E+01	CLARC 3.1	4.51E-04	CLARC 3.1	6.55E+02
141-78-6	ethyl acetate		7.20E+04		1.44E+04		1.44E+04	MTCA B	3.60E-01	Region 9	5.70E-03	Region 9	1.61E+02

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

		Soil Direct Contact		Groundwater Cleanup Levels		Drinking Water MCL[b] ug/L	Overall GW Cleanup Level		3-Phase Partitioning Model Equation for Soil Protection of GW				
CAS No.	Chemical Name	Carcinogen mg/kg	Non-carcinogen mg/kg	Carcinogen ug/L	Non-carcinogen ugL		ug/L	Source	Kd mL/g	Source	Henry's Law Constant	Source	Soil Conc. for GW Protection mg/kg
206-44-0	fluoranthene		3.20E+03		6.40E+02		6.40E+02	MTCA B	4.91E+01	CLARC 3.1	6.60E-04	CLARC 3.1	6.31E+02
309-00-2	aldrin	5.88E-02	2.40E+00	5.15E-03	4.80E-01		5.15E-03	MTCA B	4.87E+01	CLARC 3.1	6.97E-03	CLARC 3.1	5.04E-03
319-84-6	hexachlorocyclohexane; alpha (alpha-BHC)	1.59E-01		1.39E-02			1.39E-02	MTCA B	1.76E+00	CLARC 3.1	4.35E-04	CLARC 3.1	5.45E-04
319-85-7	hexachlorocyclohexane; beta- (beta-BHC)	5.56E-01		4.86E-02			4.86E-02	MTCA B	2.14E+00	CLARC 3.1	3.05E-05	CLARC 3.1	2.27E-03
319-86-8	hexachlorocyclohexane;delta- (delta-BHC)							MTCA B					
542-75-6	dichloropropene;1,3-	5.56E+00	2.40E+03	2.43E-01	2.40E+02		2.43E-01	MTCA B	2.70E-02	CLARC 3.1	7.26E-01	CLARC 3.1	1.41E-03
621-64-7	nitroso-di-n-propylamine;N-	1.43E-01		1.25E-02			1.25E-02	MTCA B	2.40E-02	CLARC 3.1	9.23E-05	CLARC 3.1	5.60E-05
1330-20-7	xylene		1.60E+05		1.60E+04	1.00E+04	1.00E+04	MCL	2.33E-01	CLARC 3.1	2.79E-01	CLARC 3.1	9.14E+01
7439-92-1	lead		2.50E+02			1.50E+01	1.50E+01	MCL	1.00E+04	CLARC 3.1	0.00E+00	CLARC 3.1	3.00E+03
7439-97-6	mercury		2.40E+01		4.80E+00	2.00E+00	2.00E+00	MCL	5.20E+01	CLARC 3.1	4.70E-01	CLARC 3.1	2.09E+00
7440-02-0	nickel, soluble salts[c]		1.60E+03		3.20E+02	1.00E+02	1.00E+02	MCL (WAC)	6.50E+01	CLARC 3.1	0.00E+00	CLARC 3.1	1.30E+02
7440-22-4	silver[c]		4.00E+02		8.00E+01	1.00E+02	8.00E+01	MTCA B	8.30E+00	CLARC 3.1	0.00E+00	CLARC 3.1	1.36E+01
7440-28-0	thallium, soluble salts		5.60E+00		1.12E+00	2.00E+00	1.12E+00	MTCA B	7.10E+01	CLARC 3.1	0.00E+00	CLARC 3.1	1.59E+00
7440-38-2	arsenic, inorganic	6.67E-01	2.40E+01	5.83E-02	4.80E+00	5.00E+00	5.83E-02	MTCA B	2.90E+01	CLARC 3.1	0.00E+00	CLARC 3.1	3.40E-02
7440-39-3	barium		5.60E+03		1.12E+03	2.00E+03	1.12E+03	MTCA B	4.10E+01	CLARC 3.1	0.00E+00	CLARC 3.1	9.23E+02
7440-41-7	beryllium		1.60E+02		3.20E+01	4.00E+00	4.00E+00	MCL	7.90E+02	CLARC 3.1	0.00E+00	CLARC 3.1	6.32E+01
7440-47-3	chromium (total)					1.00E+02	1.00E+02	MCL	1.00E+03	CLARC 3.1	0.00E+00	CLARC 3.1	2.00E+03
7440-62-2	vanadium		5.60E+02		1.12E+02		1.12E+02	MTCA B	1.00E+03	CLARC 3.1	0.00E+00	CLARC 3.1	2.24E+03
7782-49-2	selenium and compounds		4.00E+02		8.00E+01	5.00E+01	5.00E+01	MCL	5.00E+00	CLARC 3.1	0.00E+00	CLARC 3.1	5.20E+00
8001-35-2	toxaphene	9.09E-01		7.95E-02		5.00E+00	7.95E-02	MTCA B	9.58E+01	CLARC 3.1	2.46E-04	CLARC 3.1	1.53E-01
16065-83-1	chromium (III)		1.20E+05		2.40E+04		2.40E+04	MTCA B	1.00E+03	CLARC 3.1	0.00E+00	CLARC 3.1	2.00E+03
16984-48-8	fluoride					4.00E+03	4.00E+03	MCL	0.00E+00	Default	0.00E+00	Default	1.60E+01
18540-29-9	chromium(VI)		2.40E+02		4.80E+01		4.80E+01	MTCA B	1.90E+01	CLARC 3.1	0.00E+00	CLARC 3.1	1.84E+01

Notes:

GW – Ground Water

CAS – Chemical Abstract Service

(a) The lowest value of columns 3 and 4 (Soil Direct Contact) and column 14 (Soil Conc. for GW Protection mg/kg) is used in Tables 4-8 through 4-11.

(b) MCL is the drinking water maximum contaminant level from 40 CFR 141, "National Primary Drinking Water Regulations"

(c) MCL for nickel, soluble salts, from WAC-173-201A "Water Quality Standards for Surface Waters of the State of Washington