

# SMART System Functional Requirements Document

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy  
under Contract DE-AC06-09RL14728



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# SMART System Functional Requirements Document

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**APPROVED**  
*By Janis Aardal at 7:22 am, Nov 21, 2017*

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Release Approval

Date

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## TERMS

AOP	Air Operating Permit
CHPRC	CH2M HILL Plateau Remediation Company
DOE	U.S. Department of Energy
EDD	Electronic Data Deliverable
EIS	Environmental Integration Services
EM&ES	Ecological Monitoring and Environmental Surveillance
ERS	Environmental Release Summary
HEIS	Hanford Environmental Information System
HLAN	Hanford Local Area Network
MEI	Maximally Exposed Individual
MSA	Mission Support Alliance
SDF	Samples Data File
SDT	Sample Data Tracking
SMART	Sample Management and Analytical Results Tracking
TLD	Thermoluminescent Dosimeter
WRPS	Washington River Protection Solutions

## DEFINITIONS

**Electronic Data Deliverable** – a digital computer-readable data file in which the data is stored in a predefined and structured format, making it a suitable medium for sharing, manipulating, and using data.

## TRADEMARKS

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**1.0 OVERVIEW**

Acronym:	SMART (Sample Management and Analytical Results Tracking)	Hanford Information System Inventory ID:	4214	Software Grade:	D
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Mission Support Alliance (MSA) is the integrator of a multi-contractor effort to clean up the Hanford Site. MSA collaborates with the U.S. Department of Energy (DOE) and all Hanford Site contractors to find and implement new, cost-saving, safe, and practical solutions to cleanup challenges.

On behalf of DOE, MSA's Environmental Integration Services (EIS) function performs as the integrating contractor for Hanford environmental compliance. The EIS mission is to create, maintain, and deliver timely and quality environmental compliance support/products with technical services and expertise enabling Hanford contractors and MSA projects to expedite the Hanford environmental cleanup missions within the ISO 14001, *Environmental Management System*, framework.

Within EIS, the Ecological Monitoring & Environmental Surveillance (EM&ES) was organized to monitor and ensure compliance with complex environmental regulations. EM&ES provides the following monitoring and surveillance services:

- Ecological Monitoring monitors Hanford's diverse biota, including state- and federally-listed species to assess the abundance, vigor or condition, and distribution on the Hanford Site. Ecological Monitoring data is used by DOE and Hanford Site contractors to support environmental cleanup and restoration activities, mitigation actions, land use planning, and to maintain compliance with ecological resource laws.
- Environmental Surveillance conducts environmental monitoring to measure radionuclide concentrations in various environmental media including air, surface water, sediment, soil, natural vegetation, agricultural products, fish and wildlife, and external radiation levels . Environmental Surveillance Data is used to assure the public that the dose and risk from Hanford contaminants are well understood.
- Air Quality services integrate Hanford Site Air Operating Permit (AOP) activities and coordinates, prepares, and distributes sitewide reports required by the Hanford Site AOP. This team also supports regulatory compliance for MSA-operated air emission sources by maintaining the AOP database/website and coordinates development of sitewide AOP compliance strategies, tools, guidance, and interpretations.

**2.0 PROJECT DESCRIPTION**

This Functional Requirements Document was prepared to consolidate the requirements determined as a result analysis of the following EIS systems: Automated Bar Coding of All Samples at Hanford 2 (ABCASH 2), Environmental Release Summary (ERS), and Sample Data

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Tracking (SDT) systems. The purpose is to describe the mandatory and desirable functionality in the existing systems allowing the development and/or acquisition of a replacement system that will fully upgrade ABCASH and ERS to a more modern and Hanford supported technology as well as integrate the SDT functionality currently used into the new system. This new system will be referred hereafter as the Sample Management and Analytical Results Tracking (SMART).

The intended audience for this document is the MSA EIS and prospective software and service providers that can provide and support an environmental data management software solution.

## 2.1 SCOPE

The EM&ES provides the management and administration for the ABCASH2 system and ERS system. Additionally, EM&ES integrates applicable information from the SDT Application into the EM&ES information basis. The systems below provide the information basis for EM&ES to pursue SMART, a comprehensive information system solution that will consolidate the systems into a single environmental data management software solution.

ABCASH provides for the collection and tracking of samples of air (from stack emissions and ambient sources), soil, vegetation, and liquid effluent. The system uses bar code technology, handheld computers, a database for storage and acquisition, and operational procedures to automate the acquisition of sample information. ABCASH is essential in meeting the monitoring and reporting requirements imposed on the Hanford Site by such federal and state regulations such as 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H and WAC 246-247, "Radiation Protection – Air Emissions." ABCASH is used by hundreds of users and is written in Microsoft® Visual Basic 6®.

The ERS stores and presents analytical data on Hanford Site samples collected from stack emissions and ambient air, soil and vegetation; and liquid effluents. The ERS also stores data on stack and liquid discharge flows. ERS produces data reports in several report formats supporting the Hanford contractors by fulfilling federal and state reporting requirements in 40 CFR 61 Subpart H; WAC 246-247; DOE O 458.1, *Radiation Protection of the Public and the Environment*; and DOE M 231.1B, *Environment, Safety and Health Reporting*.

ERS is a critical contract deliverable system, essential for the timely compliance with federal and state reporting requirements imposed on the Hanford Site. ERS produces data reports in support of CH2M HILL Plateau Remediation Company (CHPRC), MSA, and Washington River Protection Solutions (WRPS). The ERS is used by less than 50 users and written in FORTRAN 95.

The SDT application is used to prepare Sample Authorization Forms, Chain-of-Custody Forms, and Sample Container Labels. It automates the administration needed for tracking the progress of samples through the Sample and Data Management Process at Hanford and is used in the sampling process of EIS. Currently, the system is used in conjunction with ERS and ABCASH with a need to integrate related sample management information with existing environmental information.

Neither ABCASH nor ERS are currently supported under the current Hanford system standards. Visual Basic 6 is used as the programming language for ABCASH and FORTRAN used for ERS. ACBASH testing on Windows 10 determined that the scanner drivers used in ABCASH are not compatible with Windows 10. Additionally, the Visual Basic development environment

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has proven incompatible with Windows 10. The ERS system has been in use at Hanford for over 30 years. It was migrated to its current platform of PCs connected to the Hanford Local Area Network (HLAN) in 1991. The FORTRAN programming language is beyond analyst support; therefore, the main statement of need for the upgrade to SMART is to allow continued operability of the systems because all HLAN computers will be upgraded to Windows 10 by September 2018. Additionally, the consolidation of ABCASH and ERS and SDT functionality into SMART will result in an integrated environmental data management system.

## 2.2 OBJECTIVES

The primary objective of this Functional Requirements Document is to provide an effective definition of the existing Hanford environment tracking system in a manner to support the development of a statement of work to acquire, implement, and test a mature environmental data management software system that can meet the system, security, and functional requirements allowing replacement of the existing ABCASH/ERS system with minimal customization to the acquired system. A secondary objective is for the acquired software to have the capability to incorporate existing planning, acquisition, tracking, data storage, and data reporting for samples submitted for chemical and radiological analyses currently performed using the SDT system.

Implementation of this system will minimize the cost and resource impacts of maintaining separate information stores for the systems. More importantly, implementation of a new system will resolve the ongoing risk of unsupportable software due to the age of the existing systems, obsolete programming, and current cybersecurity requirements within the Hanford Information System Enterprise with the antiquated technology.

To meet the technology upgrade schedule, this project needs to be in production by September 31, 2018.

### 2.2.1 Business

MSA provides sitewide services and integrated infrastructure to reduce operating costs and to support the cleanup mission in its role as the integrator contractor to the DOE's Hanford site in Richland, Washington. MSA has determined that existing systems supporting data management and reporting software programs for facility effluents and environmental surveillance need to be modernized.

The following regulatory drivers for collecting, managing, and reporting this data are common across the DOE Complex:

- 40 CFR 61 Subpart H, "National Emission Standards for Emission of Radionuclides Other than Radon from Department of Energy Facilities" and associated appendices for test methods, quality assurance, estimating emissions, and compliance methods;
- DOE O 458.1 *Radiation Protection of the Public and the Environment*
- DOE-HDBK-1216-2015, *Environmental Radiological Effluent and Environmental Surveillance*.

Currently, the software programs used at Hanford track and provide reporting formats for facility air and liquid effluent data, and environmental surveillance data from soil, vegetation, biota, the

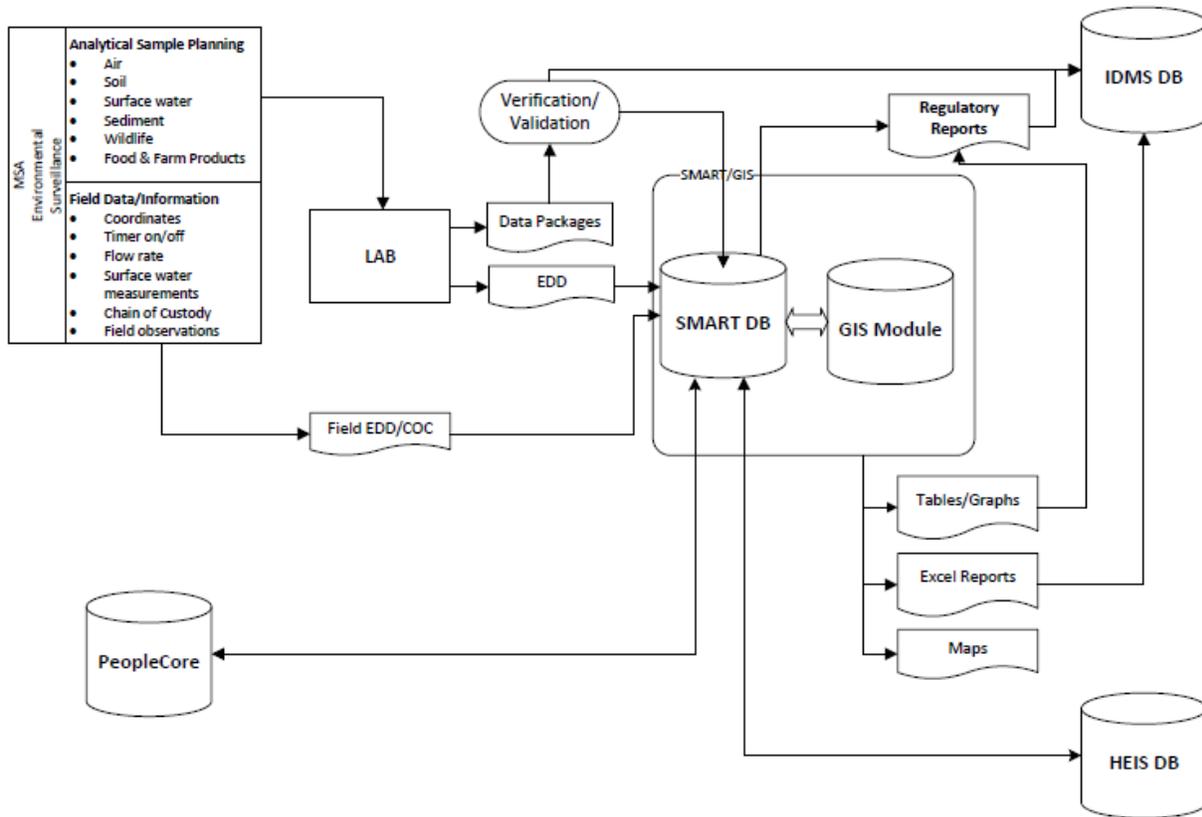
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Hanford Site Thermoluminescent Dosimeter (TLD) network, and the near and far ambient air samplers. The sample data program tracks the samples and resultant analytical data from cradle to grave (i.e., creates unique sample numbers, tracks chain of custody, interfaces with multiple labs for data transfer, stores associated field data from sampling instrumentation, combines sample volumes with analytical results to calculate concentrations, provides verification and validation checks, and provides for complete configuration control of all changes to the data). The reporting program combines the sample concentrations with stack flows and calculates resulting curies released and subsequent radiological dose from individual facilities as well as the Hanford Site; provides data trending and statistical reviews across any time period; and provides plots with options for indicating 3 sigma bars, warning levels, error bars, minimum detection level lines, etc. Sampler performance efficiencies are also calculated for comparison to the required limits.

**2.3 PRODUCT PERSPECTIVE**

The SMART system is expected to have minimal interfaces from other systems at Hanford. It may interface with Hanford PeopleCORE to verify valid users. It will exchange information with the Hanford Environmental Information System (HEIS) system. It will currently produce bar codes and exchange information with bar code readers as one method of obtaining sample readings. However, this function could be changed if new technology can be utilized for the same function. And it will interface with the document control and records management systems for the long-term management of record material produced by this system.

The system produces reports to send to the labs for conducting sample analysis. The system inputs lab results from a few formats. The system produces a number of analyses, sample management reports, and charts and plots for the regulatory reports.



**Figure 1. Context Diagram**

**2.3.1 Input Files**

Major data inputs include:

- Sample location coordinates
- Sample identification
- Flow rate (timer on/off for air samples)
- Field measurements/observations
- Chain of Custody
- Laboratory Electronic Data Deliverables (EDDs)
- Dose rate factors (used to calculate maximally exposed individual dose)
- Regulatory thresholds/action levels.

**2.3.2 Output Files**

Major data outputs include:

- Sample data and analytical results exported to HEIS
- Excel file providing direction to the laboratory for sample compositing
- Reports
- Tables

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- Trending Plots
- Document control and records management systems
  - Report in Word document
  - Report in Excel.

**2.3.3 Interfaces**

SMART must interface with the HEIS and the document control and records management systems used for managing Hanford records. HEIS is an Oracle® database consisting of tables and their supporting software objects used to manage Hanford Sitewide environmental data and promote sharing of data as a community resource.

SMART will interface with PeopleCORE to verify valid users to the system.

**2.3.4 Historical Data Characteristics**

ABCASH and ERS provide historical data since 1990.

ABCASH has 600,000 records from SQL database. The data is "clean" and is assumed will migrate with minimal issues. The data is all based on a unique location, each location has an average of 13 analytes associated with it. The ABCASH data size is 2582.81 MG and the historical data is represented in Table 1 by the number of samples collected per year and the **correlating** number of sample results from the laboratory.

Table 1. ABCASH Historical Data. (2 Pages)		
Sample Year	Number of Sample Collected	Number of Sample Results from Lab
1990	16	28
1991	7845	15688
1992	29640	59198
1993	31718	57989
1994	863	1310
1995	31962	41927
1996	27828	37973
1997	26502	39512
1998	25320	37173
1999	26721	42744
2000	26391	40514
2001	26729	40159
2002	26568	39312
2003	26413	29797
2004	26602	33223
2005	24664	34018
2006	24910	32272
2007	25039	37137

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2008	24831	34461
2009	24026	32838
2010	21963	28119
2011	19082	16169
2012	17128	15388
2013	14340	17131
2014	12959	16801
2015	12402	18872
2016	13129	20943
2017	14740	21348

The historical data from the ERS is about 3 gigabytes of data. The data historically is stored in 10,300 FORTRAN flat files. The records are based on sample number and have only 1 analyte associated with it. The data has been defined and reprocessed to extract the data from the flat files. There are 1,591 ERS data files and 110 FLO data files.

The historical environmental surveillance program data currently existing in the HEIS database is summarized in the Tables 2 and 3 based on “sample count” and “results count.” Data identified in HEIS with the “Owner ID” of PSRP, SESPMNT, and SESPSPEC will require migration to the new database. The ABCASH Owner ID will be migrated from the ABCASH database.

**Table 2. Sample Count of Historical Data Existing in HEIS Database.**

<b>OWNER_ID</b>	<b>Sample Count</b>	<b>% of Total</b>	<b>EXCEL File Size MB</b>
<b>ABCASH</b>	17140	9.82	3.45
<b>PSRP</b>	6651	3.81	1.34
<b>SESPMNT</b>	142204	81.44	28.65
<b>SESPSPEC</b>	8626	4.94	1.74
<b>Total</b>	174621	100	35.18

**Table 3. Results Count of Historical Data Existing in HEIS Database.**

<b>OWNER_ID</b>	<b>Results Count</b>	<b>% of Total</b>	<b>EXCEL File Size MB</b>
<b>ABCASH</b>	56786	9.58960555	14.06
<b>PSRP</b>	49027	8.27932221	12.14
<b>SESPMNT</b>	432075	72.9656749	106.99
<b>SESPSPEC</b>	54274	9.16539731	13.44
<b>Total</b>	592162	100	146.63

### 2.3.5 Users

The ABCASH system currently has about 440 users and the ERS system has about 20 users. Additionally, about 5 users access the SDT system for planning and tracking a portion of the EM&ES work. The ABCASH and ERS systems are predominantly used by MSA employees, with a small number of users employed by other Hanford contractors including: CHPRC and WRPS. Table 4 provides a summary of the estimated number of users by function.

<b>Table 4. Estimated System Users by Function. (2 Pages)</b>		
<b>User Group<sup>a</sup></b>	<b>Function</b>	<b>Estimated User Count</b>
Administrators	Access all menu items and all system functions	7
Engineers / Scientists	Modify inputs (e.g., sample location, sample type); upload sample information. <ul style="list-style-type: none"> <li>• add/delete/modify location data</li> <li>• add/delete/modify sample field data</li> <li>• validate sample field data</li> <li>• add/delete/modify analytical data</li> <li>• custody change</li> <li>• add/delete/modify sample analysis data</li> </ul>	35
Samplers	Upload field information, change sample custody, generate sample labels, etc. Cannot modify sample data or location. Collect and load field information into database via hand-held bar code reading device. <ul style="list-style-type: none"> <li>• add/modify sample field data</li> <li>• transfer data to and from handheld scanners</li> <li>• custody change</li> </ul>	355
Report Viewers	Can view data, create reports, and execute reports. <ul style="list-style-type: none"> <li>• view data and results only, print reports</li> </ul>	250

<sup>a</sup> Users may be in more than one group.

## 2.4 CONSTRAINTS

### 2.4.1 General Constraints

To meet the technology upgrade schedule, this project needs to be in production by September 31, 2018. Requirements for the system include the following:

- Must be Microsoft® Windows 10 compatible.
- Must be compatible with Microsoft® Office 2013.
- Accessible from Hanford standard windows workstations (Thick Clients) and Thin Clients (currently the Dell Wyse 5030 zero client).
- Operating system must be Microsoft® Windows Server 2016 or higher for the application.
- Database can be either:
  - Microsoft® Windows Server 2016 and Microsoft® SQL Server 2016 or above (preferred)
  - Or Red Hat Linux version 7 and Oracle12C or above.
- Must be able to import all historical data.
- Solution must be able to print to network-attached printers/plotters at Hanford.

### 2.4.2 User Constraints

The handheld user (e.g., health physics technician) wears personal safety protection gloves; therefore, the buttons or touch screen buttons should be as large as possible to make it easier for accurate entry. Users take the sample readings outdoors which means the mobile device must function in hot summer, cold winter, rain, and sandy outdoor elements.

### 2.4.3 Design Constraints

Design constraints include the following:

- Must be able to interface with bar code reader
- Handheld mobile device must have built in bar code scanner – be able to scan sample label and location label
- Handheld mobile device must functional in certain extreme weather condition (e.g., hot summer, cold winter, and bright sunlight)
- Handheld mobile device must be rigid for dropping on concrete floor at certain height
- Handheld mobile device with touch screen function is preferred
- Smaller size is preferred for easy carrying at the work location; tablet size is a bit too big for data collection activity.

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The current process at Hanford uses handheld bar code readers to gather data to input in the reader. Upon completion, the data is uploaded to approved workstations and subsequently uploaded into the system.

### **2.4.4 Platform Constraints**

The system may be an on premise solution or a cloud solution such as a Software as a Service solution.

The general system requirements for an on premise solution are the server portion of the system must run in a VMware® virtual server environment. Hanford will provide the resources for a development, test, and final production environment. In addition, an on premises solution must be compatible with the NetApp® Storage Area Network to support the system storage needs. Any internet connection from the solution must be identified and approved through Hanford as a one time for licensing, login, persistent, or all the above.

A cloud solution must meet Hanford cyber requirements and support connectivity questions and information gathering needs. Questions concerning data encryption must be answered adequately to support in transit encryption and encryption at rest data using government methods. Also, is the proposed Cloud Service Provider FEDRAMP certified and will data be stored in the United States. These are a few, but not all of the Cloud constraint questions that must be resolved for a cloud or Software as a Service solution to be approved for implementation to the HLAN boundary.

## **2.5 DEPENDENCIES**

The interface design should allow any system to be down without taking down an interfacing system. Systems should be able to recover smoothly from an interfacing system being down.

# **3.0 REQUIREMENTS**

## **3.1 FUNCTIONAL REQUIREMENTS**

Figure 2 shows the EM&ES data management process workflow. Samples are tracked from planning; through collection, packaging and shipment; receipt at the laboratory; laboratory analyses; receipt of laboratory EDDs; data verification and validation; and records retention through final sample disposal. Once verified and validated, laboratory results are evaluated against regulatory requirements and action criteria. Acceptable data is used to prepare trends, graphs, and tables used in internal and external reports. There are two basic types of samples: 1) effluent samples collected from facility stacks that measure concentrations of radionuclide releases and 2) environmental surveillance samples that measure the concentrations of radionuclides and chemicals in media potentially impacted from facility releases of radionuclides and chemicals to the environment. Additionally, environmental surveillance samples can consist of temporally composited samples, as well as discrete grab samples. Composited sample volumes are calculated by the software.



**Figure 2. EM&ES Data Management Process Workflow.**

### 3.1.1 Sample Planning (SP)

Sample planning for the program is typically done on an annual basis and identifies the media to be sampled, the sample collection frequency, and the laboratory analyses to be performed for each sampling event. Sample planning initiates tracking for each sampling event.

**SP.01** Ability to plan, schedule, and track sampling events for the following media:

- Effluent air (filter, cartridge, silica gel); composite and discrete
- Ambient air (filter, cartridge, silica gel); composite and discrete
- Soil
- Sediment
- Vegetation
- Surface water (pond, river transects, river grab, continuous water, seeps); composite and discrete
- Wildlife (fish, waterfowl, upland game birds, rabbits, deer, elk) including bone and tissue
- Food and farm products (e.g., milk, wine, apples, melons, cherries, apricots, alfalfa, potatoes)
- TLDs.

**SP.02** Ability to identify and create sample locations for all environmental surveillance media (see SP.01) using Washington State planar coordinates (northing and easting) and samples within a geographic area (wildlife, food and farm products).

**SP.03** Ability to identify and create unique sample locations for facility stacks (effluent air samples).

**SP.04** Ability to print bar code labels for sample locations (e.g., stacks, ambient air monitoring stations, TLD locations).

**SP.05** Ability to identify and create unique sample identification numbers.

**SP.06** Ability to plan sampling for the following collection frequencies:

- One time
- Custom
- Annual

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- Semiannual
- Weekly
- Biweekly
- Quarterly
- Monthly
- Biannual
- Triennial.

**SP.07** Ability to plan and track field quality control samples consisting of:

- Equipment blanks
- Trip blanks
- Duplicate samples
- Split samples.

**SP.08** Ability to track samples using a bar code system.

**SP.09** Ability to generate/print field sampling paperwork:

- Chain-of-custody forms
- Sample container labels
- Barcode labels
- Field collection data sheets/forms.

**SP.10** Ability to plan and track composite samples.

**SP.11** Ability to identify parameters for radiological and chemical analyses including the following:

- Laboratory
- Analytical method
- Chemical Abstracts Service (CAS) #
- Analyte
- Holding time
- Preservative
- Container type and size
- Number of containers
- Analytical priority.

**SP.12** Ability to display and report on the status of completed sampling events and outstanding sampling events, missing analyses, overdue analyses, and nonconforming/variant samples.

**SP.13** Ability to align sampling events with each contracted laboratory to support tracking of analytical costs and laboratory invoicing.

**SP.14** Ability to configure sample planning in lookup tables and create, modify, or delete a sample in accordance with workflow specifications.

**SC.15** Ability to create new instrumentation definitions and associations to sample locations that match instruments in the field integral to sampling systems at emission points (stacks).

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**3.1.2 Sample Collection (SC)**

Samples are collected for the program and submitted for laboratory analyses. Samples are tracked from planning, collection, and shipping through laboratory analyses, receipt of the data, and final sample disposal.

**SC.01** Ability to provide data input to the database system via computer workstations or handheld computerized scanners for the purpose of inputting field sampling information collected at sampling stations. This includes:

- On-and-off dates and times
- Readings from sample totalizers
- Stack-flow totalizers
- Rotameters
- Vacuum gages
- Timers.

**SC.02** Ability to receive input from handheld computerized scanners with media-specific programmed functions to capture sample-related data (some constants may be encoded in scannable bar codes) entered by the sample collector who then transfers those data to the main database at a computer workstation (or perhaps wirelessly in the future). The sample location and sample number are identified using location-specific bar codes; the field information to be manually entered while in the field includes:

- Sample collection date and time
- Instrument readings (air sampler time-on/time-off, field pH, field conductivity, field dissolved oxygen, field temperature)
- Sampler and sample custodian ID (scan barcode on employee badge).

**SC.03** Ability to input stack flow data to the minute for recording stack operating history.

**SC.04** Ability to relate a field quality control sample with the related sample set and sample delivery group.

**SC.05** Ability to support field sample compositing.

**SC.06** Ability to track sample custody from collection through receipt at the laboratory.

**SC.07** Ability to verify that all samples were collected and the correct analyses were requested.

**3.1.3 Sample Analyses (SA)**

Samples are shipped to contracted laboratories for radionuclide and chemical analyses requested on the sample chain of custody. The laboratory performs a receipt inspection of the samples and notifies EM&ES upon receipt of the samples. The sample status and results are tracked within the laboratory using a laboratory information management system. Sample results are provided to EM&ES in an EDD file generated by the laboratory information management system. Upon completion of analyses the laboratory stores the residual sample media until sample disposition is authorized by EM&ES.

**SA.01** Ability to load EDDs from analytical laboratories. EDDs include, but are not limited to, the following:

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- Sample number
- Analyte code/ID
- Analyte name
- Result
- Analytical uncertainties
- Result units
- Laboratory qualifier
- Reporting limit
- Sample volume
- Laboratory comments.

**SA.02** Ability to load TLD field exposure data (mrem) from Excel worksheets.

**SA.03** Ability to identify and report problems encountered while loading electronic data.

**SA.04** Ability to calculate laboratory results for air samples (effluent/stacks and ambient air) from units of activity ( $\mu\text{Ci}/\text{sample}$  or  $\text{pCi}/\text{sample}$ ) to units of concentration ( $\text{uCi}/\text{ml}$  or  $\text{pCi}/\text{m}^3$ ). This calculation associates the laboratory activity values (reported in the EDD) with the sample volume information (that is stored in the database) when the EDD is uploaded to the database.

**SA.05** Ability to store results of radiological analyses for samples in analyte-specific concentrations with uncertainties expressed in basic units as a percent and/or  $\pm$  standard deviations.

**SA.06** Ability to store radionuclide data with reported uncertainties, including negative results and results that are less than the estimated quantitative detection limits.

**SA.07** Ability to store analyte concentrations and radiation exposure readings (TLD) in the units reported.

**SA.08** Ability to store radiation exposure readings (TLD) with uncertainties expressed in percent.

**SA.09** Ability to store complete log of facility-specific stack operations. This data includes:

- Stack on-and-off times
- Stack emission flow rates (see Appendix A for basic description of stack operating flow rate monitoring)
- Radionuclides.

**SA.10** Ability to store analytical results for a minimum of 52 specific isotopes, 2 types of radioactivity (alpha activity, beta activity), and TLD readings in millirem.

**SA.11** Ability for sample results to be identified, indexed, and accessed by sample location ID and sample date and time, with precision to the minute.

**SA.12** Ability to differentiate between effluent samples (e.g., stack samples) and environmental samples.

**SA.13** Ability to handle an unlimited number of samples per sample location.

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**3.1.4 Data Verification and Validation (V&V)**

Data verification and validation involve checks of the field collection information and laboratory results against data requirements.

**V&V.01** Ability to check and flag sample results as they are entered into the database via mathematical testing to determine whether selected results are within the range of established limits. This check includes:

- Verifying that the contract required detection limit was met by the laboratory.
- Verifying results are within expected low and high limits (see DA.02).
- Comparing results to the maximum, minimum, and average of the last 10 results for this sample type for this sample location.
- Comparing results to the maximum, minimum, and average of results for this sample type at all locations for the previous 12 months.

**V&V.02** Ability to check data to ensure timely sample collection and receipt of analytical data and ensure traceability from scheduling to analytical results storage in the database.

**V&V.03** Ability to track and verify sample turnaround time for analytical laboratory results for each ordered analytical test against projected due date and identify “late results” in a reporting feature.

**V&V.04** Ability to modify sample data, a process requiring the recording of the reason for the modification as well as the ID of the person making the modification based on user privilege category.

**V&V.05** Ability to produce a flagging report that includes all laboratory flags and comments in a sample delivery group or user-defined sample set.

**3.1.5 Data Analysis (DA)**

**DA.01** Ability to load and update radionuclide dose factors for air samples to support conversions/calculations from units of concentration ( $\text{pCi}/\text{m}^3$ ) to units of exposure (mrem).

**DA.02** Ability to establish multiple action levels for single analytes to support evaluation of sample results against federal, state, and DOE reporting (notification) limits. Examples include:

- Results outside user determined iterations of standard deviation (above/below)
- Results exceeding 10% of 40 CFR Part 61, Appendix E, Table 2 values for stack and ambient air samples
- Results exceeding lookup values for radionuclide-specific concentrations
- Results exceeding drinking water standards
- Results exceeding federal and state ambient water quality standards.

**DA.02** Ability to address flow rate conversions for stack and ambient air samples.

**DA.03** Ability to calculate standard sample statistics including mean, standard deviation, variance, and maximum for sample sets.

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**DA.04** Ability to calculate relative percent difference for duplicate, predetermined, and ad hoc pairing sample sets.

**DA.05** Ability to compare analyte concentrations and relative percent difference at individual sampling locations to those measured at reference locations or other sample locations and evaluating the results of those comparisons.

**DA.06** Ability to compare results as data are collected to previous (historical) results to help identify unusual measurements that require further investigation or further statistical evaluation. If a result is unusual and fails any of the tests (see V&V.01, DA.02), the result is considered an anomaly and an anomalous data report is generated.

**DA.07** Ability for calculation of releases, standard deviations, and durations using an integer format including:

- Calculating air sample volume based on totalizer readings and rotameter readings, and compare between the two volume calculations.
- Calculating air sample concentration based on sample volume comparisons outcome and analytical results.
- Calculating decay for liquid release reports (historical data no longer collected but still maintained after migration into new database).
- Calculating time-weighted stack flow and releases for variable stack flow and operation (see Appendix A).

**DA.08** Ability to load data from SMART database to HEIS database.

**DA.09** Ability to produce graphical trend plots selected for individual, multiple, or user sets of location codes that present concentrations, TLD values, and releases (stacks) over specified data ranges and that incorporate for statistical comparison a selectable range of historical data related to that sample collection point. Plots will include options to include graphical presentation of concentration limits (i.e., action levels and dose-related levels), laboratory minimum detection limits, statistical relevance demarcations (lines/zones), etc.

**DA.10** Ability to perform statistical tests on inputted data based on user-specified criteria. Examples include whether activities, concentrations, releases, stack flows, or sampling equipment readings (e.g., checking whether or not action levels have been exceeded), gaps in sampling for emission points (stacks) requiring continuous monitoring, comparison to historical averages, and if sample volumes are insufficient for achieving minimum detectable levels.

**DA.11** Ability to incorporate line-loss and filter-efficiency factors in release-calculation formulas.

**DA.12** Ability to formulate algorithms to time-weight the mathematical intersection of sampling times, stack operating times, sample concentrations, and stack flow rates to derive the most accurate and defensible radionuclide release estimates (Ci) achievable.

**DA.13** Ability to formulate algorithms that will logically select a sample volume when more than one volume has been calculated for the sampling period of a stack air sample. The most typical scenario is when sample volumes are derived using the field data originating from two flow measurement subsystems within a sampling system that usually are a mass-flow totalizer

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and a rotameter with which a timer reading or elapsed time value is used in a rotameter-based volume calculation (see Appendix A).

### 3.1.6 Data Reporting (DR)

Data reports are generated from the database to support preparation of annual reports and to meet federal, state, and DOE reporting requirements. Real time and ad hoc reports are prepared by the database user.

**DR.01** Ability to produce an anomalous data report (see DA.06).

**DR.02** Ability to produce reports for radionuclide and chemical data based on sampling location, emission point, sample number, data range, and analyte(s). The reports display field sampling information; analyte concentrations; and, for gross alpha and gross beta, the formulaic steps involved in determining the concentrations. Note: For stack samples, sample concentrations (e.g., in  $\mu\text{Ci/mL}$ ) are derived by dividing activity data (e.g.,  $\mu\text{Ci}$ ) received from the laboratory with the sample flow volume derived from instrument readings of sample flow totalizers and rotameters. If both instruments are operational within a sampling system, the default sample volume selected is from the calculated totalizer volume as long as that volume is less than 120% of the rotameter-based calculated sample volume, which includes use of a timer value, if a timer exists, as long as its reading does not exceed the elapsed time. Otherwise, multiply the elapsed time by the rotameter average flow rate.

**DR.03** Ability to produce a radiological release report presenting Ci releases by isotope and type of radioactivity (i.e., gross alpha and gross beta) for one or more emission points (provide the capability of creating user sets of multiple emission points); the report will include average and peak concentrations, average operating emission point flow rate, total flow volume, number of operating days within selected date range, and correction factor used in release calculation. The Ci values are derived by multiplying the relevant concentration by the respective emission point volume for the selected period and then multiplying that result by the emission-point-specific efficiency factor.

**DR.04** Ability to produce tables for annual National Emission Standards for Hazardous Air Pollutants-required release report, selectable by location codes grouped into stack designation categories (i.e., major and minor) that contain essential emission point data (emission point identity and location, concentrations, releases, flow rates, flow volumes, and radiological dose for each emission constituent and total for each emission point) (see Appendix A).

**DR.05** Ability to produce a comprehensive report, selectable by date range and location codes, that includes all concentration, release, and stack flow data for one to multiple to all emission points (stacks).

**DR.06** Ability to produce composite sample report that shows composite sample volume and the individual volumes and IDs of samples comprising that composite sample and assign a unique sample ID to the composite sample.

**DR.07** Ability to produce a data review report (selectable by date range, sample location codes, and radionuclides) that presents concentrations and the previous 5-year historical data trend plots.

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**DR.08** Ability to generate **Trend Reports** that consist of tables that display all sample data stored for samples designated by one specified sample location code during the specified time period. If more than one sample location is selected, then more than one table will be generated.

**DR.09** Ability to generate **Stack Flow Report(s)** that show all flow rate input data, operating average flow rate, and total effluent volume by selected date range and emission point, which may include multiple emission points.

**DR.10** Ability to generate **Environmental Summary Reports** for all samples of a specified media. The report includes a section displaying analytical results and a second section showing sample statistics for the samples and analytes listed in the first section. These reports (see Appendix B) include the following:

- Standard Annual Report – Tables of elements that are tables themselves
- Standard HEIS report – Excel spreadsheets with 32 columns
- Sample Statistics – The mean and maximum concentrations for the current report year and 5-year period preceding that for each analyte
- Radionuclide Air Emissions Report tables – From pre-coded, user-controlled report definition file.

**DR.11** Ability to generate **Sampler Efficiency Reports** that over-selected periods will identify over the length of air sampler operation, time gaps in sampling based on a prescribed gap length, total sampling time per selected period, and the efficiency percentage of sampling time during a total sampling period.

**DR.12** Ability to generate **Sitewide Sample Statistics** reports.

**DR.13** Ability to generate **TLD Reports** that consist of tables of TLD exposure rates corresponding to sampling locations. The reports (see Appendix B) consist of the following:

- User specified reporting period
- Annual Report – Each section has a table for each quarter and an additional table for calculated annual averages with standard deviations
- User Data Report – Lists of data showing locations, dates, and exposure rates.

**DR.14** Ability to trend and plot data to view electronically and for the user to print and copy/paste to other document(s) (e.g., Excel). Requirements for plotting include the ability to add annotations to show sample durations, standard deviations (up to the third), linear-log plots, linear-linear plots, and curve fitting.

**DR.15** Ability to display analyte concentrations or exposure rates (TLDs). The values are plotted locations or sampler (ordinates, Y-axis) against sample dates (abscissa, X-axis). Analyte concentrations are shown on logarithmic or linear scales; TLD exposure rates are shown on linear scales. The time period is between 1 and 15 years on a linear scale. These plots (see Appendix B) include the following:

- Standard Trend Plots: one analyte, one location; either log or linear ordinate
- TLD Plots: one analyte, one to five locations; linear ordinate
- Replicate Sample Plots: one analyte, two locations; either log or linear ordinate
- Combined Alpha/Beta Plots: two analytes, one location; log ordinate.

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**DR.16** Ability to provide “tools” for the benefit of the User including, but not limited to, the following:

- Audit Reports: Lists of Samples Data Files (SDFs). These reports may include archived SDFs and SDFs which are defined as Test or Quality Assurance files. May be restricted by Hanford Area and data type.
- Census Reports: Count and list of samples in an SDF taken during a report period.
- Gap/Overlap Analyses: Listing of sample overlaps for air samplers that run continuously, gaps longer than the normal media replacement time between samples.
- Replicate Sample Analyses: Compares analyses of duplicate samples.
- User specified sample comparisons.
- SDF Verification: Analyze SDFs for obvious data errors and logical inconsistencies.
- Composite Sample Report.
- Sample Custody Change Report.
- Sample Result Transfer Report (email notification).
- Location Data Report.
- Sample ON/OFF report (air sample stations).
- Unanalyzed Sample Report.
- User Location Set Report.
- Other release reports
  - Performed for all selected environmental data point (EDP) codes (single or rolled-up based on User Set)
  - Performed for selected reporting period
  - Total stack volume
  - Stack operation time
  - Average stack flow rates (Overall and Operating)
  - Average concentrations
  - Emission per nuclide/gross alpha and gross beta released
  - Projected results for gaps in data.

**DR.17** Ability to generate release reports for special dose modeling:

- Same as DR.11 with special user set roll-up all calendar year location codes within each Hanford Area
- Adds gross alpha and plutonium-239/240 emissions together and reports sum as plutonium-239/240
- Adds gross beta and cesium-137 emissions together and reports the sum as cesium-137.

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**DR.18** Ability to generate a report for air sampling (stack emissions and ambient air) that compares releases of gross alpha and gross beta radiological activity (curies) against isotopic activity (curies) as a quality activity.

### 3.1.7 Records Retention (RR)

Records obtained from the database are required to be archived to meet federal, state, and DOE requirements.

**RR.01** Ability to send EDDs and selected reports in the database electronically to document control and records management systems, i.e., the Hanford records management system.

### 3.1.8 Historical Data Migration (DM)

Historical data for the EM&ES program exists in three databases (ABCASH, ERS, HEIS). This historical data must be converted to the new software and be useable for populating data fields that must be completed to support use of the new software.

**DM.01** Ability to convert and load historical data from existing database systems (ABCASH, ERS, HEIS) to the new database (SMART).

**DM.02** Ability to test the historical data migration to the new system and verify as ready for use.

### 3.1.9 Geospatial Data Storage and Display (GD)

Storage and display of geospatial data are desired for this project.

**GD.01** Ability to provide a geospatial interface to view spatial data and maps, potentially including layers of topography, bathymetry, vegetation cover, critical habitat, current and historic structures and infrastructure, aerial photography, terrestrial and groundwater elevation contours, and other content as provided by Hanford Site contractors to the vendor. The geospatial display should be integrated to the extent practicable with geo-tagged analytical results (or metadata groups) stored in the database. The subcontractor will work with the EM&ES team to obtain and manage project-specific geospatial data.

## 3.2 SECURITY REQUIREMENTS

Security of the system is established through its installation on the HLAN; end user accounts will be configured with HLAN user names. Additional security structure requirements include:

**SR.01** The system shall only allow authorized users to log into the program. (Validate Employee from System)

**SR.02** Provide the ability to assign end user access levels without additional programming.

**SR.03** Allow group profiles and management, enabling users to be commonly grouped for specified access levels.

**SR.04** The system must be able to restrict privileges to “read only.”

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**SR.05** The system must be able to restrict privileges to support the User Groups specified in Section 2.3.5.

### 3.3 HARDWARE/SOFTWARE REQUIREMENTS

The system must comply with the following HLAN network and operating system compatibility requirements:

**HSR.01** The system must be compatible with 64 bit Microsoft® Windows 10 Enterprise - Creators Update (Version 1703, Build 10.0.15063) and above.

**HSR.02** The system must be compatible with Microsoft® Office 2013 and above.

**HSR.03** The system must be compatible with Microsoft® Internet Explorer 11 or Google Chrome.

**HSR.04** The system must be compatible with Microsoft® Windows Server 2016 and above.

**HSR.05** The system must be compatible with either

- Microsoft® Windows Server 2016 and Microsoft® SQL Server 2016 databases or above (preferred)
- Red Hat Linux version 7 and Oracle12C or above

**HSR.06** The system must include APIs for a variety of front-end technologies such as Microsoft® .Net, Microsoft® COM , Java®, etc.

**HSR.07** The software must be able to print to network-attached printers/plotters.

**HSR.08** The server portion of the system must run in a VMware® OR- Microsoft® Hyper V virtual server environment.

**HSR.09** Compatibility with the Storage Area Network disk storage environment is required.

**HSR.10** Compatibility with Hanford standard windows workstations (Thick Clients) and Thin Clients (currently the Dell Wyse 5030 zero client).

### 3.4 SYSTEM REQUIREMENTS

#### 3.4.1 System Interfaces

**SIR.01** The application must be able to receive data from and transfer data to other entities. Data formats vary by entity. Common data import and export functionality must allow for interfacing with other data entities as the work process evolves after the product is in production.

**SIR.02** The ability to create external interfaces to/from document control and records management system is required.

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**SIR.03** The application must be able to exchange data with other databases. (HEIS)

**SIR.04** The system must be able to exchange data with bar code readers for sample data input and change of chain of custody.

### **3.5 USER REQUIREMENTS**

User requirements include the following:

**UR.01** Useful online help with modifiable and contextual help screens.

**UR.02** Useful system administration tools.

**UR.03** Customizable performance monitoring and reporting capabilities.

**UR.04** Licensed for 440 current users with the capability of expanding to 600 users.

**UR.05** Hand held device user must be able to wear personal safety protection gloves while inputting sample collection data. Buttons or touch screen buttons must be large enough to allow for easy, accurate data entry.

### **3.6 PERFORMANCE REQUIREMENTS**

Explicit performance requirements are not specified due to the difficulty of knowing the capability of the system to return queries in an explicit time, to display forms within a specified time, etc. However, there is a generic expectation that the performance will be equal to or better than the performance the user experiences today.

**PR.01** The system shall be capable of supporting use of 440 users.

### **3.7 COMMUNICATION INTERFACE REQUIREMENTS**

Communication tools required include the following:

**CIR.01** Appropriate documentation will be available such as an Application Installation Manual, Application User's Manual, and a Mobile Application User's Manual.

**CIR.02** Provide the capability for users to submit Software Change Requests and Problem Reports (PRs) to the vendor for support.

## **4.0 REFERENCES**

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.

DOE-HDBK-2016-2015, *Environmental Radiological Effluent and Environmental Surveillance*, U.S. Department of Energy, Washington, D.C.

DOE O 231.1B, *Environment, Safety and Health Reporting*, Chg 1, U.S. Department of Energy, Washington, D.C.

DOE O 458.1, *Radiological Protection of the Public and the Environment*, Chg 3, U.S. Department of Energy, Washington, D.C.

ISO 14001, 2015, *Environmental Management Systems*, International Organization for Standardization, Geneva, Switzerland.

WAC 246-247, "Radiation Protection – Air Emissions," *Washington Administrative Code*, as amended.

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**APPENDIX A**  
**ABCASH /ERS INPUT FILES AND FILE FORMATS**

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**APPENDIX A**  
**ABCASH /ERS INPUT FILES AND FILE FORMATS**

## 1. FLOW.DAT

```
ERS Stack Flow Data for CY19 <nah> 4/25/19|
A006 01/01/16 00:00 28654. 10.0
B001 01/01/16 00:00 15121. 10.0
B748 01/01/16 00:00 24390. 10.0
B748 07/07/16 00:00  0.0 0.0
B748 09/02/16 00:00 24540. 10.0
C601 01/01/16 00:00 9000.0 10.0
E013 01/01/16 00:00  770.0 10.0
E013 09/08/16 13:45  0.0 0.0
E015 01/01/16 00:00 4989.4 10.0
```

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2. TLD

Annual TLD Results, 100-B/C RA						
1st Quarter '19						
EDP Code	Site Description	mrem/hr	mrem/day	mrem/qtr	mrem/year	Days in Field
T200	116-B-11					
T201	116-B-11					
T202	116-B-11					
T203	116-C-1					
2nd Quarter '15						
EDP Code	Site Description	mrem/hr	mrem/day	mrem/qtr	mrem/year	Days in Field
T200	116-B-11					
T201	116-B-11					
T202	116-B-11					
T203	116-C-1					

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3. EDD - GEL/Test America Lab result file

Soil & Groundwater Remediation Project				
Common Requirements of the Format for Electronic Analytical Data (FEAD) Version 8				
CP-15383		Published: December 2007		Page 34
<b>4.11 RADIOCHEMISTRY – HEADER LINE FORMAT</b>				
Table 4-11. Radiochemistry – Header Line Format. (2 Pages)				
Column(s)	Field Name	Mandatory?	Type	Format/Contents
1-2	Form Number	Y	Character (2)	“R” (radchem)
3-4	Form Suffix	Y	Character (2)	“AA”-“ZZ” (See field descriptions)
5	Record Type	Y	Character (1)	“H” (header)
6-9	Format Type	Y	Character (4)	“FEAD” – specifies data format
10-11	Version Number	Y	Character (2)	The version number of the FEAD document and all associated forms
12-23	Sample Number	Y	Character (12)	Supplied with sample (See field descriptions)
24-43	Contract		Character (20)	Contract number
44-49	Lab Code	Y	Character (6)	Abbreviated laboratory name (See field descriptions)
50-55	Lab Code Suffix	<sup>1</sup>	Character (6)	Used by laboratories at the Hanford Site to specify room number (See field descriptions)
56-65	Case Number	<sup>1</sup>	Character (10)	(See field descriptions)
66-71	SAS Number	<sup>1</sup>	Character (6)	Special analytical services number (See field descriptions)
72-83	SDG Number		Character (12)	Sample delivery group number (See field descriptions)
84-93	Analytical Matrix		Character (10)	“WATER”, “SOIL”, “GASEOUS”, “OTHERLIQ”, or “OTHERSOLID”
94-103	Lab Received Date		Character (10)	MM/DD/YYYY (See field descriptions)
104-113	Collected Date		Character (10)	MM/DD/YYYY (See field descriptions)
114-118	Percent Solids		Number (5,1)	Method and media-dependent (See field descriptions)
119	Decanted	<sup>2</sup>	Character (1)	“Y”, “N”, or space; method and media-dependent (See field descriptions)
120-131	Lab Sample ID		Character (12)	Laboratory sample identifier (See field descriptions)

4. PFP lab result file

```

"?", Sample #, EDP Code, Date Off, Time Off, Alpha result (pCi/filter), Alpha 95% Conf. Int. (pCi/filter), RUN ID
"?", "S376709", "Z129", "5/03/2001", "09:27", 5.600E-7, 1.252E-6, AA105041012
"?", "S376711", "Z152", "5/03/2001", "09:53", -2.100E-7, 1.526E-6, AA105041012
"?", "S376712", "Z153", "5/03/2001", "09:55", -7.000E-8, 1.594E-6, AA105041012
"?", "S376713", "Z162", "5/03/2001", "09:57", 1.050E-6, 1.365E-6, AA105041012
"?", "S376522", "Z177", "5/02/2001", "09:36", 9.100E-7, 1.029E-6, AA105041012
"?", "S376523", "Z179", "5/02/2001", "09:28", -7.000E-8, 4.116E-7, AA105041012
    
```

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## 5. HEIS Data

	SampleNum...	SampleDateTime	LocCo...	SampleCompositeFl...	FilterOnD...	FilterOffDate
1	S470382	2017-10-09 11:35:00	Y900	0	NULL	2017-07-13 08:47:00
2	S470383	2017-10-09 11:35:00	Y900	0	NULL	2017-07-13 08:47:00
3	S470384	2017-10-09 11:35:00	Y901	0	NULL	2017-07-13 08:07:00
4	S470393	2017-10-09 11:37:00	Y850	0	NULL	2017-06-06 07:13:00
5	S470394	2017-10-09 11:37:00	Y853	0	NULL	2017-06-06 10:25:00

**APPENDIX B**  
**RADIOLOGICAL RELEASE CALCULATIONS**

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## **APPENDIX B RADIOLOGICAL RELEASE CALCULATIONS**

### **B-1 INTRODUCTION**

The equations for calculating the radiological releases are in most Environmental Release System (ERS) documents. The main question has been “How are these equations executed in the software?” Information on the actual method for the radiological release calculations has been requested for many years. The ERS has been in development since the early N Reactor days of Hanford. The primary purpose of the ERS system has been to provide release information to comply with 40 CFR 61, “National Emission Standards for Hazardous Air Pollutants,” Subpart I Appendix E. It is relied on by MSA for environmental assurance as depicted in MSC-23333, *Environmental Quality Assurance Program Plan*. It is difficult to interpret the mental processes of the original programmers as to how the laws were being adhered to in each programming step.

### **B-2 RELEASE CALCULATIONS**

The actual calculation method of the release values has been desired for several years. The system used to do the calculations originated in the N Reactor era and has progressed since then.

The system is currently written in FORTRAN and uses a binary hierarchical database that is becoming more expensive to maintain and support.

The release is simply expressed as the summation of concentration of the various isotopes times the volume of air that passes through the filter.

Release = Units Factor \* ( $\Sigma$  Concentrations \* Volumes) / Correction Factor

The key to understanding the calculation hinges on the determination of the sample volumes and the concentrations used in the calculations. The volume is calculated from the stack flow information stored in the “.Flo” files associated with the stacks. Some stacks use a constant flow rate that is stored in the sample record header. The concentrations come from the database.

### **B-3 DATE AND TIME**

The ERS accounts for each minute of actual time from 1988 through 2087 using a 32-bit integer. The system includes adjustment for daylight saving time. The change in the calculations takes care of the changing of daylight savings time from the first Sunday in April to the last Sunday in October (pre 2005) to the now current practice from the second Sunday in March to first Sunday in November.

### **B-4 RELEASE CALCULATION EXECUTION**

The calculations are performed in a subroutine named “RLCALC.” It begins with the most recent sample stored in the database, progresses backwards in time until it finds a sample that, at least in part, resides in the report interval. It checks the time span of each sample to see when the

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filter was in service against the desired reporting period. The stack flow rate is then calculated for the span of time the filter was in service using either the stack flow data stored in the “.FLO” file or constant flow rate if variable flow data is not available. See Stack Flow and Detail Description below. The volume is then calculated in cubic centimeters for that span of time and accumulated in liters.

The ERS then checks the isotopes and related data. It checks to see if a given isotope is reported. If it is not reported, the volume is stored as unaccounted volume. For isotopes that are detected, the concentration and volume are used to calculate the release.

A release may be calculated using the unaccounted volume if there were no previous concentrations. If there were previous concentration, the average between the previous concentrations and the current concentration are used to calculate the release. The unaccounted volume will also be used in the case of missing isotopes, presumably because no other data is present. Additionally, when a factor is available it will be applied to the release value.

## **B-5 STACK FLOW**

The interval of time during which a filter was in service or the part of time the filter was in service during the reporting time is used to determine the stack flow rate. The stack flow rate is then used to calculate the volume of air that passed through the filter. The span of time in which the filter was in use is compared to the sample flow data if it exists.

The stack flow routine starts with the oldest data and proceeds to more current time to find the time span of interest. It locates the time where both the stack was operating and the filter was on. The stack volume and operating time is obtained during the periods of overlap between the operating stack and the time span the sample was in service. The system then does the interim calculations:

$$\text{Operating time} = \text{Operating time} + \text{Time of overlap in this segment}$$

And;

$$\text{Volume} = \text{Volume} + \text{Time of overlap in this segment} * \text{ERS stack flow rate.}$$

Only time periods in which the stack was operating are used. The stack flow rate is then calculated as the routine ends with:

$$\text{Stack Flow Rate} = \text{Volume} / (\text{span of time between the windowed interval})$$

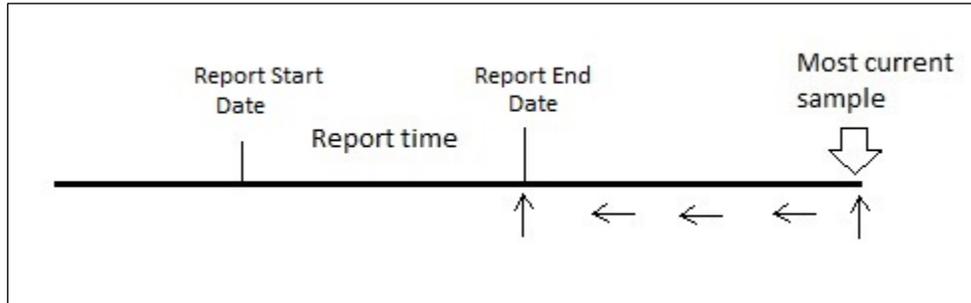
The windowed interval is usually the period of time the sample filter was in operation, though it may be smaller interval as when the sample was only in service at the beginning or end of the reporting time. For changes in the flow rates from the flow data stored in ERS, the method in ERS would make a time weighted flow rate that would be equivalent to a single rate as if the stack ran continuously during the time span.

## **B-6 DETAIL DESCRIPTION OF RELEASE ROUTINES**

The subtleties of the ERS calculations are difficult to explain in words.. The use of the following diagrams display the concepts that are implemented in the code. I believe this is the level of detail needed to understand the calculations.

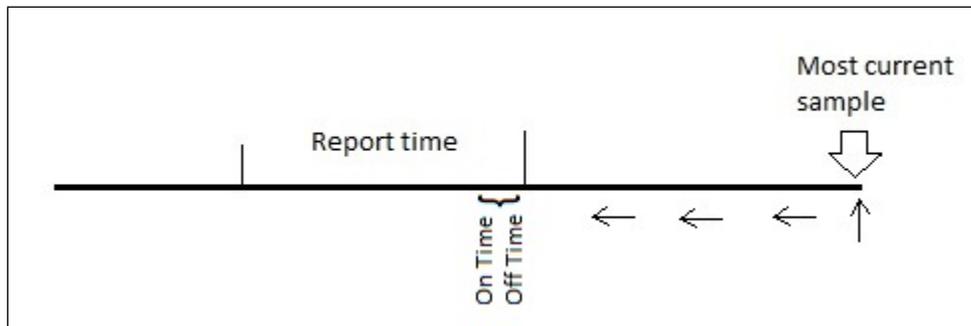
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The ERS system begins the evaluation of data with the most current sample and progresses backwards in time. Figure B-1 depicts a timeline for the ERS data. The ERS progresses backward in time until it finds data in the report time period. The report time period is specified with a start date and end date. These are usually January 1 to December 31 of any given year.



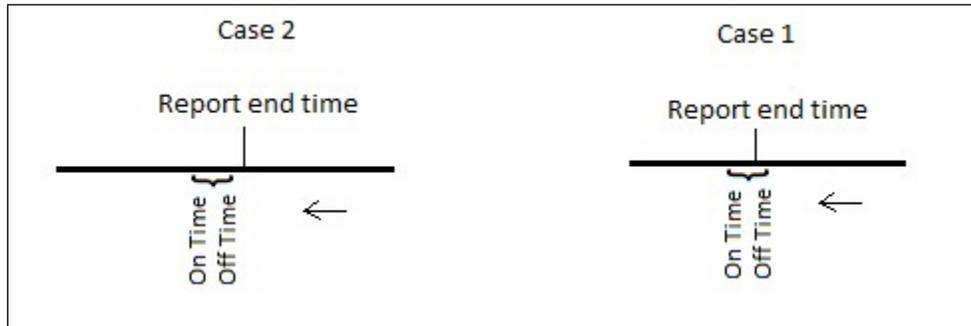
**Figure B-1. Release Calculation Setup Process.**

In Figure B-2 the ERS sorts backwards in time until the sample on time is less (earlier) than the end of the report time period. The filter on time is the time and date the filter was placed in the system. The filter off time is date and time the filter is taken out of the system and usually replaced with a new filter, thus resulting in a new filter on time.



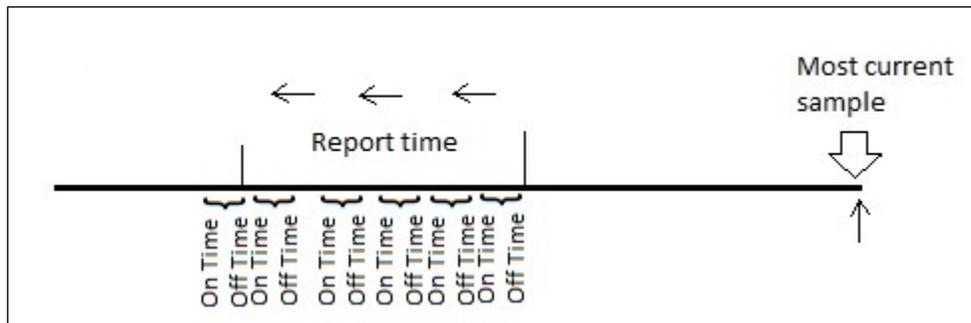
**Figure B-2. Finding the First Sample.**

In Figure B-3 two cases exist for establishing the start of the data since the sample on time is used. Case 1 is when the sample off time occurs after the end of the report. Case 2 is when the sample off time occurs before the end of the report. Both of these cases use the end of the report time as the starting time.



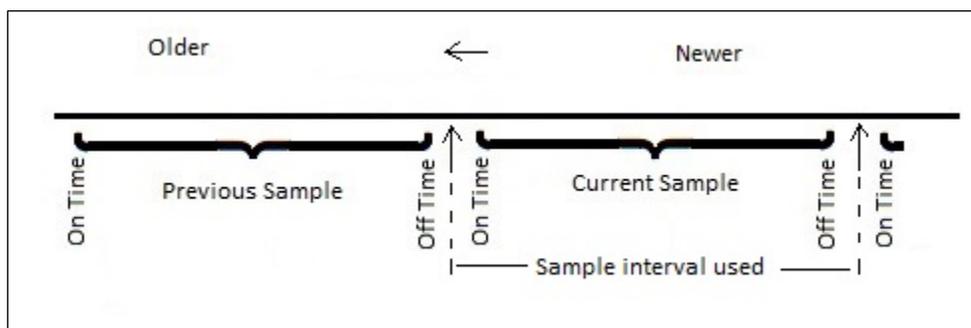
**Figure B-3. Starting Cases.**

In Figure B-4 the ERS progresses from more current data to older data calculating the release for each isotope that has meaningful data.



**Figure B-4. Continue Evaluation Samples.**

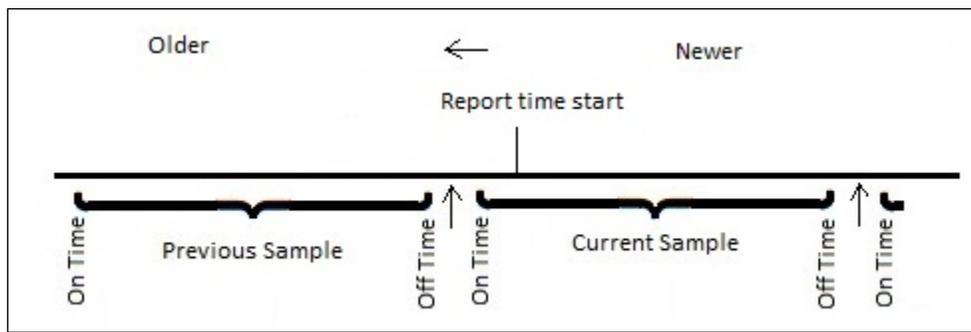
The ERS uses the time halfway between the current samples on time and the previous sample's off time. Instead of using the time between the filter on and filter off to calculate the release, the ERS uses a slightly larger time interval based on the time between the halfway points. Figure B-5 shows this larger interval. This shouldn't be a big issue usually, but be a factor with large breaks in time.



**Figure B-5. Regular Sample Intervals.**

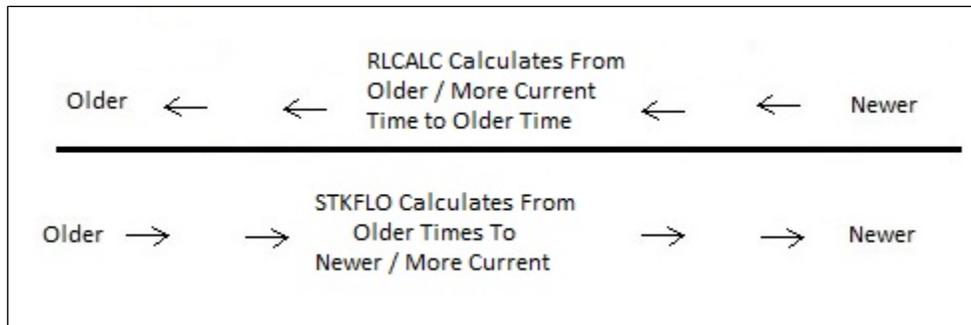
The ERS uses the first entry of the data file or the filter off time for the previous sample to note the final sample in the report period (Figure B-6). This is the start of the reporting time. Once the start of the reporting time is found, the ERS uses the report start time as the filter on time. The filter off time uses the value halfway between sample's on/off as noted in Figure B-5. This use of the report start time should have little effect on the calculations because of the method used to calculate the stack flow rate, which is the next topic.

The stack flow data are store in an accompanying file for each stack. These files contain a time when the stack was turned on, a time when the stack was turned off, a flow rate, and an uncertainty. It is assumed that the flow rate remains constant during the time period.



**Figure B-6. Final Report Time.**

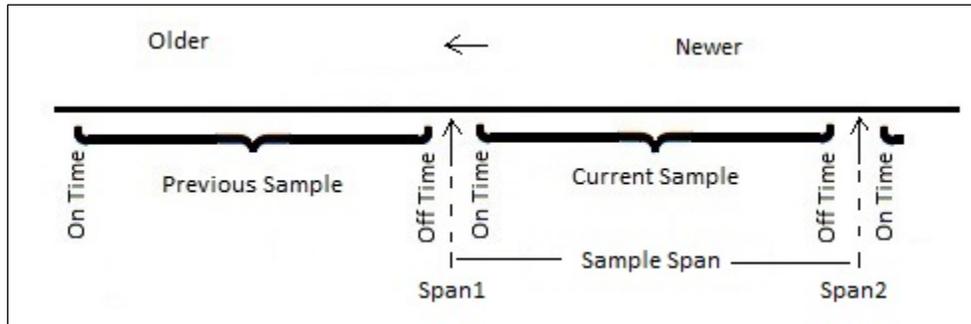
The calculation of the stack flow rate for ERS requires a bit of a paradigm shift. The routine that calculates the release values (RLCALC) starts with the most current samples time wise. It then goes backwards in time until it reaches the start of the report time or the beginning of the data file. The routine that calculates the stack flow rate (STKFLO) starts at the beginning of the data file, which is the oldest data, and works its way to the present. So they are moving in opposite directions, as depicted on Figure B-7.



**Figure B-7. Paradigm Shift**

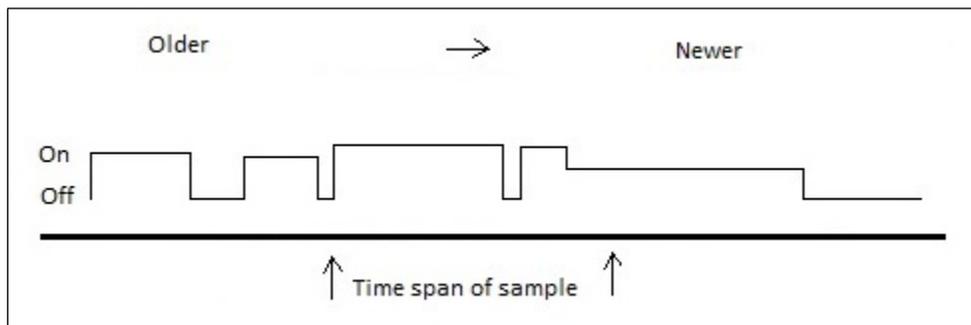
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This situation is handled in a unique way. It requires that we separate the two operations and establish a transferable reference shift. The ERS sets the time period of interest as a span of time with SPAN1 being the earlier of the times, and SPAN2 as seen in Figure B-8. Instead of the filter on time, we have a time that is similar, denoted as SPAN1, which is close but may reflect the start of the report time as in Figure B-6. Similarly, instead of a filter off time, we have SPAN2 time, which may be the end of the report time as in Figures B-2 and B-3. Both SPAN1 and SPAN2 may be the half way points too. The important aspect to concentrate on is the time span no matter how it is found.



**Figure B-8. Sample Span**

Figure B-9 shows a timeline similar to what we've seen earlier. We have two arrows pointing up that represent the SPAN1 and SPAN2 just introduced. The arrow pointing to the right is to remind us that we are moving toward more current data in time. The blocky line represents the stack flows and rates from the data file. Sometimes it is off, represented by the lower lines. The upper box-like lines are on values for the flow rates. Note that they may not always be the same rate, though this doesn't matter in the calculations.



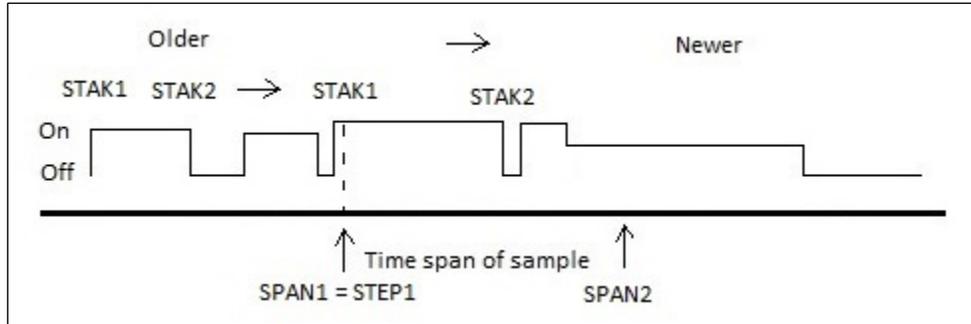
**Figure B-9. Stack Flow Data Representation.**

The use of the SPAN paradigm becomes very important in this transformation. Simply remember for this process that SPAN1 is the beginning of a span of time, and SPAN2 is the end of the span

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of time. The labels of STAK1 and STAK2 note the times the stack changes flow. The steps represent the intervals of change or steps that occur between the spans.

Figure B-10 shows STAK1 on the very left side of the diagram. This is the time at which the stack was turned on and had some flow rate denoted by the height of the rise in the line. STAK2 is the time the stack was turned off or to some lower level. ERS progresses through the stack data until we find data in the span. We mark the beginning STEP1 equal to the start of the span and set ending STEP2 equal to the time the stack flow rate changes (STAK2).



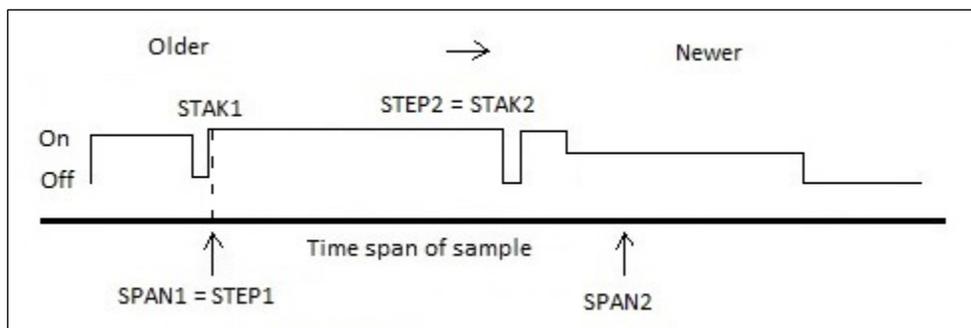
**Figure B-10. SPANs, STAKs, and STEPs.**

As we see in Figure B-11, STEP1 = SPAN1 and STEP2 = STAK2. Remember that these are times in minutes. We use these values to calculate:

Time during this step in minutes = STEP2 – STEP1;

Total time of operation = Time during this step in minutes (for now);

Total volume during this step = Stack flow rate \* Time during this step in minutes.

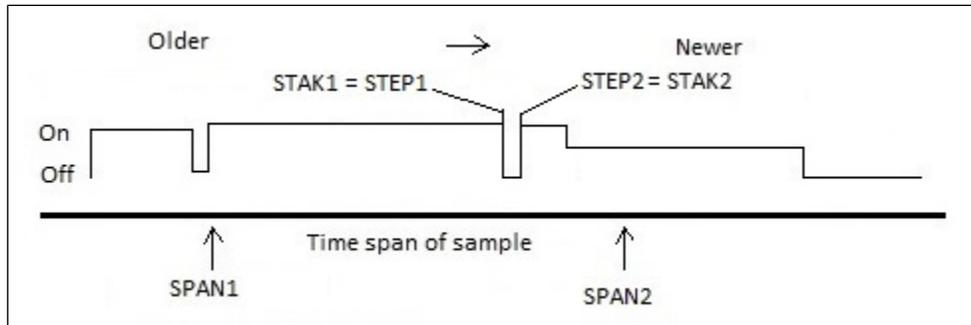


**Figure B-11. First Calculation**

Figure B-12 now shows the set STEP1 to the time which was STEP2 before. Looking at the next line of data in the stack flow file indicates that STAK1 and STAK2 change and note they are still in the interval of our span. Before we do the calculation, we note that the flow rate was 0, which

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cannot contribute to our volume calculations. We then move to the next stack flow line of data from the file.



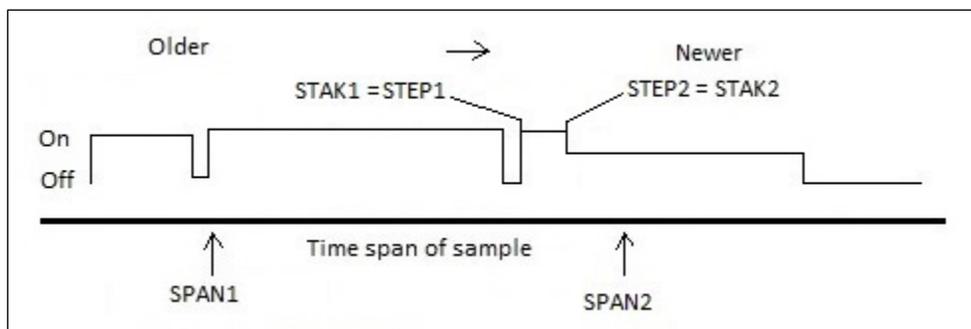
**Figure B-12. “Calculate” Off Time.**

Again moving our steps up to represent the next interval of stack flow data, Figure B-13 shows they are still in the SPAN of our sample time. So once again we can calculate:

Time during this step in minutes =  $STEP2 - STEP1$ ;

Total time of operation = Previous Total time of operation + Time during this step in minutes;

Total volume = Previous Total volume + Stack flow rate \* Time during this step in minutes.



**Figure B-13. Calculate Next Step.**

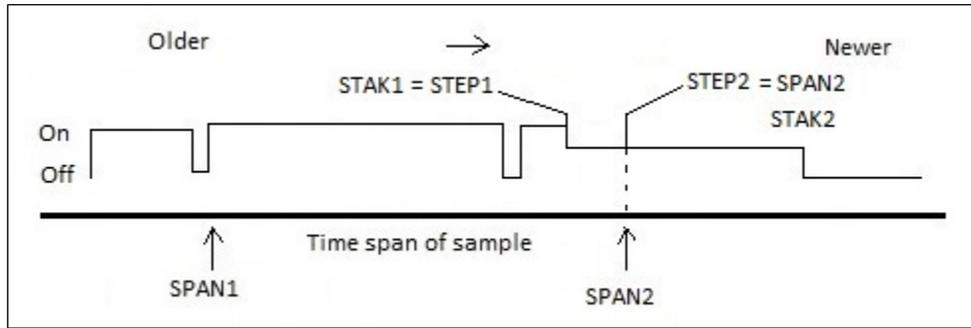
Note the contribution of this step will be different than the step interval of Figure B-11. This is more clear in the next step.

Figure B-14 shows the significance of using the step concept for passing through the sample span. We find that STAK2 is well beyond our sample span. In this case we set STEP2 equal to the end of the span (SPAN2). The flow rate for this step is much lower than the other flow rates in the span. The weight given to this step will thus be less.

Time during this step in minutes =  $STEP2 - STEP1$ ;

Total time of operation = Previous Total time of operation + Time during this step in minutes;

Total volume = Previous Total volume + Stack flow rate \* Time during this step in minutes.



**Figure B-14. Calculate Final Step.**

The ERS calculates a weighted flow rate before it returns for the volume and release calculations. The weighted flow rate is calculated by:

$$\text{Weighted flow rate} = \text{Total volume} / (\text{SPAN2} - \text{SPAN1}).$$

Note that time interval is not the time the stack was running but rather time span of the sample.

This concludes the detail methodology used in ERS. The process shown here is done for all sample intervals, or spans, throughout the reporting time. The flow rate evaluation is done for each span interval to yield a weighted flow rate. We then can see that the ERS can calculate for each stack the volume and release values as:

$$\text{Volume} = \text{Volume} + \text{Time span in this segment} * \text{ERS stack flow rate}$$

and;

$$\text{Release} = \text{Units Factor} * (\sum \text{Concentrations} * \text{Volumes}) / \text{Correction Factor}.$$

### B-7 RLCALC

```

Subroutine RLCALC !                               Release calculations
!
! This routine accumulates releases of all analytes for a file
! over the report period. Volume units are mls for the local
! variable VOLCCS and litres for the global variable VOLUME.
! Units of accumulated releases are Ci in array RELEAS and aCi
! in arrays R and UNFAC.
!
! Called by:          RLEXEC
! Calls:
!   Module Utilities: STKFLO
!   Utilities:       CHKBIT          DECODE          FETCHR
! Integer            :: I,          k_SPAN(2), Irec, IISO ! +++
! Integer, Allocatable :: ISO(:)
! Real               :: C,          RTIME,          STIME,
! & Real, Allocatable :: VOLCCS
! Real, Allocatable  :: PC(:),     R(:),          UNACC(:)
    
```

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```

!                                     Initialize
Allocate (PC(54), ISO(54), R(54), UNACC(54))
OPTIME=0.0 !                               Stack operating time (minutes); this file
VOLUME=0.0 !                               Stack volume (litres); this file
RTIME=Float(k_RPRT(2)-k_RPRT(1)) !         Report time, minutes
Write (5,*) 'in RLCALC RTIME = ', RTIME, k_RPRT(2), k_RPRT(1) ! +++
INITIALIZE_ISOTOPES: Do ISO=1, 54 ! -----|
  PC(ISO)=-1.0 !                             Previous concentration, aCi/cc
  UNACC(ISO)=0.0 ! Stack vol for which no conc reported, cc
  R(ISO)=0.0 !                               Release by isotope, aCi
  ISO(ISO)=ISO !                             No substitution
End Do INITIALIZE_ISOTOPES ! -----|
Write (5,*) 'done intializing' ! +++

!                                     Save factor extrema
If (EFF_AIR()) then ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA;
Write (5,*) 'Effluent Air', EFF_AIR()
  I=dr_%STYPE !                               Air sampler type 3
  If (I.eq.3) I=1 ! Composites and a/a data share factors 3
  If (I.eq.5) I=3 ! Put Pb-212 factors in the unused slot 3
  RELFAC(1, I)=aMin1(RELFAC(1, I), dr_%F) ! minimum F, by type 3
  RELFAC(2, I)=aMax1(RELFAC(2, I), dr_%F) ! maximum F, by type 3
  Write (5,*) 'dr_%Stype, I ', dr_%STYPE, ' ', I, ' Min/max ',
  & RELFAC(1, I), ' ', RELFAC(2, I) ! +++
End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU
!                                     Calculate the release from this sample
k_SPAN(1)=k_RPRT(2) ! Start at the end of the report period

!
! ISO_DUMP : DO IISO = 1, 54
! Write (5,*) 'ISO = ', IISO
! Write (5,*) 'REC ', ' OFF ', ' ON ', ' PRV ', ' CONC ', ' FLAG'
! Con_Dump : Do Irec = dr_%n_RECS, 1, -1
! If (.not. FETCHR(k_SMPLS(Irec), .True.)) Go To 77 !
! 77 WRITE (5,*) Irec, sr_%k_OFF, sr_%k_ON, sr_%k_PRV, sr_%C(IISO),
! & sr_%U(IISO)
! END DO Con_Dump
! WRITE(5,*)
! END DO ISO_DUMP

!
! Do REC=dr_%n_RECS, 1, -1 ! -----|
! If (k_SMPLS(REC).le.k_RPRT(1)) Exit !
! If (.not. FETCHR(k_SMPLS(REC), .True.)) Stop !
! If (sr_%k_ON.ge.k_RPRT(2)) Cycle !
! If (VOLUME.eq.0.0) then ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA;
! Save earliest date projecting began
! k_PLOT(2)=Min0(k_SMPLS(REC), k_PLOT(2)) !
! If (Float(k_RPRT(2)-k_PLOT(2)).gt.0.03*RTIME) !
! & b_NOTE(2)=.True. ! Results projected forward 3
! & Write (5,*) 'loop1 stuff ', REC, k_SMPLS(REC), k_RPRT(1), ! +++
! & RTIME, sr_%k_ON, k_RPRT(2), VOLUME, b_NOTE(2), dr_%c_FDF ! +++
! End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU
! k_SPAN(2)=k_SPAN(1) ! End of this sample's span
! If (REC.eq.1.or.sr_%k_PRV.lt.k_RPRT(1)) then ! AAAAAAAAAAAAAAA;
! k_SPAN(1)=k_RPRT(1) ! Final (i.e., earliest) sample 3
! If (sr_%k_ON.gt.k_RPRT(1)) then ! AAAAAAAAAAAAAAAAAAAAAAA; 3
! k_PLOT(1)=Max0(sr_%k_ON, k_PLOT(1)) ! "Preject" ended 33
! If (Float(sr_%k_ON-k_RPRT(1)).gt.0.03*RTIME) ! 33
! & b_NOTE(1)=.True. ! Results projected backwards 33
! & Write (5,*) 'projected backwards ', REC, k_SMPLS(REC), ! +++
! & k_RPRT(1), RTIME, sr_%k_ON, k_RPRT(2), VOLUME, b_NOTE(1) ! +++
! End If ! AAAAAAAAAAAAAAAAAAAAAAA; 3
! Else if (sr_%k_ON.le.0) then ! AAAAAAAAAAAAAAAAAAAAAAA;
! k_SPAN(1)=(k_SMPLS(REC)+sr_%k_PRV)/2 ! Grab samples 3
! Write (5,*) 'grab sample', k_SPAN(1) ! +++
! Else if (sr_%k_ON.ge.sr_%k_PRV) then ! AAAAAAAAAAAAAAA;

```

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```

      k_SPAN(1)=(sr_%k_ON+sr_%k_PRV)/2 !           Timed samples 3 |
      Write (5,*) 'timed sample ',sr_%k_ON,' ',sr_%k_PRV, ! +++
&      ' ',k_SPAN(1) ! +++
Else ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA |
      k_SPAN(1)=sr_%k_PRV !                               Sample overlaps 3 |
      n_ERRS=n_ERRS+1 !                                     3 |
      Write (7,1) n_ERRS,dr_%c_FILE,sr_%c_ID,DECODE(k_SAM), ! 3 |
&      DECODE(sr_%k_PRV) !                               3 |
      Write (5,1) n_ERRS,dr_%c_FILE,sr_%c_ID,DECODE(k_SAM), ! +++
&      DECODE(sr_%k_PRV) ! +++
1      Format (i3,' ',a4,' sample ',a8,' (' ,a8,' ) overlap', ! 3 |
&      's previous sample (' ,a8,' ).') !               3 |
End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU
!      Calculate Volume over Span Time; Accumulate Volume
      STIME=Fl oat(k_SPAN(2)-k_SPAN(1)) ! Sample span time, min
      VOLCCS=STKFLO(k_SPAN)*STIME*1.0e+3 ! Liquids, cc's from L
      If (EFF_AIR()) VOLCCS=28.316*VOLCCS ! Air, cc's from ft3
      VOLUME=VOLUME+1.0e-3*VOLCCS ! Accumulated volume, litres
      Write (5,*) 'calc vol ',STIME,' ',VOLCCS,' ',VOLUME ! +++
Write (5,*) 'Stack Flow = ',STKFLO(k_SPAN), k_SPAN(1),k_SPAN(2)
!      Calculate release of each isotope over span time
      If (VOLCCS.gt.0.0) then ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU
        ISOTOPES: Do ISO=1,54 ! -----U
          I=ISO(ISO) ! I is isotope credited with the release 3 |
          Write (5,*) 'isotope = ',ISO ! +++
!
        If (CHKBIT(ISO,hr_%d_RFLG)) then ! AAAAAAAAAAAAAAAAAAAU; 3 |
          If (.not.REPORTED(ISO)) then ! AAAAAAAAAAAAAAAAAAAU; 3 |
            UNACC(I)=UNACC(I)+VOLCCS ! Unaccounted vol, cc 33 |
            Else ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU 3 |
! If isotope not reorted - assign as unaccounted for volume
              b_SHOW(I)=.True. ! Show this analyte in report 33 | 3 |
              C=0.0 ! Assume analyte not detected 33 | 3 |
!
              If (DETECTED(ISO)) then ! AAAAAAAAAAAAAAAAAAAU; 33 | 3 |
                C=sr_%C(ISO) ! Sample concentration, aCi/cc 333 | 3 |
                If (C.gt.PEAK(I)) PEAK(I)=C ! Maximum conc. 333 | 3 |
                R(I)=R(I)+C*VOLCCS ! Release, aCi 333 | 3 |
!
                IF (I .eq. 13) then
                  Write (5,*) 'ISO1 REC, R C Vol cc ',I,' ',REC,' ',R(I),' ',C,
&                  ' ',vol CCS !
+++++
!      END If
!      End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU 33 | 3 |
!      One or more previous results not reported 33 | 3 |
      If (UNACC(I).gt.0.0) then ! AAAAAAAAAAAAAAAAAAAU; 33 | 3 |
        If (PC(I).lt.0.0) R(I)=R(I)+UNACC(I)*C ! 333 | 3 |
        If (PC(I).ge.0.0) ! 333 | 3 |
&          R(I)=R(I)+UNACC(I)*0.5*(PC(I)+C) ! 333 | 3 |
          R(I)=R(I)+C*VOLCCS ! Release, aCi 333 | 3 |
!
          IF (I .eq. 13) then
            Write (5,*) 'Release2 ',I,R(I),C,vol CCS,PC(I),UNACC(I) !
+++++
!      End IF
          UNACC(I)=0.0 ! No unaccounted volume 333 | 3 |
          End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU 33 | 3 |
          PC(I)=C ! Previous concentration, aCi/cc 33 | 3 |
          End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU; 3 | 3 |
          End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU 3 | 3 |
          End Do ISOTOPES ! -----U 3 |
          End If ! AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAU 3 |
End Do ! -----U

```





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**APPENDIX C**  
**EXAMPLE REPORTS AND PLOTS**

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## APPENDIX C EXAMPLE REPORTS AND PLOTS

**Table 2-1. Hanford Site Radionuclide Air Emissions from Major Stacks in Calendar Year 2016**  
(Radiological Dose Potential of >0.1 mrem/yr EDE to Nearest Public Receptor)<sup>a</sup> (7 pages)

Stack (Facility; Contractor; EDP Code) <sup>b</sup>	Average Operating Flow Rate, <sup>c</sup> ft <sup>3</sup> /min (m <sup>3</sup> /s)	Volume, ft <sup>3</sup> (m <sup>3</sup> )	Radionuclide or Type of Radioactivity	Average Operating Concentration, <sup>d</sup> μCi/mL	Emissions, Ci	EDE to MEI, <sup>e</sup> mrem
EP-331-01-V  (331 Building;  PNNL; NA)	61,600  (29.1)	3.24E+10  (9.17E+08)	<sup>60</sup> Co	7.1E-17	6.5E-08	1.5E-07
			<sup>90</sup> Sr	9.0E-17	8.2E-08	2.2E-07
			<sup>137</sup> Cs	5.4E-18	4.9E-09	1.7E-08
			<sup>237</sup> Np	1.5E-17	1.4E-08 <sup>h</sup>	2.7E-07
			<sup>238</sup> Pu	4.0E-17	3.7E-08 <sup>h</sup>	1.4E-06
			<sup>239/240</sup> Pu	0	<0	0
			<sup>241</sup> Am	1.0E-19	9.3E-11	3.1E-09
			<sup>243</sup> Am	4.4E-17	4.0E-08 <sup>h</sup>	1.4E-06
			gross α	3.2E-17	3.0E-08	1.2E-06
			gross β	2.3E-16	2.1E-07	7.1E-07
EP-331-01-V Total Dose:						5.3E-06

**General definitions:** ≤0 = analytical result equal to level of laboratory ambient background radioactivity or less than that level, which in practical terms means the radionuclide or type of radioactivity was not detected in the sample of the emission collected; Ci = curie; 1 Ci = 3.7E+10 becquerels (Bq); ft<sup>3</sup> = cubic feet; HT is tritium, or elemental tritium, in the form of an incondensable gas; HTO is tritiated water vapor, or tritium in the form of condensable water vapor; m<sup>3</sup> = cubic meters; min = minute; mrem = millirem; 1 mrem=0.01 mSv; NA = not applicable; s = second; yr = year.

<sup>a</sup>Determining the potential prospective dose impact of each stack necessitated using nearest public receptors, who may differ from the annually determined Hanford Site MEI.

<sup>b</sup>Abbreviations and acronyms in this column are: CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980; CHPRC = CH2M HILL Plateau Remediation Company; CSB = Canister Storage Building; CVDF = Cold Vacuum Drying Facility; EDP code = electronic data processing code, used in chain-of-custody activities to identify sampling locations; PNNL = Pacific Northwest National Laboratory; PFP = Plutonium Finishing Plant; PUREX = Plutonium-Uranium Extraction; TF = Tank Farms; WCH = Washington Closure Hanford, LLC; WESF = Waste Encapsulation and Storage Facility; WRAP = Waste Receiving and Processing Facility; WRPS = Washington River Protection Solutions, LLC.

<sup>c</sup>Reflects stack flow rate averaged over time of stack operation or averaged over the calendar year.

<sup>d</sup>Reflects concentration averaged over time of stack operation.

<sup>e</sup>EDE for MEI = effective dose equivalent for the maximally exposed individual; for calendar year 2016, the MEI was located at LSW, 3475 George Washington Way, in north Richland, Benton County, directly south of the Hanford Site 300 Area.

<sup>f</sup>Emissions from this stack are associated with cleanup operations conducted under the authority of CERCLA. Reporting its emissions in Table 2-1 demonstrates compliance with the monitoring requirements of 40 CFR 61, Subpart H, a substantively equivalent law (i.e., "applicable or relevant and appropriate requirement") as defined by CERCLA.

<sup>g</sup>Release value based on release records from annual PNNL Radioactive Gas Inventory database.

<sup>h</sup>Release value was calculated using Appendix D method of 40 CFR 61 and annual PNNL material inventories.

<sup>i</sup>Radon release value conservatively calculated, not actually measured, and is based on release records from annual PNNL Radioactive Gas Inventory database.

<sup>j</sup>Heat trace arced through the sample line sometime between 2/1/16 and 3/7/16. During that period the filter collected combustion particulates and ambient air for some unknown length of time. Therefore, the samples collected during that period do not constitute a representative sample of the PUREX Stack effluent and those results were not used to calculate emissions.

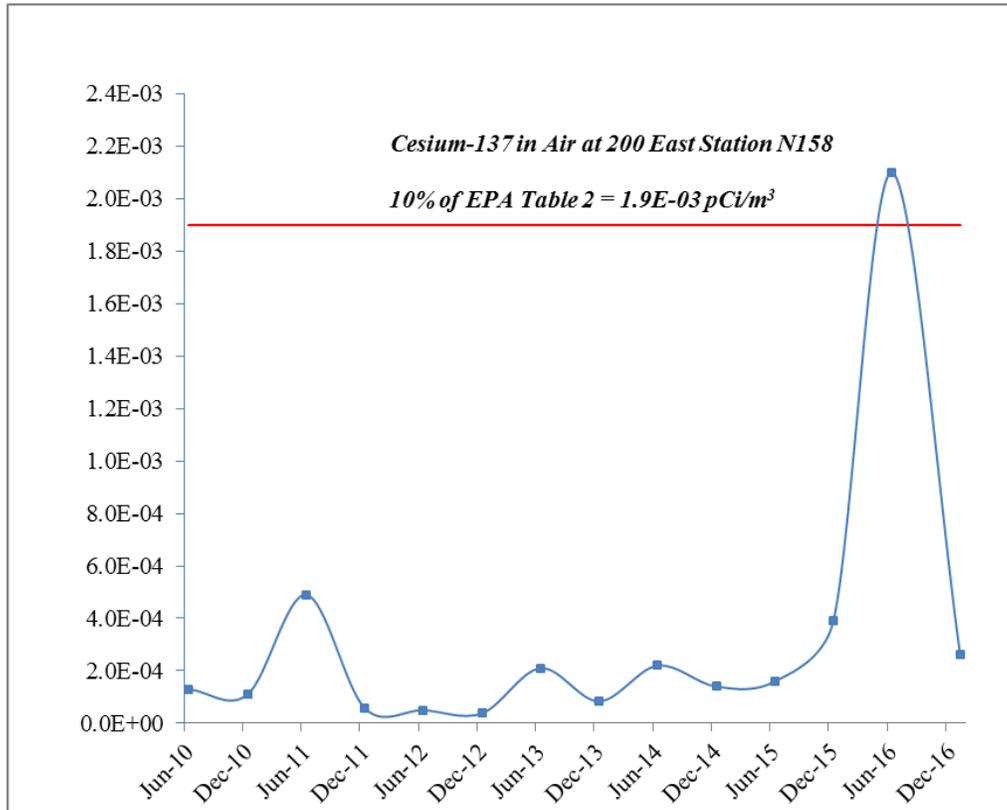
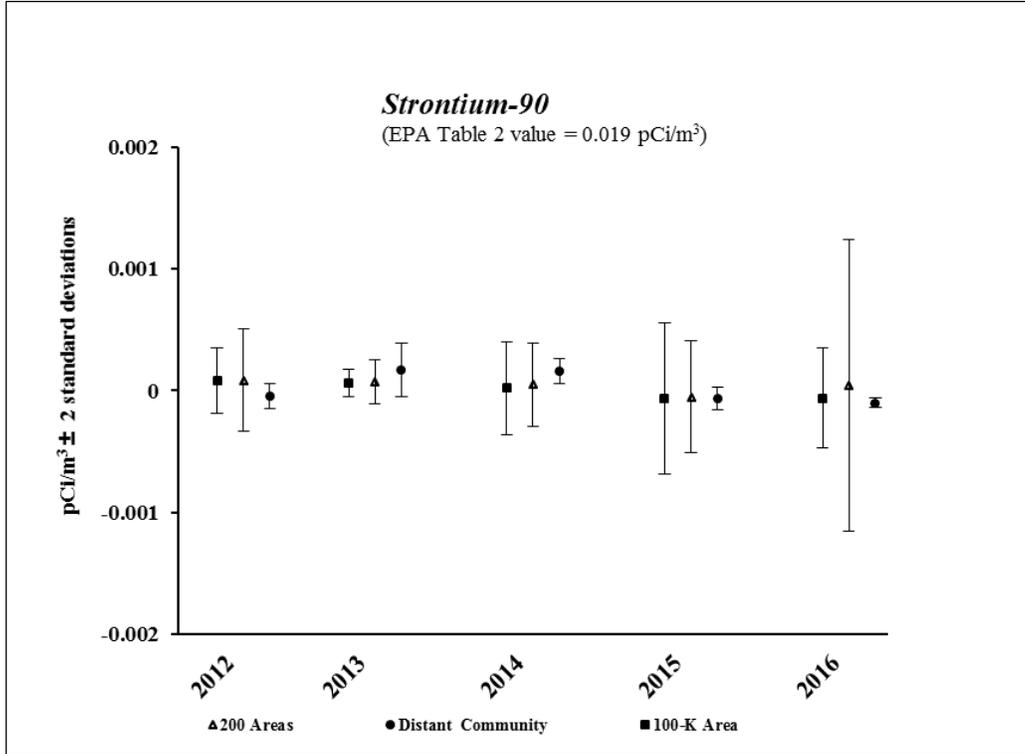
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**Table 2-2. Hanford Site Radionuclide Air Emissions from Minor Stacks in Calendar Year 2016**  
(Radiological Dose Potential of <0.1 mrem/yr EDE to Nearest Public Receptor)<sup>a</sup> (4 pages)

Stack (Facility; Contractor; EDP Code) <sup>b</sup>	Average Operating Flow Rate, <sup>c</sup> ft <sup>3</sup> /min (m <sup>3</sup> /s)	Volume, ft <sup>3</sup> (m <sup>3</sup> )	Radionuclide or Type of Radioactivity	Average Operating Concentration, <sup>d</sup> μCi/mL	Emissions, Ci	EDE to MEI, <sup>e</sup> mrem
296-P-23	858	4.5E+08	gross α	5.6E-16	9.9E-09	5.4E-09
and	(0.41)	(1.3E+07)	gross β	1.3E-15	2.2E-08	1.2E-09
296-S-25 (TF; WRPS; W190 & W145; These two stacks exhaust the same source)]						
296-P-23 and 296-S-25 Total Dose:						6.6E-09
296-S-16	20	1.1E+07	gross α	8.6E-16	3.5E-10	1.9E-10
(219-S; WRPS; S264)	(0.01)	(3.0E+05)	gross β	3.7E-15	1.5E-09	8.2E-11
296-S-16 Total Dose:						2.7E-10
296-S-23	This stack is sampled every odd year via nondestructive analysis of its primary HEPA filter.					
296-T-7	3.77	1.98E+06	<sup>137</sup> Cs	≤0	0	0
(2706-T; CHPRC; T154)	(0.001)	(5.6E+04)	gross α	≤0	0	0
			gross β	2.1E-15	1.7E-09	9.2E-11
296-T-7 Total Dose:						9.2E-11
<b>300 Area</b>						
EP-331-09-S	20,700 <sup>h</sup>	1.09E+10	<sup>14</sup> C	3.7E-13	1.15E-04 <sup>i</sup>	1.8E-06
(331 Building; PNNL; NA)	(9.8)	(3.09E+08)	gross α	3.3E-18	1.0E-09 <sup>j</sup>	4.0E-08
			gross β	1.3E-14	4.0E-06 <sup>i</sup>	1.4E-05
EP-331-09-S Total Dose:						1.5E-05
<b>400 Area</b>						
437-1-61	4,500	2.4E+09	gross α	≤0	0	0
(MASF; CHPRC; F019)	(2.12)	(6.7E+097)	gross β	2.3E-16	2.1E-08	5.0E-09
437-1-61 Total Dose:						5.0E-09
437-MN&ST	11,287	5.9E+09	gross α	2.9E-15	7.4E-07	2.0E-06
(MASF; CHPRC; F014)	(5.33)	(1.7E+08)	gross β	7.2E-15	1.9E-06	4.6E-07
437-MN&ST Total Dose:						2.5E-06

**Table 5-5. Hanford Site Far-Field Monitoring Ambient Air Sampling Results for Calendar Year 2016 (2 sub-tables, 4 pages)**

Far-Field Monitoring Ambient Air Sampling Results: Onsite, Perimeter, Nearby Community, and Distant Locations					
EDP Code	Radionuclide or Type of Radioactivity	Concentration, pCi/m <sup>3</sup>			
		1st Half	2nd Half	Average	Maximum
<i>Onsite</i>					
N900 (100-K Area)	gross α	NA	NA	1.0E-03	3.8E-03
	gross β	NA	NA	1.7E-02	4.6E-02
	<sup>3</sup> H	NA	NA	9.4E+00	9.4E+00
N901 (200-W Southeast)	gross α	NA	NA	8.4E-04	3.2E-03
	gross β	NA	NA	1.6E-02	5.8E-02
	<sup>234</sup> U	6.0E-05	ND	6.0E-05	6.0E-05
	<sup>238</sup> U	ND	4.1E-05	4.1E-05	4.1E-05
N902 (300 NE)	gross α	NA	NA	9.3E-04	3.0E-03
	gross β	NA	NA	1.7E-02	4.3E-02
	<sup>3</sup> H	NA	NA	1.5E+01	3.4E+01
	<sup>234</sup> U	5.5E-05	7.4E-05	6.5E-05	7.4E-05
	<sup>238</sup> U	ND	6.0E-05	6.0E-05	6.0E-05
N903 (300 South Gate)	gross α	NA	NA	9.1E-04	2.8E-03
	gross β	NA	NA	1.7E-02	4.5E-02
	<sup>3</sup> H	NA	NA	9.1E+00	1.0E+01
	<sup>234</sup> U	1.1E-04	3.8E-05	7.3E-05	1.1E-04
	<sup>238</sup> U	5.7E-05	5.3E-05	5.5E-05	5.7E-05
N904 (300 Trench)	gross α	NA	NA	9.8E-04	4.0E-03
	gross β	NA	NA	1.8E-02	4.4E-02
	<sup>3</sup> H	NA	NA	1.6E+01	2.8E+01
	<sup>106</sup> Ru	ND	6.4E-03	6.4E-03	6.4E-03
	<sup>234</sup> U	4.4E-05	6.3E-05	5.3E-05	6.3E-05
	<sup>238</sup> U	ND	3.6E-05	3.6E-05	3.6E-05
N905 (300 Water Intake)	gross α	NA	NA	9.4E-04	3.5E-03
	gross β	NA	NA	1.7E-02	4.6E-02
	<sup>3</sup> H	NA	NA	6.9E-03	7.5E+00
	<sup>234</sup> U	ND	7.5E-05	7.5E-05	7.5E-05
	<sup>238</sup> U	4.9E-05	3.1E-05	4.0E-05	4.9E-05
N906 (WYE Barricade)	gross α	NA	NA	9.8E-04	4.6E-03
	gross β	NA	NA	1.7E-02	4.6E-02
	<sup>234</sup> U	4.4E-05	4.0E-05	4.2E-05	4.4E-05
	<sup>238</sup> U	2.6E-05	6.5E-05	4.6E-05	6.5E-05
N918 (300 South West)	gross α	NA	NA	9.0E-04	3.2E-03
	gross β	NA	NA	1.7E-02	4.3E-02
	<sup>3</sup> H	NA	NA	2.0E+01	2.2E+01
	<sup>234</sup> U	ND	5.1E-05	5.1E-05	5.1E-05
	<sup>238</sup> U	ND	4.7E-05	4.7E-05	4.7E-05



05/18/17

# ERS STACK FLOW REPORT

Thu 16:04

## 291-A-1: PUREX MAIN STACK

01/01/16 through 12/31/16

Stack operated 366.0 days

Total Volume: 4.3e+11 Liters = 1.5e+10 ft<sup>3</sup>

Average Stack Flow Rates: Overall 28654 cfm, Operating 28654 cfm

<u>Starting</u>	<u>Ending</u>	<u>Stack Flow Rate ± Uncertainty</u>	<u>Volume</u>
01/01/16 00:00	12/31/16 23:59	28654 cfm ± 10.0%	1.5E+10 ft <sup>3</sup>

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