Department of Toxic Substances Control

Matthew Rodriquez
Secretary for
Environmental Protection

Deborah O. Raphael, Director
8800 Cal Center Drive
Sacramento, California 95826-3200

Edmund G. Brown Jr.
Governor

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“Cover Sheet” To: Final Results Report, Chemical Soil Background Study

The Final Chemical Soil Background Study (Study) Report, for the Santa Susana Field Laboratory (SSFL) was prepared for the Department of Toxic Substances Control (DTSC) by URS Corporation and is posted to the DTSC SSFL website’s “Document Library.”

The Study’s chemical analytical data represent background and the statistical results are valid and reliable for their intended purposes; based on the following:

1. Extensive work, including site visits, aerial photograph and fire history reviews, and historical research, was conducted to help ensure that the chemical background reference areas (CBRAs) were not impacted by SSFL activities. Moreover, the two western radiological background reference areas (RBRAs), of the three RBRAs selected by the U.S. Environmental Protection Agency, are located in the same general area as the Study’s CBRAs and all three RBRAs were also found not to be impacted by SSFL site-related contamination.

2. Industry-standard statistical methods were used in accord with agency guidance, along with professional judgment, to derive Background Threshold Values (BTVs) for SSFL application as discussed below.

The following summarizes DTSC’s view on using the Study’s results in developing Look-Up Table (LUT) values for the Department of Energy (DOE) and National Aeronautics and Space Administration (NASA) cleanup at SSFL under the Administrative Orders on Consent (AOCs) and for The Boeing Company’s (Boeing) SSFL cleanup under the 2007 Consent Order.

The AOCs identify that after the chemical background study is done, a look-up table of the chemical cleanup levels will be prepared, which will include both local background concentrations as well as minimum detection limits for specific contaminants whose minimum detection limits exceed local background concentrations.

The AOCs define a chemical’s “detection limit” as the “method reporting limit (or MRL), which is the lowest concentrations at which an analyte can be confidently detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision.”

The MRLs will require taking into consideration what the laboratories, contracted to analyze soils samples that are collected in accordance with the AOCs, are able to report “with a reasonable degree of accuracy and precision.” Additionally, DTSC is evaluating the BTVs that were estimated on a stratified basis (i.e., different geologic formations and topographies), as listed in the report, and on a non-stratified basis (i.e., combined) that are listed in the Report’s combined-data BTV supplement, dated December 20, 2012, that is also posted to the DTSC SSFL website’s Document Library.

The BTVs and MRLs listed in the Study’s report will aid in the process to develop the chemical LUT values. The process to develop the LUT values will be discussed with stakeholders and the responsible parties.

AOC-Based Cleanups (DOE and NASA)

Under the AOCs, the Study’s Report recommends that DTSC apply the BTVs that are estimated using the Upper Simultaneous Limit, at 95% confidence (USL95). This recommendation, accepted by DTSC, is supported by the following:

1. There are few confirmed outliers in the Study’s analytical data and these outliers were not used in the statistical evaluation that aided in deriving the BTVs. The Study’s Report documents the step-by-step process that was used to confirm outliers.

2. The AOCs’ approach uses do-not-exceed values, based on background, as the decision points. The AOC cleanup evaluation process does not require involving risk assessment, but will involve point-by-point and analyte-by-analyte comparisons for determining remediation areas. Therefore, reasonable efforts must be made to focus on contaminated areas and to avoid removing soil that is not contaminated (i.e., reduce the number of false-positive results). Compared to the other statistics examined in the Study, the USL95 provides the best method for limiting the number of false positives within the methodologies that will be employed in the AOC-based cleanups. The other statistical methods that were assessed incorporate the possibility of more false-positive results, which means that more non-contaminated areas would be removed.

Risk-Assessment-Based Cleanup (Boeing portion)

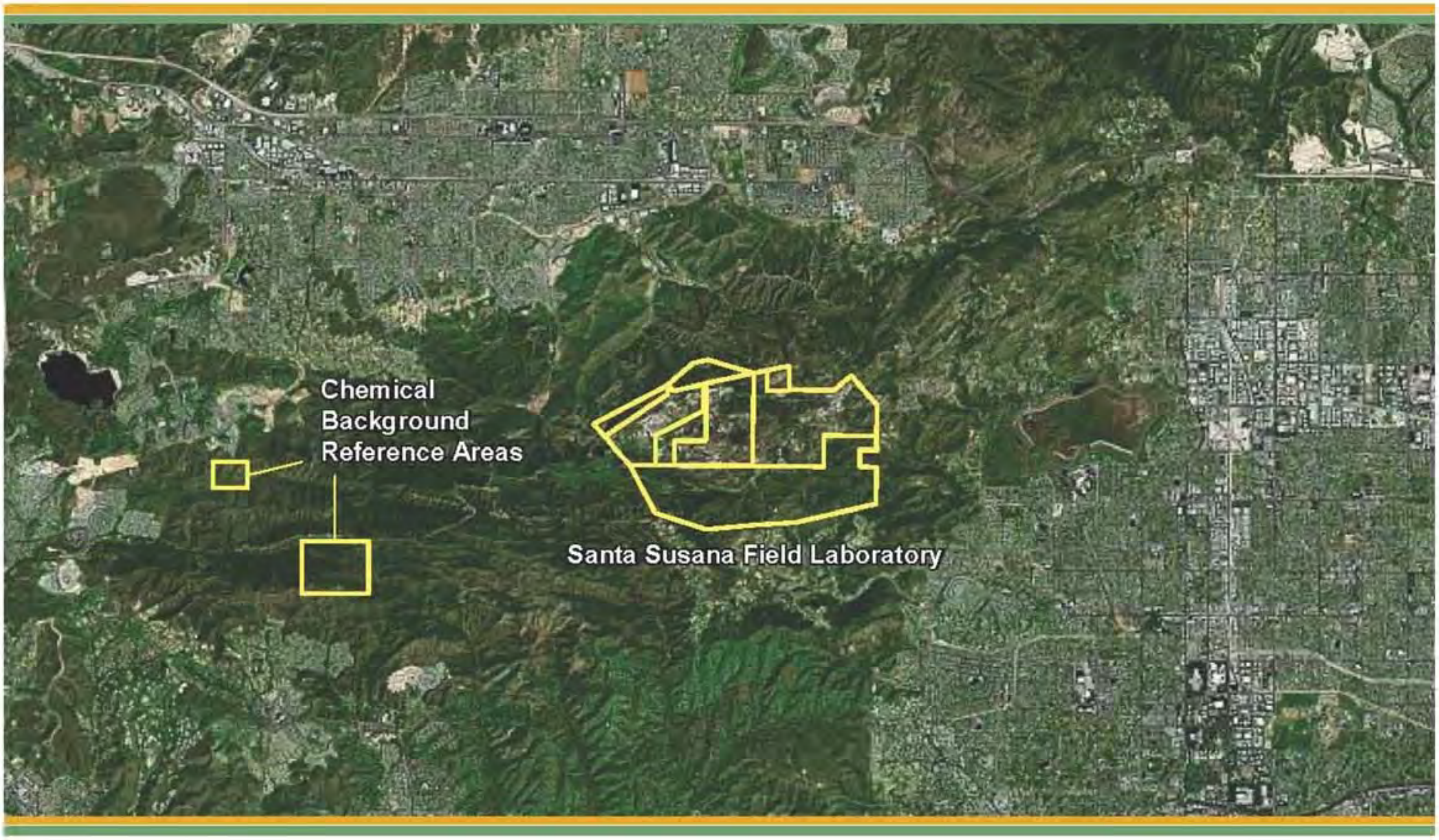
In the risk-assessment process, the Upper Tolerance Limit, with 95% coverage and 95% confidence (UTL95-95), is typically used to derive BTVs. In this process, these BTVs are compared to individual site-sample results, with the goal of differentiating non-impacted locations from impacted locations.

When compared to the USL95, using the UTL95-95 BTVs results in higher false-positive rates (i.e., where soil is indicated to be contaminated when, in fact, it is not) and lower false-negative rates (i.e., where soil is indicated as not contaminated when, in fact, it is) and end up underestimating risk for the site. Therefore, results developed using UTL95-95 BTVs are more likely to indicate locations that are identified as impacted, when they are, in fact, part of the background population.

For the Boeing (risk-based approach) portions of the site, the UTL95-95 BTVs provide a reasonable balance between the false-positive and false-negative errors.

CHEMICAL SOIL BACKGROUND STUDY REPORT

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA
Final



CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
DEPARTMENT OF TOXIC SUBSTANCES CONTROL

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FINAL

CHEMICAL SOIL BACKGROUND STUDY REPORT

SANTA SUSANA FIELD LABORATORY VENTURA COUNTY, CALIFORNIA

Prepared for

California Environmental Protection Agency
Department of Toxic Substances Control

URS Project No. 29403635

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URS

915 Wilshire Boulevard, Suite 700
Los Angeles, CA 90017
213-996-2200   Fax: 213-996-2290

CHEMICAL SOIL BACKGROUND STUDY REPORT

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

This Chemical Soil Background Study Report for the Santa Susana Field Laboratory in Ventura County, California, was prepared by URS Corporation on behalf of the California Department of Toxic Substances Control (DTSC) in a manner consistent with the level of care and skill ordinarily exercised by professional engineers, geologists, and environmental scientists. This report was prepared under the technical direction of the undersigned.

URS CORPORATION

Thomas J Dolan

Thomas J. Dolan, P.E.
Project Manager
P.E. Registration No. 42030

Brian

Brian J. Jacobs, P.G., C.HG.
Program Manager
P.G. Registration No. 6652

Ram B. Kulkarni

Ramchandra Kulkarni, Ph.D.
Project Statistical Manager

CHEMICAL SOIL BACKGROUND STUDY REPORT

SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

DEPARTMENT OF TOXIC SUBSTANCES CONTROL
SIGNATURE AND APPROVAL SHEET

Douglas I. Sheeks, P.G. 5211
Engineering Geologist / Project Manager
DTSC, Sacramento

Mark Malinowski, P.G. 6695
Supervising Engineering Geologist / Program Manager
DTSC, Sacramento

List of Tables

List of Figures

List of Appendices (on CD)

List of Appendices (on DTSC Website)

http://www.dtsc.ca.gov/SiteCleanup/Santa_Susana_Field_Lab/ssfl_document_library.cfm

%	percent
%R	percent recovery
AOCs	Administrative Orders on Consent
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
Boeing	The Boeing Company
bgs	below ground surface
BTV	background threshold value
Cal/EPA	California Environmental Protection Agency
CAS	Columbia Analytical Services
CBRA	chemical background reference area
CC	confidence coefficient
CL	compliance limits
CLP	Contract Laboratory Program
CMS	Corrective Measures Study
CrVI	hexavalent chromium
COC	chain-of-custody
COPC	contaminant of potential concern
COSCA	Conejo Open Space Conservation Agency
2,4-DB	4-(2,4-dichlorophenoxy)butyric acid
DOE	U.S. Department of Energy
DQO	data quality objective
DTSC	Department of Toxic Substances Control
ECL	Environmental Chemistry Laboratory (DTSC)
EDA	exploratory data analysis
Frontier	Frontier Analytical Laboratory
FS	Feasibility Study
GIS	geographic information system
GPS	global positioning system
HGL	HydroGeoLogic, Inc.
HSP	Health and Safety Plan
KM	Kaplan-Meier
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LLI	Lancaster Laboratories, Inc.
LUT	Look-Up Table
MDLs	method detection limits
MRCA	Mountains Recreation and Conservation Authority
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
NASA	National Aeronautics and Space Administration
NELAC	National Environmental Laboratory Accreditation Conference
NPS	National Park Service
PAHs	polynuclear aromatic hydrocarbons
PARCC	precision, accuracy, completeness, comparability, representativeness

ppm	parts per million
PT	performance test
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QC	quality control
RBRA	radiological background reference area
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RFP	request for proposal
RI	Remedial Investigation
RLs	reporting limits
RPD	relative percent difference
RSD	relative standard deviation
RSRPD	Rancho Simi Recreation and Park District
SAP	Sampling and Analysis Plan
SCM	Site Conceptual Model
SDG	sample delivery group
SIM	selected ion monitoring
SLA	Sampling Locations Addendum
SOPs	standard operating procedures
SSFL	Santa Susana Field Laboratory
SVOC	semi-volatile organic compound
UPL95	Upper Prediction Limit at 95% confidence
URS	URS Corporation
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USL95	Upper Simultaneous Limit at 95% confidence
UTL95-95	Upper Tolerance Limit for a coverage of 95% at 95% confidence
Validata	Validata Chemical Services, Inc.
WRS	Wilcoxon-Rank-Sum
x0.95	Upper Percentile at 95% confidence

The California Environmental Protection Agency (Cal/EPA) Department of Toxic Substances Control (DTSC) conducted an investigation of chemical background concentrations in soil and sediment to support the environmental investigation and closure activities at the Santa Susana Field Laboratory (SSFL) located in the Simi Hills, Ventura County, California. This Chemical Soil Background Study ("Study") was implemented by URS Corporation (URS) under DTSC's active oversight and direction. The investigation was conducted in accordance with the Final Sampling and Analysis Plan (SAP), dated May 2011; Final Sample Locations Addendum (SLA) to the SAP, dated June 2011; and Final Revised Quality Assurance Project Plan (QAPP), dated June 2011. The soil samples collected according to these planning documents were analyzed for naturally-occurring and regionally-present anthropogenic chemicals.

Purpose of Study

The purpose of this Study is to establish a regulatory agency-approved, publicly-reviewed, and technically-defensible chemical soil background dataset for SSFL environmental programs. Samples were collected from the two selected chemical background reference areas (CBRAs) that included surface soil, subsurface soil, and ephemeral (seasonal; typically dry) drainage sediments. The objective was to collect background soil samples at locations that are representative of the physical and other natural conditions present at SSFL and to provide a basis for comparing analytical results from soil samples collected at SSFL with those derived from the Study.

Identification of Chemical Background Reference Areas and Sampling Design

An extensive evaluation was conducted to identify suitable CBRAs. This evaluation identified two suitable CBRAs:

- China Flat CBRA: located approximately 3 miles west-southwest from the western SSFL boundary. The China Flat CBRA is underlain by the Chatsworth Formation.
- Wood Ranch CBRA: located northwest of the China Flat CBRA and approximately 4 miles west of the western SSFL boundary. The Wood Ranch CBRA is underlain by the Santa Susana Formation.

Site representativeness is a key criterion for an acceptable background dataset. Thus, the chemical soil background sampling and analysis design was developed to be representative of SSFL on-site soil conditions. Based on the primary geologic and landform characteristics, the chemical soil background sampling design was based on the following four soil characteristic groups:

- Chatsworth Formation / Non-Drainage
- Chatsworth Formation / Drainage
- Santa Susana Formation / Non-Drainage
- Santa Susana Formation / Drainage

Sampling and Analysis

Soil and sediment sample collection was completed between July 6 and July 21, 2011, for the Wood Ranch CBRA and between October 17 and November 1, 2011, for the China Flat CBRA. Soil sample collection and handling were conducted in general accordance with the Study's SAP and QAPP. Surface samples were collected from 0 to 0.5 feet below ground surface (bgs) in the drainage areas. For non-drainage areas, subsurface samples were collected from 3.5 to 10 feet bgs in addition to surface samples.

A total of 295 field soil samples (including 268 primary samples and 27 field duplicates) and 27 split samples were collected and submitted for laboratory analysis. The 268 primary soil samples (surface and subsurface) were analyzed for inorganic analytes and 148 of these (surface only) were analyzed for organic analytes. The inorganic analytes included metals, hexavalent chromium (CrVI), fluoride, and perchlorate. The organic analytes consisted of polychlorinated dioxin and furan compounds (dioxins/furans), pesticides, herbicides, and semi-volatile organic compounds (SVOCs), including polynuclear aromatic hydrocarbons (PAHs) and phthalates. Four additional analytes were included following further consideration; specifically alcohols (methanol and ethanol), cyanide, formaldehyde, and nitrate.

Prior to implementing the analytical program, a rigorous laboratory evaluation was conducted to identify laboratories that could consistently produce high-quality, defensible analytical data with the lowest achievable reporting limits (RLs) within a commercial laboratory environment. Based on the evaluation, Lancaster Laboratories, Inc. (LLI), of Lancaster, Pennsylvania, was selected as the primary general laboratory and Frontier Analytical Laboratory (Frontier) of El Dorado Hills, California, was selected as the primary dioxin/furan laboratory.

Following the completion of the chemical analyses, Validata Chemical Services, Inc. (Validata), in Duluth, Georgia, reviewed and validated the sample data in accordance with the quality assurance (QA)/quality control (QC) program and data quality objective (DQO) criteria outlined in the Study's final revised QAPP. The analytical dataset generated as part of this Study, as qualified, with the exception of the rejected data (0.13%), is considered usable for meeting the Study's objectives.

Statistical Evaluation

The chemical soil background data were statistically evaluated to develop background threshold values (BTVs) where applicable for each of the Study's analytes within the Study's overall suite of 111 individual constituents. The statistical process employed is similar to that used by the U.S. Environmental Protection Agency (USEPA) for its radiological background study for SSFL. The validated analytical results went through a progression of statistical steps to establish "individual" datasets that represent the same sample population devoid of confirmed outliers.

Background Threshold Values

For remedial work under the Administrative Orders on Consent (AOCs), the Upper Simultaneous Limit at 95% confidence (USL95) is recommended as the most appropriate statistic to estimate BTVs. In accordance with the AOCs, a population statistic that represents the maximum value for the population, such as the USL95, is the most appropriate statistic to represent a BTV. The AOC approach, using do-not-exceed values based on background as the decision point for remediation, is why the USL95 is recommended as the more appropriate BTV to select for conducting the AOCs' point-by-point, analyte-by-analyte comparisons.

The following summarizes the BTVs for the Study's analytes:

- Fourteen chemical analytes analyzed for the Study (acenaphthene, aldrin, alpha BHC, benzo(a)anthracene, cyanide, dalapon, diethylphthalate, dimethylphthalate, dinoseb, ethanol, formaldehyde, 1-methylnaphthalene, 2-methylnaphthalene, and toxaphene) exhibited fewer than five detections for at least one of the distinct geomorphic strata analyzed for each individual analyte. Due to the low number of detections, no meaningful and defensible statistical analysis may be performed on such a dataset consisting mostly of non-detects. The reported laboratory sample RL may be used for each of these fourteen analytes.

- Tin (combined over both formations and topographies), perchlorate (in the Santa Susana Formation) and 2,4-DB (combined over both formations and topographies) had relatively low detection rates of 10%, 10% and 9%, respectively. The majority of the detections for these three analytes were below a large percentage of the non-detects. Due to the low number of detections above the non-detects, no meaningful and defensible statistical analysis may be performed on such a dataset. Based on an overall assessment of the datasets for these three analytes, it is concluded their evaluation be handled in a non-statistical manner. Consequently, the sample RL for each of these analytes may be used.
- One-hundred seventy-five (175) datasets (representing 97 chemical analytes) analyzed for the Study had five or more detections which is enough to conduct a defendable statistical analysis. Thus, BTVs were calculated for these analytes using the USL95.

Use of BTVs and RLs to Develop Look-Up Table

For the portions of SSFL to be further investigated and/or remediated under the AOCs, the BTVs and applicable RLs represent the foundation for subsequently developing Look-Up Table values for further characterization and cleanup at SSFL. The Look-Up Table values will be developed by DTSC in consultation with the Responsible Parties and other stakeholders. Although the Look-Up Table values will be based on the BTVs and RLs, they should also incorporate management decisions and other concerns to facilitate the cleanup at SSFL.

This Report presents the results of an investigation of chemical background concentrations in soil and sediment to support the environmental investigation and closure activities being implemented at the Santa Susana Field Laboratory (SSFL) located in the Simi Hills, Ventura County, California. This Chemical Soil Background Study ("Study") was conducted by URS Corporation (URS) under the active oversight and direction of the California Environmental Protection Agency (Cal/EPA) Department of Toxic Substances Control (DTSC).

The investigation was conducted in accordance with the Final Sampling and Analysis Plan (SAP), dated May 2011 (DTSC, 2011a), the Final Sample Locations Addendum (SLA) to the SAP, dated June 2011 (URS, 2011a), and the Final Revised Quality Assurance Project Plan (QAPP), dated June 2011 (DTSC, 2011c). An original draft SAP was developed by MWH Global, Inc. (MWH), under contract to The Boeing Company (Boeing), the National Aeronautics and Space Administration (NASA), and the U.S. Department of Energy (DOE); the three SSFL Responsible Parties. In order to address community and stakeholder concerns, DTSC dispensed with the MWH draft and contracted with URS to prepare the Study's final SAP and QAPP that borrowed certain elements from the MWH draft and were included in the Study's final planning documents. The SLA was prepared by URS for DTSC as a supplement to the SAP in order to present the proposed, specific locations at which background soil samples were to be collected.

The SAP described the field sampling and laboratory analytical procedures that were ultimately completed for the Study and was consistent with DTSC (1997, 2008) and U.S. Environmental Protection Agency (USEPA) guidelines (2002a and 2002b) for soil background data collection and evaluation. The SAP was appended with a field sampling design and a preliminary draft of the QAPP that provided, respectively, a proposed sampling design and additional laboratory and sample handling requirements. The SAP was subsequently supplemented with the Final SLA that provided specific sampling locations that were confirmed in the field. In addition, the preliminary QAPP was revised, finalized, and issued to the analytical laboratories for use in this Study.

As a parallel effort, USEPA recently completed a radiological background study for SSFL (HydroGeoLogic, Inc. [HGL], 2011). For the radiological background study, a total of 149 soil samples (109 surface, 40 subsurface) were collected from the chosen radiological background reference areas (HGL, 2011). While the chemical and radiological background studies were completed separately, both studies were designed to provide data necessary to support SSFL investigation and cleanup activities.

1.1 FACILITY BACKGROUND INFORMATION

SSFL is located approximately 29 miles northwest of downtown Los Angeles, California, in the southeast corner of Ventura County. SSFL occupies approximately 2,850 acres of hilly terrain, with approximately 1,100 feet of topographic relief near the crest of the Simi Hills. Figure 1 shows SSFL's geographic location and property boundaries plus the surrounding communities.

SSFL is divided into four administrative areas (Areas I, II, III, and IV) and undeveloped land areas to both the north and south (Figure 1). The property in Areas I, III, and IV is owned by Boeing. The federal government property administered by NASA includes a 42-acre portion of Area I and all of Area II. Ninety acres of Area IV were leased to DOE. The northern and southern undeveloped lands of SSFL are owned by Boeing and have not been used for operational activities.

There are several ongoing environmental programs at SSFL, many of which require establishment and use of chemical soil background concentrations. The SSFL Resource Conservation and Recovery Act (RCRA) Corrective Action Program is currently in the RCRA Facility Investigation (RFI) phase. The purpose of the RFI is to assess the nature and extent of chemicals in environmental media, gather data to support the next phase of the RCRA Corrective Action Program (Corrective Measures Study [CMS]), and identify areas for further work. The RFI and CMS are functionally equivalent to the Remedial Investigation (RI) and Feasibility Study (FS) phases, respectively, of the California Superfund process. Investigations are being conducted at the SSFL's former operational areas (referred to as "RFI/RI Sites"), including surrounding areas, as needed, and in undeveloped land within and surrounding SSFL proper.

1.2 PURPOSE AND SCOPE

The purpose of this Study is to establish a regulatory agency-approved, publicly-reviewed, and technically-defensible chemical soil background dataset for SSFL environmental programs. Both Cal/EPA and USEPA regulatory guidance state that a key criterion for the background dataset is site (i.e., SSFL) representativeness (DTSC, 1997 and 2008; USEPA, 2002a and 2002b). More specifically, these guidance documents state that the background sample locations should have the same basic physical, chemical, geological, and biological characteristics as the site in question (i.e., SSFL), including similar soil depths, soil types, and terrain (USEPA 2002a). This requires that the SSFL background dataset be developed and used in a manner representative of the range of naturally-occurring chemical concentrations that are related to topographical, geological, soil, and biological conditions present at SSFL.

The scope of the Study includes the following:

- Developing the sampling rationale and design
- Collecting soil and sediment samples at the Chemical Background Reference Areas (CBRAs)
- Analyzing the samples for potential naturally-occurring and anthropogenic chemicals
- Compiling and validating the chemical soil background dataset
- Conducting a statistical analysis for the soil and sediment data collected at the CBRAs to determine a background threshold value (BTV) for each detected chemical, where applicable, and
- Reporting the study's results.

The SAP addressed sampling rationale and design, field sampling activities, laboratory analyses, and quality assurance requirements for the Study. The SLA and QAPP (dated June 2011) provided staked, field sampling locations and additional laboratory requirements. DTSC secured, oversaw, and directed the services of URS, an independent, qualified and experienced contractor, to help conduct the field study, evaluate the background data, and report the results.

Based, in part, on community and stakeholder input, the chemical soil background samples were collected from the two selected CBRAs, located as far away as possible from SSFL operational areas while still meeting the other criteria required for the program. Samples were collected from surface soil, subsurface soil, and ephemeral (seasonal; typically dry) drainage sediments. The samples were analyzed for naturally-occurring and regionally-present anthropogenic chemicals. The objective was to collect background soil samples from locations that are representative of the physical and other natural conditions present at SSFL. The data collected from the chemical soil background field sampling effort are reported herein in a similar format and using similar statistical evaluations as USEPA applied for their SSFL radiological background study results.

1.3 REGULATORY FRAMEWORK AND DATA QUALITY OBJECTIVES

DTSC developed the scope and approach for the Study using the USEPA data quality objective (DQO) process (USEPA, 2006a), incorporating appropriate regulatory guidance (USEPA, 2002a and 2002b) for soil background evaluations. DTSC established criteria for selecting the CBRA sampling locations that are representative of SSFL characteristics and ambient conditions. DTSC (1997) guidance defines ambient conditions as concentrations of inorganic constituents in the vicinity of a site that are unaffected by site-related activities. USEPA (2002a) guidance defines ambient as having characteristics that include levels of both naturally-occurring and anthropogenic chemicals. USEPA (2002a) guidance also states that the CBRAs should have similar physical, chemical, geological, and biological characteristics as the site being investigated, but have not been affected by activities at the site. For the purposes of this Study, background is defined as chemical concentrations representative of local, ambient conditions related to both naturally-occurring and regional anthropogenic inputs.

The DQO approach is used for the Study because it provides a solid framework to help ensure that sufficient data of high quality are collected to meet the study’s objectives. The DQO process consists of the following seven steps:

1. State the problem
2. Identify the goals of the study
3. Identify information inputs
4. Define the boundaries of the study
5. Develop the analytic approach
6. Specify performance or acceptance criteria, and
7. Develop the plan for obtaining data.

The problem statement for the Study is as follows:

> *Soil chemical concentration data for selected constituents are needed from off-site CBRAs to establish a regulatory agency-compliant, publicly-reviewed, and technically-defensible chemical soil background dataset to be used in SSFL environmental programs for characterization and cleanup activities.*

The SAP described the evaluations conducted to identify the CBRAs, inputs considered to develop a representative dataset of naturally-occurring and ambient chemicals, and procedures to be used to implement the fieldwork and laboratory analyses. Table 1 summarizes the DQOs for the Study.

1.4 REPORT ORGANIZATION

This Report is organized as follows:

Section 1: Presents the introduction, facility background information, purpose and scope of work, regulatory framework and DQOs, and the organization of this document

Section 2: Presents an overview of site selection and sampling/analytical rationale, including CBRA selection, sampling approach, and the analytical program for the Study

Section 3: Presents the field program and sampling methodology used during implementation of the Study

Section 4: Presents the laboratory analytical data results

Section 5: Presents the statistical process completed for the Study

Section 6: Presents the background threshold values for each chemical

Section 7: Presents a summary of findings and conclusion

Section 8: Presents the references cited in this document, and

Section 9: Presents a glossary that defines technical terms used in this Report.

This Report, plus both prior and future documents for the Chemical Soil Background Study, may be found on the DTSC website (link below), in the established DTSC public repositories listed below, and at DTSC's offices in Chatsworth, California.

http://www.dtsc.ca.gov/SiteCleanup/Santa_Susana_Field_Lab/ssfl_document_library.cfm.

The established DTSC public repositiories are:

- California State University, Northridge - Oviatt Library, Northridge, Califorrnia
- Platt Library, Woodland Hills, California
- Simi Valley Library, Simi Valley, California

This section provides an overview of the basis for and scope of the approach to collecting and analyzing soil and sediment samples from the two CBRAs. Section 2.1 describes the CBRA selection process and includes a description of the CBRAs' physical characteristics (geology, topography, drainage, soils, etc.). Section 2.2 provides the sampling rationale and approach. Section 2.3 describes the sampling location verification and logging. Section 2.4 describes the scope of the chemical soil background analytical program.

2.1 CHEMICAL BACKGROUND REFERENCE AREA (CBRA) SELECTION

Based on DTSC and USEPA guidance (DTSC 1997, 2008; USEPA 2002a, 2002b, 2006), the Study's DQOs described in Section 1.3, and stakeholder input, the CBRA locations must:

- Be situated on the same geologic formations that occur at SSFL and otherwise have similar physical characteristics (i.e., soil and landform types)
- Be as close as possible to SSFL to be representative of site soil conditions, but sufficiently distant to address stakeholder concerns regarding potential airborne impacts by SSFL operations
- Have a similar recent fire history (since 2005)
- Be limited to natural areas undisturbed by localized human activities that may influence chemical concentrations (i.e., disturbed areas, near roads, debris areas, etc.), and
- Be both physically and permissibly accessible for use in this study.

The following subsections describe the selection process based on these criteria.

2.1.1 CBRA Selection Process

Extensive evaluations were conducted to identify the suitable CBRAs. DTSC collaborated with the USEPA, community members, and other stakeholders to identify potential background reference areas suitable for both the chemical and radiological background studies. Several candidate background reference areas were identified on public, open-space land situated on the Chatsworth and Santa Susana Formations using published geological maps (Yerkes and Campbell, 1995; Dibblee, 1992). These rock types, as shown on Figure 2, are not exposed at the ground surface at distances greater than approximately 6 miles southwest and northeast from SSFL. As described above, the candidate CBRAs are located close to, but sufficiently distant from SSFL operations – each is located approximately southwest about 3 to 4 miles away from SSFL's western boundaries. Several field trips were conducted to observe reference area conditions, including geology, soil type and thickness, landform and drainage patterns, and to identify disturbed areas (for exclusion). Other evaluations were performed as well, including reviewing available historical aerial photographs and wildfire histories, assessing available wind data from SSFL and neighboring areas, and interviewing property owner representatives to identify and evaluate areas of historical use. Additional evaluations were conducted that involved archeological and biological monitors during all soil sampling, making location adjustments as needed, and eliminating from consideration any and all known potential sources of concern such as roads, structures or other obvious improvements, locations displaying evidence of prior disturbance, etc.. These measures constitute reasonable precautions that were taken to minimize, if not eliminate, potential impacts to the sample locations.

Certain candidate background reference areas were disqualified based on one or more of the following concerns: recent dissimilar wildfire history, the presence of property improvements or other signs of human activity (e.g., debris areas), and/or property inaccessibility (physical as well as reasonably obtainable permission). This evaluation identified two suitable CBRAs (Figures 3 and 4):

- China Flat CBRA: located on National Park Service (NPS) and Rancho Simi Recreation and Park District (RSRPD) properties, approximately 3 miles west-southwest from the western boundary of SSFL Area IV. The China Flat CBRA is underlain by the Chatsworth Formation.
- Wood Ranch CBRA: located northwest of the China Flat CBRA on Mountains Recreation and Conservation Authority (MRCA) property, approximately 4 miles west of the western boundary of SSFL Area IV. The Wood Ranch CBRA is underlain by the Santa Susana Formation.

A portion of the China Flat CBRA was included as a radiological background reference area (RBRA) for the USEPA radiological background study (HGL, 2011).

2.1.2 Physical Characteristics of the CBRAs

This section describes the physical settings of the two CBRAs, including geology, topography and drainages, and soil types. Optimally, geology, drainage, landforms, soil type, etc., are similar enough to SSFL site conditions such that constituents detected in background samples are representative of the full range of ambient, naturally-occurring, and regional anthropogenic chemical concentrations at SSFL.

2.1.2.1 Geology

A fundamental DTSC requirement for the CBRAs is that their geology be comprised of the same formations underlying SSFL, since parent rock material plays an important role in soil chemistry. SSFL and the CBRAs are underlain by similar geology; that of the late Cretaceous Chatsworth Formation and Paleocene Santa Susana Formation (Yerkes and Campbell, 1995; Dibblee, 1992). Quaternary Alluvium is also a mapped geologic unit within the China Flat CBRA and at SSFL. Quaternary Alluvium is material deposited over the last approximately 1.6 million years that is derived from underlying or surrounding geologic formations.

Chatsworth Formation

The Chatsworth Formation is a deep-sea turbidite deposit that consists primarily of sandstone interbedded with lesser amounts of shale, siltstone, and conglomerate. As shown on Figure 2, the Chatsworth Formation outcrops occur regionally along a broad swath from the Rocky Peak area, in the northeast, to near Thousand Oaks, in the southwest, including the China Flat CBRA located near the westernmost limit of exposed Chatsworth Formation. Approximately 93 percent (%) of SSFL is underlain by the Chatsworth Formation, with localized occurrences of Quaternary alluvium in some drainage courses.

Santa Susana Formation

Geologically younger, the Paleocene-age Santa Susana Formation is also a turbidite deposit and is composed mostly of marine clastic sediments consisting of dark-gray micaceous shales, sandstone with interbedded siltstones, and shales (Dibblee, 1992). At the far western end of SSFL, the Santa Susana Formation is present in the hills south of, and topographically above, Burro Flats where it is comprised mostly of claystone/siltstone and to the south where there are narrow outcrops of friable sandstone and conglomeratic members. At the Wood Ranch CBRA, the Santa Susana Formation appears to occur mostly as claystone and siltstone, with outcrop bands of friable sandstone, based on Dibblee (1992).

2.1.2.2 Topography and Drainage Basin Characteristics

Topography and drainage basin characteristics (i.e., landform morphology) are important factors because of their interrelationships with erosion, sediment transport and deposition, and ultimately soil formation. Relevant landform parameters include overall relief and topography and, for streams, drainage basin characteristics.

SSFL occupies approximately 2,850 acres of hilly terrain, with approximately 1,100 feet of topographic relief near the crest of the Simi Hills. Elevations at SSFL range from 2,240 feet above mean sea level (msl) along outcrop ridges in the southern portions of Areas I and II to 1,180 feet msl in southern undeveloped land at Dayton Canyon. Elevations within and near the CBRAs span smaller ranges; 1,725 to 2,325 feet msl (600 feet of relief) at China Flat and 1,250 to 1,450 feet msl (200 feet of relief) at Wood Ranch.

Drainage basin size, combined with other basin characteristics (e.g., topography and relief, bedrock type, etc.), is important because the combination of these parameters controls the dynamic processes responsible for the formation of soil and sediments. SSFL’s 2,850 acres are divided into three main watersheds and are drained primarily by ephemeral streams exiting to the south via Bell Canyon, with lesser portions draining north via the Northern Drainage and to the west via Runkle Canyon. Acreage at the CBRAs ranges from approximately 30 acres at Wood Ranch to approximately 200 acres at China Flat and are situated at headwaters of ephemeral drainages with drainage basins less than 160 acres (western RSRPD drainage).

2.1.2.3 Soil Types

Based on United States Department of Agriculture (USDA, 2010) soil survey maps, the CBRAs are characterized generally by hilly terrain with thin, loamy soils over bedrock and by relatively narrow drainages containing thicker accumulations of sediment. Native soils are generally composed of weathered Chatsworth or Santa Susana Formation materials and are typically fine-grained silty sands, with sandy silts and silty clays present. These materials and their occurrences are similar to those at SSFL (MWH, 2004). As presented in the Study’s SLA (URS, 2011a), CBRA soil depths in the non-drainage hilly areas ranged from several inches to as great as 10 feet; soil depths in the drainage areas always exceeded the maximum soil sampling depth of 0.5 feet.

2.2 SAMPLING APPROACH RATIONALE

As described in Section 1.3, site representativeness is a key criterion for an acceptable background dataset (DTSC, 1997 and 2008; USEPA, 2002a and 2002b). Thus, the chemical soil background sampling and analysis design was developed to be representative of SSFL on-site soil conditions and considered how the data may be used for SSFL environmental programs. This section describes the sampling design developed to represent SSFL conditions at the CBRAs. The following key, on-site characteristics were considered when the sampling design was developed.

- **Geology**: Two primary geologic formations are present at SSFL; the Chatsworth and Santa Susana Formations. Geology influences the inorganic chemical and physical characteristics of soil since parent rock chemistry and grain size are major factors in determining soil composition, most particularly metals concentrations. Geologic formations may also influence the physical and biological conditions on a site. As described above, Chatsworth Formation terrain varies from steep, rocky outcrops with limited vegetation, where thick sandstone beds occur, to more gentle topography with more dense vegetation and thick soil development in areas where more shales or siltstones occur. Further, the presence of geologic fractures and faults may influence where drainages or surface water pathways occur.
- **Topography**: SSFL is characterized by variable topography and landforms, ranging from steep bedrock cliffs to flat alluvial basins and narrow, rocky to gentle meandering drainages with variable-width over-bank deposits. A simple topographic scheme divides landforms between non-drainages (e.g., hillside and flat areas) and drainages. Due to natural geomorphic processes, it is expected that these two landform types could have some different naturally-occurring constituent concentrations due to differences in the amount of fine-grained soil present in each terrain. Some constituents, including some metals and organic compounds, may preferentially ‘sorb’ (or adhere) to finer-grained sediments and may be contained within the clay structure. Fine-grained soils may be influenced by geologic substrate, as described above, or by erosional processes and are potentially present in drainages and over-bank deposits.

Based on these primary geologic and landform characteristics, the chemical soil background sampling design was based on the following four soil characteristic groups:

- Chatsworth Formation / Non-Drainage
- Chatsworth Formation / Drainage
- Santa Susana Formation / Non-Drainage
- Santa Susana Formation / Drainage

These four soil characteristic groups are identified as geomorphological ‘strata’ for the Study and form the geomorphological basis for the Study’s Site Conceptual Model (SCM) and the selection of target chemical analytes as presented in Section 2.4. The term “strata”[1] is used in this context for its statistical meaning; relatively homogenous subsets of a heterogeneous population. For this

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[1] The terms *stratum or strata* as used in this document are not intended to strictly conform to the common statistical definition associated with stratified-random sampling designs. In such designs, results of strata sampling may be proportionally recombined to develop population estimates. In this Study**,** an equal number of organic and inorganic samples from each stratum were collected and statistically tested prior to determining usability, acceptance, and application for SSFL on-site data comparisons.

Study, “stratum” is defined as the smallest data comparison group for evaluation during the Study that may also be used for SSFL characterization and/or cleanup decisions.

As described above, each stratum may have differences in naturally-occurring and ambient soil concentrations for some constituents, making the background population potentially “heterogeneous.” Collecting samples from each stratum (or characteristic geomorphological group) ensures that the entire background sample dataset is representative of all characteristic groups.

Depth as an individual characteristic is not included at the level of a specific stratum because of SSFL on-site soil mixing and drainage deposition conditions. Both shallow and deep samples were collected from each of the Study’s non-drainage strata and only shallow samples were collected from each of the drainage strata (further described in Section 2.2.1). This approach is based on the following considerations:

- In non-drainage areas, soil chemistry may vary between shallow or deep soils due to geologic substrate materials, soil development processes, or anthropogenic air dispersion/deposition (i.e., shallow and deeper chemistry may be different for different constituents). However, while depth differences may exist for some chemicals at the CBRAs, the SSFL RFI/RI data generally do not allow distinct comparisons.
- The background sampling design includes both shallow and deep samples within the non-drainage strata to capture heterogeneity within a soil column.
- In drainage areas (including over-bank deposits), sedimentation patterns continually change and evolve through time since drainages are well mixed, dynamic systems. Shallow soils should adequately represent both current and historical drainage conditions.

2.2.1 Selecting the Number of Samples

The number of soil samples collected (‘*n*’) was determined based on the decisions made as to how the chemical soil background data may be used. Designing flexibility into the background study affects the number of background samples that are needed and is based on a conservative approach. DTSC designed the sampling approach to be able to:

- Allow for population comparisons (e.g., compare Chatsworth Formation values to Santa Susana Formation values), and
- Develop “bright-line” estimate comparison values (e.g., single values representative of population maximums or upper limits).

The Upper Tolerance Limit (UTL) statistic is one potential comparison statistic with which to estimate background threshold values (BTVs) as described in USEPA guidance (USEPA, 2007). While a specific statistical confidence level is not always specified, a 95% confidence level is commonly used for environmental site investigation and cleanup decisions (e.g., USEPA, 1999a; 2001; and 2004). For this Study, the UTL95-95 was used to derive the number of samples as described below; the UTL95-95 statistic is described further in Section 5.3.1.3.

As described in the SAP (DTSC, 2011a), the minimum sample number (‘*n*’) necessary to calculate a UTL95-95 is 59 per stratum. For the Study, this minimum number was rounded up to

60 so that an equal number of shallow and deeper samples (i.e., 30 samples) may be collected in the non-drainage strata.

Based on the four basic strata listed above and 60 proposed samples per stratum, 240 primary background soil samples were proposed to be collected. This sampling approach was developed and is appropriate considering the physical soil characteristic groups described above. Collecting 60 samples per stratum allows for 30 surface and 30 subsurface soil samples from the non-drainage strata for inorganic constituents (as described below, organic constituents were analyzed only in surface samples). Ultimately, 28 additional surface samples were collected from the non-drainage strata, as described below in Section 2.3.2.1.

Based on the nature of physical characteristic groups, or strata, a combination of systematic and random sampling methodologies were used to provide good coverage for each stratum with an element of randomization so that the sample locations, samples, results, and subsequent statistical analyses are representative of background conditions at SSFL. Deviation from random sample locations (i.e., moving a randomly-located sample or placing sample locations in a haphazard or subjective manner) introduces a non-quantifiable bias that decreases data representativeness and the usefulness of statistical comparisons.

2.3 VERIFICATION AND LOGGING OF SAMPLE LOCATIONS

Suitable soil sample locations were identified within both CBRAs in general accordance with the approach presented in the Study’s SAP, but the location of prospective sample locations was selected in the field based on higher-resolution topographic maps, accessibility, depth of soil cover, and consideration of archeological and biological resources. Sample location staking in the field was completed between March 30 and April 21, 2011. The mapped sample locations for the China Flat and Wood Ranch CBRAs are presented on Figures 3 and 4, respectively. Per the SAP, the identification (ID) numbers for the sample locations for the China Flat and Wood Ranch CBRAs are prefixed with ‘CZ’ and ‘WR’, respectively. A summary of the final field-selected sample locations (including global positioning system [GPS] coordinates) is provided in Table 2, which also includes the supplemental locations selected during the soil sampling event (as discussed in Section 2.3.2.1).

2.3.1 Topographic Mapping and Preliminary Sample Grid Overlay

To more accurately define the drainage and non-drainage areas and the associated elevation changes, high-resolution photo-base maps were generated with superimposed topographic lines at 10-foot contour intervals for the two CBRAs using a geographic information system (GIS). Per the approach presented in the SAP, a network of 30 grid cells was superimposed on each topographic map to provide geographic reference areas within which a randomly-collected sample would represent one of the 30 non-drainage sample locations. Based on the topographic maps and field scouting visits, the original conceptual grid overlay was revised and the revised network of grid cells took into account obvious accessibility issues and potential lack of soil (i.e., rock outcroppings) within certain areas. Portions of the CBRAs where anthropogenic use occurred or may have occurred (i.e., roads and trails, archaeological sites, previous usage by the movie industry) were excluded from consideration as potential sampling locations. In addition, prospective locations for drainage samples were revised based on the anticipated and observed inability to access a particular drainage segment in a safe and practical manner.

2.3.2 Sample Location Procedures

As fully described in the Study's SLA (URS, 2011a), a combination of systematic and random sampling methodologies was used to select proposed sampling locations at the two CBRAs between March 30 and April 21, 2011. A systematic sampling design was used to provide uniform coverage of each CBRA – a grid overlay for non-drainages and systematically placed transects for drainages – and an element of randomization was incorporated so that the sampling stations, samples, results, and subsequent statistical analyses are representative of physical characteristics at SSFL. Potential field locations were excluded only when one or more of the following factors precluded establishment of locations as determined by professional judgment in the field: rock outcrops, insufficient depth of soil, extensive vegetation that could not be penetrated without significant habitat removal or damage or posed a health risk (e.g., poison oak), and unsafe terrain due to steepness or instability. To aid in relocating each selected location for later soil sample collection, each location was "staked" with a small flag or survey tape that was removed when the sampling was completed.

2.3.2.1 Non-Drainage Areas

Prior to field mobilization, a preliminary list of 30 prospective non-drainage sample locations, one within each grid cell, was generated for each CBRA. The sample location within each grid cell was randomly selected. Using the GIS, GPS coordinates as latitude and longitude were assigned to each prospective location.

Both surface and subsurface soil samples were collected at the non-drainage sampling locations. Surface samples were limited to 0 to 0.5 feet below ground surface (bgs). The subsurface samples were collected at randomly-selected (URS, 2011a) depths between 2 and 10 feet bgs, unless bedrock refusal was met. If bedrock refusal was met before 3.5 feet bgs, then no subsurface sample was collected at that sampling station and an alternative sample location was selected as described below. A minimum soil thickness of 3.5 feet was selected because it would provide 18 inches of soil sample volume (within 2-inch-diameter stainless steel sleeves), which is approximately the minimum soil volume required to conduct the Study's laboratory chemical and grain-size analyses. As part of the sample location field program, the available soil thickness was determined by hand augering a "pilot hole" and recording the depth at which refusal was met, up to a maximum of 10 feet bgs. The actual sample location was offset a maximum of a few feet (typically less) from the pilot hole. In the field, non-suitable sampling locations (e.g., soil cover less than 3.5 feet) within a particular grid cell were disqualified and a new sampling location was selected using the procedures as presented in the SLA.

The original intent of the field program as presented in the SAP was to co-locate the surface and subsurface non-drainage soil samples. However, due to either lack of sufficient soil cover for the deeper samples or inaccessibility, sample points were not established in 15 of the 30 grid cells in the China Flat CBRA and 13 of the 30 grid cells in the Wood Ranch CBRA. In consultation with DTSC, this shortfall was addressed by locating a second ("supplemental") non-drainage location in the 15 China Flat CBRA grid cells and in 13 of the 17 Wood Ranch CBRA grid cells where sufficient soil had been initially documented. These replacement locations were randomly located within the grid cells in areas where sufficient soil was judged to be potentially present; the adequacy of the soil thicknesses was verified via augered pilot holes. The final 30 selected co-located sampling locations within the China Flat and Wood Ranch CBRAs exhibited soil covers that averaged 7.5 and 5.0 feet in thickness, respectively, and ranged from 3.5 to 10 feet, thereby covering the entire range of proposed soil sample depths.

Because there was the potential for bias to be introduced by eliminating sampling locations from certain areas within the CBRAs where it was determined that there was less than the 3.5 feet of soil, shallow soil samples (0 to 0.5 feet bgs) were collected during the sampling phase at accessible locations. These locations were determined within the original grid cells that were not considered because the soil depth was less than 3.5 feet using the same professional judgment and random-selection process employed throughout. For the China Flat CBRA, an additional 15 surface samples were collected from 10 of the 15 originally excluded grid cells (Table 2 and Figure 3). For the Wood Ranch CBRA, an additional 13 surface samples were collected from each of the 13 originally excluded grid cells (Table 2 and Figure 4).

2.3.2.2 Drainages

The CBRA drainages target the historical lateral extent of stream flow in which sediment is transported downstream. The full lateral extent includes the active streambed and bank slopes. Soil samples collected from accessible drainage areas were limited to surface samples from 0 to 0.5 feet bgs. Consequently, in the drainages, a pilot hole was not required to determine the thickness of the soil cover.

Drainage sampling locations were selected using a combination of systematic and random methods. Prior to initiation of the fieldwork, prospective drainage segments were first identified on aerial photograph base maps of each CBRA. An initial sample transect location was then selected along each drainage segment. Additional transect locations were then added at regular intervals both upstream and downstream from the initial location until the ends of each segment were reached.

Prior to field mobilization, latitude and longitude coordinates were assigned to each of the 60 transect locations in each CBRA. The transects were established perpendicular to the drainage and extended up to a maximum of 15 feet to each side (30 feet total) from the drainage centerline, so to include bank deposits. If the bank deposits were inaccessible or less than 30 feet wide, then the available footage was used as the transect length. Sampling locations were randomly located along each drainage transect. If the random location corresponded with unsuitable sampling conditions due to lack of soil or access considerations, then a new random sampling location along the transect was selected by repeating the process until a suitable location was obtained. If no suitable sampling location existed for a given transect, then the transect location was revised to the closest available location along the drainage. Such revisions were relatively rare, however, and typically involved adjustments in the transect location of 10 feet or less.

Staking at 16 of the originally-planned 60 drainage transect locations at the China Flat CBRA was not completed due to access limitations associated with steep slopes, thick brush, and Poison Oak. To partially compensate for this shortfall, two additional accessible drainage transect locations (CZBS0072 and CZBS0073) were added to achieve a total of 60 drainage sample locations. An additional 14 new transects (and the sampling locations along them) were established during the soil sampling phase by randomly selecting locations along those drainage reaches where the previous transects were established. This resulted in new transects being located between those that were previously established. All of the originally-planned drainage transect locations at the Wood Ranch CBRA were established with only minor changes at a few locations. Per the original program objective, 60 drainage sample locations were selected and documented.

2.4 CHEMICAL ANALYSIS SELECTION

The chemical analyses for this background Study are listed below and include both naturally-occurring and potential regional anthropogenic chemicals. As noted above, organic chemicals (e.g., dioxins) were analyzed only in surface samples, with inorganic (e.g., metals) constituents analyzed in both surface and subsurface samples. In addition to the chemical analyses, all samples were analyzed for particle-size distribution.

As related to the selection of target chemical analytes, the Study's SCM takes into account both the geology and drainage characteristics of the two CBRAs and the processes (e.g., aerial deposition) that similarly affect both CBRAs. Taking into account the four basic strata defined above and the organic and inorganic analyses, there were a total of six sample populations that were characterized by the sampling program. The definitions of the six sample populations are summarized in Table 3.

Each of the 268 total primary soil samples (surface and subsurface) was analyzed for inorganic analytes and 148 of these (surface only) were analyzed for organic analytes.

The following describes the chemical analysis rationale and plan for the background Study:

Organic Chemicals

- Polychlorinated dioxin and furan compounds (dioxins/furans) – Dioxins are documented to have background concentrations; occurring as a result of wildfires (Cleverly et al., 1997; Ferrario and Byrne, 2000) or may be present due to fallout from the air having been dispersed from anthropogenic sources such as vehicle exhausts or incineration.
- Pesticides/herbicides – While not naturally occurring, pesticides and herbicides may be present in soil due to aerial application associated with historical agriculture operations in nearby Simi and/or San Fernando Valleys prior to the 1960s/1970s when significant residential development began. Pesticides and herbicides may also be present due to fallout from the air.
- Semi-volatile Organic Compounds (SVOCs):
    - Polynuclear aromatic hydrocarbons (PAHs) – Some PAHs are likely to have background concentrations in soil, occurring naturally as a result of wildfires (Verma et al, 2009). PAHs are documented byproducts of incomplete combustion of organic materials (wood, fuels, etc.) and are components of urban particulates also originating from non-point sources such as petroleum combustion (cars and trucks), fumes, and fireplaces (Stout et al., 2006).

- Phthalates – While not naturally occurring, phthalates may be present in soil due to air-fall deposition; similar to dioxins/furans, PAHs, pesticides, and herbicides.

Organic chemicals were analyzed for only in the Study's surficial soil samples since they would be the result of surficial deposition due to natural or anthropogenic processes (e.g., fire ash deposition, aerial spraying of pesticides). Because organic chemical concentrations are not influenced by geology, two additional ("combined") strata are defined for the organic samples:

- Chatsworth Formation and Santa Susana Formation / Drainages
- Chatsworth Formation and Santa Susana Formation / Non-Drainages

Based on the final sampling design, 148 total surficial soil samples were analyzed for organic chemicals since organic chemical concentrations in drainage and non-drainage areas are expected to be similarly influenced by natural processes related to aerial deposition affecting both CBRAs. A minimum of 60 samples per stratum are sufficient to achieve the UTL95-95-derived goal described above in Section 2.2.1.

Inorganic Constituents

- Metals – Total metals are routinely included in background datasets since they are a primary component of rock-forming minerals.
- Hexavalent chromium (CrVI) – CrVI may be present in soils resulting from natural reduction of total chromium. Studies at California army bases have reported background concentrations of 2 parts per million (ppm) at a 95% confidence level (Hunter et al., 2005). Additionally, CrVI has been detected in soils following wildfires (Wolf et al., 2007).
- Fluoride – A naturally-occurring inorganic compound (i.e., sodium fluoride, a water-soluble salt).
- Perchlorate – Under certain conditions, a naturally-occurring inorganic compound (i.e., a water-soluble salt).

Inorganic constituents were analyzed for in both surface and subsurface soil samples from each formation since they may result from natural soil development processes above a bedrock substrate. Since inorganic chemical concentrations may be affected by geology, the following four basic strata are defined for the inorganic samples:

- Chatsworth Formation / Drainages (surficial)
- Santa Susana Formation / Drainages (surficial)
- Chatsworth Formation / Non-Drainages (surficial and subsurface)
- Santa Susana Formation / Non-Drainages (surficial and subsurface)

Based on the final sampling design, 268 total soil samples were analyzed for inorganic chemicals. As described in Section 2.2.1, a minimum of 60 samples per stratum are sufficient to achieve the UTL95-95-derived goal.

Additional Constituents

In addition to the target chemical analytes presented in the Study's SAP (DTSC, 2011a), based on further consideration of a request from the Responsible Parties (Boeing, 2011), the following four additional analytes (and associated sample strata) were included in the QAPP (DTSC, 2011b):

- Alcohols (methanol and ethanol): subsurface samples from non-drainages
- Cyanide: samples from the four inorganic strata including surface and subsurface
- Formaldehyde: samples from the four inorganic strata including surface and subsurface
- Nitrate: samples from the four inorganic strata including surface and subsurface

The rationale for including these four additional analytes is provided in the SAP.

2.5 LABORATORY SELECTION

On behalf of DTSC, URS conducted a rigorous laboratory evaluation process to support the Study. The overall objective of the evaluation was to identify laboratories that could consistently produce high-quality, defensible analytical data with the lowest achievable reporting limits (RLs) within a commercial laboratory environment. The laboratory evaluation process and final results were presented in a Laboratory Selection Technical Memorandum (URS, 2011b) submitted to DTSC (also posted to DTSC's SSFL website).

In consultation with DTSC and DTSC's Environmental Chemistry Laboratory (ECL), URS employed a multi-step selection and evaluation process that included the following individual phases:

1. Initial candidate laboratories were selected from the National Environmental Laboratory Accreditation Conference (NELAC) Institute certification list of accredited laboratories.
2. A request for proposal (RFP) packet was sent to each of the initial candidate laboratories. The RFP requested that the laboratories submit documentation which would qualify them to compete for the background Study's analytical work.
3. The next phase of candidate selection required the laboratories to document their proposed method detection limits (MDLs) and RLs by submitting current MDL/RL study results with raw data and/or to conduct specialized MDL and RL studies to determine the lowest concentrations that the laboratories could achieve using either standard USEPA procedures or documented modifications to the USEPA procedures.
4. The fourth phase of laboratory selection entailed the submittal of a set of performance test (PT) samples to the candidate laboratories to gauge whether or not they were able to achieve accurate sample results in accordance with standard NELAC guidance.
5. The fifth phase of the candidate evaluation entailed visitations to the laboratories by a qualified URS chemist (with the participation of ECL) to observe laboratory conditions, assess analyst competence, and witness laboratory procedures under actual operating conditions.

6. In addition, supplemental evaluation information was reviewed that included internal audit reports and RLs for actual soil samples collected from SSFL.

Each phase of the evaluation process was factored into the final selection. Based on the final rankings, Lancaster Laboratories, Inc. (LLI), of Lancaster, Pennsylvania, was selected as the primary laboratory and Columbia Analytical Services (CAS) of Kelso, Washington, was selected as the quality assurance/quality control (QA/QC), or secondary, laboratory. One of the evaluation factors that ranked LLI above CAS was the lower achievable RL ranges based on a review of analytical results for co-located SSFL soil samples.

Frontier Analytical Laboratory (Frontier) of El Dorado Hills, California, demonstrated throughout the evaluation process that it could achieve high-quality defensible data with the lowest RLs for the requested dioxin/furan analysis and was recommended as the primary dioxin/furan laboratory. LLI demonstrated the ability to achieve lower RLs than CAS and was recommended as the QA/QC, or secondary, dioxin/furan laboratory.

2.6 QUALITY ASSURANCE PROJECT PLAN

The Study's QAPP (DTSC, 2011b) describes the QA/QC elements that governed the activities conducted to investigate chemical background concentrations in soil and sediment samples from the two CBRAs. The QAPP was appended to the Study's SAP (DTSC, 2011a). Subsequently, the QAPP, dated June 2011 (DTSC, 2011b), was released by DTSC as a stand-alone document for use during the Study's implementation.

The QAPP also describes sample collection and laboratory analysis of selected chemicals in CBRA soils to support the development of BTVs for future use in developing characterization and cleanup decisions at SSFL. It includes discussions regarding project organization and communication, background information, project task descriptions, DQOs, field and laboratory data quality criteria, training and certifications, sampling and analytical methods, field quality control (QC) procedures, laboratory QC elements, instrument/equipment maintenance and calibration, quality assurance oversight, and data validation.

2.7 ANALYTICAL METHODS AND METHOD MODIFICATIONS

The standard operating procedures (SOPs) for all the laboratory analytical chemical methods employed by the primary and secondary laboratories were based on the 3rd Edition of the USEPA's Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, also known as SW-846 (USEPA, 2011a). As incorporated in the QAPP (DTSC, 2011b), the laboratory methods and the RLs (for the 111 individual chemical analytes) are presented in Table 4. In summary, the USEPA methods for the major analyte groups were the following:

- Anions (fluoride and nitrate): USEPA Method 300.0/9056A
- Cyanide: USEPA Method 9012A
- Formaldehyde: USEPA 8315A
- Alcohols (methanol and ethanol): USEPA 8015B
- Chlorinated herbicides: USEPA Method 8151A

- CrVI: USEPA Methods 7199/7196A
- Mercury: USEPA Methods 7471A/7470A
- Metals: USEPA Methods 6010B/6020A (including aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, thallium, tin, titanium, vanadium, zinc, and zirconium)
- SVOCs (PAHs and phthalates): USEPA Method 8270C and 8270C with selected ion monitoring (SIM)
- Organochlorine pesticides (OCPs): USEPA Method 8081A
- Dioxins/furans: USEPA Method 1613B
- Perchlorate: USEPA 6850/6860.

In addition, soil particle size was analyzed by the following method prescribed by the American Society for Testing and Materials (ASTM):

- Grain size: ASTM Method D421/D422.

The QAPP (DTSC, 2011b) includes as appendices the entire set of the laboratories' SOPs applicable to this Study. In addition, the SOPs include several method modifications that were approved by DTSC after reviewing the MDL/RL studies submitted by LLI and Frontier in an effort to achieve the lower RLs. The method modifications included the following:

Lancaster Laboratories, Inc.

- Perchlorate (USEPA Method 6850): increased sample mass and use of a different chromatography column
- Herbicides (USEPA Method 8151A): increased sample mass and decreased final volume
- Pesticides (USEPA Method 8081A): increased sample mass and decreased final volume.

Frontier Analytical Laboratory

- Dioxins/Furans (USEPA Method 1613B): increased sample mass and decreased final volume.

The soil sampling field program for the Study was completed in two phases. Soil and sediment sample collection was completed between July 6 and July 21, 2011, for the Wood Ranch CBRA and between October 17 and November 1, 2011, for the China Flat CBRA. The field program and soil sampling methodology are presented in this section.

3.1 FIELD TEAM AND SITE ACCESS

The core field team typically present in the field included the following individuals:

- Doug Sheeks, P.G., DTSC Engineering Geologist/Project Oversight
- Erich Weaver, P.G., URS Field Manager/Senior Geologist
- Richard Shore, URS Senior Technician/Project Geologist, and
- Deanna Jones, Topanga Anthropological Consultants/Archeological Monitor.

Other key participating individuals present during portions of the fieldwork included:

- Paul Carpenter, P.G., DTSC Senior Engineering Geologist/Project Oversight (temporary, as-needed replacement for Doug Sheeks)
- Yvette LaDuke, DTSC Public Participation Specialist (present only on days when community observers were present)
- Jeff Brooks, URS Project Geologist (sample collection/handling/transport), and
- Carol Thompson, URS Biologist, (California Gnatcatcher monitoring at Wood Ranch CBRA).

Additional individuals accompanied the field team at various times, including observers from MWH (contractor for Boeing), biological monitors from the U.S. Fish and Wildlife Service (USFWS), and other interested observers from the community.

Required permits and access agreements for each of the field areas were obtained by DTSC prior to the fieldwork and complied with over the project’s duration. These permits/agreements included the following:

- U.S. National Park Service-Santa Monica National Recreation Area – Research Permit Conditions (China Flat CBRA)
- RSRPD – Access Permit Conditions (China Flat CBRA)
- MRCA – Temporary Right–of-Entry Permit Conditions (Wood Ranch CBRA)
- USFWS – “No Take Concurrence,” and
- Conejo Open Space Conservation Agency (COSCA) – Temporary Encroachment Permit for Vehicular Access.

Additionally, DTSC coordinated with the appropriate agencies concerning access and natural/cultural-resource monitoring.

3.2 HEALTH AND SAFETY

All fieldwork was conducted in accordance with a site-specific Health and Safety Plan (HSP). The HSP was developed specifically for the two CBRAs to establish personal protection standards and mandatory safety procedures and to provide for contingencies that potentially could have arisen during field operations. The HSP complies with, but does not replace, Federal Health and Safety Regulations as set forth in Title 29 Code of Federal Regulations, Sections 1910 and 1926, California Health and Safety Regulations as set forth in Title 8 California Code of Regulations, and guidance established by Cal/EPA. Prior to field mobilization, the HSP was approved by a Certified Industrial Hygienist.

All URS field personnel were required to be familiar with the HSP prior to conducting fieldwork. URS personnel led daily safety briefings attended by the entire field crew and observers prior to initiating work. The primary site hazards identified and emphasized during the safety meetings included slip/trip/fall hazards associated with the rugged terrain, heat exhaustion, dehydration, sunburn, insect bites (primarily ticks), rattle snakes, poison oak, barbed wire fencing that required crossing, and four-wheel-drive road conditions. Health and safety issues that came to the attention of field personnel were also discussed at the conclusion of the field day, as appropriate.

The role of Site Safety Officer (SSO) was assigned to the URS Field Manager (Erich Weaver). The SSO conducted daily tailgate safety briefings for the field team prior to entering the study areas. Except for one reported tick bite, no recordable health or safety incidents occurred during the field program.

3.3 BIOLOGICAL AND ARCHEOLOGICAL MONITORING

3.3.1 Biological Monitoring

An initial biological orientation was provided for the core field team by USFWS biologists at the beginning of the fieldwork to provide information regarding endangered flora and fauna that are present, or potentially, present in the China Flat and Wood Ranch areas. Thereafter, biological monitoring was limited to the Wood Ranch CBRA, where there was a concern regarding the potential presence of the California Gnatcatcher. A Gnatcatcher was tentatively identified in the area during sample staking activities on April 4, 2011, based on a possible sighting, and again on April 6, 2011, based on auditory (bird call) evidence. Based on these tentative identifications, a URS biologist qualified for Gnatcatcher monitoring accompanied the field team for the duration of the sampling effort at the Wood Ranch CBRA. However, no further indications of the species were observed and its presence in the area remains unconfirmed.

3.3.2 Archeological Monitoring

Archaeological monitoring was conducted during each field day to inventory possible archeological resources encountered and to ensure that they were not disturbed during sample staking and collection activities. A comprehensive report of the archeological findings from the monitoring is presented in Appendix A. In summary, potential archeological resources encountered were minimal and the field program did not affect archeological sites.

3.4 PUBLIC PARTICIPATION

As part of DTSC's public-outreach efforts, members of the general public were afforded the opportunity to observe the field activities. Per a lottery conducted by DTSC, individuals selected one or more available dates when a DTSC Public Participation Specialist was available to provide escort. Three individuals observed a portion of the sample-locating tasks and an additional three individuals observed a portion of the soil sampling activities. These individuals were transported to the work areas in a URS vehicle. URS required the individuals to sign a liability waiver as a prerequisite for providing the transportation.

3.5 FIELD SAMPLING AND FIELD QA/QC PROCEDURES

3.5.1 Sample Collection

Soil sample collection and handling were conducted in general accordance with the Study's SAP (DTSC, 2011a) and QAPP (DTSC, 2011b). Soil and sediment sample collection was completed between July 6 and July 21, 2011, for the Wood Ranch CBRA and between October 17 and November 1, 2011, for the China Flat CBRA.

3.5.1.1 Drainage Transect Sampling

Surface samples were collected along each drainage transect as shown on Figures 3 and 4. The transect locations were re-occupied based on the prepared field map, the recorded GPS coordinates, and the marking flags that were placed during the prior sample staking event. The position of the sample collection point along each transect is indicated as the "offset" in Table 2 and represents the direction and distance, in feet, from the drainage centerline.

Drainage samples were collected from 0 to 0.5 feet bgs using a slide hammer equipped with a sampling head lined with 2-inch diameter by 6-inch long stainless steel sleeves. The sampling heads and sleeves were both cleaned prior to sampling at each location, as described below in Section 3.5.6. The number of sample sleeves collected at each location is indicated in Table 2 and was based on the suite of laboratory analyses to be completed and whether duplicate, split, and/or matrix spike (MS)/matrix spike duplicate (MSD) aliquots were required. Between three and nine sleeves were driven into undisturbed soil within an approximately 1-foot diameter area to achieve sufficient sample volume for the required laboratory analyses.

Soil designated for CrVI analysis was collected at each sampling location by dislodging soil from a sample sleeve into a laboratory-provided, clean polycarbonate (plastic) jar. Either one or three polycarbonate containers were filled at each location, depending on whether split/duplicate samples or MS/MSD samples were required for QA/QC purposes. Following collection, the jars were sealed with lab-supplied plastic screw-top lids.

3.5.1.2 Non-Drainage Sampling

Both surface (0 to 0.5 feet bgs) and subsurface (3.5 to 10 feet bgs) soil samples were collected at the non-drainage sampling locations shown on Figures 3 and 4. The surface samples were collected and handled as described above for the drainage locations, except that no transects or associated sample offsets were involved.

The subsurface samples were collected by first advancing a hand-augered boring to a depth of 1 foot above the target sampling depth[2]. The borings were offset a maximum 1 to 2 feet from the previously completed pilot borings and were logged by a California Professional Geologist in accordance with the SAP specifications and the Unified Soil Classification System (USCS). The field boring logs are presented in Appendix B.

Subsurface sampling depths at each location were randomly selected from the available soil thickness, as determined from the pilot hole completed during the prior sample staking event. Potential sampling depths were therefore limited to 3.5 feet up to 10 feet bgs maximum, in 0.5-foot increments. Sample collection and handling and equipment decontamination procedures were followed as previously described, except that EnCore® samplers were used for collecting samples for analysis of alcohols in accordance with USEPA Method 5035. EnCore® samples were collected by manually driving 25-gram EnCore® container plugs into the soil at one end of a filled sample sleeve using the laboratory-supplied T handle. Upon filling, the container was capped, placed in a supplied sealing envelope, labeled, and then transported and stored along with the other collected samples. Except as otherwise described, EnCore® samples were collected, labeled, handled, transported, stored, and shipped as described for the other sample container types.

3.5.1.3 QA/QC Samples

Field QC samples, including duplicate and split samples, were collected at each of the locations highlighted in yellow in Table 2. MS/MSD samples were collected at each of the locations highlighted in blue. Split and duplicate samples were collected at a rate of 10%, or more, of the primary sampling locations for each area, while MS/MSD samples were collected at 5% of the locations, or more. Primary, duplicate, split, and MS/MSD samples were collected simultaneously at the same depth interval using the same procedures.

Unlike the other QA/QC samples, split samples were not separated from the primary samples or uniquely labeled in the field, as indicated by their combined listing in Table 2; only additional sample volume was collected. With several exceptions, the bulk of the total sample volume was subsequently homogenized at LLI (the primary laboratory) in accordance with its SOP for soil homogenization. Soil homogenization was used to help ensure analytical results that represent the entire collected sample and to remove bias that would otherwise result from the selection of the sub-sample analyzed by the laboratory. Sample volumes required for the split sample and the dioxin/furan analysis were then separated by LLI and shipped to the secondary general chemical laboratory (CAS) and the primary dioxin/furan laboratory (Frontier), respectively. A split sample was also retained by LLI in its capacity as the secondary laboratory for dioxin/furan analysis. By this procedure, the composition of the primary and split samples remained as close to identical as possible. A portion of the sample volume in the stainless steel sleeves was separated by LLI prior to homogenization of the main sample and designated for SVOC analysis (i.e. SVOC samples

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[2] It was originally estimated that the sample depth interval required to provide sufficient volume for laboratory analyses would be 1.5 feet and, thus, the minimum sample depth would be 3.5 feet bgs (at least 2 feet below the surface, plus the 1.5-foot sample depth interval). Pilot borings were augered during the sample location staking event to evaluate the suitability of subsurface sampling locations with respect to sufficient soil based on this 3.5-feet value. However, subsequent to the sample location event, based on laboratory estimates of the required sample volume, the minimum sample depth interval was revised downward to 1 foot.

were not homogenized). Similarly, the discrete samples in the EnCore® samplers and polycarbonate jars for alcohol and CrVI analysis, respectively, were not homogenized. The decision not to homogenize these samples (or sub-samples) is based on the concern that the homogenization process could have resulted in the loss of the target analytes due to volatilization.

Additional QA/QC samples included trip blanks, equipment blanks, and field blanks. Trip blanks consisted of glass vials filled with clean, deionized water prepared by the laboratory that travelled with the primary samples in the cooler. Because trip blanks were only analyzed for alcohols, they were only placed in coolers containing primary samples to be analyzed for the alcohols. One equipment blank sample was prepared at the conclusion of each sampling day by pouring laboratory-supplied deionized water over a cleaned slide-hammer sampling head into 1-liter amber jars. One field blank sample was prepared each field week by pouring laboratory-supplied deionized water into a 1-liter amber jar. The number of QA/QC sample containers was dictated by the number and type of analyses for each sample, as indicated in Table 2.

All duplicate, MS/MSD, trip blank, equipment blank, and field blank samples were labeled with a unique ID number, the date and time, and the initials of the individual that prepared the sample.

3.5.2 Field Documentation

Field documentation of the soil sampling event included the field soil boring logs, sample location summary logs, and a photographic log.

The soil boring logs are presented in Appendix B. Information was annotated on the field boring logs for each soil sample collected at the China Flat and Wood Ranch CBRAs and includes the following:

- Project geologist
- Sample identification number
- CBRA (China Flat or Wood Ranch)
- Map grid cell
- Date
- Time of sample collection
- Depth of sample(s)
- Inches driven/inches recovered
- Percentage of gravel, sand, silt, and clay
- USCS soil type, and
- Soil sample description (including Munsell color classification).

The sample location summary logs are presented in Appendix C. These summary logs provide detailed location and descriptive information, including photographs for each of the sampling locations. Appendix C includes both the original set of location logs developed during the soil sample location events (see Section 2.3.2) as presented in the Study’s SLA (URS, 2011a) plus the 42 supplemental location logs developed during the soil sampling events. The sample location summary logs document the following information:

- Location number
- CBRA (China Flat or Wood Ranch)
- Date and time
- Map grid cell
- GPS coordinates (latitude and longitude)
- Transect specifications and sample offset
- Suitability Issues (access, lack of soil, etc.)
- Corresponding photograph numbers
- Biological resource issues observed, and
- Archeological resource issues observed.

In addition, during the soil sampling events, photographic documentation of each sample location was collected. The photographic log is presented in Appendix D and includes a photograph of each sample location with relevant identifiers (i.e., sample location identification number, date, and time).

3.5.3 Sample Identifiers

Sample identifiers were assigned to each sample (e.g., WRBS0001S055) accordingly:

- A two-letter, SSFL RFI-type site identification code: ‘WR’ for Wood Ranch or ‘CZ’ for China Flat. These site IDs are specified for each CBRA
- The field sample type: ‘BS’ for boring sample
- A four-digit sample location number: ‘0001’, ‘0002’, etc.
- A sample designator: “S” for primary samples or “D” for duplicate samples
- A three-digit sample depth number. The depth of the sample is coded as feet bgs, using one decimal place; for example, 005 is for 0.5 feet bgs, and 055 is for 5.5 feet bgs. Note that a soil boring location (e.g., WRBS0001) may have multiple samples collected; e.g., WRBS0001S005 and WRBS0001S055.

In addition, field blanks and equipment blanks (equipment rinsates) were named in the following manner:

- Field Blank: FBQW0000 where 0000 is an incremental sequential number.
- Equipment Blank: EBQW0000 where 0000 is an incremental sequential number.

3.5.4 Sample Handling, Labeling, and Identification

Disposable latex gloves were donned prior to handling each sample container by the field personnel. Upon collection, sample sleeves were sealed with Teflon sheeting and plastic end-caps. A waterproof label indicating the CBRA, sample number (includes sample location, type and depth information), date, time, and the collector’s initials were placed on all sample containers. Sample containers were then placed in re-closable bags, sealed, and placed in a backpack for field transport. Due to the limited number of clean sampling heads available at a time, collecting surface samples was limited to no more than four consecutive locations before transporting the samples back to the field vehicles and cleaning the equipment.

Upon returning to the field vehicles for equipment decontamination, the filled sample containers from the completed locations were placed in coolers with ice for the remainder of the field workday. Drainage samples were typically placed in the coolers within 1 hour or less after collection. Non-drainage samples were generally placed into the coolers within 1 hour after collection. The elapsed times were never allowed to exceed 2 hours.

3.5.5 Sample Packaging, Shipping, and Chain-of-Custody Requirements

Primary and QA/QC samples were repacked using fresh ice at the end of each field day for overnight shipment to the analytical laboratory. All sample shipments were accompanied by chain-of-custody (COC) documentation listing each sample number, the number of containers, date and time of their collection, and the requested analyses. Sample shipments were inspected by both URS personnel and a DTSC representative prior to shipping and both parties signed the COC documentation. Each sample cooler was sealed with security-custody tape prior to shipment to allow detection of any subsequent opening of the cooler. All samples were shipped via express overnight delivery to LLI in Lancaster, Pennsylvania. LLI managed all sample receipt and subsequent shipping of primary and spilt samples to Frontier Analytical and CAS, respectively. All samples were received and managed by LLI the day following collection.

3.5.6 Sampling Equipment Decontamination

Slide-hammer sampling heads and sample sleeves were cleaned prior to each use using a scrub brush and a water-and-Liquinox solution. The equipment was then double rinsed using laboratory-supplied deionized water and dried using disposable paper towels before being placed in a clean stuff sack for transport to the next sampling location.

3.6 INVESTIGATION-DERIVED WASTE

Investigation-derived waste included soil cuttings from the pilot holes and soil borings, equipment wash and rinse water, disposable gloves, and miscellaneous trash. Soil cuttings were placed back into each boring after completion of sampling, to the extent possible, with remaining cuttings occasionally distributed over the nearby ground surface. Wash and rinse water was transported to an off-site, secured storage center and poured into a 55-gallon, U.S. Department of Transportation-approved drum at the end of each field day. Upon conclusion of the fieldwork, the drummed water was sampled and tested for total petroleum hydrocarbons, volatile organic compounds, and California Title 22 metals prior to disposal as non-hazardous waste (under a non-hazardous waste manifest) on November 29, 2011, at the Crosby & Overton facility in Long Beach, California.

This section presents a summary of the data validation process and laboratory analytical results.

4.1 CHEMICAL DATA VALIDATION

This section summarizes the findings of the data validation completed for 295 soil samples (including 27 field duplicates) and 27 confirmation (split) samples. These samples were collected between July 6 and November 1, 2011.

LLI in Lancaster, Pennsylvania, analyzed the primary soil samples for all analyses with the exception of dioxin/furan analytes (by USEPA Method 1613). CAS in Kelso, Washington, and Rochester, New York, analyzed the confirmation (split) soil samples for all analyses with the exception of dioxins/furans. Dioxin/furan analyses for the primary samples were performed by Frontier in El Dorado Hills, California, and split sample analyses were performed by LLI.

Validata Chemical Services, Inc. (Validata), in Duluth, Georgia, reviewed and validated the sample data in accordance with the QA/QC program and DQO criteria outlined in the Study's final revised QAPP, dated June 2011 (DTSC, 2011b). The DQOs are quantitative and qualitative statements that specify the quality of data necessary to support project decisions.

The laboratory results were obtained as USEPA Level IV data packages. Full data validation equivalent to USEPA Stage 4 Verification and Validation (USEPA, 2009) was performed on 100% of the data in accordance with recommendations from:

- *USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Laboratory Data Review, Organics* (USEPA, 2008)
- *USEPA CLP National Functional Guidelines for Laboratory Data Review, Inorganics* (USEPA, 2010)
- *USEPA CLP National Functional Guidelines for Dioxin/Furan Data Validation* (USEPA, 2005)
- *Santa Susana Field Laboratory-Soil Background Study Quality Assurance Project Plan* (DTSC, 2011b).

Validata provided a comprehensive data validation report for each sample delivery group (SDG). These reports are included in Appendix H that also includes the Level IV data packages. The data review process involved evaluating the following parameters: sample receipt, holding times, laboratory blank results, laboratory control sample results (LCS/LCS duplicate), surrogate recoveries, MS/MSD results, instrument calibrations, internal standards, field quality control samples (equipment blank, trip blank, and field duplicate samples), split samples, and compound identification and quantitation. After evaluating these parameters, an overall assessment with respect to the quantitative and qualitative data quality assurance parameters of precision, accuracy, completeness, comparability, representativeness (PARCC) and sensitivity was formulated.

4.1.1 Overall Assessment

The analytical dataset generated as part of this Study, as qualified, with the exception of the rejected data (0.13%), is considered to be usable for meeting the Study's objectives. As such, the analytical completeness for the Study is 99.87%; defined as the ratio of the number of valid analytical results (valid analytical results include values qualified as “estimated”) to the total number of analytical results requested on samples submitted for analysis. Additionally, because all samples in this dataset were collected and analyzed under similar prescribed conditions, the data within this set are considered to be comparable.

4.1.2 General Limitations

Based on validation of the laboratory data, 99.87% of the data generated are valid and useable for meeting the Study’s objectives. However, while considerable effort was made to minimize potential biases in the analytical process, two issues of potential low bias were identified:

1- The results for the herbicide dinoseb from 38 samples were qualified as “rejected” (R) due to low LCS recoveries. The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps. Dinoseb, being a strong acid, reacts readily with alkaline substances and may be lost during extract clean-up or analysis (USEPA, 1996). For several analytical batches, due to the loss of dinoseb during the analytical process, the laboratory could not detect much of the dinoseb originally present in the LCS (i.e., a control sample). Consequently, the associated sample results were rejected. This resulted in 125 non-useable dinoseb data points (77% of the collected dataset). The resulting dataset contained one dinoseb detection (a duplicate Chatsworth non-drainage surface sample) which necessitated the non-statistical evaluation of this analyte (as discussed below).

2- As part of the Study’s requirements to monitor the laboratories’ capabilities to accurately report detections down to the Study-specific lowered RLs, a LCS at the RL concentration (RL-LCS) was included with each analytical batch. This LCS was prepared and analyzed in addition to standard LCS/LCSD samples that were included with each analytical batch. For the vast majority of the analyses (over 99% for the reported data), RL-LCS recoveries were within the acceptance criteria (DTSC, 2011b). However, for a few analytical batches, the RL-LCS for the herbicides and/or pesticides dalapon, dinoseb, 2-(4-chloro-2-methylphenoxy)-propanoic acid (MCPP), and aldrin were below the acceptance criteria (approximately 0.2% of the data). Consequently, the sample results for these analytes in the associated analytical batches were reported with the standard laboratory RLs and not the Study-specific “ultra-low” RLs. For these select organic compounds, the application of Study-specific “ultra-low” RLs was not feasible and the higher standard laboratory RLs were applied.

4.1.3 Data Qualifiers

The use of data qualifiers for the Study is in accordance with its QAPP’s recommendations (DTSC, 2011b), with one addition. The “X” qualifier was added that refers to an elevated quantitation limit due to RL-LCS failure as discussed in Section 4.1.2. The data qualifier definitions and reason codes are included in this report’s Appendix E.

Approximately 17% of the data were qualified as “estimated” and flagged as either “not detected-estimated” (“UJ”) or “detected-estimated” (”J”). Data qualified as detected and estimated in the chemical dataset are useable at their reported estimated values for the statistical analyses discussed in this report (Section 5.1). Data qualified as not detected and estimated in the dataset are useable as "non-detect" values at the method detection limit and also used as such for the statistical analyses discussed in this report.

Approximately 1.5% of the data were qualified as "anomalous" ("U") to reflect potential high bias due to blank contamination. Data qualified as "anomalous" in the chemical dataset are useable as "non-detect" values at the reporting limit for the statistical analyses reported herein. Data qualified as "rejected" ("R") in the dataset are -"non-data-points" and are not used in the statistical analyses discussed in this report. In keeping with EPA National Functional Guidelines (2008; 2010), a "U" qualifier is applied during data validation and review in cases of suspected blank contamination to indicate a potential high bias in detected sample concentrations that meet prescribed Functional Guidelines criteria. This indicates that a low-level detected result should be considered non-detect at the adjusted reporting limit. This should not be confused with the common practice of analytical laboratories for using a "U" qualifier to indicate a non-detect. Qualifiers applied during data validation are standardized by the USEPA. No standardization exists for analytical laboratory footnotes or qualifiers and they are applied on a lab-by-lab basis for the laboratories' own individual reasons. Each non-detect value is denoted in Appendix E by an 'ND' in the "Concentration" field.

Overall, with the exception of the rejected data, analytical results meet the DQOs (see Section 4.1.1) and are considered to be useable for the Study's objectives. Due to the small percentage of data qualified as "U" and "R," these qualifications do not have any material impact on the overall quality and robustness of the dataset.

4.1.4 Evaluation of Field Duplicates, Split Samples, and Field QC Blanks

4.1.4.1 Field Duplicates

Twenty-seven (27) field duplicate samples (10% of the primary samples) were collected in the same manner and at the same depths as the primary samples, in accordance with the QAPP's requirements, to assess field and analytical precision. Field-duplicate samples were analyzed for the same parameters as the associated primary samples. Results for field-duplicate samples were evaluated by calculating relative percent differences (RPDs) between the primary sample results and duplicate sample results. QAPP precision acceptance criterion is a RPD of ≤50%. Approximately 0.3% of the data were qualified as "estimated" ("J" or "UJ") due to field duplicate imprecision. Of all the target analyte results reported for the field duplicate pairs, 95.8% of the results met the ≤50% RPD criterion.

In general, the field-duplicate results indicate that the overall precision (sampling and analytical precision) is acceptable and do not adversely impact the quality or usability of the data. The field-duplicate results also do not appear to indicate significant inhomogeneity and suggest that the samples collected may be considered representative of the sampled medium.

4.1.4.2 Split Samples

Twenty-seven (27) confirmation (split) samples (10% of the primary soil samples) were prepared and submitted by the primary laboratory for analysis by separate QA/QC laboratories in accordance with the QAPP's requirements for inter-laboratory comparison. Results for split sample analyses were evaluated by calculating RPDs between the primary and split sample results only for concentrations detected above the RL. Due to MDL/RL variations between the primary laboratory and the QA/QC laboratories, reported results were considered non-comparable when one (or both) of the following conditions was present:

- Both the original and/or duplicate (i.e., split) results were less than the RL
- One or both results were qualified as “estimated” (“J”-flagged) or “rejected” (“R”-flagged) or were suspected of blank contamination (“U”-flagged).

For this Study, the QAPP precision acceptance criterion is a RPD of 30%. For results that were compared, approximately 51% of the results met the 30% RPD criterion. For more typical RPD acceptance criteria (for soil sample comparisons) of 50% and 100%, 72% and 96% of the results met the criteria, respectively.

4.1.4.3 Field QC Blanks

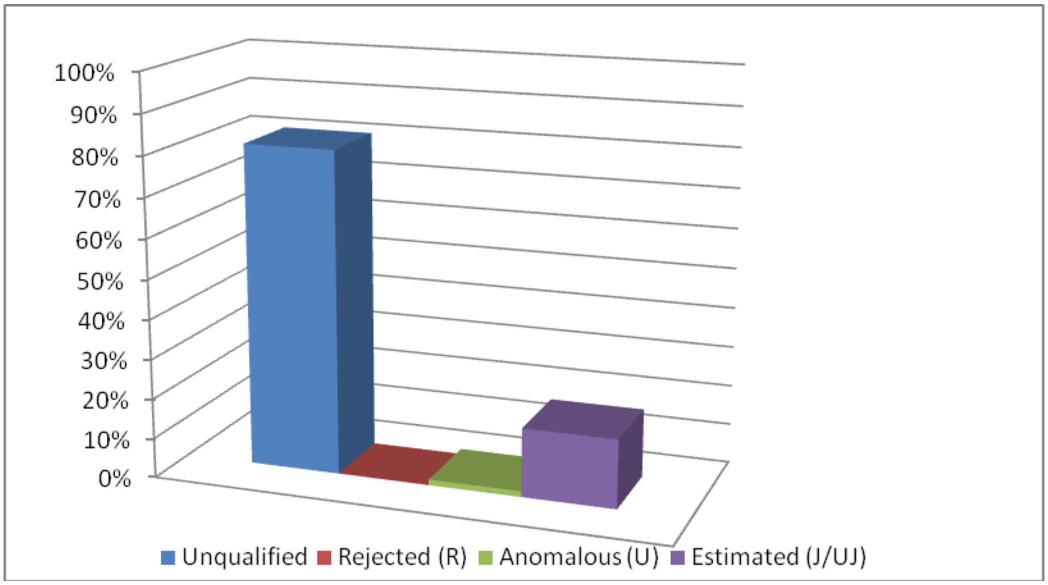
Field blanks, equipment rinsate blanks, and trip blanks were collected and analyzed in accordance with the QAPP requirements to monitor errors associated with the sampling process, field-related contamination, or sample handling. The field QC blanks results satisfied the QAPP’s DQO requirements and the vast majority of the results (99.3%) were below the RL for each of the target constituents. However, trace levels of contamination (less than the RL) were reported for several target analytes. Consequently low-level sample results associated with these blanks (approximately 0.46% of the data) were qualified as “non-detect” (“U”) to reflect the potential high bias.

4.1.5 Data Usability

This section presents an evaluation of the following QAPP data-usability criteria: completeness, precision, accuracy, representativeness, comparability, and sensitivity.

4.1.5.1 Completeness

A total of 295 field soil samples (including 27 field duplicates) and 27 spilt samples were submitted for laboratory analysis. All analyses were performed as requested on the COCs. The laboratories reported that all requested analyses and the deliverable data reports were complete. With the exception of the rejected data, the data reported, as were qualified, are considered to be usable for meeting the Study’s objectives. The analytical completeness for the Study is over 99%; defined as the ratio of the number of valid analytical results (valid analytical results include values qualified as “estimated”) to the total number of analytical results requested on samples submitted for analysis. The QAPP requirement for completeness was 90%. Out of approximately 29,579 individual analytical results (both detected and not detected), 7,335 results were qualified; the unqualified data (22,224 individual results) are acceptable without any bias. Of those data that were qualified, less than 1% (only 44 results) were qualified as “rejected.” Based on these findings, the Study’s completeness objectives were achieved. The distribution of data with respect to qualification categories is presented in the figure on the following page:



4.1.5.2 Precision

Precision is defined as the agreement between a set of replicate measurements without assumption and knowledge of the true value.

Twenty-seven (27) duplicate samples were collected and analyzed for the same analytical parameters as the associated primary samples. Over 99% of the duplicate soil sample results met the QAPP acceptance criteria. Thus, the overall precision (sampling and analytical precision) is acceptable, although several results for the field duplicate pairs were qualified as “estimated” (“J” or ”UJ”).

The precision of laboratory measurements was additionally evaluated by comparing MS/MSD and LCS/LCSD results. Over 95% of all duplicate results satisfied the applicable evaluation criteria. As such, the overall level of analytical precision demonstrated is considered acceptable.

4.1.5.3 Accuracy

Accuracy is defined as the degree of agreement of a measurement to an accepted reference or true value. Accuracy was measured as the percent recovery (%R) of an analyte in a reference standard or spiked sample.

LCS Summary – Every analytical batch for the Study included a pair of LCS and LCS-duplicate (LCSD) samples and one LCS at the concentration of RL. Less than 1% of the data were qualified as “estimated” (“UJ” or ”J”) due to LCS recoveries that were outside of control criteria. In addition, the results for dinoseb for 38 samples were qualified as “rejected” (“R”) due to low LCS recoveries (0.13% of the data).

The vast majority of the LCS recoveries (over 99%) were within their respective QAPP acceptance criteria, indicating that acceptable levels of accuracy were attained on clean sample matrices. Overall, the LCS results indicated that acceptable accuracy was obtained by the respective analytical method on a control sample matrix.

Surrogate Summary – Appropriate surrogate compounds were spiked into each sample for all applicable analyses. The vast majority of the surrogate recoveries (approximately 99.5%) were within QAPP acceptance criteria. Therefore, the surrogate compound recoveries indicate that the overall level of accuracy demonstrated on the individual sample matrices is acceptable.

MS/MSD Summary – Site-specific MS and MSDs samples were analyzed for each analytical method at the rate of 10% of the primary samples analyzed. The vast majority of the MS/MSD recoveries (for approximately 89% of the data) were within their respective QAPP acceptance criteria. The results associated with MS/MSD recoveries that were outside of control criteria (11% of the data) were qualified as “estimated” (“J” or ”UJ”) due to matrix interferences (e.g., organic material, other chemicals or constituents besides the analyte in question, or moisture).

Overall, the level of accuracy demonstrated by the analyses is considered to be acceptable.

4.1.5.4 Representativeness

Representativeness is a qualitative parameter that expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variation at a sampling point, or an environmental condition.

Representativeness was evaluated through reviewing the results from QC blanks (laboratory preparation blanks and field QC blanks), field duplicate samples, and split samples.

Field QC blanks included trip blanks, equipment rinsate blanks, and field blanks. A total of 23 trip blanks, 21 equipment rinsate blanks, and eight field blanks were collected and analyzed for all the applicable parameters. In addition, laboratory method blanks were analyzed at the required frequency for each analytical method. The vast majority of all blanks were found to be free of target-analyte contamination. Approximately 1.5% of the data were qualified as “non-detect” (“U”) to reflect the potential bias introduced due to blank contamination. Data qualified as “non-detect” in the chemical dataset are useable at the adjusted RL (based on the level of blank contamination) for the statistical analyses reported herein. Data qualified as “rejected” (“R”) in the dataset are “non-data-points” and are not used in the statistical analyses discussed in this report. Sample results for analytes detected in an associated blank were qualified in accordance with the principles presented in *National Functional Guidelines*. For results qualified as “non-detect” (“U”), when the reported value was less than the RL, the standard RL for that analyte became the effective RL. For results qualified as “non-detect” at a value above the RL, the reported value became the effective RL.

Representativeness was also evaluated by comparing the results obtained for field duplicate sample pairs and split samples. The vast majority of the results satisfied the QAPP’s field duplicate evaluation criteria.

Based on the above findings, the background samples are considered to be representative of the soils that were sampled.

4.1.5.5 Comparability

Comparability expresses the confidence with which one dataset may be compared to another. Comparability may be related to accuracy and precision because these quantities are measures of data reliability. Data are comparable if collection techniques, measurement procedures, the analytical method, and reporting are equivalent for the samples within a sample set.

As the soil background Study's samples were analyzed in accordance with the QA/QC measures prescribed in the QAPP, as well as the application of approved laboratory-specific SOPs, including DTSC-approved modifications to the SOPs, and that acceptable levels of overall accuracy and precision were attained, the data within these sets are considered to be comparable to each other.

Additionally, because all samples in the Study's dataset were collected and analyzed under similar prescribed conditions, the data within this set are considered to be comparable.

4.1.5.6 Sensitivity

Sensitivity refers to the ability of the analytical system to attain the detection limits necessary for meeting the Study's objectives.

Sensitivity was evaluated through reviewing calibration, MDL, RL and RL-LCS results. All results met the QAPP's acceptance criteria, with the following exceptions: the RLs for dalapon, dinoseb, MCPP, and aldrin collectively for 42 samples (0.2% of the data) were elevated due to unacceptable RL-LCS results.

The MDLs and RLs obtained for samples with less than a 10-times (10X) dilution satisfied the QAPP's requirements. However, for samples analyzed at a dilution of 10X or greater, one or more target analytes was detected. Thus, with the exceptions listed above, there are not expected to be any limitations on the use of the data with respect to the detection limits that were obtained.

4.1.6 Laboratory Visits

As noted in Section 2.5, the laboratory selection and evaluation process included visitations to the selected laboratories to observe laboratory conditions, assess analyst competence, and witness laboratory procedures under actual operating conditions. Following final selection of the three laboratories for this Study (i.e., LLI, Frontier Analytical, and CAS), follow-on laboratory visits were conducted as part of the overall QA/QC program to monitor the laboratories' adherence to the QAPP, applicable laboratory SOPs, and implementations of the recommendations made during the initial visits by URS chemists. These recommendations were:

1. USEPA Methods 8141A, 8081A: MDL studies needed to be performed and verified based on method modifications
2. Organic Preparation: A spike witness was required for all organic extractions performed for the Study
3. Metals Preparation: For each lot of disposable digestion vials, a container check needed to be performed and documented to measure the accuracy of measurement.
4. Organic Preparation: For accuracy of measurement, a graduated pipet, in lieu of comparison vial, to measure the final volume of extract needed to be utilized.

Experienced, qualified URS chemists (Lily Bayati and David Blaushield) were present on July 7/8, 2011, at LLI during receipt of the first set of soil samples collected from the Wood Ranch CBRA. The URS chemists monitored sample receiving, handling, log-in, homogenization procedures, forwarding of primary and split samples to Frontier Analytical and CAS, respectively, and initial sample preparation. Subsequently, a URS chemist visited LLI on approximate a weekly basis (from July 15 through August 9, 2011) to monitor analysis of the Study's samples and ensure the implementation of the QAPP requirements and recommendations of the initial audit. In addition, a URS chemist visited LLI again on October 25/26, 2011, during analysis of the China Flat CBRA samples. Both Frontier Analytical and CAS were also visited during analysis of the China Flat CBRA samples; on November 17 and December 6, 2011, respectively.

The laboratory visits were useful from a coordination standpoint and no significant laboratory deficiencies were noted during the visits. Each visit confirmed that all analyses were performed in accordance to the QAPP, SOPs, and DTSC-approved method modifications. During these visits, two minor issues were discovered and resolved. The first set of equipment blank (EB) samples had trace-level detections of several target analytes. Although these detections had no impact on the results of the site samples, careful examination and corrective actions were implemented by the laboratory and the field personnel to discover the source of contamination. After thorough review, it was determined that the de-ionized water used to prepare equipment blanks, which was provided by a local vendor, was contaminated at extremely low levels. After this finding, LLI provided reagent-free de-ionized water to be utilized on site for EBs. Another minor issue was the updating of statistical windows by LLI for LCS recoveries for the following analytes: aluminum, iron and titanium. This was due to the laboratory's use of a new lot of LCS reference materials.

4.2 LABORATORY ANALYTICAL RESULTS

This section presents the laboratory analytical results for the Study's 111 chemical analytes and also presents the grain-size results for 271 soil samples.

4.2.1 Chemical Results

In summary, a total of approximately 29,579 individual analytical results were reported by the Study's three selected laboratories. As presented in Section 4.1, the analytical dataset underwent a rigorous data validation process and QA/QC review. Overall, 99.87% of the analytical data are considered usable for meeting the Study's objectives.

The validated analytical results for each of the 111 chemical analytes are presented as an individual table in Appendix E. Each table is further summarized by formation (i.e., Chatsworth or Santa Susana) and topography (drainage or non-drainage). The information provided by each table also includes the following:

- Sample ID
- Sample date
- Sample depth
- Units
- Concentration
- Reporting limit
- Method detection limit
- Qualifier(s), and

- Outlier flag (see Section 5.2.5).

The complete set of Level IV data packages and the data validation reports are presented in Appendix H.

As presented in Sections 5 and 6, this validated dataset underwent statistical evaluation that included the exclusion of process-confirmed outliers. The resulting standard statistical parameters (including the mean, standard deviation, and range) for each analyte per statistically-similar sample strata are included in Table 5.

4.2.2 Soil Grain Size

As part of the Study, 271 soil samples were analyzed for grain size by ASTM Method D421/D422 – 136 samples from the China Flat CBRA and 135 samples from the Wood Ranch CBRA. The soil samples, along with their USCS soil type based on the particle-size distribution, are listed in Table 6. The laboratory reports (as excerpted from the full Level IV data packages) are presented in Appendix F.

Over one-half of the soil samples (170) were fine-grained and classified as sandy silt to silt (“ML”). The 101 coarse-grained samples were predominantly silty fine sands (“SM”). For the China Flat CBRA, 48 soil samples (35%) were sandy silts, while 88 samples (65%) were silty sands. The predominance of sand within the China Flat CBRA correlates with the presence of the Chatsworth Formation (Figure 2), which consists of sandstone with interbeds of siltstone and shale. For the Wood Ranch CBRA, 122 soil samples (90%) consisted of silt, while only 13 samples were coarse-grained. The predominance of silt at the Wood Ranch CBRA is associated with the Santa Susana Formation (Figure 2), which consists mostly of claystone and siltstone, with outcropping bands of sandstone, within the CBRA.

This section provides an overview of the processes employed to evaluate the chemical soil background data and develop either background threshold values (BTVs) or non-statistical parameters (i.e., RLs) for each of the Study’s 111 individual chemical analytes. Once defensible and representative background datasets, free of confirmed outliers and representing site conditions not affected by SSFL-related activities, were established, BTVs were estimated for the 97 analytes that were found with five or more detections by using documented and well-established statistical procedures available in the environmental statistical literature.

5.1 STATISTICAL PROCESS OVERVIEW

For each chemical analyte, the statistical evaluation process included the major steps discussed below. Figures 5A and 5B, respectively, summarize the statistical processes employed to establish background datasets and compute BTVs.

Description of Statistical Datasets: The validated analytical results went through a progression of statistical steps to establish individual datasets that represent the same sample population devoid of confirmed outliers. To better describe the statistical process, the following descriptive terms are used in this section to identify the stage of the dataset being discussed:

Initial Datasets	Derived wholly from the validated analytical data for each of the six geomorphological strata (i.e., four strata for inorganic analytes and two strata for organic analytes. *Initial* datasets are “raw” in the sense that no dataset merging or outlier removal has been performed.
Distinct Datasets	Represent data from the same population; if statistically the same, *initial* datasets are merged into a combined *distinct* dataset (retaining potential outliers), but if statistically different, the *initial* dataset is retained as an independent *distinct* dataset (also retaining potential outliers)
Established Datasets	Derived from the *distinct* datasets; potential outliers are identified and confirmed outliers are removed. Resulting *established* datasets are used for the computation of BTVs.

***Established* Background Datasets:** Individual distinct *established* datasets for statistical analysis were developed using a sequential process:

- *Initial Datasets*: For each chemical analyte, individual *initial* background datasets were assembled from the validated analytical results for each of the six geomorphological groups or “strata” (used here in a statistical sense).
- *Merge Datasets*: For each analyte, *initial* datasets were compared across strata (i.e. applicable groups of geologic formations and topography per the SCM). Datasets that did not show statistically significant differences were merged into a combined *distinct* dataset. The remainder, for which it was determined that merging was not appropriate due to statistical differences between strata, were retained as individual *distinct*

background datasets. This step resulted in identifying one or more *distinct* datasets for each analyte.

- *Identify Outliers*: For each analyte, within each *distinct* dataset identified in the previous step, potential outliers (if any) were identified and confirmed outliers (if any) were excluded from the *distinct* dataset (see discussion on outliers below in Section 5.2.5). This resulted in identifying one or more "*established*" background datasets for each analyte. Statistical parameters were then computed separately for each of the *established* background datasets.

Select Appropriate BTV Statistical Parameter(s): In accordance with the expected use of the data by DTSC and the Responsible Parties, potential statistical parameters that could represent BTVs were evaluated and the most appropriate parameters were selected for BTV computation (see Section 5.3).

Compute Statistical Parameters: For each *established* background dataset, both basic statistical parameters (e.g., mean, range, and standard deviation) and upper statistical limits (representing BTVs) were computed using applicable statistical methods that accounted for both the population distribution and the presence of non-detects in the datasets.

Each of the above steps in the statistical process is also described herein in more detail in subsequent sections.

5.2 *ESTABLISHED* BACKGROUND DATASETS

5.2.1 *Initial* Datasets Based on Strata

As summarized above in Section 2, two CBRAs were identified for the Study: the China Flat CBRA, underlain by the Chatsworth Formation, and the Wood Ranch CBRA, underlain by the Santa Susana Formation. In accordance with the Study's SAP (DTSC, 2011a), samples were collected for inorganic and organic analyses to represent combinations of geomorphological groups or "strata" based on the Study's SCM and represent the *initial* datasets.

For **inorganic analytes** (metals and perchlorate), there are **four** pre-defined sample populations:

- Chatsworth Formation / Drainage Topography
- Chatsworth Formation / Non-Drainage Topography
- Santa Susana Formation / Drainage Topography
- Santa Susana Formation / Non-Drainage Topography

In addition to the inorganic analytes, the *initial* datasets for two organic analytes (i.e., cyanide and formaldehyde) and for fluoride and nitrate are also represented by these four pre-defined populations.

For the majority of the **organic analytes** (except for cyanide and formaldehyde as noted above), there are **two** pre-defined sample populations:

- Combined Formation (Chatsworth and Santa Susana) / Drainage Topography
- Combined Formation (Chatsworth and Santa Susana) / Non-Drainage Topography

In addition, based on the sampling design outlined in the SAP (DTSC, 2011a), alcohols (ethanol and methanol) are represented by a single population, based on the collection of non-drainage, subsurface samples from both the Chatsworth and Santa Susana Formations.

For the inorganic analytes, both surface and subsurface soil samples were collected and analyzed in the non-drainage topography and only surface soil samples were collected and analyzed in the drainage topography. For organic analytes, only surface soil samples were collected and analyzed in the two strata identified above. In total, considering both the inorganic and organic analytes, a total of six background *initial* datasets were collected. The six *initial* datasets and the number of background soil samples collected and analyzed for each set are summarized in Table 3. It should be noted that for the alcohols (i.e., ethanol and methanol), only subsurface soil samples were collected from non-drainage topography (30 samples each from Chatsworth and Santa Susana Formations) in accordance with the Study's SCM that such relatively high-volatility compounds would not be present in surface or near-surface soils.

As presented in Section 4, the laboratory analytical results were subjected to a rigorous data validation process and 99.8% of the data were determined to be useable. Furthermore, as presented in Table 3, the number of analytical samples ranged from 60 to 88 (not including duplicates) for the six strata. Consequently, the sample population for each stratum met or exceeded the minimum sample size of 60 as established in the SAP to meet the requirements to calculate an Upper Tolerance Limit under a coverage of 95% of the population, with a confidence level of 95% (i.e., UTL95-95; see Section 5.3.1.3 for further description). Overall, the chemical background *initial* datasets are robust from both data usability and sample-size standpoints.

5.2.2 Non-Detects, "U"-Flagged Data, and "J"-Flagged Data

Laboratory analytical results reported as being less than a MDL were treated as non-detects and "censored" at the MDL; i.e., the results were considered to be less than or equal to the MDL. "U" flagged data values were also treated as non-detects; however, they were censored at the RL. For "J"-flagged data, which are between the MDL and the RL and considered present in the sample, but of an estimated concentration, their reported "estimated" values were used for BTV estimation. This is one of the methods recommended in Helsel (2005) for handling data that is higher than the MDL but lower than the RL without introducing a bias. This method accounts for the distinction between a true non-detect (below the MDL) and a value that is a confirmed detect, although not fully or precisely quantified (between the MDL and the RL). Censoring at the RL would lose this distinction with a consequent loss of some information. The "J"-flagged values were used collectively with other values to derive unbiased estimates of statistical parameters.

5.2.3 Duplicate Sample Results

Although duplicates are collected primarily for QA/QC purposes, both the primary and duplicate results are valid concentration values at a given sampling location and neither should be ignored in any statistical evaluation. An unbiased estimate of the concentration at the location is the average of the two values. Discrete duplicate-sample results were replaced with a simple average of the primary sample result and its associated duplicate sample result. Duplicate samples are expected to be correlated because of their spatial proximity and, therefore, provide overlapping information (i.e., the results are not independent). Treating such duplicate samples as independent data points would falsely increase the overall sample size and would result in assessing unjustified greater precision for the statistics derived from such data. The data from both the primary and duplicate sample results represent valid data and the averaging process merges the results from both samples.

A common practice, repeated for this Study, is to replace each duplicate sample result with a single data point, for which the best estimate of the concentration is taken to be the average of the duplicate-primary sample values. One concern about duplicate averaging is that the variability of the averaged values is less than the variability of the single measurements.

However, as asserted by USEPA (2009) guidance, when the percentage of duplicate samples relative to the total number of samples is small (e.g., no more than 10%), the impact of duplicate averaging on the data variability should be negligible and duplicate averaging is a reasonable option. For the data used in this statistical analysis, the maximum number of duplicate samples was about 10% of the total number of samples. Duplicate averaging, therefore, was used in this statistical analysis.

Per USEPA (2009), if both the duplicate-primary sample pair values were non-detects, they were replaced with a single non-detect value at the average MDL of the primary sample and its duplicate. If a duplicate's result was a detected value and its primary sample's result was a non-detect value, then the non-detect value was replaced with the reported MDL value and then averaged with the detected value. The same approach was used if the primary sample result was a detected value and the duplicate sample result was a non-detect value.

5.2.4 Dataset Merger

The *initial* inorganic datasets were compared across the four applicable geomorphological strata (Section 2.4) and the *initial* organic datasets were compared across the two applicable additional geomorphological strata. The purpose of this step was to identify those *distinct* datasets (for each analyte) that statistically could be recognized as representing a single population whose data could be merged together to form a more robust overall *distinct* dataset for statistical analysis. For the *initial* datasets (i.e., strata) that were not merged, there are as many as four discrete BTVs for each detected inorganic analyte and two discrete BTVs for each detected organic analyte (see Section 5.2.1).

The multiple *initial* datasets for each analyte exhibited statistical characteristics that made the use of a parametric method to statistically compare the *initial* datasets inappropriate. These characteristics included non-normal distribution, unequal variances, presence of non-detects, and/or presence of potential outliers. Therefore, a nonparametric method that would be robust with regard to these characteristics was used to statistically compare the multiple *initial* datasets for each analyte. Specifically, the Kruskal-Wallis test was used to compare the four *initial* datasets for each detected inorganic analyte and the Wilcoxon-Rank-Sum (WRS) test was used to compare the two *initial* datasets for each detected organic analyte. These tests were applied using the commercial statistical software JMP developed by the SAS Institute (JMP, 2010).The purpose of these two tests is to determine whether the individual *initial* datasets are statistically similar and represent the same (or different) sample population(s)

For each inorganic analyte, if the Kruskal-Wallis test showed no overall significant difference (at 5% significance level) across the four individual *initial* datasets, all four *initial* datasets were merged to define a single *distinct* dataset. If the test did show a significant overall difference, the two topographies within each geologic formation were then compared to determine whether there are significant differences (based on topography). If the difference between the two topographies within a formation was not significant, the individual *initial* datasets for the two topographies within that formation were merged to define a single *distinct* dataset for the formation. If the difference between the two topographies within a geologic formation was significant, the individual *initial* datasets from the two topographies were not merged, but retained as two *distinct* background datasets for the formation.

For each organic analyte, if the WRS test showed no significant difference between the two topographies, the corresponding individual *initial* datasets were merged to define a single *distinct* dataset. If the WRS test did show a significant difference between the two topographies, the individual *initial* datasets were retained as two *distinct* datasets.

As shown in Table 5, approximately 86% of the initial inorganic datasets were either fully or partially merged and 76% of the initial organic datasets were fully merged. Each resulting merged or non-merged dataset was termed a *distinct* dataset that was further evaluated for the presence of outliers, as described in the following section.

5.2.5 Outlier Identification

Following the assembly of the *distinct* datasets, these *distinct* datasets were screened for potential outliers. To determine outliers, exploratory data analysis (EDA) was utilized, followed by a formal statistical test. In DTSC's guidance (2008), EDA is described as: “...an iterative process that uses several tools to evaluate data characteristics, make appropriate adjustments to the dataset (e.g., adjust for censored [i.e., "non-detect"] values), and refine the dataset (e.g., remove outliers). Prior to beginning EDA, all data is (sic) reviewed to ensure that it (sic) represents the target population...and that it is appropriate to include the data in the analysis...”

For the background study, EDA also involved using multiple lines of evidence to evaluate potential outliers in the background *distinct* datasets. These lines of evidence include ensuring the data are valid (e.g., reviewing field and lab reports, data validation reports, etc.); visually examining graphical data representations (e.g., histograms, box-and-whisker plots, and probability plots); and confirming outliers using statistical tests (e.g., Rosner's Test). Graphical displays provide added insight (e.g., presence of outliers, data distributions and patterns, visual comparison of two or more groups) into *established* datasets that is not possible to visualize and understand simply by reviewing the outlier test statistics.

The fact that a background concentration value exists in an initial, properly-collected set of data and that it is later determined to be an outlier does not, in any way, indicate that the reported concentration is not a valid result, or that it is not naturally occurring, or that it does not reflect the conditions that exist at the location where the associated sample was collected. However, the outlier concentration is considered to be an anomalous result. Retaining the concentration in the dataset would result in skewed statistics that would reduce the conservatism of BTVs and is not appropriate without additional evidence that may demonstrate that the anomalous result is truly representative of the background population.

To identify potential outliers, graphical displays of the data (box-and-whisker plots, histograms, and normal probability plots) were prepared using the JMP software. These displays were examined visually to identify any isolated data values that appeared to be separated by large gaps from all the remaining data. Data values that were visually identified were checked for field or laboratory errors. However, no field or laboratory errors were identified. Field boring logs were also consulted to determine if there were exceptionally anomalous sampling conditions that would make the concerned data values very different from the rest of the background data, but none were identified. Consequently, all potential outliers were subjected to a formal statistical test using the ProUCL software (version 4.1.01). To test for outliers, the Dixon's test was used if the sample size was less than 25 and the Rosner's test was used if the sample size was greater than or equal to 25. The outlier test was performed on detected results only. As such, after a detected result was confirmed as an outlier by the test, any non-detects with elevated MDLs greater than this detected result were also unusable in the statistical analysis and were treated as confirmed outliers. Elevated MDLs were due to interferences from the sample matrix. Statistically-confirmed outliers were excluded from the subsequent analysis.

The details of these graphical methods and outlier tests may be found in *ProUCL 4.1.00 Technical Guide* (Singh et al., 2010), *Data Quality Assessment: Statistical Methods for Practitioners* (USEPA, 2006b), and *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987). Confirmed outliers were excluded from each *established* dataset before conducting further statistical evaluations. Outlier identification for each analyte is included in Appendix E.

For each analyte, each distinct dataset, after excluding confirmed outliers (if any), was considered to be an *established* background dataset. Appropriate BTVs were then derived for each *established* background dataset containing detected results, as described in the next section.

5.3 SELECTION OF BTV STATISTICS

Because BTVs are computed based on an *established* background dataset and multiple on-site SSFL observations are to be compared with parameters (i.e., Look-Up Table values; see below and Section 6.2) derived from the BTVs, an appropriate statistic that maintains the proper balance between false positives and false negatives should be used. This is especially important and warranted for this Study because many SSFL on-site observations will be compared with parameters derived from the respective BTVs for many chemical analytes.

At many sites, USEPA often uses the 95th percentile or a 95% upper prediction limit to establish BTVs because risk assessments and professional judgments may be used when it is determined that some on-site sample results above the BTVs may be false positives. Both DOE and NASA have entered into Administrative Orders on Consent (AOCs) with DTSC, (2010a, 2010b) that require cleanup to background levels in the portions of SSFL under their responsibilities. The AOCs assert that any on-site sample that exceeds the respective Look-Up Table value must be resampled, and the soil remediated, if the analytical results are reproducible. However, care must be exercised to appropriately balance false-positive and false-negative error rates in BTV selection. False positives represent those situations where an SSFL on-site concentration of a chemical analyte exceeds its respective Look-Up Table value and is falsely considered an indicator of contamination. In the AOC case, minimizing false positives will result in reducing the prescriptive remediation of SSFL site soils. False-negative errors result in incorrectly selecting a sample as background when it is actually impacted by contamination, which results in the sample being removed from further evaluation. The impact of each type of these errors must be evaluated in the context of the processes that will be used at SSFL.

5.3.1 Overview of Candidate BTV Statistics

Four different statistical limits were evaluated as potential statistics to determine the Study's BTVs:

- 95% Upper Percentile (x0.95)
- Upper Prediction Limit at 95% confidence (UPL95)
- Upper Tolerance Limit with 95% coverage and 95% confidence (UTL95-95), and
- Upper Simultaneous Limit at 95% confidence (USL95).

A brief description of each of these statistics is included in the following sections.

5.3.1.1 Upper Percentile (x0.95)

The Upper Percentile (x0.95) represents an estimate of the 95th percentile of background population (Singh et al., 2010; USEPA, 2011b). Under this approach, it is expected that 95% of the values coming from the background population would be less than or equal to x0.95. If a population is comparable to the background population, there is a 95% probability that a random observation would be less than or equal to x0.95. An "observation" in this context is a measurement of chemical concentration at a particular location. By definition, about 5% of background values would exceed x0.95. The statistic x0.95 does not take into account variability of future observations. A "future" observation in this context is a new observation at a location representative of background conditions that is not a part of the current background dataset. When a large number of site observations are to be compared to a BTV, the use of x0.95 as the BTV may lead to an unreasonably high number of false positives.

5.3.1.2 Upper Prediction Limit (UPL95)

A prediction interval is an estimate of an interval in which future observations will fall, with a certain probability or level of confidence, based on what has already been observed. The UPL95 establishes a limit that would classify future observations at or below this limit as being taken from the background population with a confidence coefficient (CC), or level, of 95%. In most practical applications, the choice of the 95% CC provides a good compromise between false positives and false negatives (USEPA, 2011b). UPLs are useful when only a few known number of future observations are to be compared against a UPL. However, using UPL95 to compare many future observations may result in a relatively high number of false positives (a value declared to be exceeding background when, in fact, it is drawn from the range of background population values).

5.3.1.3 Upper Tolerance Limit (UTL95-95)

A tolerance interval establishes limiting values that include a fixed proportion of a population with a stated level of confidence. The UTL95-95 is a value that represents the upper limit of a tolerance interval such that 95% of the observations from the background population will be less than or equal to that upper-limit value with a CC of 95%. The UTL95-95 is designed to simultaneously provide coverage for 95% of all potential observations (current and future) from the background population with a CC of 95%. Alternatively, the UTL95-95 represents a 95% upper confidence limit for the 95th percentile (x0.95). From an exceedance perspective, a UTL95-95 is the value that will be exceeded less than 5% of the time by all values potentially coming from the background population, with a CC of 95%. This is true for each chemical analyte. A parametric UTL95-95 takes into account the variability of current and future observations. When the dataset does not follow a discernible distribution, a nonparametric UTL represented by a higher-order statistic (for example, the largest value or the second largest value) may be used as an estimate of BTV. Results derived using the ProUCL software were used to determine UTL95-95 BTVs (see Appendix G, page 3). If a dataset follows no discernible distribution, ProUCL determines the order statistic for a nonparametric UTL95-95 based on the sample size. This means that the order statistic to use is not fixed a-priori in ProUCL. The technical details, including the mathematical equation for determining the order statistic, are described in Section 3.4.4 of the ProUCL Technical Guide (Singh et al, 2010).

5.3.1.4 95% Upper Simultaneous Limit (USL95)

The USL95 is the statistic such that all potential observations (present and future) from the background population will be less than or equal to USL95 with 95% confidence (Singh and Nocerino, 1997; USEPA, 1999b). A USL95 represents the upper limit such that all observations, not some proportion or percentile, from the established background dataset will be less than or equal to USL95 with a CC of 95%. It is therefore expected that *all* potential observations (present and future) coming from the background population will be less than or equal to USL95 with a 95% CC.

Under the USL95, for each chemical analyte, the false-positive error rate does not change with the number of comparisons since USL95 is meant to perform many comparisons simultaneously (USEPA, 2011b). A parametric USL95 takes into account the variability of current and future observations. When the dataset does not follow a discernible distribution, a nonparametric USL, represented by the largest value in the dataset, may be used as an estimate of BTV.

Whereas USL95 provides 100% coverage (with 95% confidence) for all present and future background observations, UTL95-95 provides 95% coverage (with 95% confidence) for all present and future background observations, and UPL95 provides 100% coverage (with 95% confidence) only for the fixed number of future observations. The USL95 is an appropriate approach to estimate BTVs when the variability in the background dataset used to derive USL95 is relatively small (i.e., the relative standard deviation is less than 50%) and there are no potential outliers that may represent impacted locations (i.e., not representing the background population).

5.3.2 Recommended BTV Statistics

In a real-world context, the candidate BTV statistics [discussed above] represent a spectrum of statistics with varying balances between false positive (i.e., samples falsely characterized as exceeding background) and false negatives (i.e., samples falsely characterized as representing background). In a ranked order, the statistics with *decreasing* chance of false positives are the following: x95, UPL95, UTL95-95, and USL95. Figure 6 provides an example of the four statistical results of upper limits (including the mean) for a metal (thallium) and demonstrates that the background BTV value increases for those statistical parameters with inherent decreasing chance of false positives.

5.3.2.1 Administrative Orders on Consent (AOCs)

For remedial work under the AOCs, it is recommended that the USL95 is the most appropriate statistic to estimate BTVs. This recommendation is based on the following factors:

- Extensive research on the CBRAs' sampling sites (site visits, aerial photograph interpretation, and historical research) indicated that they were unimpacted.
- Study's analytical data is robust from both data-quality and sample-size perspectives.
- Relatively few outliers in the Study's analytical data and these outliers are not being included in the statistical evaluation.
- As presented in Section 6.2, AOCs require that any on-site sample that exceeds a Look-Up Table value (derived from the respective BTV) must be retested for reproducibility or remediated. Therefore, care must be exercised to limit the number of false positives in SSFL on-site samples so that resources may be directed toward cleaning up locations where contamination is present.
- Limiting false positives will also lessen the potential for unnecessary remediation that may result in ecological damage as compared to other statistics (e.g., UTL95-95). Such other statistics inherently incorporate the possibility of a greater number of false positives that would require remediation (with associated potential for ecological damage).

In summary, a population statistic that represents the maximum value for the population, such as the USL95, is recommended as the most appropriate statistic to represent BTVs that are used to derive values that are a basis for cleanup (in accordance with the AOCs). The AOC approach, using background-based do-not-exceed values in conducting point-by-point comparisons as the decision points for remediation, is why the USL95 is the more appropriate statistic.

5.4 BTV STATISTICAL PROCESS

As discussed in the previous section, the USL95 is recommended for estimating BTVs under the AOCs' requirements. This section summarizes the individual steps used to compute the two sets of BTVs (for both the USL95 and the UTL95-95) for each *established* background dataset. As described previously, confirmed outliers were removed from the *established* background datasets.

5.4.1 Datasets Containing No Non-Detects

For each *established* background dataset containing no non-detects, the normality of the data was first checked using the "goodness-of-fit" test in the ProUCL software. Based on the ProUCL guidelines, the Shapiro-Wilk W test was used for a sample size of 50 or less and the Lillifors test was used for a sample size greater than 50. If the data fit a "normal" distribution, the parametric ("normal") method was used to derive the associated BTVs. In this and subsequent steps, the USL95 was calculated using the Scout 2008 software (version 1.00.01) (Singh et al., 2009).

If the data did not fit a “normal” distribution, a possible fit to a “gamma” distribution was evaluated. If the data fit a “gamma” distribution, the parametric (“gamma”) method was used to derive the BTVs. If the data fit neither a “normal” nor a “gamma” distribution, the nonparametric method was used to derive the associated BTVs (and other standard statistical parameters).

5.4.2 Datasets Containing One or More Non-Detects with a Minimum of Five (5) Detects

For each *established* dataset containing one or more non-detects, but at least five detects, the Kaplan-Meier (KM) method was used to derive the associated BTVs. Exceptions were made for tin, perchlorate, and 2,4-DB for the reasons discussed in Section 6.1.2.

5.4.3 Datasets Containing Fewer than Five (5) Detects

No meaningful statistical analysis is feasible for *established* datasets with fewer than five detects and, under such circumstances, non-statistical considerations should be used to define BTVs in such cases. For those analytes where there are either no detects (e.g., ethanol; dalapon) or less than five detects (e.g., cyanide in Santa Susana Formation; dinoseb), it is recommended that the sample RL may be used.

The rationale for this recommendation applied in both these cases is that selecting the sample RLs is consistent with the AOCs’ requirements. However, the recommendation to use the sample RLs should be considered within the overall process to develop the Look-Up Table values that takes into account various elements of concern, including data quality (e.g., sample quality assurance and control; data validation results; and method uncertainty), analytical measurement variability, and spatial distributions of analytical results.

5.5 DATA VARIABILITY AND UNCERTAINTY

Formal statistical methods such as USL95 explicitly account for random variability in the current and future observations from the background population. The method directly controls the probability of a false-positive error (i.e., incorrectly concluding an observation is greater than background when, in fact, it is not) to an acceptable level. If the random variability in the background data is large and the background sample size is small, the probability of a false-negative error (i.e., incorrectly concluding that an observation is not higher than background when, in fact, it is) may be large. However, for this Study, the nominal background sample size of 60 (or greater) and the observed relatively small random variability of the background data enable controlling the probability of the false-negative error to an acceptable level.

However, statistical methods do not protect against systematic variations (“bias”) in the sampling data; for example, any bias introduced by field or laboratory equipment or procedures. The data QA/QC procedures in a sampling plan are critical to guard against such bias. Criteria regarding percent recovery and relative standard deviation (RSD) between field duplicates (or laboratory duplicates) should be met consistently both for the background and SSFL on-site datasets. If there are any systematic differences in the MDLs between the background and SSFL on-site data, this would create uncertainty in dealing with non-detects in the two datasets. Uncertainty is also created when the MDLs are close to, or higher than, the statistical limit derived to represent a BTV; or when all detected values are lower than the MDL of several non-detects. Future adherence to strict QA/QC procedures during SSFL sample collection and analysis should minimize the potential for biases or systemic differences between the background and SSFL site datasets.

This section presents the results of the statistical evaluation and the estimated BTVs for all the Study's individual detected chemical analytes.

6.1 RESULTS OF STATISTICAL EVALUATION

The statistical evaluation process discussed in Section 5.4 utilized all analytical results judged usable by the data validation process for the intended purpose of estimating BTVs. The results of this evaluation are presented in graphical format in Appendix G, and include a set of the following graphs for each individual chemical analyte:

- **Box Plots**: Box plots of the analytical results illustrate the median and range of chemical concentrations and were used to identify potential outliers and similarities between or among the geomorphological strata from which the soil samples were collected.
- **Data Distribution Graphs**: These graphs include probability plots, box-and-whisker plots, and histograms for each *distinct* dataset of each analyte. Probability plots were used to infer whether a sample population exhibited a particular distribution (normal or gamma) and also provide additional insights into the presence of potential outliers. Histograms and box-and-whisker plots were also useful to understand the nature of data distribution (skewed versus symmetric) and to identify potential outliers. The potential outliers on both graphs are shown with a distinct symbol (a blue triangle) for ease of identification.
- **Scatter Plots**: Scatter plots show the overall distribution of the analytical results; in addition, the sample mean of the population and the BTVs (including UTL95-95 and USL95) are superimposed on the plots to provide a visual comparison with the actual detected concentrations (and MDLs for non-detects, if any) of the analyte.

As a guide to interpreting the statistical graphs, a narrative description of the statistical process for two specific analytes (arsenic and bis(2-ethylhexyl)phthalate) is provided as an introduction in Appendix G.

Table 5 presents a compilation and summary of the evaluation results for each of the 111 chemical analytes for each of the 193 *established* datasets derived after evaluating the populations comprising the original individual sample strata and merging statistically similar *initial* datasets. This table includes the following parameters and results:

- Sample Counts and Detection Frequency
    - Number of excluded outliers
    - Number of samples (after excluding outliers)
    - Number of detects
    - Detection rate
    - Number of detections qualified “J”
    - Percentage of detections qualified “J”
- Summary Statistics
    - Mean
    - Standard deviation

- Detected Values
    - Minimum
    - Maximum
- MDL (or Censoring Limit) of Non-Detects
    - Minimum
    - Maximum
- RL of Non-Detects and Detections Qualified - “J”
    - Minimum
    - Maximum
- Background Threshold Values (BTVs)
    - Statistical Method
    - 95th percentile
    - UPL95
    - UTL95-95
    - USL95
    - Notes, with recommendations

6.1.1 *Established* Datasets with Less than Five Detections

The following 14 chemical analytes (15 *established* datasets – cyanide having two) analyzed for the Study exhibited fewer than five detections for at least one of the distinct geomorphic strata that were evaluated for each individual analyte (also see Table 5):

Analyte	Formation / Topography	No. of Detects
Ethanol	Both / Non-Drainage	0
Cyanide	Chatsworth / Non-Drainage Santa Susana / Both	4 2
Formaldehyde	Both / Both	3
Dalapon	Both / Both	0
Dinoseb	Both / Both	1
Aldrin	Both / Both	3
Alpha BHC	Both / Both	3
Toxaphene	Both / Both	3
1-Methylnaphthalene	Both / Both	3
2-Methylnaphthalene	Both / Both	4
Acenaphthene	Both / Both	0
Benzo(a)anthracene	Both / Non-Drainage	4
Diethylphthalate	Both / Both	1
Dimethylphthalate	Both / Both	4

Due to the low number of detections, no meaningful and defensible statistical analysis may be performed on such an *established* dataset consisting mostly of non-detects. In addition, any detection in an *established* dataset consisting mostly of non-detects must also be evaluated with caution (USEPA, 2011b).

Based on an overall evaluation of these 14 analytes, it may be determined that they either do not or rarely occur at the background locations. However, a value needs to be determined to provide for subsequent Look-Up Table comparisons with SSFL on-site sample results. Consequently, as discussed previously, the sample RLs may be used for those analytes listed above with zero detects and for each analyte with less than five detects.

6.1.2 *Established* Datasets with Majority of Detects Below Maximum Censoring Limit of Non-Detects

Tin (combined over both formations and topographies), perchlorate (in the Santa Susana Formation) and 4-(2,4-dichlorophenoxy)butyric acid (2,4-DB) (combined over both formations and topographies) had relatively low detection rates of 10% (28 detects), 10% (13 detects) and 9% (13 detects), respectively. Due to variations in the sample-by-sample MDLs and the proximity of the detected values to the MDLs, , and "U"-flagged data for tin, the majority of the detections for these three analytes were below a large percentage of the non-detect censoring limits (see Table 5 and Appendix G).

These are situations in which there are a small number of detected values and a large number of non-detects with censoring limits greater than all detected values. Thus, statistical analysis using only the small number of detected values would be unreliable. Such non-detects need to be considered "indeterminate" relative to the detected values because one would not know whether they were above or below the detected values. For tin and 2,4-DB, no detected value is above the maximum censoring limit of non-detects. For perchlorate, only one detected value is above the maximum censoring limit of non-detects. Using only the detected values in such cases could lead to biased results. For this reason, a non-statistical method is recommended.

Due to the low number of detections above the non-detect censoring limits, no meaningful and defensible statistical analysis may be performed on such a dataset. Based on an overall assessment of the *established* datasets for these three analytes, it is concluded that BTVs cannot be calculated and the sample RLs should be used instead.

6.1.3 *Established* Datasets with Five or More Detections

One-hundred seventy-five (175) *established* datasets (representing 97 chemical analytes) analyzed for the Study had five or more detections. Because five detections are enough to conduct a defendable statistical analysis, BTVs were calculated for these analytes using the four statistics discussed above. The statistical parameters and BTVs for these chemical analytes are included in Table 5. As summarized in Section 5.4, the steps employed to calculate BTVs are presented in a set of graphs for each *established* dataset in Appendix G.

As noted in Section 5.2.1, for **inorganic analytes** (metals and perchlorate), there were **four** pre-defined sample populations:

- Chatsworth Formation / Drainage Topography
- Chatsworth Formation / Non-Drainage Topography

- Santa Susana Formation / Drainage Topography
- Santa Susana Formation / Non-Drainage Topography.

In addition to the inorganic analytes, the *established* datasets for cyanide, formaldehyde, fluoride, and nitrate were also represented by these four pre-defined populations. However, as presented in Section 6.1.1, all the *established* datasets for formaldehyde had fewer than five detects and two of the three *established* datasets for cyanide had fewer than five detects.

For the majority of the **organic analytes** (except for cyanide and formaldehyde as noted above), there were **two** pre-defined sample populations:

- Combined Formation (Chatsworth and Santa Susana) / Drainage Topography
- Combined Formation (Chatsworth and Santa Susana) / Non-Drainage Topography

Based on the sample design, the alcohols (ethanol and methanol) were represented by a single *distinct* dataset (i.e., one set of combined data not broken down by strata), based on the collection of non-drainage, subsurface samples from both the Chatsworth and Santa Susana Formations.

For each analyte (except the alcohols), each of the *initial* datasets was statistically compared to each other to determine if they were similar enough to be merged. The resultant BTVs for the *established* datasets, after the merging and outlier evaluation, are presented in Table 7.

6.1.3.1 Inorganic Analytes

There were relatively few inorganic compounds that exhibited results that were statistically similar across all the *initial* datasets. Of the 32 metals, fluoride, and nitrate, single *established* datasets and single BTVs were developed for only three: antimony, mercury and zinc. None of the *initial* datasets for the following five metals were statistically similar: barium, chromium, copper, , nickel, and selenium,. Consequently, the *initial* datasets representing the four geomorphic strata were retained for individual BTV estimation.

As noted in Section 6.1.2, no statistical analysis was performed for tin. For the remaining 25 inorganic analytes, the *initial* datasets exhibited statistically significant differences based on formation. However, in some cases, the topographies were merged for a specific formation. As noted in Section 6.1.2, the results of perchlorate samples from the Santa Susana Formation were non-statistical. However, the perchlorate results (57) for the Chatsworth Formation were statistically valid to compute BTV values for the combined topographies.

6.1.3.2 Organic Analytes

As previously noted in Section 2.4, based on the Study's SCM, the sampling design assumed that the organic analyte results from the Chatsworth and Santa Susana Formations (with the exception of alcohols, cyanide, and formaldehyde as discussed above) represent a single population. Consequently, the evaluation of the organic analytes assessed whether the *initial* datasets representing the drainages and non-drainages were statistically similar and should be merged.

Of the 72 organic analyte *initial* datasets (representing dioxins/furans, herbicides, pesticides, and SVOCs), approximately 75% were determined to be statistically similar with regard to topography and the *initial* datasets were merged for BTV estimation. The remaining 25% were retained as individual *distinct* datasets and BTVs were computed for both drainage and non-drainage topographies.

In addition, BTVs were computed for the sole *established* dataset for cyanide with greater than five detects that represents the Chatsworth/Drainage stratum. BTVs were also computed for methanol as a single combined *established* dataset as prescribed by the original sampling design; samples for methanol analysis (a volatile organic compound) were only collected from the subsurface (per the SCM) in non-drainage areas on both formations.

No statistical analysis was performed for ethanol and formaldehyde because of no or low detections.

6.2 USE OF BACKGROUND THRESHOLD VALUES

For the portions of SSFL to be further investigated and/or remediated under the AOCs, the Study’s BTVs represent the foundation for subsequently developing Look-Up Table values for characterizations and cleanup. The Look-Up Table values will be developed by DTSC in consultation with stakeholders and the Responsible Parties. The AOCs’ requirements state that the Look-Up Table values will be based, in part, on the results from DTSC’s background Study. For the investigation at SSFL, these Look-Up Table values will be compared to individual discrete soil samples collected on site. The AOCs assert that any SSFL on-site sample that exceeds a Look-Up Table value must be resampled and, if the analytical results are reproducible, the soil must be remediated. Although the Look-Up Table values will be derived from the Study’s results, they will also incorporate management decisions to facilitate cleanup at SSFL. Developing the Look-Up Table will also take into account the appropriate cleanup values to apply to SSFL site soils that have been disturbed or mixed together (by construction, demolition, remediation, etc.), or otherwise do not exhibit a distinct geomorphological profile.

SUMMARY

Under the active oversight and direction of DTSC, URS implemented an investigation of chemical background concentrations in soil and sediment to support the environmental investigation and closure activities at SSFL. The investigation was conducted in accordance with the Study's Final SAP, dated May 2011; Final SLA to the SAP, dated June 2011; and Final Revised QAPP, dated June 2011. The findings of the Study are summarized in this section.

The purpose of this Study is to establish a regulatory agency-approved, publicly-reviewed, and technically-defensible chemical soil background dataset for SSFL environmental programs. The objective was to collect background soil samples that represent the chemical composition of soil/sediment present at SSFL prior to its operational activities.

Two suitable background reference areas were identified:

- China Flat CBRA: This area is located approximately 3 miles west-southwest from the western SSFL boundary, and is underlain by the Chatsworth Formation.
- Wood Ranch CBRA: This area is located northwest of the China Flat CBRA approximately 4 miles west of the western SSFL boundary, and is underlain by the Santa Susana Formation.

Site representativeness is a key criterion for an acceptable background dataset. Thus, the chemical soil background sampling and analysis design was developed to be representative of SSFL on-site soil conditions. Based on the primary geologic and landform characteristics, the chemical soil background sampling design was based on the following four soil characteristic groups:

- Chatsworth Formation / Non-Drainage
- Chatsworth Formation / Drainage
- Santa Susana Formation / Non-Drainage
- Santa Susana Formation / Drainage

Soil and sediment sample collection was completed between July 6 and July 21, 2011, for the Wood Ranch CBRA, and between October 17 and November 1, 2011, for the China Flat CBRA. Soil sample collection and handling were conducted in general accordance with the Study's SAP and QAPP. Surface samples were collected from 0 to 0.5 feet bgs in the drainage areas. For non-drainage areas, subsurface samples were collected from 3.5 to 10 feet bgs in addition to surface samples.

Two hundred sixty-eight (268) primary soil samples (surface and subsurface) were collected and analyzed for inorganic analytes and 148 of these (surface only) were analyzed for organic analytes. The inorganic analytes included metals, hexavalent chromium (CrVI), fluoride, and perchlorate. The organic analytes consisted of polychlorinated dioxin and furan compounds (dioxins/furans), pesticides, herbicides, and semi-volatile organic compounds (SVOCs), including polynuclear aromatic hydrocarbons (PAHs) and phthalates. Four additional analytes were included following further consideration; specifically, alcohols (methanol and ethanol), cyanide, formaldehyde, and nitrate.

Following the completion of the chemical analyses, the data were reviewed and validated by an outside contractor. The analytical dataset generated as part of this Study, as qualified, with the exception of the rejected data (0.13%), is considered usable for meeting the Study's objectives.

The chemical soil background data were statistically evaluated to develop BTVs for each of the Study's individual detected chemical analytes within an overall suite of 111 constituents. The validated analytical results went through a progression of evaluation steps to establish individual datasets that represent the same sample population devoid of confirmed outliers.

For remedial work under the AOCs, the USL95 is recommended as the most appropriate statistic to estimate BTVs for those analytes with at least five detections and that sample RLs be used for those analytes with fewer than five detections. In accordance with the AOCs, a population statistic that represents the maximum value for the population, such as the USL95, is the most appropriate statistic to represent a BTV. The AOC approach, using do-not-exceed values based on background as the decision point for remediation, is why the USL95 is recommended as the appropriate statistic for estimating BTVs and sample RLs for use in deriving the Look-Up Table values to be used in conducting the AOCs' point-by-point, analyte-by-analyte comparisons.

The following summarizes the BTVs for the Study's analytes:

- Fourteen chemical analytes analyzed for the Study (acenaphthene, aldrin, alpha BHC, benzo(a)anthracene, cyanide, dalapon, diethylphthalate, dimethylphthalate, dinoseb, ethanol, formaldehyde, 1-methylnaphthalene, 2-methylnaphthalene, , and toxaphene) exhibited fewer than five detections for at least one of the distinct geomorphic strata analyzed for each individual analyte. Due to the low number of detections, no meaningful and defensible statistical analysis may be performed on such a dataset consisting mostly of non-detects. The reported laboratory sample RL may be used for each of these fourteen analytes.
- Tin (combined over both formations and topographies), perchlorate (in the Santa Susana Formation) and 2,4-DB (combined over both formations and topographies) had relatively low detection rates of 10%, 10% and 9%, respectively. The majority of the detections for these three analytes were below a large percentage of the non-detects. Due to the low number of detections above the non-detects, no meaningful and defensible statistical analysis may be performed on such a dataset. Based on an overall assessment of the datasets for these three analytes, it is concluded their evaluation be handled in a non-statistical manner. Consequently, the sample RL for each of these analytes may be used.
- One-hundred seventy-five (175) datasets (representing 97 chemical analytes) analyzed for the Study had five or more detections which is enough to conduct a defendable statistical analysis. Thus, BTVs were calculated for these analytes using the USL95.

CONCLUSIONS

A technically-defensible chemical soil background dataset for SSFL environmental programs has been developed. For the portions of SSFL to be further investigated and/or remediated under the AOCs, the calculated BTVs and sample RLs represent the foundation for subsequently developing Look-Up Table values for characterizations and cleanup at SSFL. The Look-Up Table values will be developed by DTSC in consultation with stakeholders and the Responsible Parties. Although the Look-Up Table values will be based, in part on the Study’s BTVs and sample RLs, they should also incorporate management decisions to facilitate cleanup at SSFL.

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Acceptance Criteria: Acceptance criteria address the adequacy of existing information proposed for inclusion into the project. These criteria often apply to data drawn from existing sources ("secondary" data).

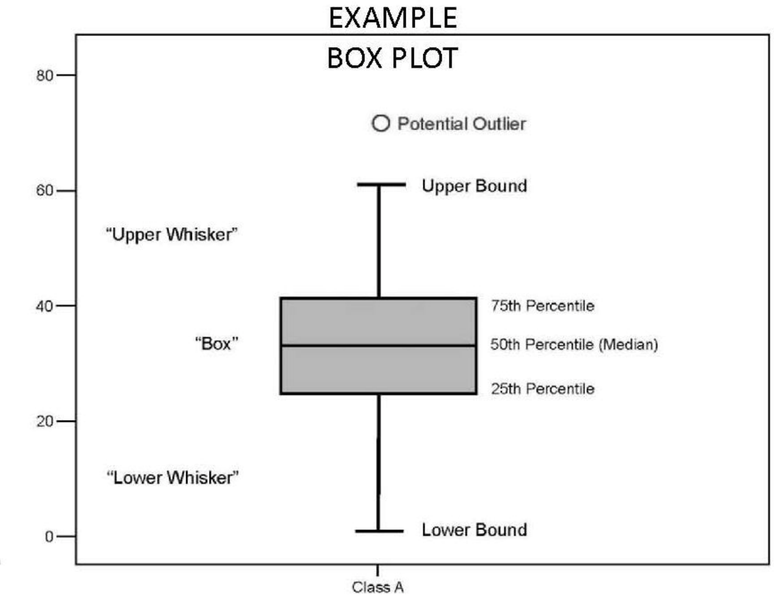
Accuracy: A measure of the overall agreement of a measurement to a known value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. USEPA recommends using the terms *"precision"* and *"bias,"* rather than "accuracy," to convey the information usually associated with accuracy.

Analyte: An element, ion, chemical compound, or chemical moiety (i.e., chemical characteristics such as pH, alkalinity, etc.) which is to be determined by an analytical procedure.

Assessment: The evaluation process used to measure the performance or effectiveness of a system and its elements.

Audit: A systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

Box Plot: A concise graphical display summarizing the distribution of a dataset. It provides visual summaries of the center and spread of the data.



Censored: A procedure to include (or not include) the value of a measurement or observation that is only partially known, often associated with values detected outside the calibration range of a measuring instrument. For example, "J"-flagged values are estimated concentrations between the method detection limit (MDL) and the reporting limit (RL). If the data are censored at the RL, all the "J"-flagged values are classified as non-detects and if the data are censored at the MDL, the estimated "J"-flagged values are classified as detections and used in the statistical evaluations.

Chain-of-Custody (COC): An unbroken trail of accountability that ensures the physical security of samples, data, and records.

Comparability: A measure of the confidence with which one dataset or method can be compared to another.

Completeness: A measure of the amount of valid data obtained from a measurement system.

Confidence Coefficient (CC): The confidence coefficient (a number between 0 and 1) associated with a confidence interval for a population parameter is the probability that the random interval constructed from a random sample (dataset) contains the true value of the parameter; also known as **level of confidence** or **confidence level**. The confidence coefficient is related to the significance level of an associated hypothesis test by the equality: Significance Level = 1 - Confidence Coefficient.

Contract Laboratory Program (CLP): The CLP is a national network of USEPA personnel, commercial laboratories, and support contractors whose fundamental mission is to provide data of known and documented quality. The CLP supports USEPA's Superfund program, created under the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and currently under the 1986 Superfund Amendments and Reauthorization Act (SARA).

Corrective Action: Any measures taken to rectify conditions adverse to quality and, where possible, to prevent recurrence.

Data quality: A measure of the degree of acceptability or utility of data for a particular purpose.

Data quality assessment: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use.

Data Quality Indicators: The quantitative statistics and qualitative descriptors used to interpret the degree of acceptability or utility of data to the user. The principal data quality indicators are bias, precision, accuracy (bias is preferred), comparability, completeness, representativeness, and sensitivity.

Data Quality Objectives (DQOs): The qualitative and quantitative statements derived from the DQO process that clarifies a study's technical and quality objectives, defines the appropriate type of data, and specifies tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

Data Quality Objective Process: A systematic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use. DQOs are the qualitative and quantitative outputs from the DQO process.

Data Validation: An analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific dataset. Data validation includes a determination, where possible, of the reasons for any failure to meet method, procedural, or contractual requirements, and an evaluation of the impact of such failure on the overall dataset.

Data Validation Qualifier: Codes applied to the data by a data validator to indicate a verifiable or potential data deficiency or bias.

***Distinct* Dataset:** For each chemical analyte, *initial* datasets are compared across applicable groups of geologic formations and topography (“strata”). Datasets that do not show statistically significant differences are merged into a combined dataset and the remainder are retained as individual background datasets. This step results in identifying one or more *distinct* datasets for each analyte.

Dixon’s Test: Dixon's Extreme Value test can be used to test for statistical outlier(s) when the sample size is less than 25. This test assumes that the data without the suspected outlier are normally distributed. The test evaluates one suspected outlier at a time and, therefore, if a dataset contains multiple suspected outliers, one should apply the test to the least extreme value first.

Dry-Weight Basis: Reporting the analyte concentration in a solid sample by excluding the weight of the water (i.e., moisture) in the sample.

Equipment Blank: Rinsate from the equipment that is used to take the sample. The purpose of the equipment blank is to assess the potential of cross-contamination of samples due to insufficient decontamination of sampling equipment.

***Established* Background Dataset:** For each chemical analyte, within each *distinct* dataset, potential outliers (if any) are identified and confirmed outliers (if any) are excluded from the *distinct* dataset. This results in identifying one *established* background dataset for each *distinct* dataset for each analyte. Statistical parameters are computed separately for each of the *established* background datasets.

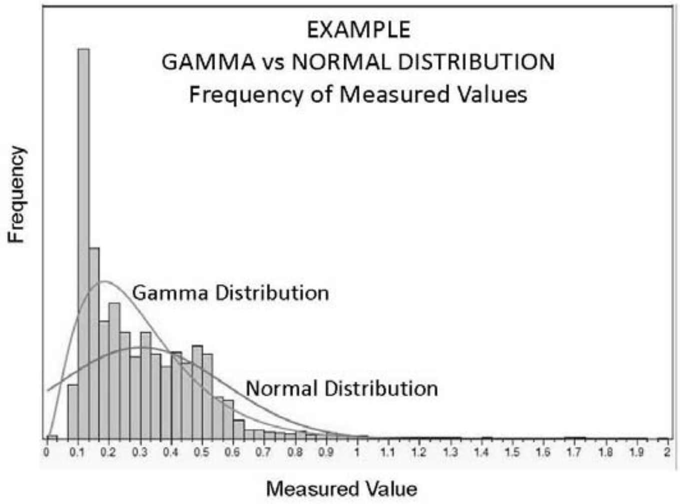
False-Negative Error: Finding of no statistically significant difference when there is, in fact, a chemical difference in the underlying populations or between a single population and a fixed compliance standard; also known as beta (β) or Type II error.

False-Positive Error: Finding a statistically significant difference when there is, in fact, no chemical difference in the underlying populations or between a single population and a fixed compliance standard; also known as alpha (α), significance level, or Type I error.

Field Blank: A reagent-free sample exposed to the same field conditions as the site sample, opened in the field. Its purpose is to assess the potential for field contamination.

Field Duplicate: A duplicate sample taken in the field from the same location as the original sample to ascertain sampling precision.

Gamma Distribution: A gamma distribution is a continuous probability distribution that could be used to model (fit) a positively-skewed distribution (i.e., a probability density function which has a high-peak at the lower-end of data values and then gradually drops at the high-end of data values, often with a long tail).



Goodness-of-Fit (GOF): The level of agreement between an observed set of values and a set wholly or partly derived from a model of the data.

Histogram: A histogram displays the number and proportion of observations falling in different data “bins” or data intervals (shown in the figure above as the vertical bars).

Holding Time: The period of time a sample may be stored before analysis. While exceeding the holding time does not necessarily negate the validity of analytical results, it causes the qualifying or “flagging” of any data not meeting all of the specified acceptance criteria.

Hypothesis: Hypothesis is a statement about the population parameter(s) that may be supported or rejected by examining the dataset collected for this purpose. There are two hypotheses: a null hypothesis, H_0, representing a testable presumption (often set up to be rejected based upon the sampled data), and an alternative hypothesis, H_A, representing the logical opposite of the null hypothesis.

***Initial* Dataset:** For each chemical analyte, an individual *initial* background dataset includes all validated analytical results from a given geomorphological group or “strata.”

“J”-Flagged Value: An analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample; due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the reporting limit (RL).

Kaplan-Meier Method: A method for estimating summary statistics of censored data. It is a recommended statistical method to analyze environmental data containing non-detect values.

Kruskal-Wallis Test: Analogous to the Wilcoxon-Rank-Sum test, but applied for comparisons involving three or more datasets.

Laboratory Control Sample (LCS): A well-characterized sample of known analytes and concentration. A reagent-free matrix is spiked with known concentrations of analytes and carried through the same preparation and analysis procedure as a sample. For each analytical batch, at least one LCS should be prepared from the same source as the calibration standards. A reference material containing certified amounts of target analytes may be used as an LCS. The percent recovery of the target analytes in the LCS is compared to established control limits and assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy. The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps.

Left-Censoring: A data point is below a certain value, but it is unknown by how much, as a result of a measurement below the detection limit of the analytical instrument or laboratory method.

Lillifors Test: A test of normality for large datasets ($n > 50$) when the mean and variance are unknown.

Matrix Spike/Matrix Spike Duplicate: A known amount of a target analyte is added to a specified amount of a project sample prior to preparation and analysis to ascertain any matrix effects on recoveries and to determine the accuracy and precision of the method in that matrix.

Mean: The sum of all the values of a set of measurements divided by the number of values in the set; a measure of central tendency.

Median: The middle value for an ordered set of n values. Represented by the central value when n is odd or by the average of the two most central values when n is even. The median is the 50th percentile.

Method Blank: An analyte-free matrix (water, soil, etc.) subjected to the entire analytical process to demonstrate that the analytical system itself does not introduce contamination. Analysis of a method blank is used to assess contamination from the laboratory environment, sample processing equipment, and/or reagents. A method blank is included with the analysis of every sample preparation batch, every 20 samples, or as stated in the method, whichever is more frequent.

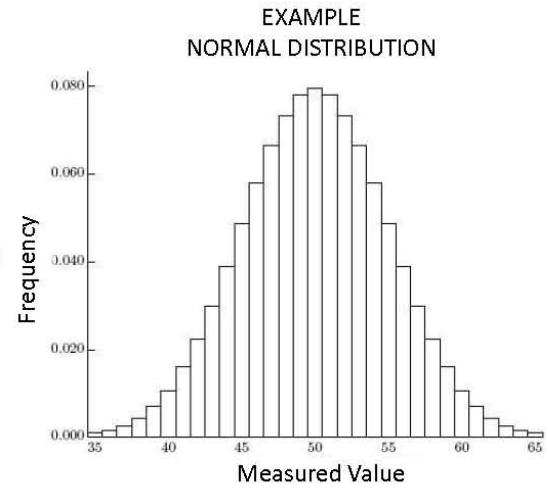
Method Detection Limit (MDL): The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero in a specific matrix.

Non-Detect (ND): Observations below the Method Detection Limit (MDL).

Non-Normal: A population which could not be assumed to be normally distributed.

Non-parametric: A term describing statistical methods that do not assume a particular population probability distribution and are, therefore, valid for data from any population with any probability distribution, which can remain unknown.

Normal Distribution: A normal (or Gaussian) distribution is a continuous probability distribution that has a bell-shaped probability density function, with the population mean in the center and the data values symmetrically distributed around it.



Outlier: An extreme observation that is shown to have a low probability of belonging to a specified data population.

Parameter: A quantity, usually unknown, such as a mean or a standard deviation characterizing a population. Commonly misused for “variable,” “characteristic,” or “property.”

Parametric: A term describing statistical methods that assume a particular, well-defined type of population probability distribution, such as normal distribution and gamma distribution.

Performance Criteria: Address the adequacy of information that is to be collected for the project. These criteria often apply to new data collected for a specific use (“primary” data).

Precision: A measure of agreement among repeated measurements of the same property under identical, or substantially similar, conditions; expressed generally in terms of the standard deviation.

Prediction Interval: A prediction interval is an estimate of an interval in which future observations will fall, with a certain probability or level of confidence, based on what has already been observed.

Probability Plot: A probability plot is used to determine how well data fit a theoretical distribution, such as the normal or gamma distribution. The theoretical distribution appears as a straight line so that departures of the actual data points from the distribution can be more easily perceived.

Qualified: Chemical analytical data which are reported with a specified condition, in accordance with Quality Assurance Project Plan (QAPP) requirements.

Quality: The totality of features and characteristics of a product or service that bears on its ability to meet the stated or implied needs and expectations of the user.

Quality Assurance: An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

Quality Assurance Project Plan (QAPP): A formal document describing in comprehensive detail the necessary quality assurance procedures, quality control activities, and other technical activities that need to be implemented to ensure that the results of the work performed will satisfy the stated performance or acceptance criteria.

Quality Control (QC): The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality.

Quality Control Limit: A specified boundary on a control chart that, if exceeded, indicates a process is out of statistical control and the process must be stopped and corrective action taken before proceeding.

Quality Control Sample: An uncontaminated sample matrix spiked with known amounts of analytes from a source independent of the calibration standards. Generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.

Quantified: A sample value is said to be fully quantified when the actual measured concentration is reported by the laboratory, for which it is not censored or qualified (i.e., a detected concentration reported above the reporting limit).

Quantitation Limit: The lowest concentration level for an analytical method which can be reliably achieved within specified limits of precision and accuracy under routine laboratory operating conditions.

Reporting Limit (RL): The lowest concentration level for an analytical method which can be reliably measured by a laboratory.

Representativeness: The measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Rosner's Test: Rosner's test can be used to detect up to 10 outliers for sample sizes of 25 or more. This test assumes that the data without the suspected outliers are normally distributed.

Sensitivity: The capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest.

Shapiro-Wilk W Test: A test of normality for small datasets ($n \leq 50$) with the null hypothesis that a dataset $x_1, ..., x_n$ comes from a normally-distributed population.

Significance Level: The error probability (also known as false-positive error rate) that is tolerated if falsely rejecting the null hypothesis and accepting the alternative hypothesis.

Spike: A substance that is added to an environmental sample to increase the concentration of the target analyte by known amount; used to assess measurement accuracy (spike recovery). Spike duplicates are used to assess measurement precision.

Split samples: Two representative portions taken from one sample in the laboratory and analyzed by two different laboratories. Prior to splitting, a sample is mixed (except for volatiles, or when otherwise directed) to minimize sample heterogeneity. These are quality control samples used to assess precision, variability, and data comparability between different laboratories.

Standard Deviation: A measure of variation (or spread) from an average value of the sample data values.

Standard Operating Procedure (SOP): A document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps to be followed. It is officially approved as the method for performing certain routine or repetitive tasks.

Statistically Significant Difference: Statistical difference exceeding a test limit large enough to account for data variability and chance.

Tolerance Interval: A tolerance interval establishes limiting values that include a fixed proportion of a population with a stated level of confidence.

Trip Blank: A clean sample of water that is free of measurable contaminants and is taken to the sampling site and transported to the laboratory for analysis without having been exposed to sampling procedures. Analyzed to assess the contamination introduced during sample shipment. Trip blanks are analyzed only for volatile organic compounds.

Upper Percentile (x0.95): A statistical parameter represents an estimate of the 95th percentile of a population. It is expected that 95% of the values coming from the same population would be less than or equal to x0.95.

Upper Prediction Limit (UPL95): The UPL95 establishes a limit that would classify future observations at or below this limit as being taken from the same population with a confidence coefficient (CC), or confidence level, of 95%.

Upper Simultaneous Limit (USL95): The USL95 is the statistic such that all potential observations (present and future), not some proportion or percentile, from the same population will be less than or equal to USL95 with 95% confidence level.

Upper Tolerance Limit (UTL95-95): The UTL95-95 is a value that represents the upper limit of an tolerance interval such that 95% of the observations from the same population will be less than or equal to that upper limit value with a confidence coefficient (CC), or confidence level, of 95%.

Wilcoxon-Rank-Sum (WRS) Test: The Wilcoxon-Rank-Sum (or Wilcoxon-Mann-Whitney) test is a non-parametric test used for determining whether a difference exists between two population distributions. The WRS tests whether or not data values from one population consistently tend to be larger (or smaller) than those from the other population based upon the assumption that the dispersion of the two distributions are roughly the same.